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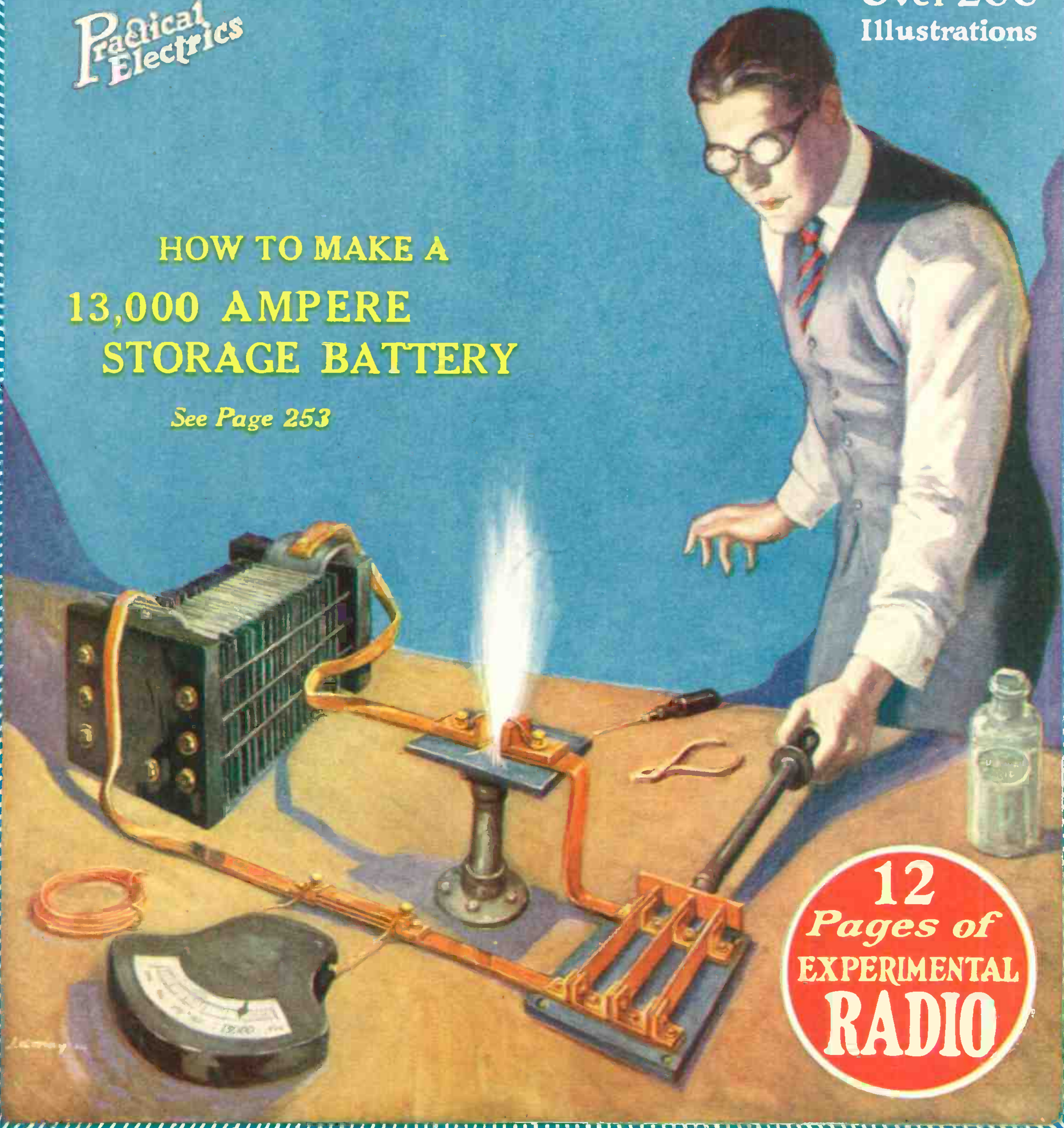
See Page 253



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The EXPERIMENTER

Vol. 4 **Contents** **No. 4**

FOR FEBRUARY

IMPORTANT ARTICLES IN MARCH ISSUE

HIGH VOLTAGE STUNTS AT THE UNIVERSITY OF CALIFORNIA. High frequency Tesla coil described by a Faculty Member of the University of California. Marvelous experiments such as drawing foot-long sparks from your head, etc., and instructions on how to make the apparatus; the annual exhibition at the University.

RADIO EXPLAINED BY MECHANICAL EXAMPLE. The action of the vacuum tube so little understood by the majority of people, is here explained by a complete mechanical analogy.

FUN WITH GASES. How to experiment with gases in the laboratory, using the simplest apparatus and doing good work.

MAKING CELLULOID BATTERY JARS. A very clear description of a process of manufacturing battery jars which may be applied to many other purposes.

MERCURY VAPOR LAMP. One of Dr. Russell G. Harris' valuable articles, written for the home experimenter.

SULPHUR PANELS. This is a most suggestive article. It tells the experimenter how to use sulphur panels of home manufacture, instead of the more expensive bakelite ones bought in the store.

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THE EXPERIMENTER is published monthly on the 20th of each month, by THE EXPERIMENTER PUBLISHING CO., INC. (THE GERMOTT PUBLISHING COMPANY, INC.), owner, at 53 Park Place, New York City. THE EXPERIMENTER is entered as second-class matter, October 14, 1921, under act of March 3, 1879.

All communications and contributions to this magazine should be addressed to: Editor, THE EXPERIMENTER, 53 Park Place, New York City. Unaccepted contributions cannot be returned unless full postage has been included. All accepted contributions are paid for on publication. A special rate is paid for novel experiments; good photographs accompanying them are highly desirable.

THE EXPERIMENTER is for sale at all news stands in the United States, Canada and also at the principal news stands in all foreign countries.

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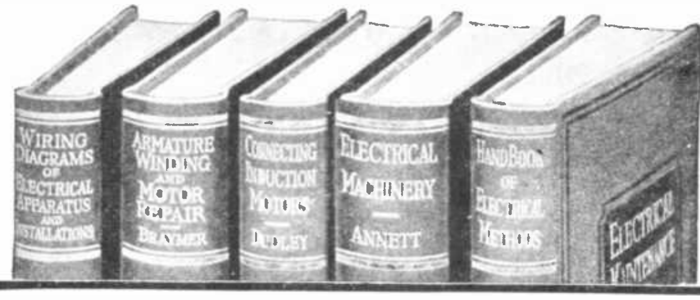

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Volume 4
No. 4

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

February
1925

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

The Purpose of Experimentation

By Hugo Gernsback

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

EXPERIMENTING may be divided into two classes:

(1) Experimentation for instructive purposes;
(2) Experimentation with a certain definite end in mind.

The first may also be called amateur experimentation, done as a sort of hobby, as a recreation, and to enlarge one's knowledge of certain scientific phases.

It is one thing for the amateur experimenter to read about certain experiments, and quite another to actually perform these experiments himself. Both differ as widely as day and night. While certain knowledge may be gained from reading up certain experiments, the reader who has never performed them gets but a hazy idea and misses all the beauty of the subject. It is like reading glowing descriptions of a perfume or of a cigarette, etc. You can get only an idea, and that is all. The actual performance is always the important point for which we should strive.

Usually the dyed-in-the-wool experimenter gains a vast store of knowledge, because even the simplest experiments sometimes bring out most surprising by-products that were not expected, and this is what makes experimenting so fascinating and makes it so utterly unlike any other activity. You start to carry out a certain experiment and wind up in an entirely different direction, a thing that would never be possible if you simply read a description of what you are now doing. Great inventions have been made in this very manner.

The writer remembers when, some years ago, he invented an electrolytic interrupter for radio purposes. This was a glass tube with a small hole at its lower end, into which was fitted a German silver rod, so that the rod itself closed the small glass aperture. The entire device was immersed in a sulphuric acid solution. The other connection was a lead plate, also immersed in the same solution. The electrolytic interrupter was in series with D.C. circuit including a specially made high tension transformer and giving a potential of 110 volts. When the writer first experimented with the device, he noticed that the acid would commence rising up in the inside of the tube, and for that reason an overflow had to be provided in the tube so that the superfluous acid was allowed to escape and to return into the solution.

One day he constructed an especially long tube upon the same lines, and noticed that a vigorous flow of acid could be maintained over a distance of three or four feet. He then constructed a still different tube and found that the acid could be raised very violently for a distance of many feet. In other words, actual work would be performed. This same device is now actually being used to pump acid; in other words, the device really constitutes an electrical pump. There are no valves of any kind. It is simply the action of the electric current that performs the work of raising the liquid.

Now, coming back to the above discussion, when the writer started out making the electrolytic interrupter, he had not the faintest idea of an electric pump. This happened to be a by-product, pure and simple, and the pump would never have been invented had it not been for the experimenting done on the electrolytic interrupter.

Many similar instances could be enumerated, and indeed it is an unobserving experimenter who sooner or later will not run across something useful in the course of his work.

This brings us to the second phase; that is, experimenting with a certain purpose in view. In most of our industrial establishments, be they electrical manufacturers, chemical manufacturers, or radio manufacturers, you will find a staff of experimenters whose sole purpose it is to evolve new products. These may be termed commercial experimenters, and these men are usually paid to do just one thing, and that is to improve present articles or devices, or chemicals, or to discover new and better ways of performing the present work. Now, if it is your intention to become a professional experimenter, you must be an amateur experimenter first.

The writer has already mentioned in his previous editorials the great importance of keeping notes of all your work. Often such notes become of tremendous value. A novel experiment made, of which no record is kept, is a positive crime, because notes of what you have done, if they are accurately made and witnessed as to date, may later on be worth a fortune.

It is a mistaken idea of many people that an idea is only valuable once it is patented. Nothing could be more erroneous. Let us take an example. You experiment for two years on a certain device. Finally this device becomes perfected. No notes have been kept of what you have done. You immediately go to a patent attorney, the papers are prepared and the patent application is dispatched to the patent office. You engage yourself in the business of manufacturing the device, and actually start manufacturing. Six months afterwards you receive a notice from the patent office that your patent application is in interference with another one. The minute this happens, your patent application becomes worthless and you have to fight it out in court with the other inventor, who may have come to the Patent Office a few weeks later than you, which, however, does not alter the case. It then narrows down to a fight as to *who actually conceived the invention first*. It is a question only of date of invention, and this must be proved. If you have no well-authenticated notes, and the other fellow has, the chances are that you will lose out. In other words, it is not the patent application or the patent that counts, but rather *the date of conception of the idea*, and this dates right back to the first experiments.

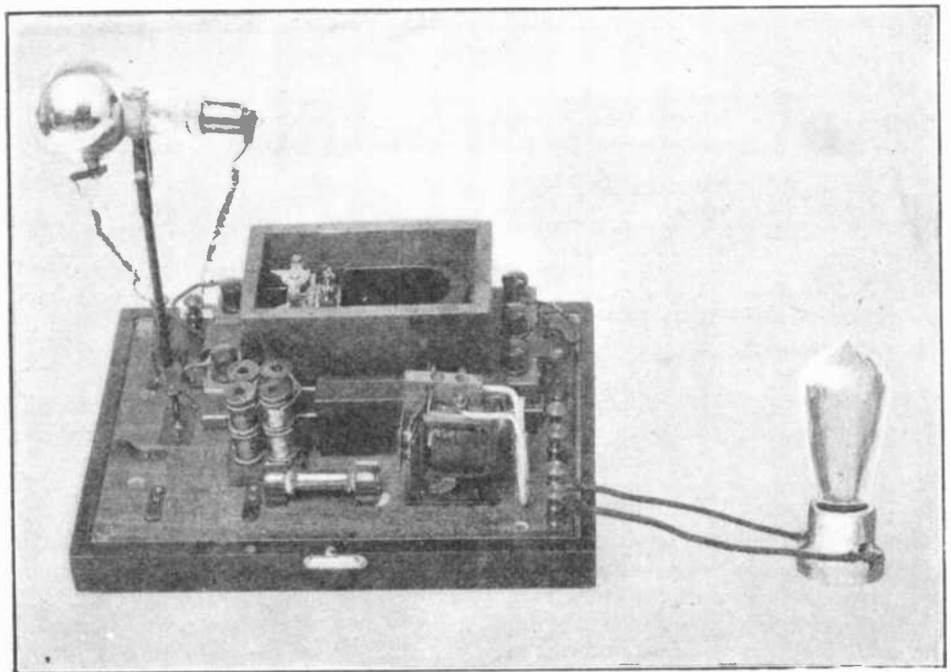
Therefore, the writer's advice to all experimenters is if you run across something at all novel, that looks new to you, get it on paper at once and have it witnessed before a notary. The next best step would be, in some cases, to send a copy of the experiment to a national publication, such as THE EXPERIMENTER. If the journal publishes the experiment, this gives you the best possible protection you could think of. From the minute the experiment is published in a national publication you have two years within which to make a patent application.

The Vacuum—There's Something In It

Abstract of Lecture, By Dr. W. R. Whitney

Director, Research Laboratory, General Electric Company

(Continued from December Issue)



In the unusual flashing apparatus illustrated above, the light given off by the incandescent lamp at the right excites a photoelectric cell on the left and the resulting current through the cell actuates a relay which opens the lamp circuit, and thus extinguishes the lamp. With the light out the photoelectric cell ceases to act, the relay resumes its normal position and the lamp is once more lit. The cycle now is started again.

Magnetron

As the negatively charged grid cuts off the current of the three-element tube, so an external magnetic field will also do it in the two-element tube, by so influencing or directing the moving electrons that they cannot reach the plate. Such a device, called a magnetron, was shown. This particular magnetron, consisting of a cylindrical plate in a vacuum and a central filament within it, had a coil of wire wound on the outside of the glass. A feeble current was sent through the coil from a battery. A magnetic field produced within the coil by this current was intentionally made about equal to that of the earth's magnetic field, so that by moving the whole apparatus about in space (thereby at one time adding to the earth's field, at others opposing it), the magnitude and direction of the earth's magnetic field could be disclosed by a meter which indicated the resultant current. When the magnetron pointed toward the north pole, the meter showed no current, while in other positions currents were measured.

Axiotron

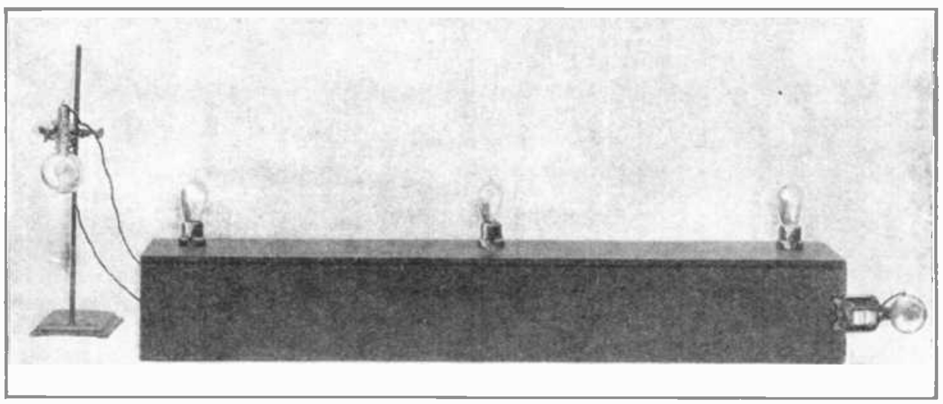
Another useful vacuum tube of this type is one in which the magnetic field of the filament current itself becomes great enough during each current cycle to deflect the electrons so that they will not reach the plate. By this tube, "the axiotron," the frequency of an alternating current may be doubled or direct current be changed into alternating.

Photoelectric Cell

Another vacuum tube is the photoelectric cell. One of these was shown connected with a relay to a lamp so that when light shone upon the cell, the burning electric lamp was extinguished, and was relighted on cutting off light from the photoelectric cell. In other words, it turns on the lights when it is dark, and turns them off when it is light. This depends on the fact that some metals like potassium emit electrons when light falls upon them. These electrons in vacua constitute a current when they are made to move by the electrical impulse. To repeat, applying potential to a vacuum tube having a potassium electrode and another electrode for leading off the current causes current to flow as negative electrons from the illumined metal, and this current actuates the electrical switch which turns off the lighting current of the burning lamp.

The Nerve

This led to the next, an ambitious physiological experiment. A photoelectric cell was made to represent a crude "eye" which was connected to a so-called "nerve" leading to a "brain." The nerve was merely a long box, having electrical capacities and suitable amplifiers or three-electrode tubes within. The capacities served to slow down the apparent rate of flow of the feeble current from the artificial eye so that indicating lamps along the top of the box or "nerve" would light up, one after another, as the impulse from the "eye" passed along that path, or the nerve. After the last lamp was thus lighted by these amplified currents, an electric bell rang to indicate reception at the "brain" end of the circuit. This was not shown as a reliable replica of the real nervous system, but as an application of the vacuum tube which amplified the slight energy available and necessary for the experiment. With such slight energy it became practicable to show the delayed transmission and reception which is necessary for an illustration of nerve action. Nerve impulses travel much slower than electricity usually does, and this slow speed was one objection to visualizing nerves as electrical conductors until Crehore and Williams showed that nerves might be naturally so constructed as to transmit slowly.



The box contains several stages of vacuum tube amplifiers of large capacities. Capacity in the circuit reduces the effect of instantaneous currents. When the photoelectric cell at the left is excited the growth of this current is so slow that it is seen by the successive illuminations of the pilot lamps above the box. At the last stage of the amplifier an electric bell rings.

X-Rays

In order to show another vacuum product (the X-ray tube), an effect of X-rays was demonstrated which is not usually thought of in connection with X-rays. Three rubber balloons, suspended close together by long cords, were first charged electrically by being rubbed on the head of the speaker. They then repelled each other and stood stationary in space as at the corners of a larger triangle. As soon, however, as a feeble beam of X-rays was projected toward them they quickly discharged and fell to their original position in contact with one another. X-rays ionize air or make it conducting so that the balloons could not retain their mutually repelling charges. This is the basis of a method for measuring the intensity of beams of X-rays.

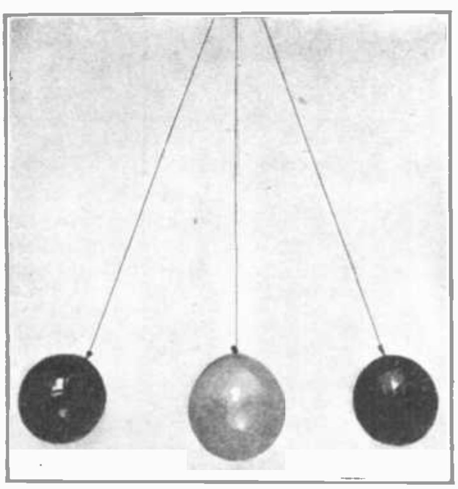
Spectra

References were made to the various applications of X-rays, as in the study of internal structure of crystalline chemical compounds and elements. Cathode rays, currents of negative ions in vacuo when speeded up by high voltage, produce by their impact, X-rays which are characteristic of the material on which they impinge; one may say characteristic of the mass of the atom of the substance of the target. It is through this fact that the X-ray spectra of the elements considered as to wave-lengths are arranged in the same order as the atomic masses in the periodic table of Mendelejeff, and by this very method the newest known element, hafnium, has been recently added to the known metals. Referring again to our bee analogy, let a fast-flying swarm strike bells so hard that they make them ring. From the sound of musical notes we guess roughly the size of the bells. We could thus place them in their musical series. The sound corresponds to the X-rays produced when the bees are electrons of cathode rays and sound waves are ether waves. The mass of the bell is disclosed by the tone or frequency, the mass of the atom, by the same sign, is disclosed by the ether wave frequency. When a certain mineral was used as a surface for the electrons to hit, a new musical note in the ether was found. It was recorded photographically. Its place in the scale of elements had been predicted as accurately as middle C on the piano might have been predicted if it had never been heard.

With higher voltages the velocity of the cathode rays (or electrons) always increases. In the X-rays thus far produced, however, the penetration or transparency is practically limited to about a quarter of an inch of lead. It is interesting to note that the similar rays from radium, the so-called gamma rays, can penetrate nearly a foot of lead. This corresponds to an exceedingly high electromotive force. Thus radium rays (gamma rays) might be made in vacuum X-ray tubes if millions of volts were applied.

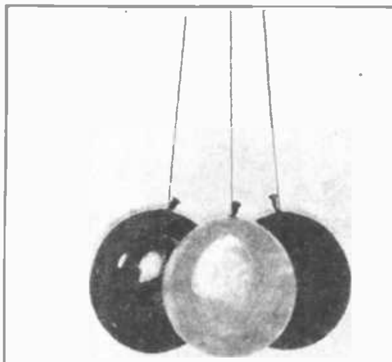
Atom Layers

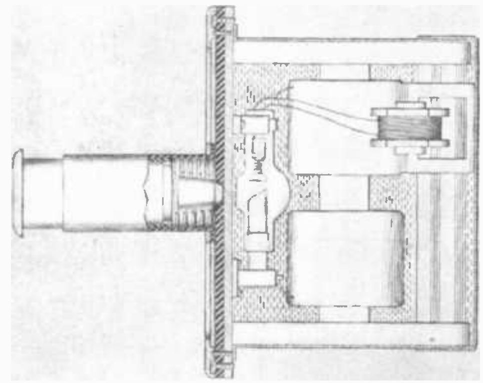
An apparatus was shown, devised by Dr. Hull, which is essentially a two-electrode vacuum tube, the tungsten filament having a little thorium in it. At a certain very high temperature this thorium rapidly diffuses to the filament surface. This thorium surface then has the peculiar power of emitting electrons a hundred thousand times as rapidly as pure tungsten at the same temperature. An ordinary lamp was lighted in this experiment by letting this thorium electron emission current flow throughout the lamp filament. The vacuum tube containing the thorium-coated tungsten also contained a little gas. When the lighted lamp was short-circuited for an instant by a switch, the potential on the vacuum tube was thereby greatly increased, and this caused positive ion bombardment of the filament and thus tore the thorium all off the tungsten surface so that very few electrons were being emitted, *i. e.*, those characteristics of pure tungsten at that temperature. Then the load (the lamp) could no longer be "carried"



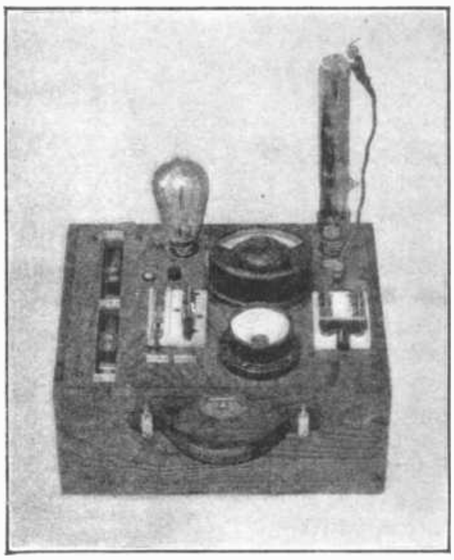
Inflated India rubber balloons are charged by friction or stroking with a cat's skin or other animal substance, and they repel each other.

by the electron current. To repeat, the heavy positively charged gas ions under the impulse of the raised electrical potential act like a powerful sand blast and effectively clean the thorium from the tungsten, thus greatly reducing the emission current. By highly reheating the filament for a few seconds only, a fresh layer of thorium diffused anew to the surface of the filament from within the tungsten, so that then at the previous lower temperature the load or lighting current for the lamp was carried as before by electrons emitted from the thorium surface. This was mentioned as a proof of the production of a layer of thorium on the





The balloons just described are discharged by X-rays projected upon them and immediately come together.



This experiment illustrates the power of thorium. There is a two electrode vacuum tube whose filament of tungsten is charged with a salt of thorium. This gives it the power of emitting electrons one hundred thousand times as rapidly as the pure tungsten filament would. Suddenly raising the potential within the tube caused the gas atoms to act as a sand blast and to scour off the thorium and the conductive power of the tube was enormously diminished.

tungsten only one atom deep. The electron current from thorium on tungsten is greater than from pure tungsten and also than pure or massive thorium and is maximum when the single atom layer is present. This is confirmed by experiments on partial recovery of the surface and supported by thousands of successive repetitions of this experiment on one filament.

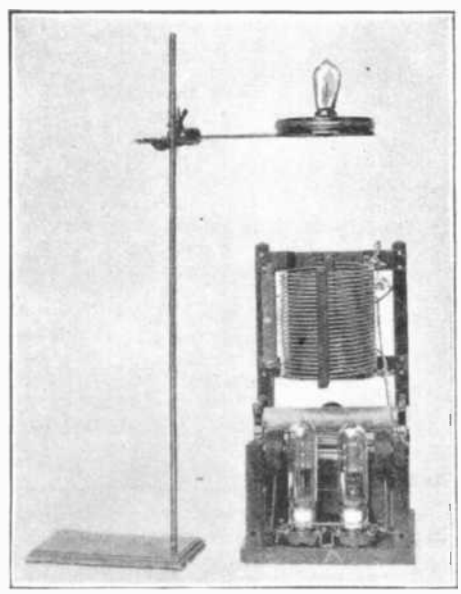
High Frequency

The production of high frequency current by means of pliotrons was shown and an ordinary incandescent lamp was lighted by being brought within a foot of a coil which was carrying the current of several million cycles. This was said to be about as near to wireless transmission of power as we now have. This high frequency principle is also being used by Professor Northrup, of Princeton, for special electric furnaces.

Loud Speaker

During part of the address a loud speaker devised by Dr. Hewlett was in use. This consisted of a 26-inch flat conducting disc in a magnetic field. The vibrations of the disc corresponding to the voice currents produced the sound waves without the intervention of a horn. The use of vacuum tubes in this device consisted in the following:

A microphone was placed near the speaker and the sound waves of his voice caused to be generated in this microphone feeble electromotive forces which were applied to the grid of a pliotron. These feeble electromotive forces caused relatively large variations in the electric current flowing between filament and plate, which in turn were used to secure larger electromotive forces to be applied to the grid of another pliotron. By the use of several amplifying pliotrons the original feeble electrical currents were multiplied several thousand times and supplied to the loud speaker which reproduced the original sounds with many times the original volume and great faithfulness of quality. To operate this amplifier of pliotrons required a direct current and several hundred volts. This was obtained by first trans-

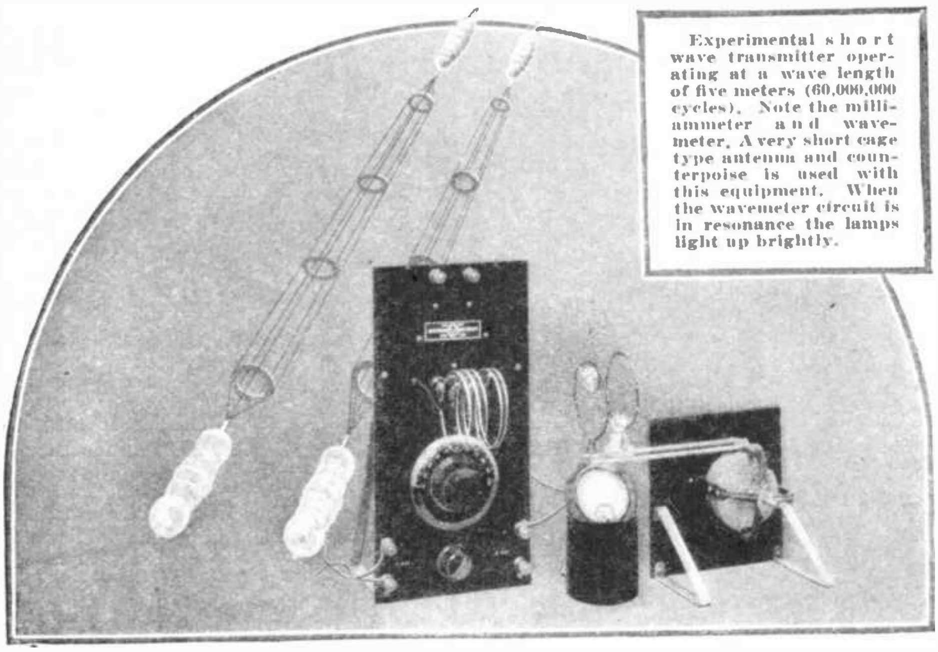


Here high frequency discharge travels through space and lights a lamp. The coil passed several million cycles per second.

forming the power from the ordinary alternating current lighting circuit to a relatively high voltage, next rectifying this high voltage alternating current by means of kenotrons, and finally smoothing out this pulsating current by means of special electric circuits.

EXPERIMENTAL RADIO

Conducted by Clyde J. Fitch



Experimental short wave transmitter operating at a wave length of five meters (60,000,000 cycles). Note the milliammeter and wavemeter. A very short cage type antenna and counterpoise is used with this equipment. When the wavemeter circuit is in resonance the lamps light up brightly.

Future Radio

By Clyde J. Fitch

REVIEWING the history of radio during the past 30 years one may wonder what the future will bring forth. During the past five years the strides have been so rapid that it resembles geometric progression; that is, the faster we advance the more fields are opened up for advancement, and each new discovery leads to many others.

Over 30 years ago Hertz proved conclusively that short radio waves obeyed the same laws as did waves of light with regard to speed of propagation, reflection, refraction, and diffraction. But as theory was far in advance of practice, experiments in short wave radio transmission ceased and for a long time research work and commercial wireless telegraphy were carried on with waves of longer lengths or lower frequencies. But now conditions are different. We have at our disposal many types of vacuum tube oscillators capable of generating extremely high frequencies, in the neighborhood of 60,000,000 cycles per second. These can radiate waves of five meters or a little over 15 feet in length. The present tendency seems to be in the direction of short-wave transmission. Judging from amateur work, which is always a year or two in advance of commercial work, we can prophesy that within a few years all broadcasting and commercial transmitting will take place at wave lengths below 100 meters.

Today many broadcast stations transmit their programs simultaneously on short and long wave-lengths, and on account of the extremely high frequencies involved there is plenty of room for every radio station in the world to operate at the same time in a wave-length band of four to five meters without interference. Thus, it seems logical to assume that in the near future we shall all be working on short wave-lengths. We not only have the advantage of using small aerials for this work, but transmission at these wave-lengths is much more efficient and interference from static is slight. We may soon expect a short-wave portable receiver with a folding antenna about two feet long that may be conveniently carried in a person's coat pocket.

The tests show that short waves behave quite differently from long waves in their propagation, and that the weak periods followed by a recovery in signal intensity observed at sunset and sunrise with long waves over great distances do not occur in the case of short waves. Also there is probably no sharp limit between short and long waves, and the change from the behavior of short waves (of, say, 100 meters) to that of long waves (say, 10,000 meters) may follow a slow process of transformation.

The difficulties involved in short wave transmission are due to tube capacities. At the extremely high frequencies it is necessary to obtain circuits having very low distributive capacity. This requires vacuum tubes having low internal capacities. The smaller the tube, the lower the capacity, and small tubes are required to generate currents of high frequency. Small tubes mean small power, and at present it is practically impossible to transmit on a wave-length of five meters with power tubes. Transmission is now accomplished at this wave-length by tuning the aerial circuit to a harmonic of the oscillator circuit. In the future we may expect vacuum tubes that will directly generate oscillations of sufficient power to transmit at this wave-length.

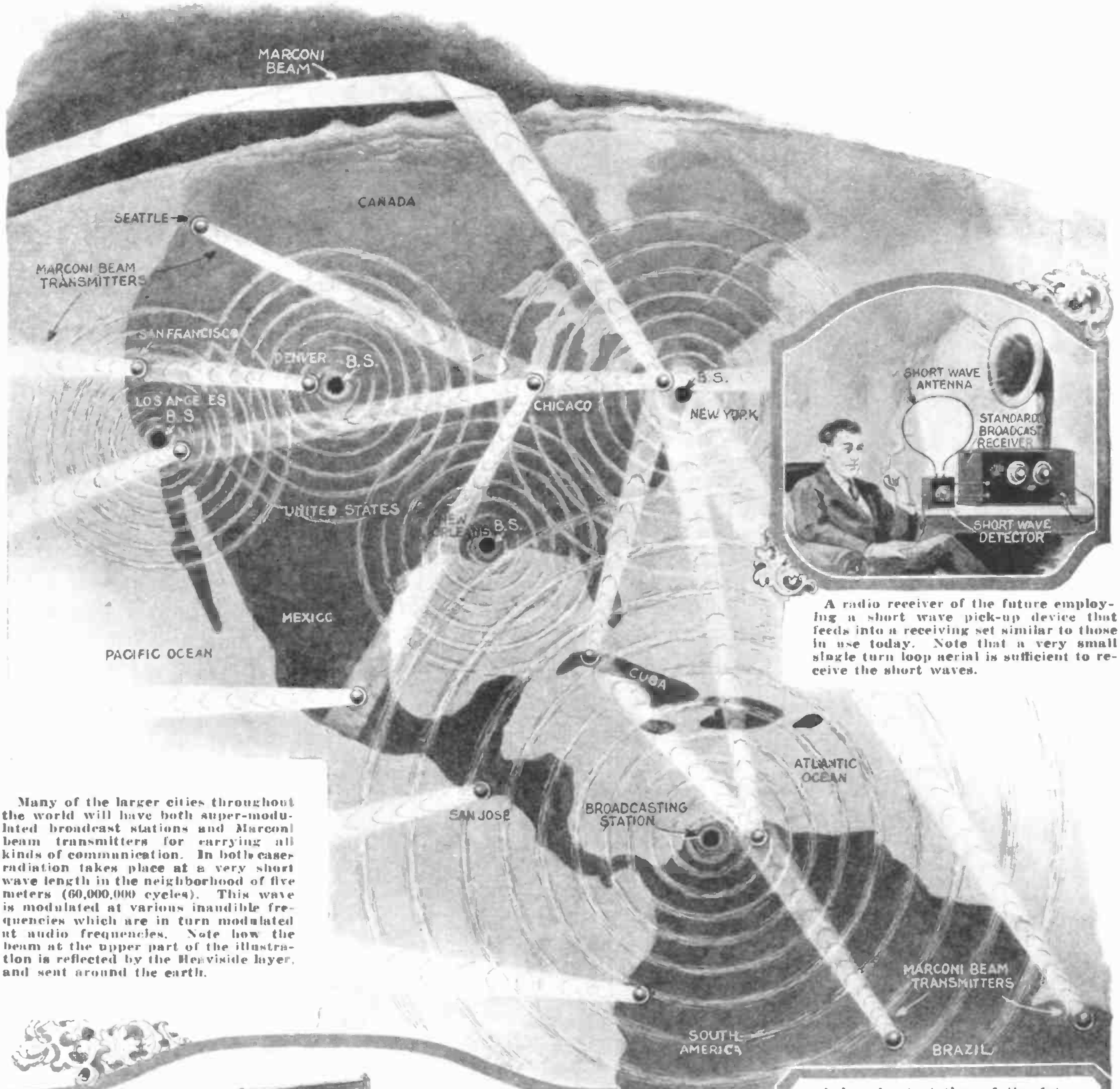
The reproduced photographs show an experimental five-meter radio transmitter. The diagram shows the circuit used. In order to decrease electrostatic capacity in the circuits as much as possible, the base of the vacuum tube was removed and the connections made as short as possible. The receiving circuit is also shown in one of the illustrations. It consists of a single turn of wire connected directly to a variable condenser. A small flashlight bulb lights up brilliantly in the circuit at a distance of several feet, when the circuits are in resonance. This apparatus was developed by Mr. William A. Bruno, A.I.E.E., of New York.

In our full page illustrations a proposed system of carrying on radio communication, both broadcasting and commercial, is shown. This system makes use of identically the same principles that are involved in present day transmission except that higher frequencies are employed. Broadcasting stations of today transmit on wave-lengths ranging from 200 to 600 meters or frequencies ranging from 1,500,000 to 500,000 cycles per second. These frequencies are in turn modulated by audio frequencies ranging from 250 to 4,000 cycles per second. For example, suppose we take a 600-meter station broadcasting at a frequency of 500,000 cycles. This frequency is easily modulated by all the frequencies of the musical scale simultaneously and each note is faithfully carried to the receiving station. Suppose we have two bells at the broadcasting station, one of which gives a note of 1,000 cycles and the other a note of 4,000 cycles. Both notes are distinctly heard at the receiver. The two notes are detected and amplified by the audio amplifier. If we have a very selective audio amplifier that may be tuned to a definite frequency, we could tune the amplifier to the 1,000 note or to the 4,000 note and hear either one or the other bell as desired.

In our proposed scheme the same conditions hold true except that all frequencies are higher. Suppose, for example, we multiply the highest audio note of 4,000 cycles by 15, we get a frequency of 500,000 cycles or a wave-length of 600 meters. We shall also multiply the 600-meter wave-length of 500,000 cycles by 15. This gives us a frequency of 62,500,000 cycles, or a wave-length of 4.8 meters. Therefore, whether we modulate a 62,500,000 cycle wave by 500,000 cycles or a 500,000 cycle wave by 4,000 cycles we get the same effects. Oscillograph readings of the modulated wave in both cases would be identical. The proportions hold true and would remain true for all frequencies.

Thus we see that by broadcasting on a frequency of 62,500,000 cycles or 4.8 meters, we can modulate this wave at the present broadcasting frequencies. And this 4.8 meter wave can be modulated by several hundred separate frequencies within the range now used for broadcasting without interference, and each one of these frequencies in turn can be modulated at audio frequencies. This means that a large number of separate programs can be sent out without interference at the same time from one super-modulated broadcasting station transmitting on a wave-length of 4.8 meters.

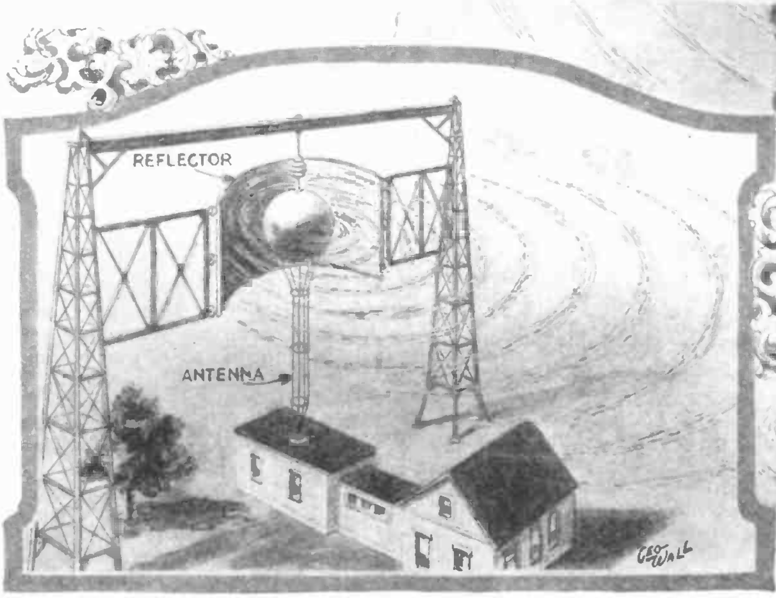
The receiver is very simple. This is shown in one of the illustrations. A detector that operates on the 4.8 meter wave detects the modulated frequencies and feeds them into a standard broadcast receiver. This receiver may be tuned to any one of the modulated frequencies and any one of the desired programs can be heard, with-



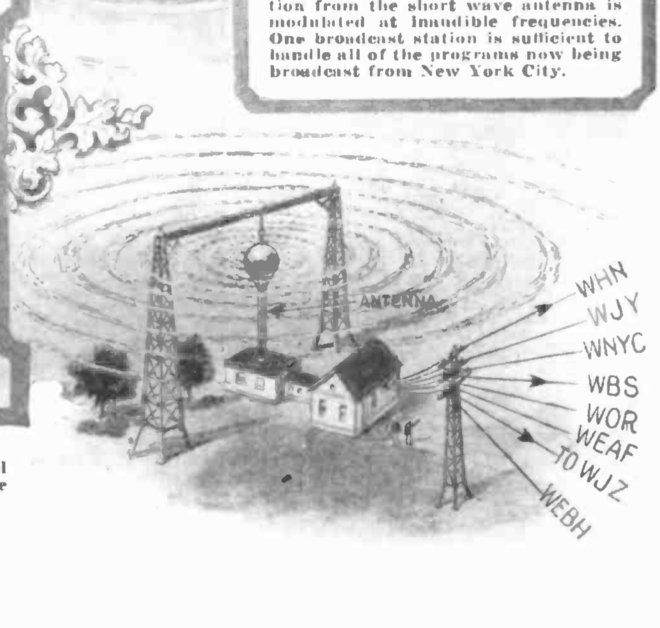
A radio receiver of the future employing a short wave pick-up device that feeds into a receiving set similar to those in use today. Note that a very small single turn loop aerial is sufficient to receive the short waves.

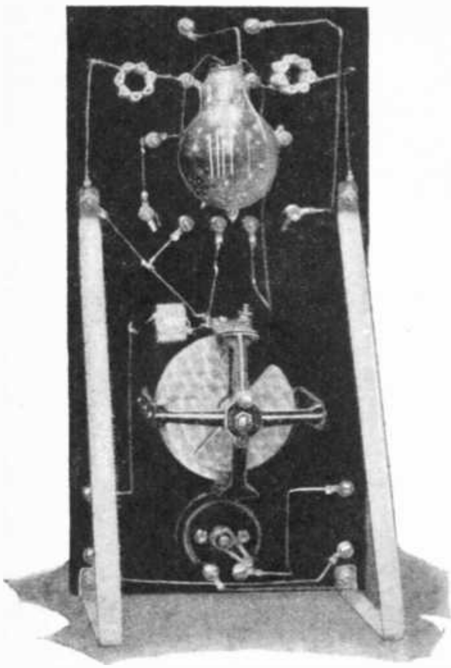
Many of the larger cities throughout the world will have both super-modulated broadcast stations and Marconi beam transmitters for carrying all kinds of communication. In both cases radiation takes place at a very short wave length in the neighborhood of five meters (60,000,000 cycles). This wave is modulated at various inaudible frequencies which are in turn modulated at audio frequencies. Note how the beam at the upper part of the illustration is reflected by the Heaviside layer, and sent around the earth.

A broadcast station of the future employing the supermodulated system described in the text. The radiation from the short wave antenna is modulated at inaudible frequencies. One broadcast station is sufficient to handle all of the programs now being broadcast from New York City.



A Marconi beam transmitter for commercial work. Note the large reflector that sends the waves out in a beam. It is calculated that several hundred separate telephone and telegraph messages can be transmitted over a single beam without interference.



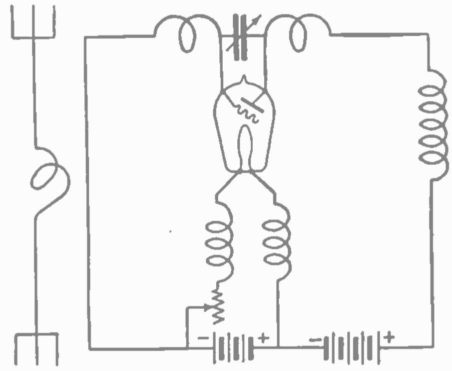


Rear view of the five meter oscillator showing the tube with base removed, choke coils, tuning condenser, and rheostat.

out interference from the others. Instead of several broadcasting stations scattered all around the city of New York as at present, we shall have one super-modulated short wave transmitter located somewhere on Long Island that will be connected by wire to all of the present broadcast studios. These stations will each modulate the super-modulated station at a frequency corresponding to its present wave-length. If the super-modulated station is capable of transmitting all over the earth, each one of the broadcasting stations will be heard with equal volume in all parts of the world. This removes the difficulty of critical tuning on the shorter wave-lengths, as all tuning will take place at the present broadcast wave-lengths. The short wave detector is tuned once and for all and need not be touched again.

Three or four super-modulated stations in different parts of the United States will be capable of handling all of the broadcasting stations now in use.

For commercial purposes beam transmitters will be used. The Marconi Company is now installing a beam system of communication between England and Australia. As was stated at the beginning of this article radio waves of short lengths may be reflected the same as light waves. By reflecting the waves in a certain direction we not only obtain secrecy of communication, but the efficiency of transmission is improved. One of the illustrations shows such a reflector placed behind the aerial of a short wave transmitter. By reflecting the beam so as to follow the line from transmitter to receiver between two points, we can transmit thousands of messages over the one beam at the same time without interference by the super-modulated method described above. The system is similar to that of multiplex communication in which case several telephone conversations and telegraph messages take place at the same time over one set of wires without interference. Wired radio is also similar except that the waves of various



Hook-up of the five meter oscillator. Note the R. F. chokes in the "A" and "B" battery leads.

wave-lengths travel over a wire instead of over a beam. The large illustration shows a system of beam transmitters for carrying on telephone and telegraph communication between various cities of the world. A number of super-modulated broadcasting stations are also shown.

A Novel Source of Plate Voltage Supply

THE following is a description of a method adopted by the writer for obtaining "B" battery supply for a low-power transmitter by means of an induction coil, neon tubes, and chokes and condensers. The original source of current was a 6-volt storage battery.

The usual arrangement employing a two-electrode valve as rectifier was first tried, but was discarded owing to the additional battery which was necessary to light the filament of the rectifying tube. A vibrating-reed rectifier and a small chemical rectifier were both tried in turn, but proved decidedly inefficient. The method finally adopted made use of the well-known neon lamps.

As is now generally known, neon lamps have the peculiar property of not allowing any current to pass until a certain critical voltage (about 140 for ordinaryy tubes) is reached, and they are therefore suitable for rectifying an alternating current such as that obtained from the secondary of an induction coil which has a much higher voltage impulse in one direction than in the reverse, since if sufficient tubes are placed in series the smaller impulse produced by the "make" of the primary will be insufficient to render the tube conductive, while the high-voltage impulse obtained at the "break" will easily pass through the tubes.

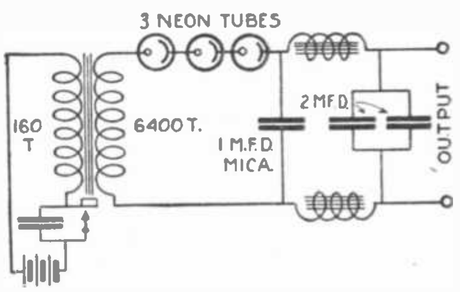
The Circuit

The circuit is given in the illustration. It will be seen that three ordinary neon tubes are connected in series with one of the secondary leads, the output being passed through a smoothing circuit. The lamps should be connected so that the larger electrodes are lit up by the secondary voltage produced by the break of the primary, as they offer least resistance to such voltage when they are so connected. The smaller electrodes should not light up.

The transformer was a 1-in. spark coil with a new secondary winding consisting of 6,400 turns of No. 28 D.C.C., giving a primary-to-secondary turn ratio of 1 to 40. The two chokes were spark-coil secondaries and the condensers were of the ordinary type except the one next to the last neon lamp, which, because it is directly subject to the high voltage impulses, has mica dielectric.

With 6 volts on the primary a perfectly smooth D.C. output could be obtained, but it was not possible, owing to the high resistance offered by the chokes and three neon lamps in series, to obtain a greater current than 4 milliamperes. It was, however, found possible to run a two-tube receiver on this, and no hum was noticeable providing the actual transformer was removed some distance from the set.

With a view to overcoming the necessity of using three lamps in series, one of the lamps was hardened by running it for a few minutes each on 300, 400 and 600 volts.



Connections of the "B" battery supply unit operated from the six volt "A" battery. A spark coil and neon lamp rectifier are used, giving an output of 20 milliamperes at 100 volts.

If the full 600 volts was applied at first it was difficult to stop the glass supports melting under the heat generated in the lamp, but by raising the voltage in steps the heating was minimized and the glass showed no tendency to melt. After hardening, the lamp glowed a pale lilac color and required a much higher voltage than previously to make a lamp conductive; it was then found possible to replace the three ordinary neon lamps with a single hardened lamp, which effectively rectified the output from the coil. A considerably increased current was then obtained. The original chokes had a resistance of several thousand ohms each, and these were then replaced with chokes wound with a heavier gauge of wire and having a resistance of only a few hundred ohms (actually the chokes used were a number of 60-ohm relay coils which were wound with No. 30 wire).

An output of 20 milliamperes at about 100 volts could then be obtained, but the voltage varied with the current which was drawn from the output terminals; if more current was taken the voltage dropped proportionately, while if no current at all was taken the condensers quickly charged up to about 400 volts and discharged back through the neon lamp, which thus effectively safeguarded the condensers, since these would undoubtedly have broken down if they had attained a voltage much exceeding 500 volts. The condensers had to be carefully chosen since, although a new condenser will stand 400 to 500 volts, a large number of the ex-Government condensers on the market will not hold their charge at this voltage. Out of eight 2-microfarad condensers which the author obtained only three were found to have high insulation.

An interesting method of obtaining greater power for telegraphy than the normal steady output is to use a much harder neon tube as rectifier, with 6 or 12 volts on the primary coil, and to pass the rectified current into a very large condenser—say 24 microfarad—which is allowed to charge right up. If now the high voltage leads to the transmitter are connected to the condenser one gets the full benefit for a few seconds of, say, 600 volts on the plate of the valve, but the voltage, of course, falls rapidly as the condenser discharges. In practice, if rapid keying is employed and a longer space than usual left between each word, the reservoir condenser can be maintained at an average of 500 to 600 volts, though while keying the voltage will, of course, steadily drop, since the current supplied through the rectifier is not sufficient to compensate for the heavier current demanded by the power valve in the same time.

5 G F, Amateur Wireless.

The Tauleigne Amplifier

The Tauleigne amplifier opened up. Contact pressure between carbon point and button is varied by screw at left that tips it

THE much talked of Tauleigne amplifier has at last been given a thorough test in our laboratories and the results from an experimenter's point of view were very gratifying. We first connected this amplifier to a simple crystal receiver employing a fixed detector (the receiver shown in one of the illustrations) and immediately upon making the last connection music issued from the loud speaker. After a few tuning adjustments, the music was distinctly heard throughout a large room, but quietness had to be maintained in order to appreciate it. The broadcasting station received was WEAF, located a distance of one and three-quarter miles away. A few more adjustments with the substitution of a sensitive galena detector employing a fine catwhisker contact in place of the fixed detector furnished with the set brought in the station with a little more volume. The quality of the music was very good.

Due to the fact that the instrument requires careful adjusting and that the volume is not loud enough for entire satisfaction, even though the receiver be located only a few blocks from the broadcast station, the instrument is not suitable for ordinary loud speaker reception, and in its present state of development will not replace the vacuum tube. We did not try two of these units connected in cascade as a two-stage amplifier and cannot predict how such a scheme would work out; but the loudest of signals do not produce a very marked effect in the loud speaker and we doubt if two units connected in cascade would improve results. The experimenter, however, will find the instrument very amusing. He may also find other uses for it or make improvements in its construction.

The Tauleigne amplifier consists of a high resistance telephone receiver magnet placed underneath an iron armature on which is soldered a copper-plated carbon button. The plating is removed from the upper surface of the button and a light contact is maintained between this carbon surface and a small carbon pencil. This is clearly shown in the illustrations. The details of the instrument are also given so that the experimenter may construct one for himself.

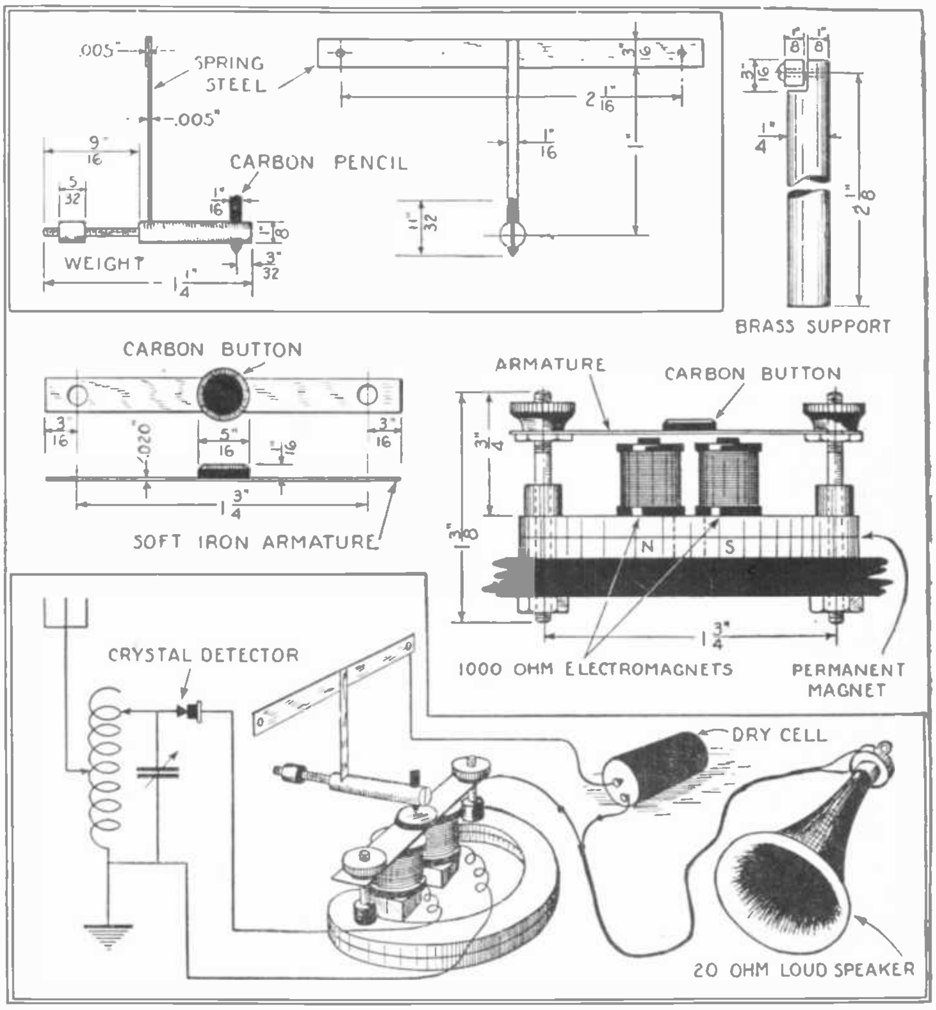
The pressure between the carbon pencil and button is regulated by means of a small metal weight screwed on the free end of the lever that holds the carbon pencil. Gravity holds the carbon contact point in place. The whole unit is hinged to the box with a cloth hinge, and by means of the adjusting screw which tips the instrument up a very fine regulation of the pressure is obtained. It was found that for strong signals the pressure had to be greater than for weak signals. The quality was also better with the greater pressure.

The high resistance telephone magnet winding connects directly to the crystal receiver as shown in the diagram. The carbon contact of the microphone is connected in series with a 20-ohm loud speaker and one dry cell. It is interesting to note that signals were louder when using one dry cell than when using two in the circuit.

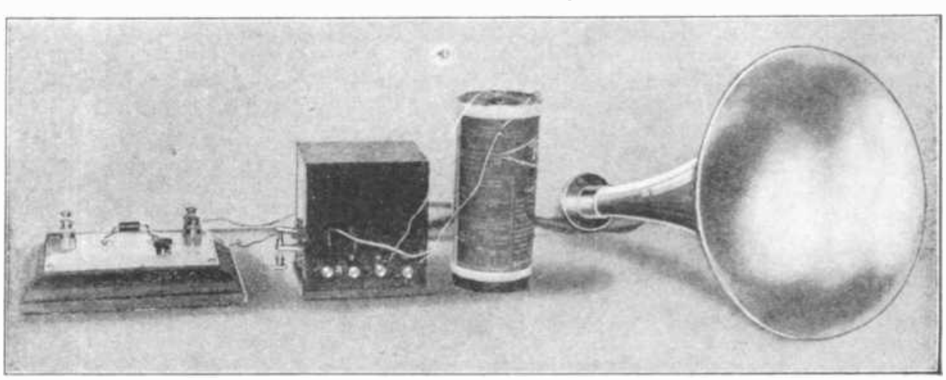
The loud speaker employed a phone unit of the usual construction except that the magnet windings were wound for a resistance of 20 ohms. It is important that the polarity of the dry cell be such that the current through the loud speaker tends to strengthen rather than weaken its permanent magnet. The correct polarity is easily determined by trial.

The illustrations show all the details required for building the instrument. It may be placed in any suitable wooden box. The experimenter may use an ordinary 1,000-ohm phone for this purpose by removing the shell. Of course, the dimensions given in the illustrations may have to be changed to suit the particular type of phone unit used.

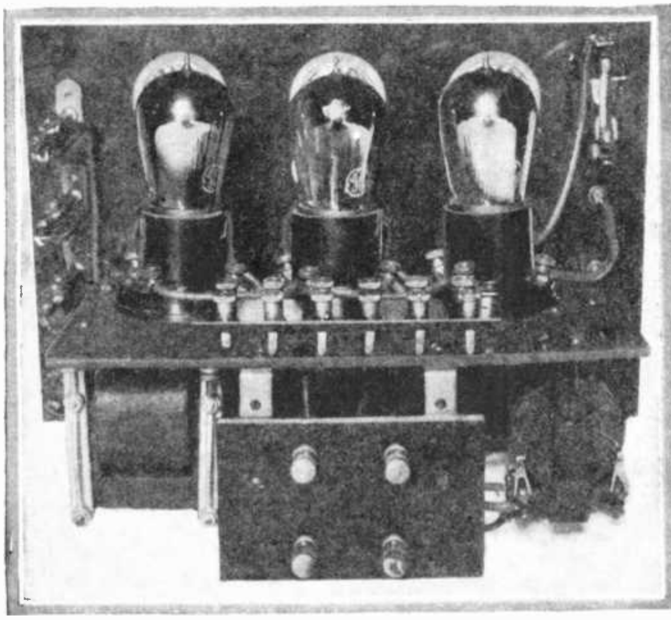
It is not necessary to use this instrument always in connection with a crystal receiver. It may be used with a vacuum tube receiver. It seems to be adapted to reflex circuits also. In this case a vacuum tube radio frequency amplifier and crystal detector should be used. The currents from the crystal are then amplified by the microphone relay and the output of the amplifier fed back through a step-up transformer to the grid and filament of the vacuum tube.

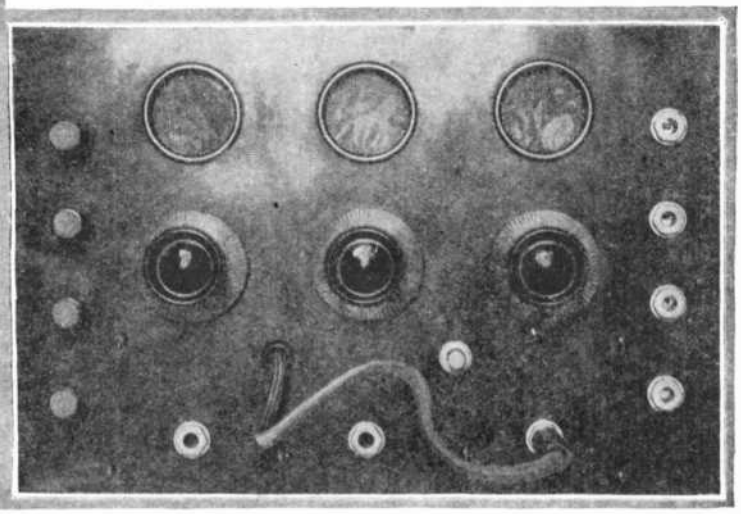


The experimenter may build a Tauleigne amplifier by following the dimensions given. The lower illustration shows the instrumnt connected with a crystal receiver.



The complete apparatus, the crystal receiver at left, amplifier, battery and loud speaker.





Front and rear views of the experimental detector-amplifier unit. This unit is provided with several telephone jacks, enabling the experimenter to plug in to different parts of the circuit and adapt the instrument for many uses. Note the compact arrangement of the parts.

Experimental Detector and Two-Stage Amplifier

By Leon L. Adelman, 2AFS, A. M. I. R. E.

THE average experimenter is never fully satisfied with the equipment he may have previously constructed, and in the majority of cases, pulls his set apart and rebuilds it. This process may go on until inevitably, the parts must be thrown away, since they are so full of unnecessary holes and unsightly scratches that in the colloquial term, "it looks terrible."

It is the purpose of this article to describe a unit which will readily adapt itself to the most exacting cases and dispose of them in a manner that will give ultimate satisfaction—the satisfaction of knowing that all will not have to be ripped apart, so as to conform with some unforeseen problem.

The unit as built will act in conjunction with any circuit whatsoever, as a detector and two-stage audio frequency amplifier. In case it is desired to test out a set already equipped with a detector tube, provision is made by using the external detector jack, in which case, the unit acts only as a two-stage audio frequency amplifier. In conjunction with an ordinary microphone, the two-stage amplifier serves admirably as a voice amplifier. If a power or push-pull amplifier unit is to be connected, the matter resolves itself simply to plugging into the output jack.

Where a tuner is to be tested, no matter what circuit is to be employed, three jacks connected in series will allow several headphones to be connected, either on the detector, one step, or two steps, without the necessity of external connecting blocks. But the experimenter is not satisfied only with the construction of a device; he wants to know something, if not all, about its fundamental operation, care and maintenance. There is no better arrangement for learning about the intricacies of radio than this instrument presents. Provision is made for battery connections in the most facile manner. Then, too, meter readings can be taken which will prove of inestimable value later on. Although not imperative, at 0 to 6-volt meter, a 0 to 10 milliameter and a 0 to 5 ammeter should be bought in conjunction with the rest of the instruments and their first cost will be more than repaid by the knowledge which will result from their timely use.

To begin with, the panel is laid out as shown in the diagram, Fig. 1. Deviation from exact dimensions is sometimes necessary and is quite allowable. The transformers are underslung on the sub-panel and are thus protected from mechanical injury and afford a greater degree of balance and neatness to the outfit. No by-pass condensers or leak resistances are used, since they simply waste energy. The connections are clearly shown in the diagram, Fig. 2. Advantage is taken of the knowledge gained in the following paragraphs concerning the characteristics of the tubes and thus with the proper voltages in each circuit, amplification without distortion is the result.

List of Materials Required

- 1 Bakelite panel 12" x 8" x 3/16".
- 3 Fada rheostats, 6 ohms.
- 3 Naald sockets, standard.
- 3 UV-99 adapters.
- 3 Double circuit jacks.
- 4 Single circuit jacks.
- 1 Plug.
- 2 Transformers, one Amotran 4 to 1 and one Acme 3 to 1 ratio.
- 1 .00925 grid condenser.
- 3 Grid leaks, 1/2, 1 and 2 megohms.
- 1 Miniature single pole switch.
- 1 1/2 Dozen binding posts.
- 1 Sub-panel 8" x 6".
- 2 Large brackets.
- 2 Small brackets.
- Miscellaneous screws and nuts.
- 3 Bezels.
- 1 Filament switch.
- 1 3/8" Hard rubber bushing.

Since the second transformer must carry the total aggregate load, it is a little heavier in construction, and has a 3 to 1 ratio. The first transformer has a ratio of 4 to 1. Higher ratio transformers tend to distort and cause noise. It will be seen that the cores of the transformers, though far apart, are at right angles. This is to prevent interaction with resultant howling. No shields are necessary. The wiring should be done as neatly as possible and should be carefully soldered at connecting points.

The binding posts for battery connections are racked in the rear, while those on the front of the panel are for connections to the different sets to be tried out.

The detector and amplifier will work practically equally well, with any regular tubes providing, of course, that the "A," "B" and "C" battery voltages are changed to correspond with the rated values given by the manufacturers. UV-200, 201s, 201As, C-300s, 301As, UV-199s, C-299s, WD-11s, 12s, C-11s, 12s, VT-1s, VT-2s and 216As can be used with great success.

After the unit has been connected, the experimenter can make many tests showing the characteristics of vacuum tubes. Some of these tests will now be described.

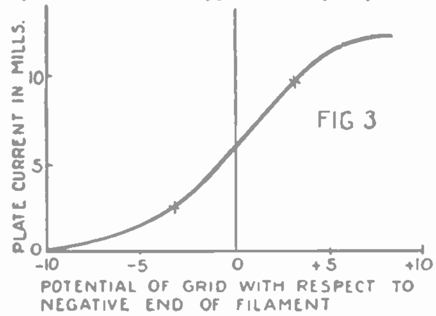
The fundamental operating characteristic of the audion is that expressing the current flowing from filament to plate in terms of the potentials supplied to the grid. Graphically, and in terms readily understood, it can be seen by Fig. 3 what is meant. In this case, a small negative potential, 10 volts impressed on the grid by the "C" battery completely cuts off the plate current. As this negative grid charge approaches zero, the plate current increases very rapidly. Now we arrive at a stage where the grid potential is zero and we have a certain plate current.

As the grid is charged positively, the plate current continues to increase up to the saturation point. Between the two bends in the curve it will readily be seen that a small change in grid potential affords a relatively large plate current variation, without distorting the wave form of the incoming signals. It is, therefore, obvious that the straight-line portion of the curve is the one to utilize in an amplifier or repeater, whether for amplifying radio or audio frequency currents.

Fig. 4 shows a curve representing the values of plate current, obtained when the plate potential is varied keeping the filament, current or temperature constant. Plainly, it is evident from the graph, that as the plate potential is increased, the plate current increases up to the saturation point, above which increases in voltage produce no increases in current.

Thus, the saturation point is reached in two ways: first, by a sufficient positive charge on the grid, and second, by too high a plate voltage. The experimenter should plot a number of curves with various values of plate and grid voltages, as in Fig. 5. In this way he can select the most suitable "B" and "C" battery voltages.

As in the case of all electric circuits it is best to arrange the plate circuit so that its impedance should approximately equal the internal impedance of the tube. Thus, for example, the 301A has an internal plate to filament resistance of approximately 14,000 ohms. It would, therefore, be necessary to use in conjunction with this tube a pair of phones or amplifying transformer whose A.C. resistance was of this value, in order to have the tube function at highest efficiency.



Characteristic curve of a vacuum tube. This curve was obtained from measurements made with the detector-amplifier unit.

The amplification factor or constant (K) is what is known as the ratio of the plate and grid variation which will produce an identical variation of the plate current. Thus the plate voltage change equals (K) times the voltage. In other words, it would take a change in the plate potential (K) times as large to cause the same variation in the plate current as a given grid potential. Thus if (K) is large, the tube is suitable as an amplifier. See Fig. 6 for connection. The slider of the potentiometer is adjusted until there is a minimum sound in the head-set. The resistance R_2 divided by R_1 is the amplification factor.

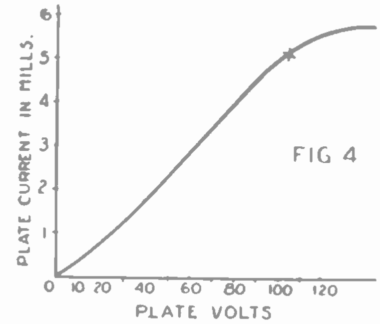
As the internal plate impedance is the A.C. resistance between the plate and filament, and as it becomes necessary to have the external resistance equal to this A.C. resistance, the circuit in Fig. 7 shows how the impedance of a tube is measured.

In the use of a vacuum tube for receiving two distant actions are manifest. One is amplification, the other rectification. Of these amplification, as was seen, is by far the simpler. It may be well, therefore, to review the electron theory in conjunction with rectification.

When a conductor joins two points of different potentials, current will flow from the higher potential to the lower potential. Now, a body is said to be charged positively with respect to another similar body, when it has lost some of its electrons through heating, rubbing or any other means. Electrons are small negative charges of electricity free to move through the conductor. If the conductor is heated, the velocity of the electrons increases, so that in the case of a vacuum tube, myriads of them break through the surface of the conductor and fly off in all directions, some attracted by the positively charged plate, some returning to the filament.

Thus the current flows from the plate to the filament by means of the electronic stream flowing from the filament to the plate and it becomes obvious that the tube is conductive in one direction only.

We are dealing with three circuits, the plate, grid and the filament. What happens in one causes a corresponding change in the others. Refer now to the detector tube in Fig. 2. As the grid condenser is alternately charged positively and negatively, the grid will be made to behave in the same manner. When the grid is negative, very little or no current flows in its circuit. When the grid is positive, negative electrons will flow not only to the plate, but also to the grid and charge the grid condenser. As the oscillations continue, it becomes charged negatively to a marked value, and this charge distributes itself on the grid, so that soon we have the grid charged enough to render the tube inoperative; *i. e.*, the plate current stops. It therefore becomes necessary to remove this negative charge from the grid after rectification of each group of oscillations. If the tube is a "soft" tube or has a high gaseous content, these negative charges leak back to the filament by means of the hot ionized gases. However, with a hard tube, trouble is soon experienced if a grid leak is not included in the circuit. If the grid leak has too low a resistance, it is useless, because it will cause an appreciable loss of signal strength. If on the other hand it has too high a resistance, the negative charges will escape in spurts, causing pulsating clicks.



Curve showing the relation of the plate current to plate voltage, as measured from a standard tube in the detector amplifier unit.

Most tubes have a tungsten filament,

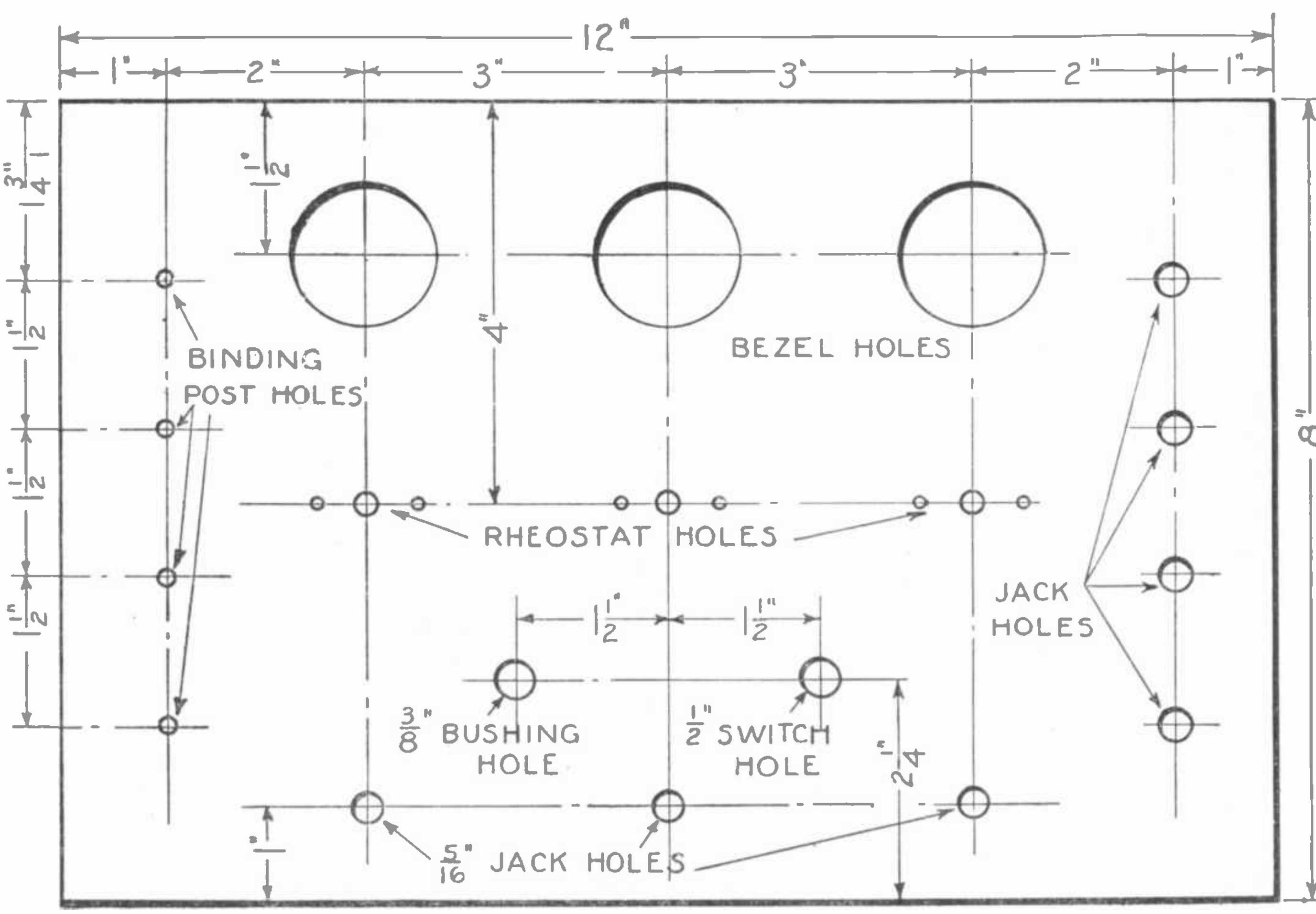


FIG. 1

Panel drilling showing the locations of the holes required for building the amplifier. Before drilling, the experimenter should check the sizes of the holes as they depend upon the particular instruments used. The panel should be of bakelite 3/16" thick.

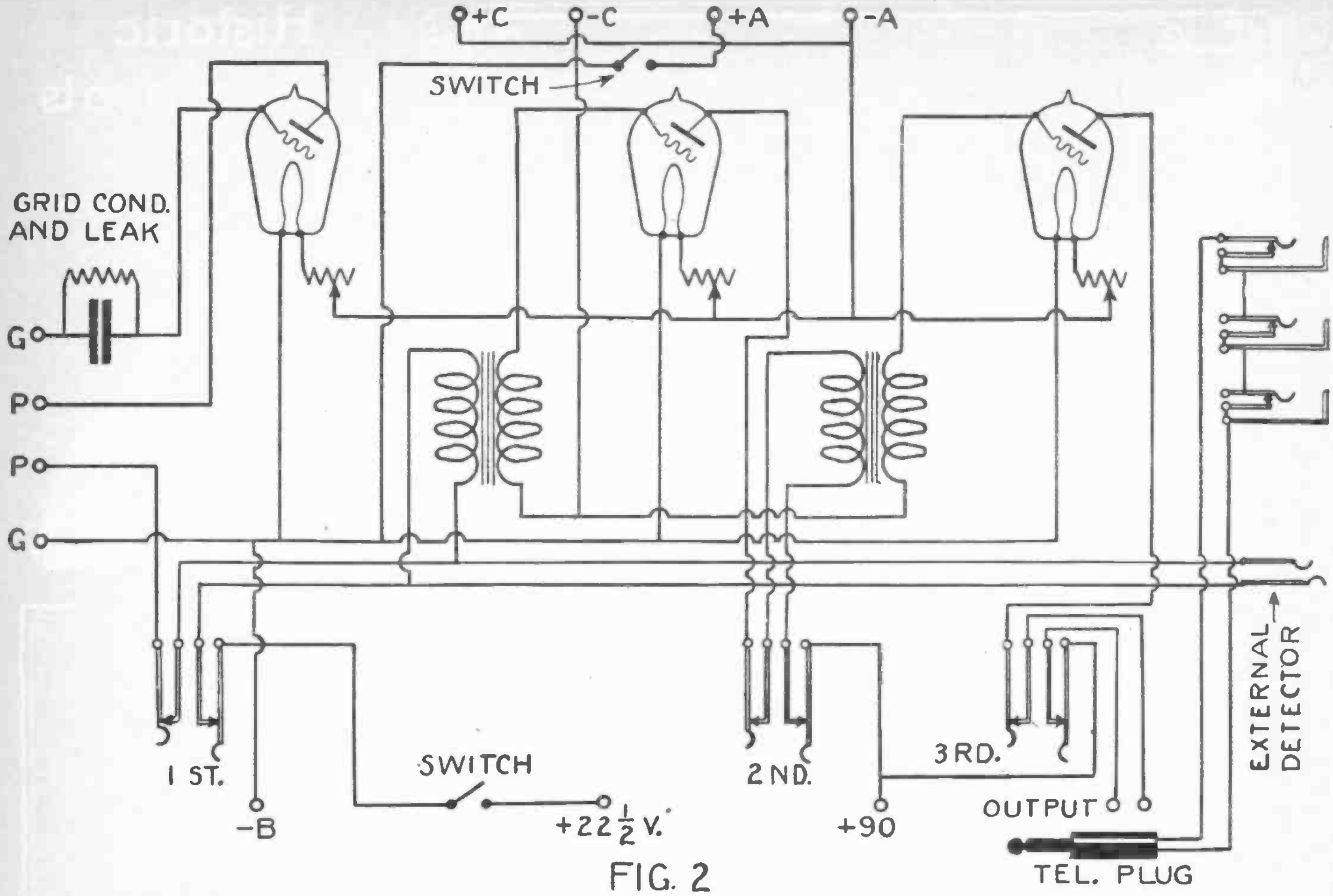


FIG. 2

Wiring diagram of the detector and two stage amplifier. Note the number of telephone jacks used, making the unit very flexible as to its adaptability. The telephone plug connected to the three jacks allow three head sets or loud speakers to be connected in series to either detector, first or second stage.

and as tungsten has a low cold resistance, there can be no less danger than burning out a tube, if the "A" battery switch is suddenly turned on with the rheostats left in their former position. We must not forget that after a short period of recuperation, the battery will be more likely than not, to "blow" out tubes.

It is therefore always advisable to slightly turn down the rheostat before turning on the "A" battery switch. As seen in the ordinary diagram, one leg of the filament carries more current than the other, so that after continuous operation, there is imminent danger of burning out the tube. It is advisable, therefore, to reverse the filament terminal leads after several months of operation. The best and safest means of operating the set is obtainable only by the use of the smallest possible plate voltage. This is reached upon careful consideration of the characteristic curves.

The filament current should never be raised above the rated value of the tube. If possible, operating should be done within 10 per cent. of normal. The filament rheostat should be carefully inspected once in a while to make sure that the lever arm makes good contact with the wire. All metals when heated expand, tungsten being no exception, so that a tube mounted vertically is safest. Ionization is due to faulty construction, in allowing too much gas in the tube when evacuating it. It is evidenced by a blue or purplish glow. This can also be caused by excessive plate voltage, and is liable to injure the tube if operation is continued.

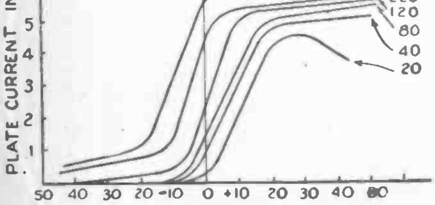


FIG. 5

A number of curves obtained from a vacuum tube with various plate voltages. These curves show at a glance the best values of the "B" and "C" battery voltages, for use with the particular tube measured. In this case the 120-volt curve is the best.

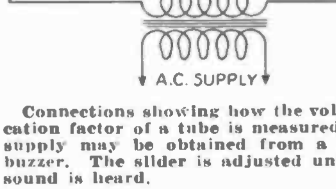


FIG. 7

Connections showing how the voltage amplification factor of a tube is measured. The A. C. supply may be obtained from a battery and buzzer. The slider is adjusted until minimum sound is heard.

For power oscillators, where the filament is subjected to strains and undue loads, it is best to use A. C. for the filament, as then it will carry an equal amount of current in both legs. The center tap method of connecting the plate circuit to the secondary of the filament transformer obviates all danger of unequal load, thus greatly prolonging the life of the tube. Although too high a plate voltage is injurious to the tube, it is often found that a greater output can be realized by using a higher plate potential. Under this condition, what is known as electrolysis of the glass takes place after a short time, with the result that gas begins to fill the tube and its efficiency drops off. This electrolysis, more liable to abruptly end the life of a tube than a filament burn-out, is caused by the seepage of the metals contained in the glass, around the grid leak, causing it to become blackened. Hot glass is an electrolytic conductor, its conductivity is enhanced by an electric current which breaks it up into its constituents. On account of this black deposit of metals, leakage soon occurs where the negative leads are sealed in the glass, and the hours of the tube are numbered.

The life of a tube depends largely upon the life of its filament. When the "A" battery switch is thrown on, a very large current flows at first, but as it gets hotter, the resistance of the filament increases, so that there is a diminution of current

(Continued on page 272)

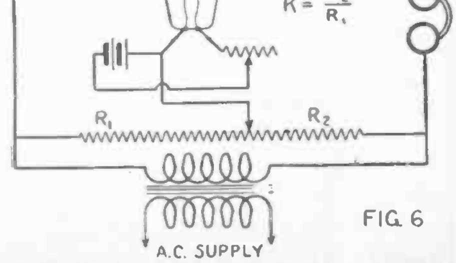


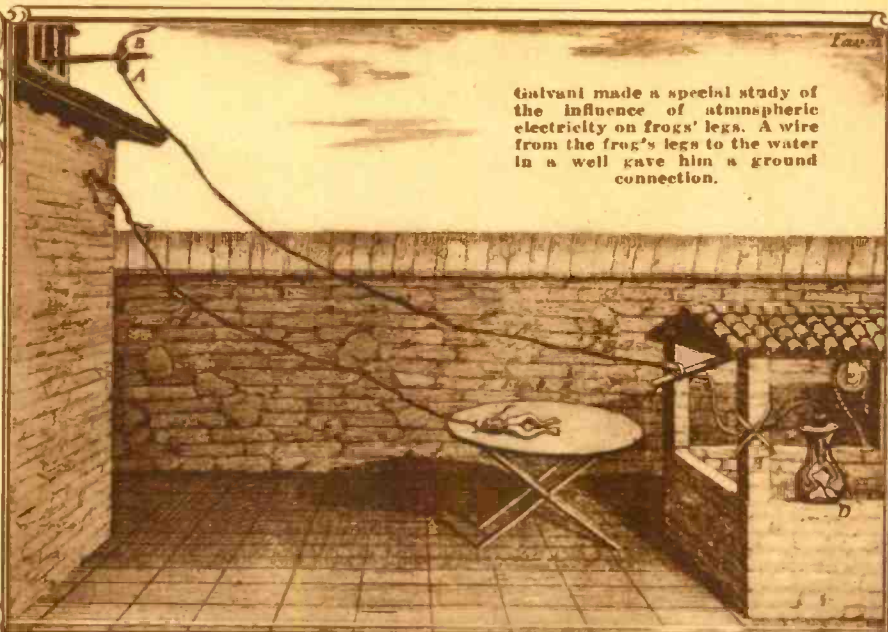
FIG. 6

Circuits showing how the internal impedance of a vacuum tube is measured. This test is easily made with the same instruments used in Fig. 6.

Historic Experiments

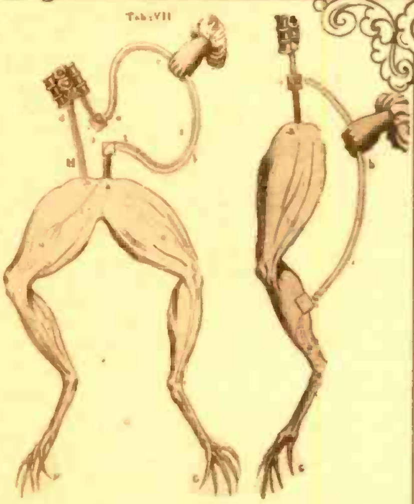
No. 4

Galvani and Animal Electricity



Galvani made a special study of the influence of atmospheric electricity on frogs' legs. A wire from the frog's legs to the water in a well gave him a ground connection.

Luigi Galvani, Italian physicist.

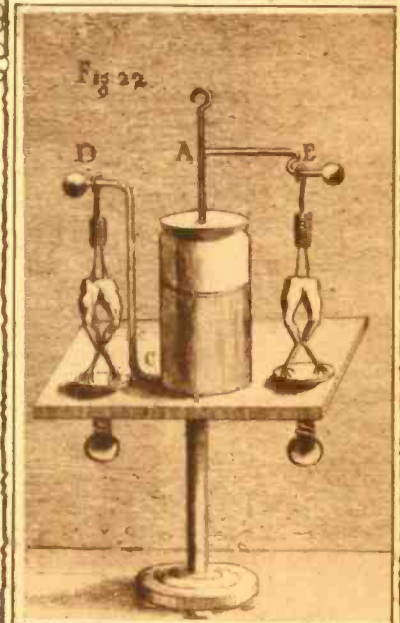


Most of Galvani's experiments were concerned with the effect of electrical currents on the muscles of frogs' legs. He contended that the muscular effect was due to electricity lodged in their legs.

LUIGI GALVANI

The history of electrical science is marked with a few great men whose insight and perseverence coupled with an innate genius led to the breaking of new paths in scientific research. To this class of scientists belongs Luigi Galvani, who, though his chief concern was with physiology, was in a large measure responsible for that lively impetus given to electrical developments, in the latter part of the eighteenth century. Like all great pioneers of science, his interest was not limited to his particular field, but was broadened by a study of philosophy and literature which he pursued throughout his life.

He was born in 1737 at Bologna, where he spent most of his life and where he later became professor of anatomy. He noted unusual electrical effects in animals, particularly in frogs' legs, and in explanation advanced the theory that a source of electric current was lodged in the nerves of animals. This view was vigorously opposed by Volta, his contemporary, whose experiments we described in the preceding issue of The Experimenter. The controversy between these two noted scientists was followed with interest throughout the civilized world, and showed fruitful results in the discoveries of Volta. The achievements of Galvani had been recorded in his famous masterpiece, "De Viribus Electricitatis is Motu Musculari Commentarius" ("Commentary on the Effects of Electricity on Muscular Motion").

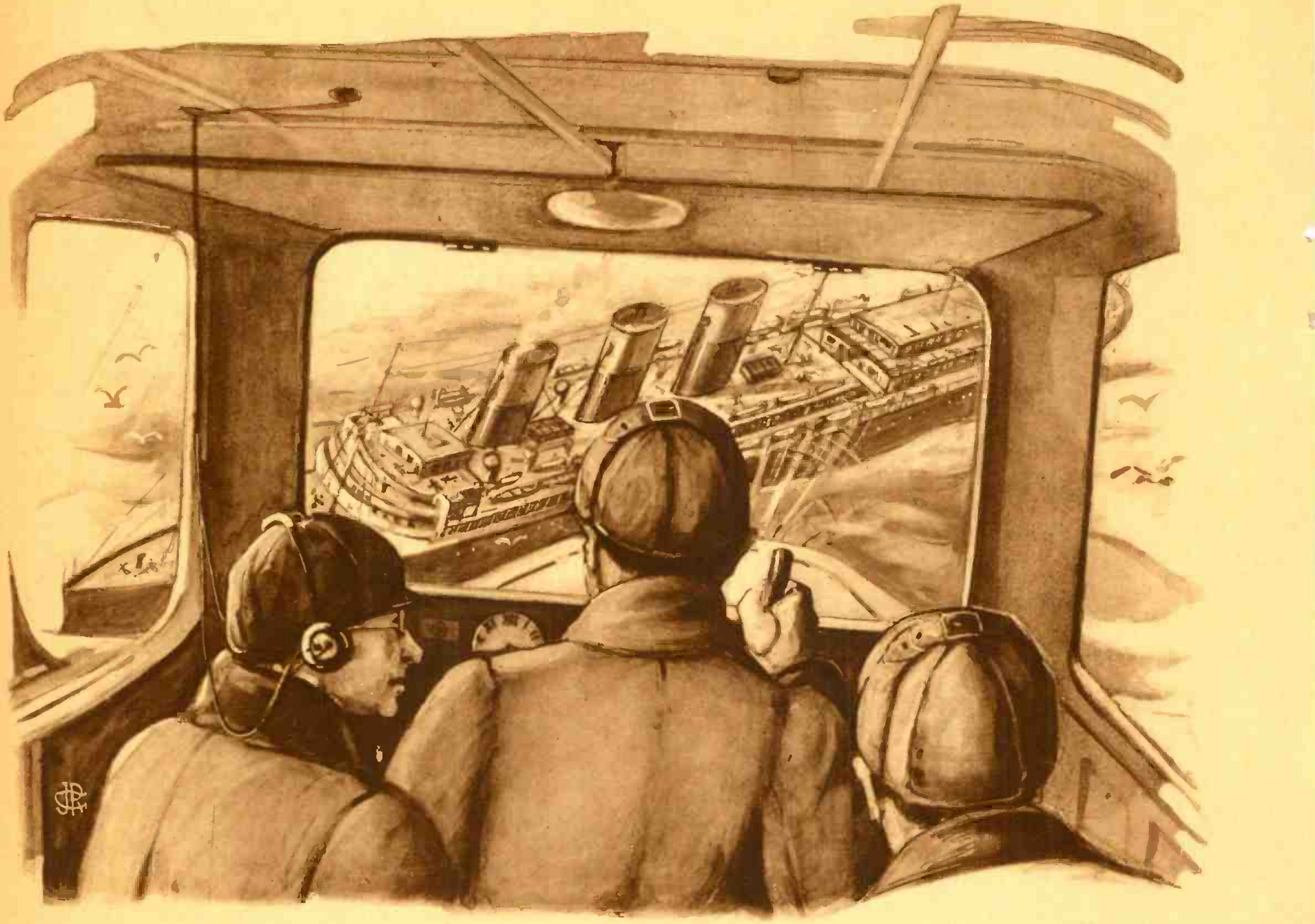


The frogs' legs are here connected to the electrodes of a Leyden jar. When the jar is charged the legs distend and are convulsed, forming a sort of animal electroscope.

After making an exhaustive study of frogs' legs, Galvani turned to other animals. At the left is one of his illustrations showing an electrical experiment on a lamb. At the right is a later experiment showing the effects of an electric current on a bull's head. The tongue first pulled out of the mouth, and touched with the lumbar nerve of a frog held in one hand of the experimenter while the other hand is in contact with the bull's ears, causes an electric current to flow through the frog's legs, which then become convulsed. Galvani's theory was that a difference of electric potential existed in all animals between the cutaneous or outer surface and the mucous or inner surface of muscles.

The Ark of the Covenant

By Victor MacClure



"There was something terrifying in the helplessness of the great liner. Broadside to the rollers, she lay sluggishly, swaying and veering amongst the oily hummocks, and about her was the silence of death. Not a soul stirred on her decks, and the thin whisp of steam that curled from one of her smoke-stacks was the only thing about her that moved."

(What Has Gone Before)

A number of New York banks have been robbed. The time is near the end of this century. The President of one of the banks stands by his son's bedside early in the morning and wakes him. Instinctively the son realized that something was wrong, and seeing that his father was in deadly earnest, no questions were asked, but with his roadster and airplane he undertook to rush him to the city.

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

The tarnishing of the gold is a problem for the chemist, and curiously enough, powdered glass is found in the street to add to the strange events. Heavy little boxes came into the Post Office by mail. Bombs were suspected and upon being opened the boxes were found to contain lead cases whose weight indicated that they were quite thick.

The wonderful Merlin takes an active part in the story, the fastest of all airplanes. The range of the speed dial is insufficient. The mystery deepens when it is found that some millions of dollars of securities have been returned to the banks but a slightly larger amount of gold has been taken. Anaesthetic bombs are thought of. It develops that the boxes in the Post Office contained some radium compound which accounted for the lead cases. An unheard of amount of the rare salt seems to be in there. A provision store has been robbed and money left to pay for it. Thousands of gallons of gasoline have disappeared from a Standard Oil station. Starting at the most mysterious point of the story the tale goes on.

A short interview with the two policemen convinced my friend and myself that their story was true. They had concealed the fact of having fallen asleep in fear of losing their jobs, and it was only the news of Wall Street had given them the courage to tell the truth.

Surmises Without Result

Dan and I had heard as much as we needed, and as we drove to the Cortlandt Street Ferry at an easy pace, my scientific friend weighed the thing up.

"They do connect up, Jimmy," he said.

"I'm sure they do," I agreed.

"They link up, so far, only through the use of the anæsthetic," he went on. "But I can find no sane connection in the things stolen. Two and a half millions in gold, a hundred kilos of provisions, and five thousand litres of gasoline. It's a mad thing, however you look at it."

"It's crazy," I admitted. "Jackdaw crazy."

"If we could find out what they wanted with such a queer collection," said Dan, "we'd be on the track of what they are."

"Suppose," said I, "that it's a gang with headquarters in the country somewhere, a regular band of raiders operating on a large scale. They have a fleet of trucks, each equipped with the latest appliances for bank-breaking. They want the gasoline for the fleet of cars, and the provisions for feeding the gang——"

"A concentration of that sort would immediately arouse suspicion in the country, Jimmy."

"I don't know so much about that, Dan. It might be quite an innocent-looking factory, or foundry, with accommodations for the men——"

"Yes, asking folks to notice it by never dealing with the local stores——"

"Shucks, Danny!" said I. "Look at my own experimental shops. Right on a lonely strip of beach, and two or three kilometres from the nearest village. Except for a government inspector or two once in a way, nobody ever comes near me—and half my men live on the premises."

"Yes, but your experimental shops don't come under the factory laws. None of your men belong to a trade union, you've told me?"

"That's right."

"Well, if any gang of crooks got up a stunt such as you imagine, it would be difficult to escape detection in the ordinary routine of factory inspection."

"But listen, Dan! If I wanted to go in for bank-robbery, it would be easy enough —given that I had a dope—"

"Great snakes, Jimmy!" Dan exclaimed. "You're on the business for sure! Could you land that new bus of yours in Broadway?"

"I'll bet you five thousand dollars I do—with wheels instead of floats——"

"What would your new bus carry?"

"In her present condition, without her fighting kit, about three thousand kilos, besides a crew of six."

"Then two buses such as the *Merlin* could have made that robbery in Wall Street and Broadway possible?"

"Sure," I said. "And, what's more, could be in the Rockies by this time——"

"Then we're on the trail, Jimmy——"

"Yes—if we wash out the question of the gasoline, Dan. There's a difficulty there. And, besides, there's only one *Merlin*—unless smoebody has stolen a march on me. But say that somebody has a design as good. It's not only a question of lift, remember, but of taking off down Broadway. But say the supposed machines could. Do you see them dropping into that New Jersey gasoline station and getting away with five thousand litres of oil? I don't. I don't see even five *Merlins* doing it."

Not a Helicopter

"What about a helicopter?"

"The helicopter is a washout as far as lateral speed is concerned. It hasn't been applied successfully to a plane yet."

"Airship then?"

"More like it—but, phew!—you're getting up a whale of a theory, Dan!"

"I know that, Jimmy," said he, "but it's a whale of a robbery."

By this time we were at the ferry, and our discussion was shelved in the business of getting aboard the waiting ferry-boat. Once on Manhattan, we drove straight for the Metallurgical National. When Dan and I got into my father's room, we found the old man looking a bit worn.

"I won't be ready for you until seven, Jimmy," he said at once. "And I've a lot to do before then. Wall Street has gone mad and there isn't a thing on the list that hasn't dropped. There's been a run on the country branches of all five banks, and some of the others as well. I have a meeting of bank presidents at six."

"Righto, dad," I said. "We'll clear out——"

"If Dan and you are on something new, why not bring him over to Hazeldene for the night, and let's do our talking there?"

"How about it, Dan?"

"Fine," he said.

"But your analysis of the tarnishing?"

"My fellows can do the test all right. I'll take a run up and see how they've got on, and fetch my kit down here."

"I'll come with you, then. The landing-stage at seven, dad?"

"I'll be there, son," and with a nod to Dan and myself he became immersed in his papers again. We were just going out of the door, however, when he called us back.

"Perhaps you'd better take the elevator to the top of the building and see the janitor; Klenski. He has some weird story about houses hanging from the sky, or something. He's no temperance advocate, Klenski, but you might get something out of it."

Dan and I exchanged a look and bolted for the elevator.

III

The Story Told by the Finn

Up on the roof, we found Klenski, a Finn, born in America, whose faded blue eyes, uncertain movements, and indistinct voice showed at once the soaker. The man was eaten into by alcohol.

"What was it you saw last night, Klenski?" I asked him, as soon as we'd got him out on the roof.

He pulled in the corners of his mouth, in an effort to stop the twiching of the lips that always preceded his speech.

"A cabin—like a rail'ay coach—smaller—'ging b'ropes f'm sky. . . ."

"Where was this? At what time?"

He butted his head towards the railings on the parapet wall.

"There?"

He nodded jerkily.

"What time was this, Klenski?"

"Las'ni — 'smorning — s'm'time — coonsay. . . ."

"About three this morning, maybe?" Dan insinuated.

Klenski turned to him gratefully, and chucked a jerky nod at him.

"What were you doing about at that time?" I asked him.

The Cabin Hanging in the Air—The Blue Wall

"G't up t'git s'mthing—c'm'out see what s't night 'twas—saw cabin—like rail'ay coach c'min' down out'n sky on ropes—'slike that. . . ."

He made a jerky downward gesture of the hand.

"Did you look up to see where the ropes came from?"

He shook his head and gazed at the concrete under our feet.

Dan pointed up at the sky, thinking the man did not understand. But the eyes of the Finn did not follow the hand, and we realized that the man could not bear to look up at the sky. I'd seen the same disability in an alcoholic before.

"Well, what happened then?" Dan asked gently.

"Went over to railings 'nd looked down. 'N blue wall came over my eyes. 'Sall. Went back t' bed. Cold."

"Blue wall?" said Dan. "What sort of blue wall?"

The Finn gazed at him pathetically.

"Blue wall," he said in his gentle indistinct way. "Blue wall . . . other side 'frailings. Down—down—'slike that. . . ."

Again he made that downward gesture of the hand.

"Did you hear any noise?" I asked.

The lips twitched desperately, and a silly smile came into the Finn's face.

"Whisper—whisper—'sper. Binz-z-z!" he imitated. "'N I d'n' know any more, please."

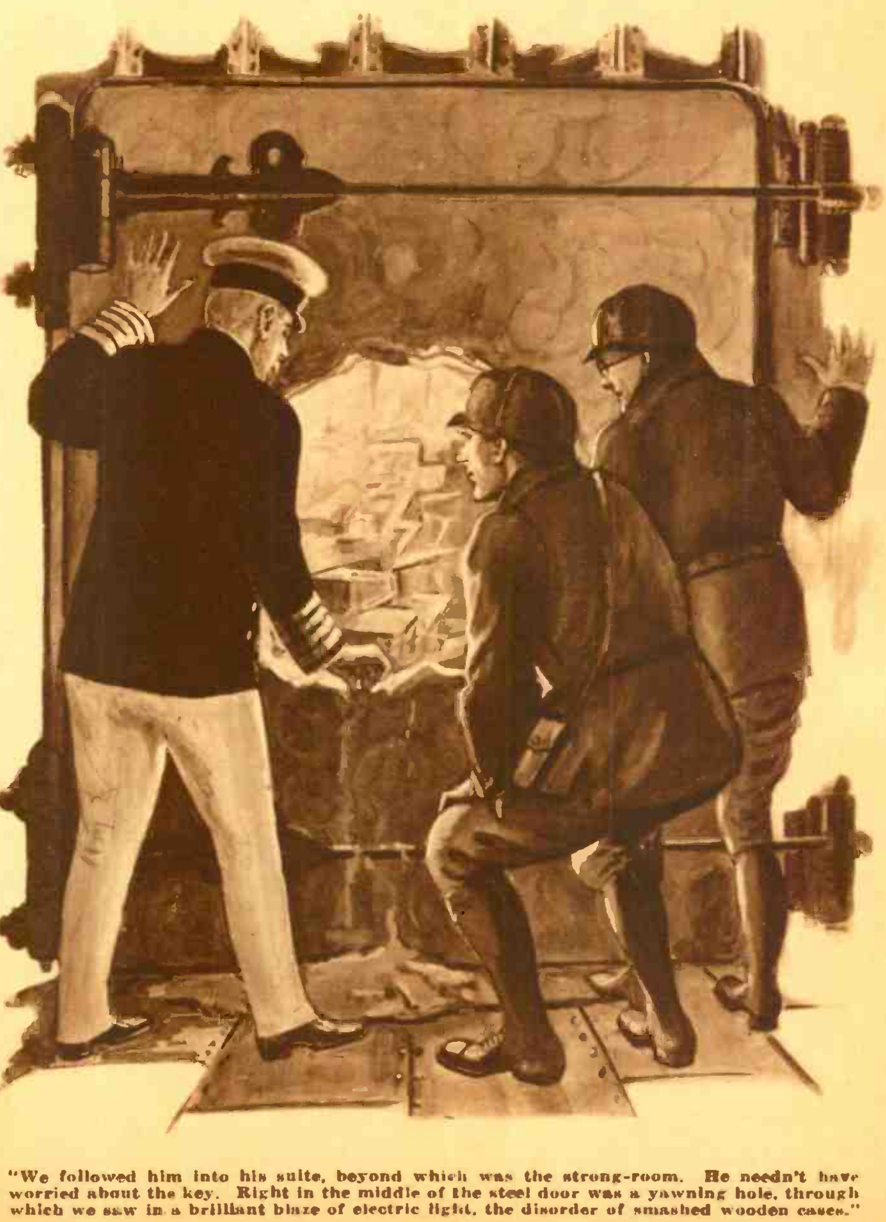
We left it at that, for it was painful to talk to the man, he had such terrible difficulty in talking—or even thinking.

"Dare we interpret the maunderings of that dipsomaniac into evidence for the airship idea, Jimmy?" Dan asked when we were in his roadster again.

"Let's," said I, "and see what it leads to."

"He got up for another drink, you know," said Dan. "It might all be drunken imagination."

(*Continued on page 273*)

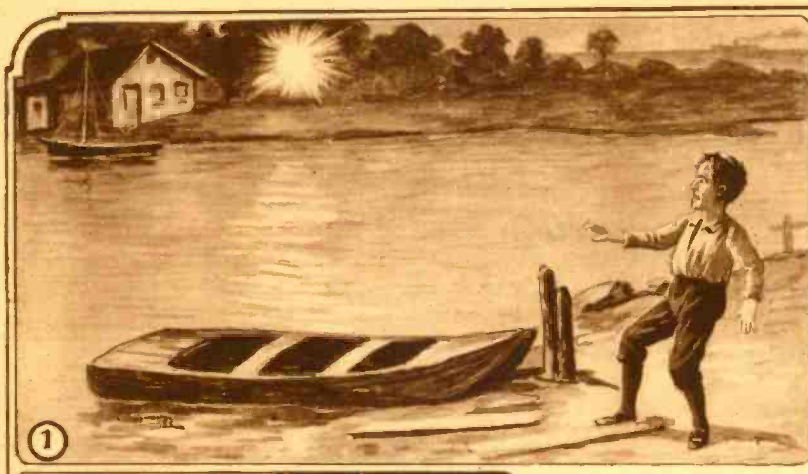


"We followed him into his suite, beyond which was the strong-room. He needn't have worried about the key. Right in the middle of the steel door was a yawning hole, through which we saw in a brilliant blaze of electric light, the disorder of smashed wooden cases."

A Much Debated Phenomenon

Ball Lightning

Here are a few of many descriptions of ball lightning which have been received by us. The incidents are absolutely authentic, and the letters detailing them are on file.



1.

WHILE playing on the beach of the Columbia River in Oregon one evening, I saw a red ball of fire, about the size of a basketball, slowly floating in the air, coming from the direction of the ocean.

After excitedly telling the folks what I had seen, they started back to the beach with me. There we could still see the ball floating in the air about a third of the way across the Columbia River, where some minutes later it faded in the dusk.

Waynes Palo, Astoria, Ore.

2.

A COUSIN of mine was standing on the landing at the head of a flight of stairs with her year old baby, when lightning struck the house and tore through the roof, knocking her and the baby down.

The ball of lightning rolled down the stairs, tearing the baseboard all around the living-room to shreds, rolled into the dining-room, partially tearing the woodwork there, and then ripped the kitchen sink to pieces.

John Barrack, Nashotak, Wis.

3.

I WAS working in a field a few feet from a wire fence when suddenly a large ball of fire flew past, and I heard a crash—all in a fraction of a second.

A few rods away in the path of this supposed-to-be lightning, a tree was badly burned.

Kenneth Guth, Huntley, Illinois.

4.

A BALL of fire about the size of a hen's egg followed my antenna lead in through the window to my set, burning it up. Then the ball rolled across the floor into the bathroom, where it struck the water tank and disappeared.

C. H. Stowe, Paris, Texas.

5.

JUST as I rounded the corner of the street going to school, there was a blinding flash, and had I taken another step I would have been hit by a ball of golden yellow fire.

This ball seemed to be about 2 feet in diameter, and the color could not be reproduced by any artist. To prove that it was hot, the sidewalk was dried as completely as if it were a hot summer day, and the odor of brimstone—(ozone or nitrogen oxides?)—was very strong.

Louis Keyer, Dayton, O.

6.

FROM the window of our hotel we saw a ball of fire travel slowly along a trolley wire. When the ball passed a supporting wire it bounced a foot in the air and landed on the wire again. Reaching the street corner, the ball leaped and came down on one of the guy wires.

The ball followed the guy wire where it was hitched to a brick building, exploded and tore pieces from the bricks.

A. E. Starkey, Lynn, Mass.

7.

ABOUT twelve years ago, while I was still a girl at home, mother was sitting by the kitchen stove trying to keep warm, one foot resting on the leg of the stove. Suddenly there was a sharp flash of lightning and a ball of fire came through the window, doing no damage to the glass, and lit on the stove.

It rolled around on the stove, while mother was trying to take her foot away, lit on her foot and burst.

Mrs. F. W. Stumpff, Jamestown, Pa.

Ball Lightning Made In the Laboratory

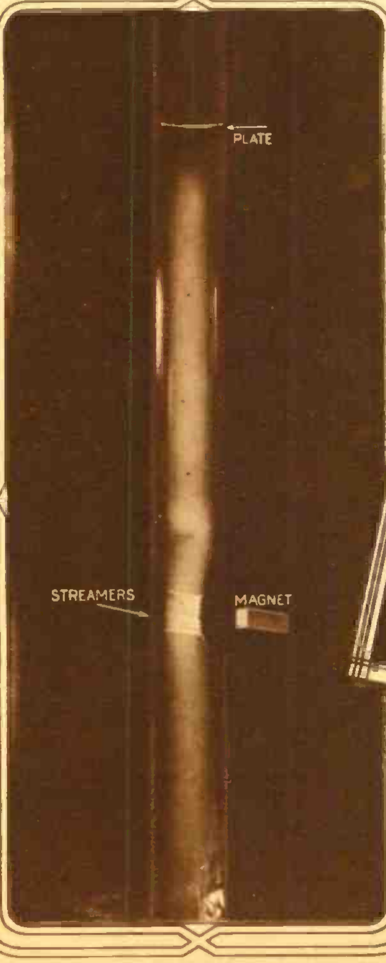
THE history of modern physics is replete with experiments on gaseous conduction. The field seems especially rich in possibilities, chiefly perhaps because we are there concerned more directly with that fundamental factor in electrical phenomena—the electron. Gases under atmospheric conditions have comparatively low densities; that is, their molecules are spaced further apart than in solids or liquids, and the free electrons have larger spaces over which to roam aimlessly or to fly rapidly, impelled by electromagnetic forces. In rarefied gases, the motions of the electrons are far more vigorous than in everyday conditions.

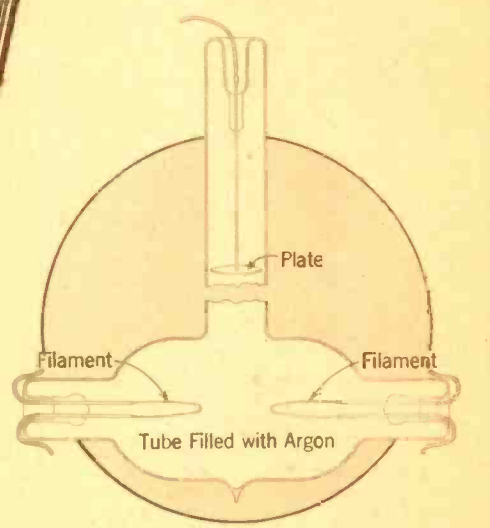
Free for a moment from the influence of the atom, the electron will display unusual properties and give rise to phenomena, whose beauty and novelty contribute much to the prevalent interests in electrical conduction through low pressure gases.

Observe, for instance, the photograph in Fig. 1. That sinuous electrical discharge, so beautifully simple, is peopled with myriads of agile particles that move about, impotently swaying now under the influence of electric, now under magnetic forces. This is no ordinary discharge through a vacuum, but one actuated by some, as yet unknown, forces. A moment before the picture was taken, the arc was stretched motionless through the tube, glowing with a quiet purplish red color. Then through a momentary interruption of current, the arc gains life and tears itself away from the tube with the writhing motion of a snake, while from a tungsten filament at the base of the tube melted tungsten is sputtered and

(*Continued on page* 255)

Mr. Found of the General Electric experimenting with the streamer discharge has the miniature ball lightning formed in the tube, under perfect control. Under the influence of the horseshoe magnet these balls of fire can be made to move up and down the tube.



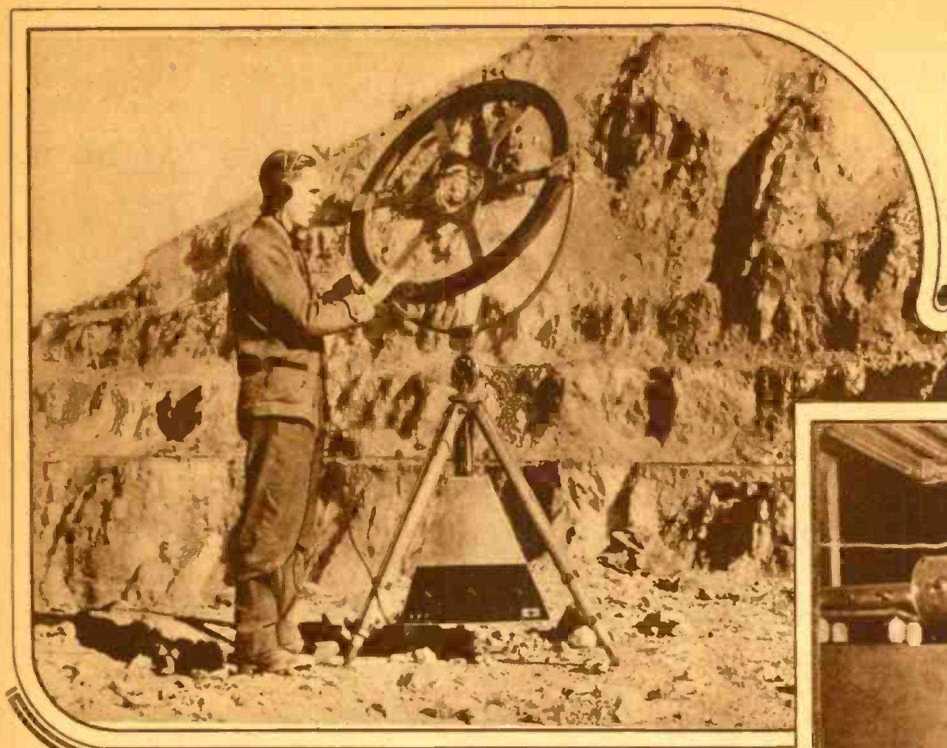


Left: The agitation in the argon arc which is writhing like some strange electric snake, is caused by a sputtering of melted tungsten from the incandescent filament at the base of the tube.

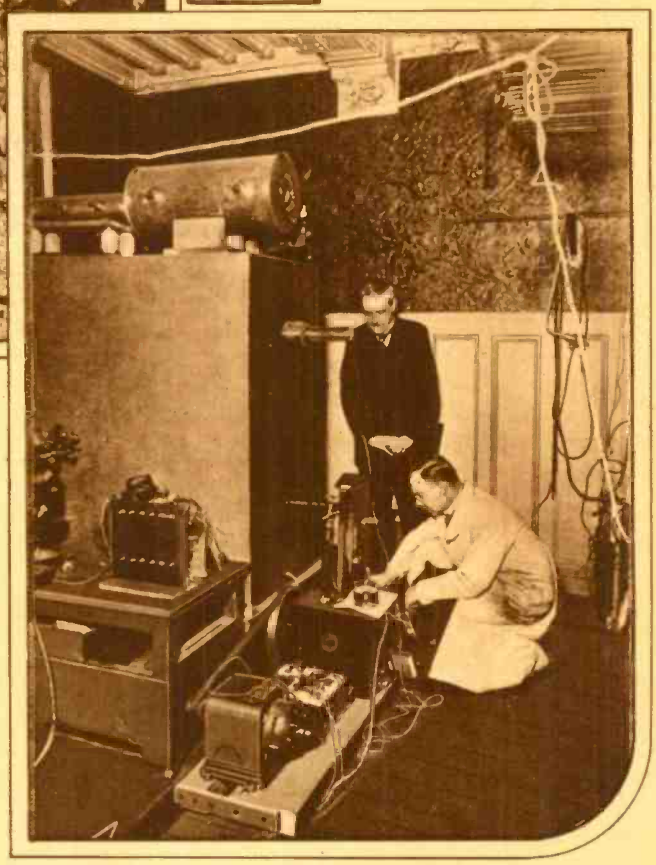
Above: A cross-sectional view of the discharge tube in which the prenomenon of ball lightning was observed. The tube is filled with argon at very low pressure, and with the filament heated to incandescence, a reddish arc is formed between the plate and the filament.

The argon arc shown at left is deflected by a magnet. The transverse, filamentary streamers are in reality small globules of incandescent tungsten moving rapidly across the arc. The globules of liquid fire are, in formation and behavior, very similar to the incandescent spheres of ball lightning. These unusual effects are produced by only .000001 gram of tungsten emitted by the filament.

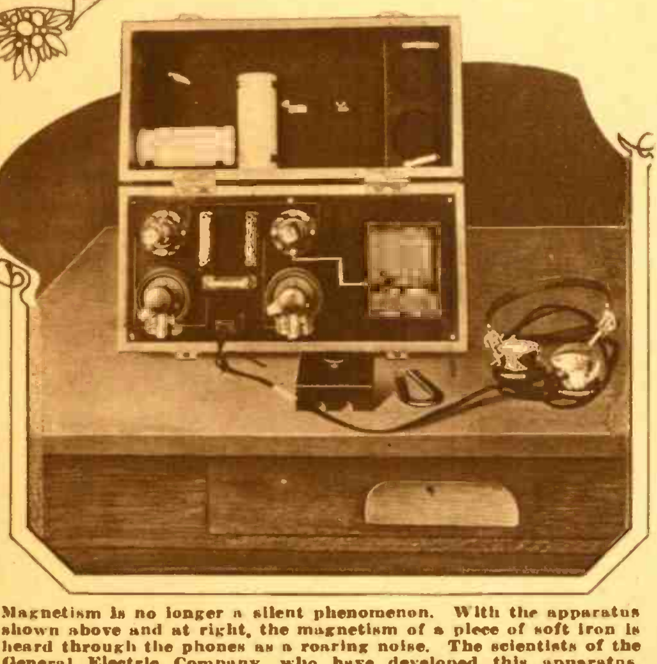
What Experimenters

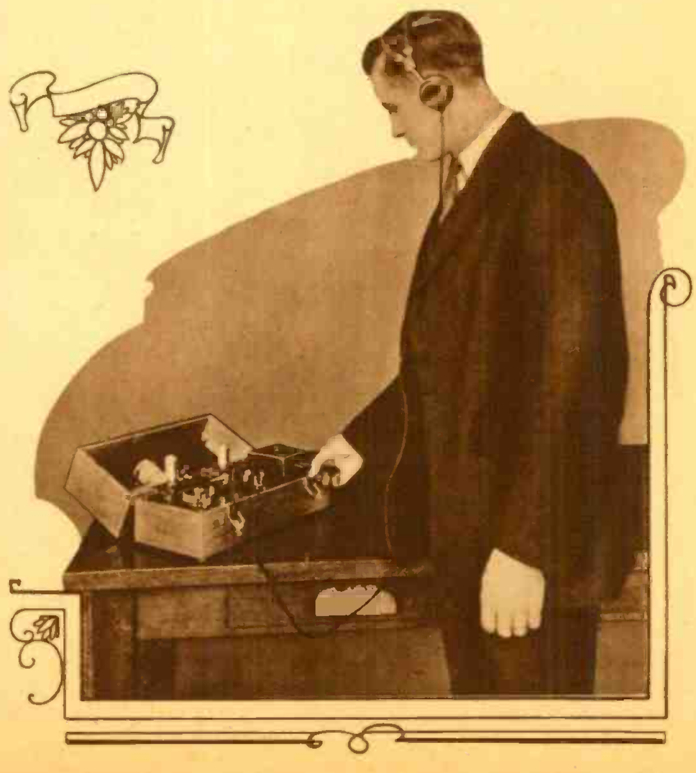


The new underground ore detector invented by B. G. Chilson, E. E., is actually a sensitive radio receiving apparatus which detects ether waves radiated by the veins of conducting ore to which a transmitting apparatus is connected. By connecting the transmitter to the ore the location and outline of the entire ore bed can be determined.



The laboratory of the Duke of Broglie shown at right is one of the best equipped in France. Broglie (standing) is famed for his experiments on X-ray phenomena, and he has also achieved remarkable discoveries in radio research.

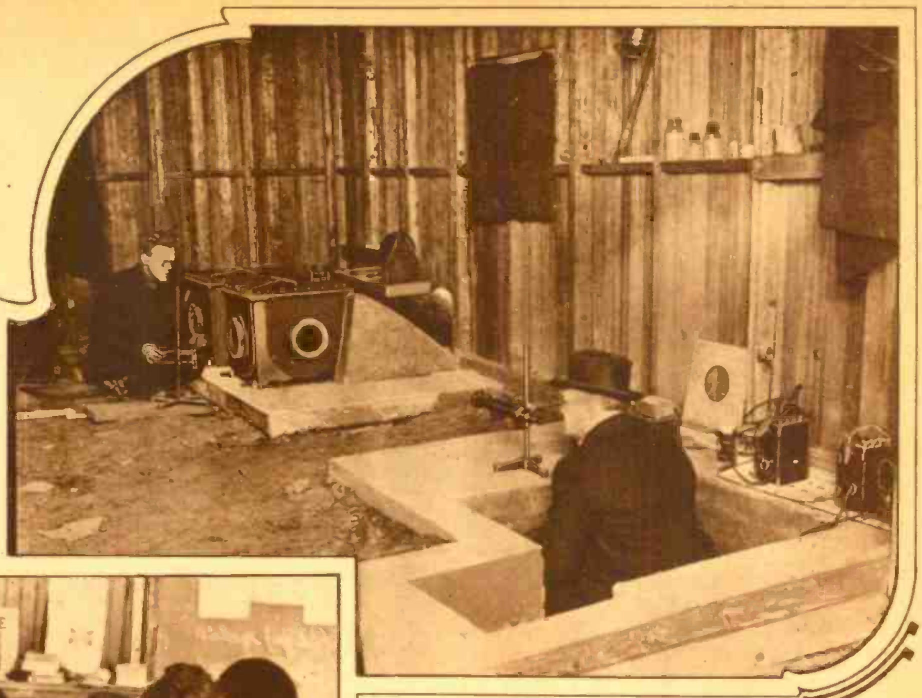




Magnetism is no longer a silent phenomenon. With the apparatus shown above and at right, the magnetism of a piece of soft iron is heard through the phones as a roaring noise. The scientists of the General Electric Company, who have developed this apparatus, claim that the sound is due to the motion of molecular magnetic particles within the iron. In the apparatus a piece of soft iron is inserted in a coil of 17,000 turns. The coil is then attached to an amplifying set to which the ear-set is connected. It is fair to say that comparatively few people realize on what the operation of radio receiving sets depends. The exact action is to receive infinitesimal energy, from the ether presumably, and to relay it up to such strength that a telephone can make it audible. There are three elements, all of extreme sensitiveness, concerned. When the telephone was invented, Professor Preece of England noted the minute current which sufficed to work it. Then we have the vacuum tube, which also effects its magnification, and finally we have the human ear, which, although we do not realize it, is in itself of extreme sensitiveness. Referring now directly to our experiment, the disturbances in the iron are relayed by the vacuum tube up to a strength sufficient to affect the telephone, and the telephone in its turn affects our ears.

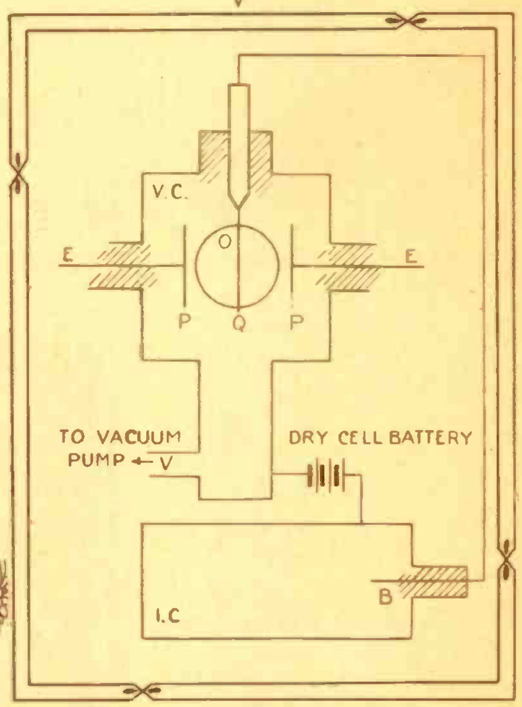
Are Doing To-day

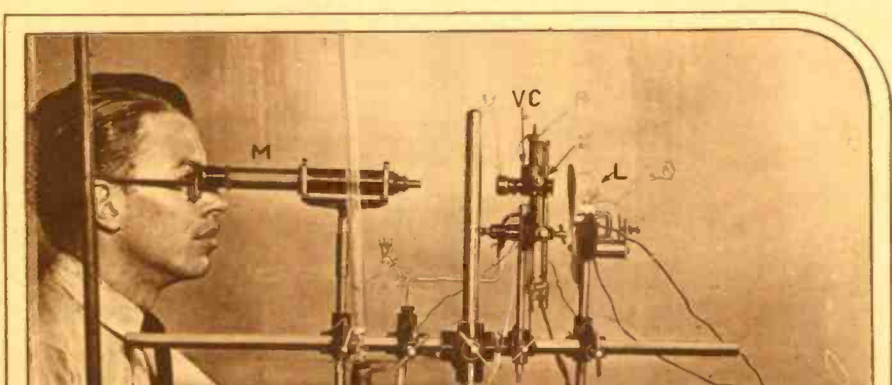
The Einstein theory is to be put to a rigorous experimental test, by the famous American scientist, Prof. A. A. Michelson and Prof. H. G. Gale of the University of Chicago. To eliminate errors due to the vibrations of instruments, all apparatus is mounted on concrete columns built on bed rock.



On the left is shown a group of young women taking practical lessons in radio construction. This was in one of the prominent Continuation Schools of the City of Chicago, Ill. It indicates the broadening of the scope of woman's work no longer restricted to minor functions as of knitting and sewing.

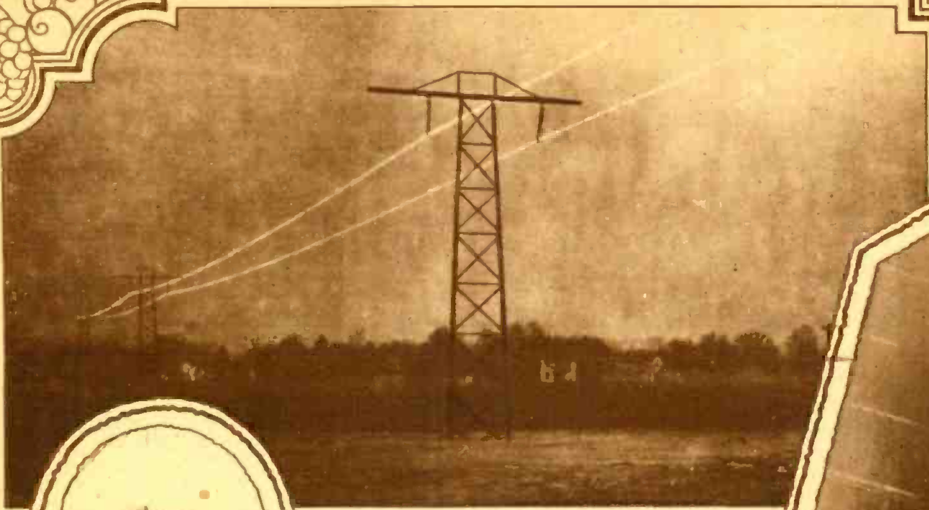
With the apparatus shown below the feeble ionization of the atmosphere can be measured. The device is really a very delicate electroscope, so constructed that the deflections of a quartz fibre can be measured. Through the microscope, M, the motion of the quartz fibre located in a vacuum chamber, V C, is observed. The lamp, L, serves to illuminate the vacuum chamber.

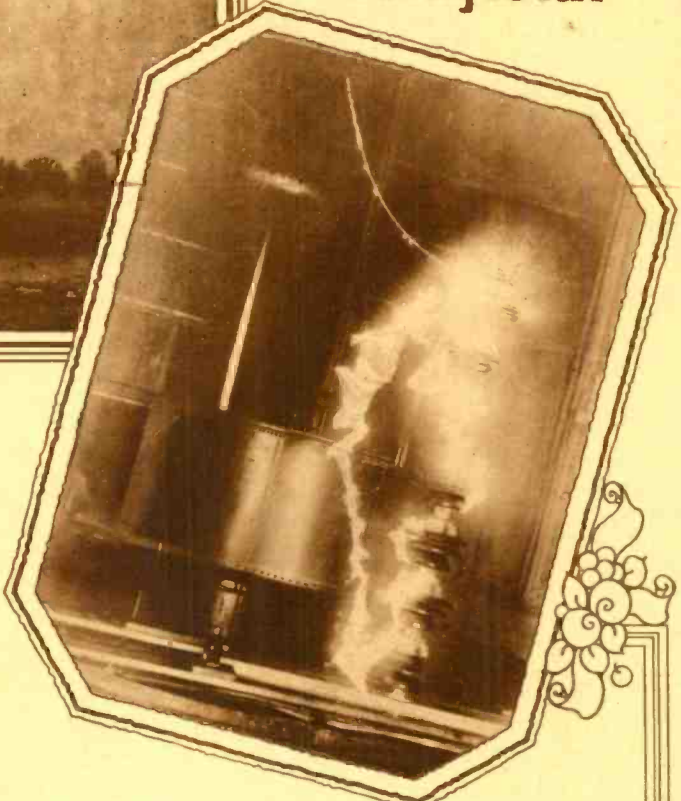




The charges due to the ions of the atmosphere collect on the electrode, B in the ionization chamber, I C. The charge is conducted to the silvered quartz fibre, Q, in the vacuum chamber, V C. A low voltage is impressed on the plates, PP, and under the influence of the electric field established by this potential difference, the charged quartz fibre is deflected from its normal position. The rate of this deflection as measured on a scale in the eyepiece of the microscope is a measure of the ionization in the chamber, I C. The apparatus is extremely sensitive and will detect the ionization due to a single "alpha" particle, that is, due to a single atom of helium carrying two positive charges. It was developed by Professor W. F. G. Swann of the University of Chicago.

Lightning Real and Artificial





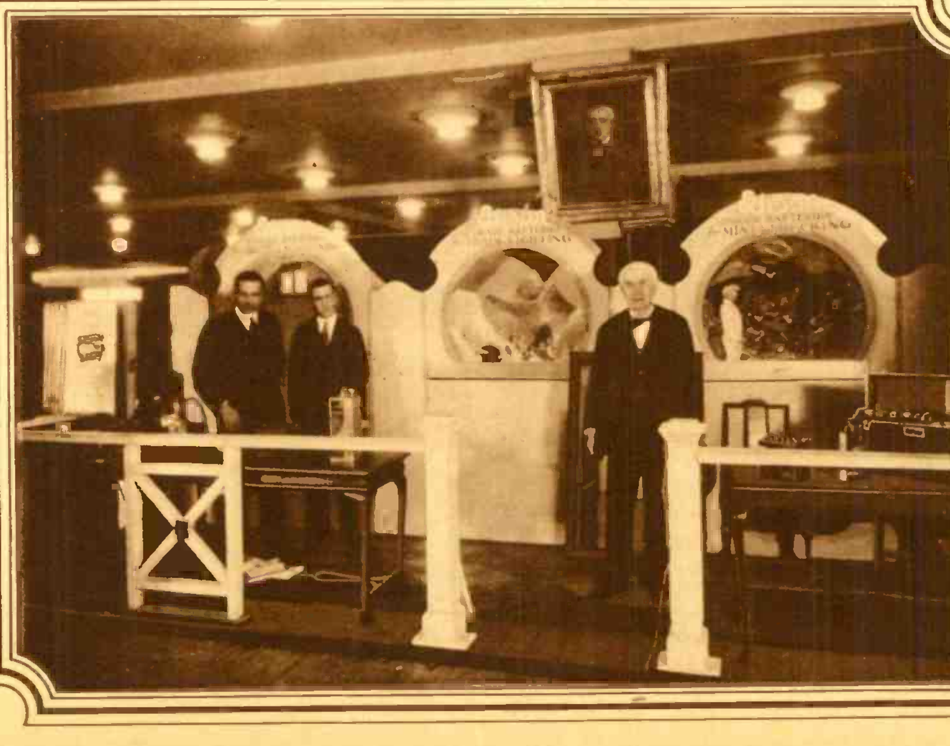
On high voltage transmission lines an eerie glow is seen at night. The glow is due to the ionization of the atmosphere in the vicinity of the wires. A potential of 600,000 volts was impressed on the transmission line shown above. This transmission line is used for experimental purposes at Purdue University. The corona glow occurs only where energy is radiated from the wire and on transmission lines this effect represents considerable losses. Often radiation of energy from wires occurs without such appearance. Indeed, such is the case in radio transmitting aerials. Such aerial wires have a corona of ultraviolet light around them which while invisible to the eye gives clear impressions on the photographic plate.

In modern testing laboratories all the severities of weather to which insulators are subjected are reproduced on more than their natural scale. At the laboratories of the Westinghouse Electric, the insulators shown at the right were subjected to the strain of 650,000 volts in an artificial rainfall of 12" of water per hour.

A strange effect of the idiosyncrasies of lightning flashes is seen in this wreck of a brick chimney. The fact that this is the second lightning bolt descending on this chimney throws doubt on the old adage that lightning never strikes twice in the same place.

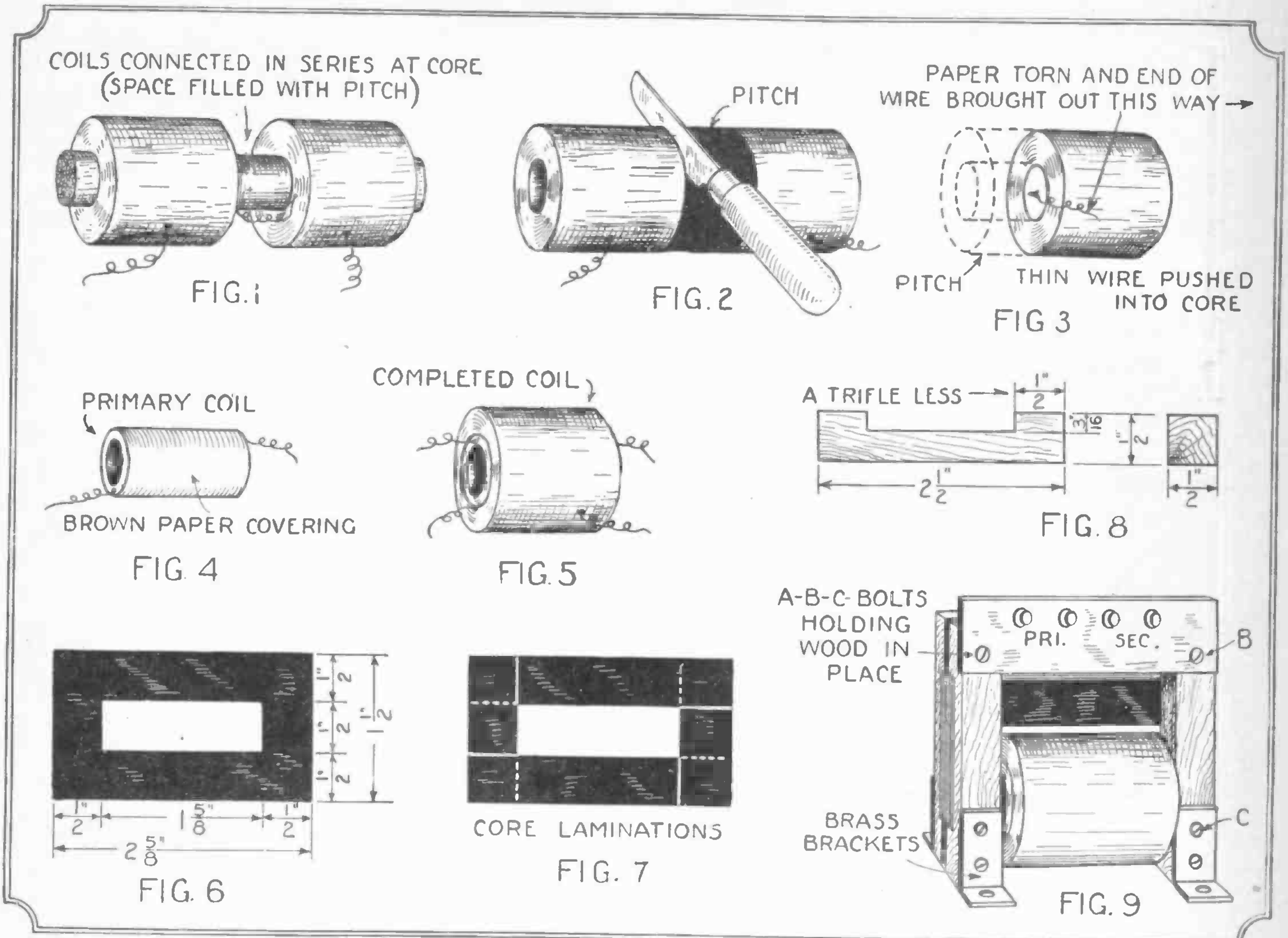
EDISON

At the age of 77, Edison still retains that restless curiosity that animated his youth and keeps a watchful eye on the growth of his numerous inventions. He makes annual visits to the New York Electrical Show, where there is hardly an exhibit that is not directly or indirectly an offspring of his own researches. The photograph at the right was taken in the exhibition booth of the Edison Storage Battery Company. The now well known Edison storage battery marks Edison's success in the field of electro-chemistry.



How To Make An Audio Frequency Transformer

By Mayer Rabinowitz



Constructional details of an audio frequency amplifying transformer the coils of which are obtained from an old Ford spark coil. Note that the inside of one of the spark coil secondaries forms the primary, and the outside of the other coil forms the secondary. The completed transformer is shown at Fig. 9.

EVERY man knows that most experiments are just experiments and gives it up after becoming disgusted. But, on the other hand, some of our most useful appliances were once experimental. However, I can truthfully say that the transformer described is a finished electrical product.

As an audio frequency transformer requires a few thousand turns in the primary coil, the secondary will require several times that number according to the ratio, so the making of such a transformer seems rather complicated to the average layman. But, as the saying goes, "Where there's a will, there's a way," so I have thought out the following. We all know that a spark coil is composed of the iron wire core, the primary winding, and the coils of very thin wire for the secondary. We will first get an old Ford spark coil, which can be procured at any garage for the asking. The vibrating part is removed and the case broken open, but, as the coil is incased in pitch, great care must be taken in removing it.

The two secondary coils are connected in series near the core (Fig. 1a). The intervening space between the coils is filled with pitch which should be carefully removed by the following process. Heat the blade of a knife, first putting some grease on it. When it is very hot, cut into the pitch at the end of one coil and slice that coil off (Fig. 2). Through the core of the other coil locate the end of the thin wire and carefully bring it out to the inside of the core by cutting the paper (Fig. 3). When this is done, heat the knife again and slice off the pitch, but be careful not to cut the thin wire. This coil will be used for the primary, but a number of turns must be removed. As it is thoroughly solid, having been soaked in oil and pitch, it is impossible to separate the windings and make two coils (primary and secondary) out of one large coil. It will, therefore, be necessary to use both coils. The one just described will be the primary. Either unwind each layer or cut the layers off until there is about one-fifth of the original coil left.

Take the brown paper that insulated the primary from the secondary of the spark coil and paste it with shellac to the outside of the coil. The primary winding is now finished (Fig. 4).

The next step is the secondary. Beginning at the inside of the other coil the wire is carefully unraveled until the primary coil slides into it tightly. The ends of both coils are brought out. The complete coil is shown in Fig. 5.

The next important step is the core which is composed of strips of ordinary sheet iron. The size of the window opening for the coil should be 1⅝" x ½" (Fig. 6). Allowing one-half inch for overlapping (Fig. 7), the dimensions of the strips would be 2⅛" x ½" and 1" x ½", piled ½" high. Three legs of the core are built up, the coil slipped on, and then the remaining leg is put on. The problem now is to bring out the wires to binding posts and make the whole transformer firm and compact. Procure four sandpapered and smooth strips of wood 2½" long and ½" x ½" in cross section. Chisel out a piece from each a trifle less than ½" from both ends (Fig. 8). The four blocks are then put on each end of the transformer and holes drilled through the ends for bolts (Fig. 9).

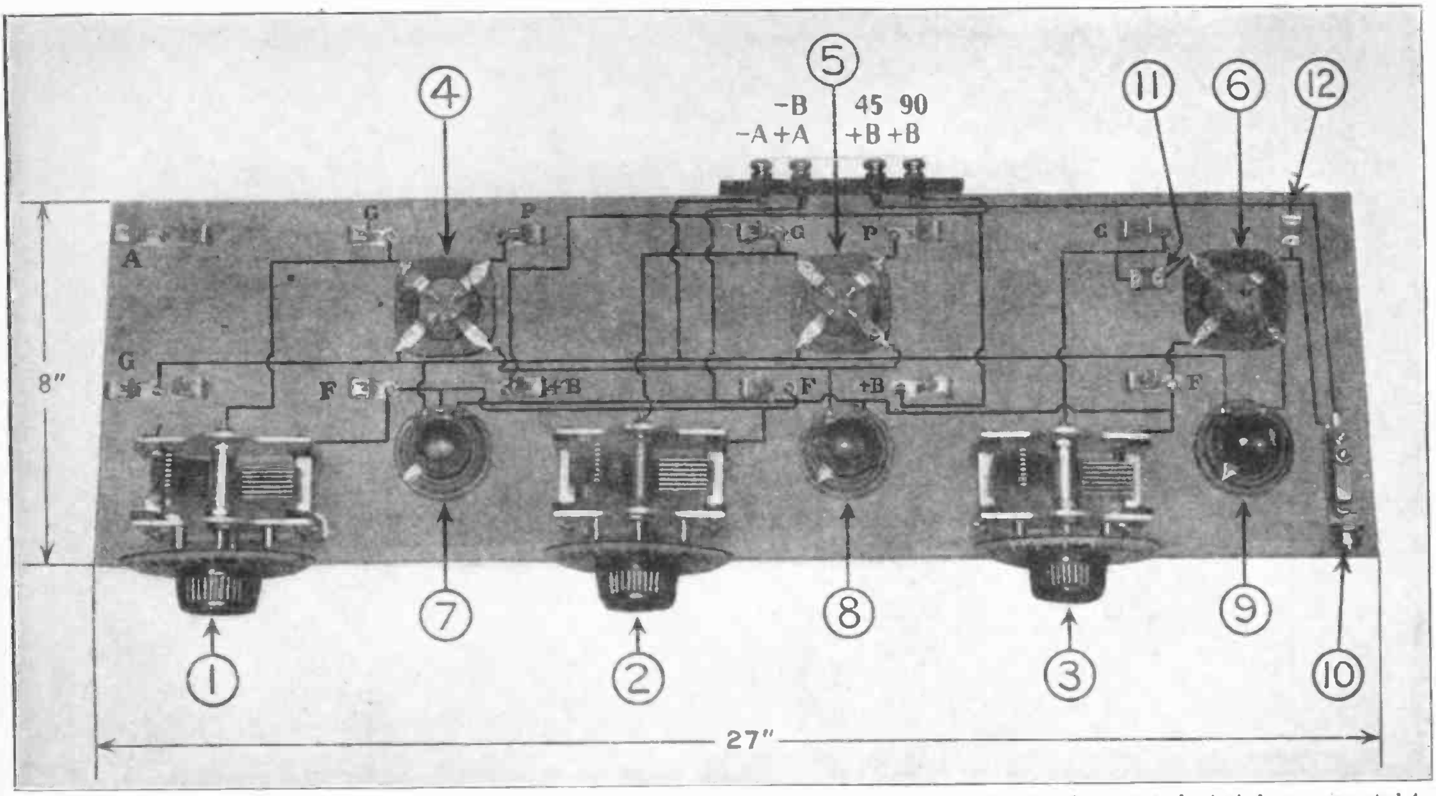
The panel for the binding posts is a strip of bakelite ¾" x 2⅝" with four holes drilled in it and posts inserted. It is fastened on the top of the transformer by the clamping bolts. This is shown in the illustration of the completed transformer.

I use four brass L-shaped brackets ¾" x ½" to hold the transformer upright. Two holes are drilled or punched out on the ¾" side and one hole on the ½" side. The top hole on the ¾" side securely fastens each bracket to one block of wood by a screw. The other hole is for the brass bolt. The wood should be given a coat of varnish and the completed transformer is ready for use.

When connecting the wires to the binding posts be sure to connect them as follows: The outside turn of the secondary or outer winding connects to the grid terminal. The inside turn of the outer winding connects to the filament terminal. The outside turn of the inner coil connects to the plate terminal, and the inside turn of this coil connects to the B terminal. The coils should be placed on the core in such a way that the windings are in the same direction. The transformer may be tested by connecting it in series with a dry cell and headset.

Tuned Radio Frequency Circuits

By Clyde J. Fitch



An experimental hook-up board for testing tuned radio frequency circuits and transformers. The transformers to be tested are connected to the spring terminals lettered P, +B, G and F. The numbers designate the following instruments: 1, 2, 3, tuning condensers; 4, 5, 6, sockets; 7, potentiometer; 8, 9, rheostats; 10, jack; 11, grid condenser and leak; 12, by-pass condenser.

THE popularity of five-tube tuned radio frequency receivers was caused by a very peculiar patent situation. Heretofore regenerative receivers have been considered the most efficient and practical for broadcast reception, but the majority of manufacturers were unable to obtain licenses for manufacturing these sets, and fortunately for the public they were forced to turn their attention to other ideas. The only loop hole seemed to be in tuned radio frequency amplifier circuits.

While this type of circuit employs five tubes and is no more sensitive than a three-tube regenerative circuit, it has many advantages that make it ideal for broadcast reception. The main advantage is non-radiation. If all the five-tube receivers in use today were changed over to three-tube regenerative sets, it would be virtually impossible to receive radio concerts. The noises from these small receivers would drown out everything. Another ideal advantage of the tuned RF receiver is that the three dial settings are practically the same, within one or two degrees, and stations are easily logged. Tuning is also simplified. Thus we see that due to monopoly caused by the patent situation the radio public has benefited considerably and the small set manufacturers have profited.

In order to interest the experimenter in working along these lines, we are giving complete details of a simple experimental hook-up board for testing different transformers and circuits. A number of radio frequency transformers that have made their appearance on the market together with several RF circuits are also shown.

The illustrations clearly indicate the construction of the test board. The experimenter will note that only three sockets are used. With this arrangement we obtain two stages of radio frequency amplification and detector. By plugging the phones in the detector jack, comparisons of different circuits and transformers can easily be made. The filament connections of the circuits are wired permanently. Four Fahnestock clips are provided for each socket for connecting the coils. All wiring is made with No. 20 D.C.C. wire underneath the board. The illustration shows the connections in full for clearness.

The main trouble in all receivers of this class is due to coupling between the circuits causing oscillations. In order to obtain amplification it is necessary to prevent the circuits from oscillating. Several methods have been used for doing this, but only a few are satisfactory. In order to prevent feed-back coupling between the circuits, we must first understand where the feed-back occurs. Feed-back in the electrodes of the vacuum tube cause the most trouble. The grid and plate electrodes form a small condenser which couples the plate circuit to the grid circuit and causes oscillations. By means of a bridge connection it has been possible to neutralize this tube capacity, and the circuit is successfully used in neutrodyne receivers.

> The following parts were used:
> 1 Soft wood board, 8 x 21 x 5/8".
> 3 *Freshman* 15-plate condensers.
> 3 *Cutler Hammer* tube sockets.
> 2 *Rasco* 30-ohm filament rheostats.
> 1 *Rasco* potentiometer.
> 1 Single circuit jack.
> 1 Binding post strip with 4 binding posts.

Feed-back also occurs between the coils themselves. The magnetic and electrostatic fields of the coils extend far out into the surrounding space, and energy is fed from the plate circuits to the grid circuits and oscillations are produced. In the neutrodyne type of receiver, feed-back between the coils has been reduced by mounting the coils at such an angle that their fields have no effect. The type of coil used in the neutrodyne is shown at A in Fig. 10. The details of the coil are given so that the experimenter may construct them. B shows a similar coil except that it is of the low-loss construction. The wire is supported by thin strips of insulating material instead of being wound on bakelite tubes. The coil shown at C is also of the low-loss construction. It is stagger wound. The experimenter may wind these coils on a suitable form, after which they may be removed, tied with a string, and the wire cut in two places at the center so as to form the primary winding.

Spider-web coils may be used also. This type of coil is shown at D. It may be wound in the same manner as the stagger wound coil with the winding cut in the center in two places so as to form the primary. Coils C and D being smaller in size than coils A and B, have a smaller external field and consequently do not have as great a tendency to cause oscillations. Coil E is of interest in that electrostatic coupling between primary and secondary winding is considerably reduced by winding the primary in the form shown. Greater amplification is obtained because more primary turns can be used without oscillations. The coil shown at F has no external field at all. It is wound torroid shape so that the entire magnetic field is inside. This type of coil looks like a doughnut. It may be placed in any position or in the vicinity of metal objects without causing any noticeable effects in the circuit. The experimenter may make these coils by winding the wire in one layer on a tube. Gummed paper is then stuck along one side of the coil and it is removed. The winding is then bent around in the shape shown and securely fastened. In this case a few of the turns are cut out for the primary. The "D" coil shown at G gives a similar effect. The wire is wound figure 8 fashion on a tube having two slots. Thus the magnetic field goes through one-half of the tube and back the other and does not extend far out into space. H represents a similar coil except that it is wound on two separate tubes placed close together.

RADIO FREQUENCY AMPLIFIER CIRCUITS

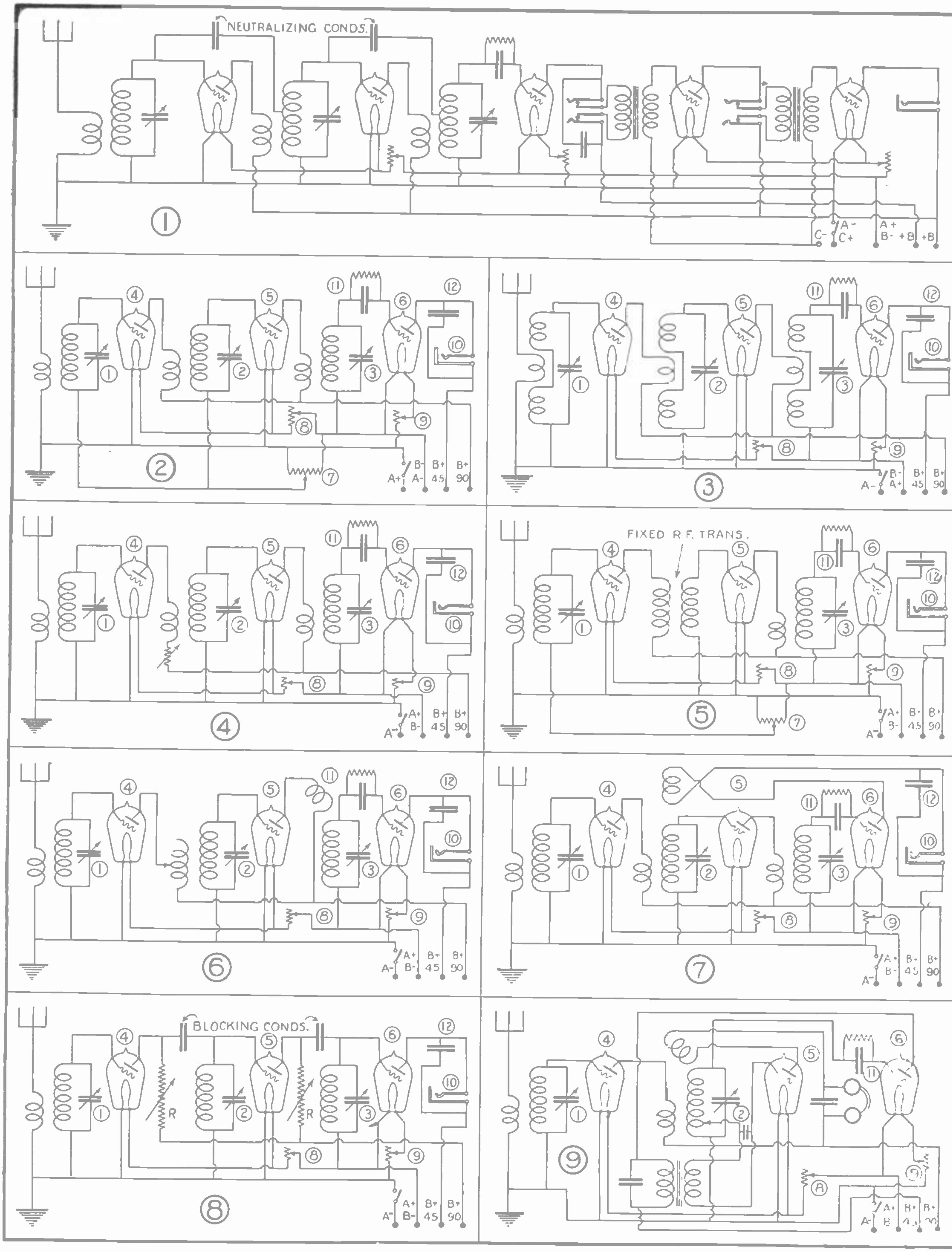
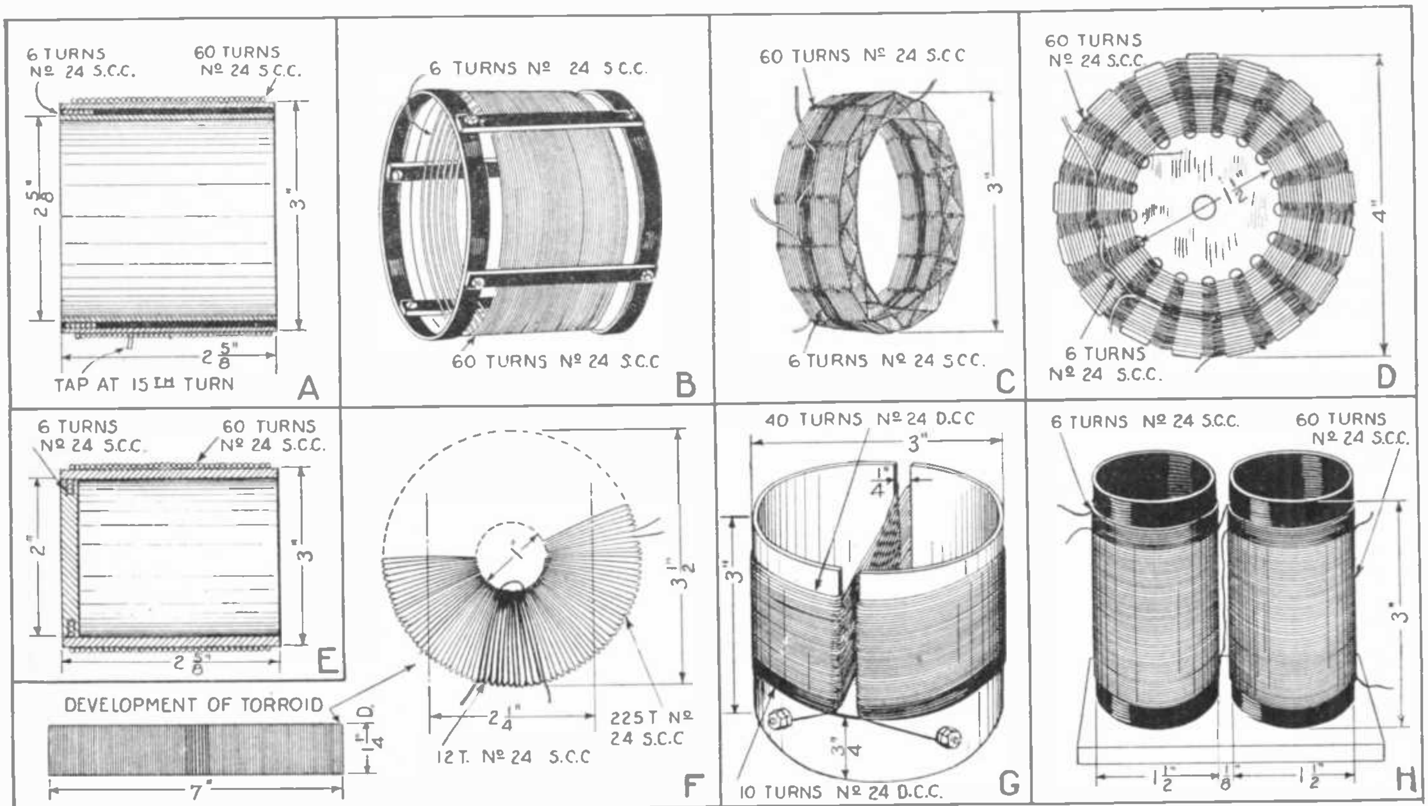


Fig. 1, standard 5-tube neutrodyne showing neutralizing condenser control; Fig. 2, potentiometer controlled circuit; Fig. 3, circuit in which oscillations are suppressed by design of transformers; Fig. 4, resistance stabilizer in plate circuit; Fig. 5, two tuned and one fixed R.F. transformer with potentiometer control; Fig. 6, circuit with variable primary for oscilla tion control; Fig. 7, reversed feed-back control; Fig. 8, resistance coupled circuit; Fig. 9, tuned reflex circuit.



Various designs of radio frequency transformer coils that are now used in many commercial receivers. Note that the tendency is towards the use of low loss self supporting windings with low external magnetic fields. The experimenter can easily try the various coils on the hook-up board.

A study of these coil designs shows that the object is to produce a coil that will not cause feed-back between the circuits. If we have much feed-back the circuits will oscillate, and in order to prevent them from oscillating, we have to decrease the number of turns in the primaries of the transformers and this, of course, decreases the amplification. By designing our coils and mounting them so that very little feed-back occurs, we can use a greater number of primary turns and obtain greater amplification. As amplification without oscillation is required, extreme care should be taken in constructing the coils. The experimenter should try various sizes and shapes of windings, and in that way he may produce a coil that will allow the use of the entire amplification factor of the utbe.

Neutrodyne Circuit

The full page of diagrams shows a number of radio frequency circuits. Fig. 1 shows the complete five-tube neutrodyne circuit. This comprises two stages of radio frequency amplification, detector, and two stages of audio frequency amplification. In the other circuits only three tubes are shown, as the connections of the two-stage audio amplifier are the same in each case and have been omitted. Coils A, B and E may be used successfully in the neutrodyne circuit. These coils are tapped at the first 15 turns for neutralizing purposes. The neutralizing condensers are shown in this diagram. When properly neutralized this circuit gives very high amplification.

RF Amplifier With Potentiometer Control

Fig. 2 shows one of the first tuned RF amplifier circuits that has ever been used. To prevent oscillations, a potentiometer is used. This changes the grid potential of the amplifier tubes, and with its use they may be operated on any portion of their characteristic curves. This is a very poor method of control, as in order to prevent oscillations, the potentiometer must be adjusted so that the amplification factor of the tubes is reduced sufficiently. While this method controls oscillations, it reduces the amplification considerably and results are comparatively poor.

Tune RF Without Control

The circuit shown in Fig. 3 is used in many of the five-tube sets now on the market. No control is provided for stabilizing the circuit. The design of the transformers is such that as many turns as possible are used in the primaries so that the circuit does not oscillate on the lower settings of the condenser dials. In this way the set works comparatively well throughout the entire range without oscillating. The design of the coils, therefore, must be such that they do not feed back energy from one circuit to the other. The coils shown at C, D, F, G and H have been successfully used in the circuit.

Plate Circuit Stabilizer

Fig. 4 shows the circuit used in the Deresnadyne receiver. This circuit is the same as the one shown in Fig. 3 except that a variable resistance is connected in the plate circuit of the first tube. Assuming that the circuit oscillates with the resistance shorted, we can easily understand that by adding the resistance a certain value will be reached where oscillations cease. This resistance may be in the order of 4,000 or 5,000 ohms. A Bradleyohm No. 10 may be used.

Tuned RF Circuit With Fixed Transformer

In order to reduce the number of tuning controls, a fixed transformer that covers the entire broadcast range may be used for one of the amplifiers. A Rasco transformer works very well. The connections are shown in Fig. 5. Any of the above methods of stabilizing the circuit may be used. Although the selectivity is not quite as great as when using three tuned circuits, the amplification is about the same and tuning is simplified.

Tuned RF Circuit With Variable Primary

Another idea that works very well for controlling oscillations is shown in Fig. 6. Two of the RF transformers may be any of those shown in Fig. 10. The other transformer connected to the detector tube has variable coupling between the primary and secondary. Therefore, instead of reducing the number of turns of the primary until oscillations cease, the coupling between primary and secondary can be reduced instead, and it can be set at a value that gives best results throughout the entire tuning range. Any standard variocoupler may be used for this transformer.

Tuned RF Circuit With Reverse Feed-Back

Fig. 7 shows a circuit in which reversed feed-back is used to prevent oscillations. This principle is used in the superdyne receiver. Reverse feed-back is obtained by connecting a coil in the plate circuit of the detector tube and coupling it to the first or second RF transformer. Any one of the above circuits except the neutrodyne with any of the coils shown in Fig. 10 may be stabilized by this method. Very good amplification is obtained.

(*Continued on page 272*)

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The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

RADIO RECEIVER CIRCUITS

Contrary to the general impression which many radio fans have acquired there are only a few circuits in general use, and the many circuits that are known under the myriad different names are only special designs of these few circuits. The operation of all radio circuits involves the same principles and differences existing among the various named circuits are those of detail in the application of these principles.

Without considering accessories such as batteries, phones, jacks, etc., radio circuits may be considered in a general way with respect to the following classification:

1. Source of excitation
   - (a) Ordinary antennas of various designs
   - (b) Coil antenna
   - (c) Condenser antenna
2. Tuned circuits
3. Fundamental tube circuit
   - (a) Regenerative
   - (b) Non-regenerative
4. Detectors
5. Amplifiers, single or in cascade
   - (a) Transformer coupled
   - (b) Impedance coupled
   - (c) Capacity coupled
   - (d) Resistance coupled
   - (e) Diode coupled

Every radio circuit known at the present time involves various combinations of the above. With regard to the practical application of these it does not make much difference how various things are accomplished just so the entire circuit is designed accordingly. Thus, in a tuning circuit we require inductance; how to get it does not matter so much provided we do not inject into the circuit other things which we do not want. Also, in regenerative circuits what we want is a feed-back of energy from the plate to the grid; whether we obtain it through the coupling of the tube or by means of feed-back coils (ticklers) does not matter much, provided the one method can be controlled as easily as the other, or that the efficiency of the set is not impaired. As another illustration, fundamentally it does not make any difference whether we build our coils of one shape or the other, just so we get the inductance we require and do not put excessive resistance into the circuit.

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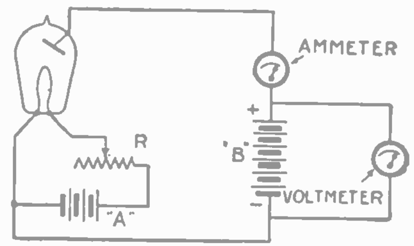
The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE ELECTRON TUBE

A general idea of electrons was given in Radio Data Sheet 1-4 and 1-5, and in this sheet one application of electronic phenomena will be discussed, in connection with the electron tube used in radio receivers and transmitters.

It has been explained (1-5) that electrons can be liberated from solids by heating. How the heating is accomplished does not make much difference, but in the electron tube the most convenient arrangement is to allow a filament of thin metallic wire to be the source of the emission, and to have this filament heated by an electric current. This is the arrangement shown in the figure.



The electrons emitted from the incandescent filament fill the space within the tube. The filament is lighted by the current from the battery marked "A", and the temperature of the filament is controlled by controlling the current through it by means of the rheostat "R".

It has also been explained before (1-2) that unlike charges attract each other, so that if a plate be inserted into the tube, and this have a positive charge on it, the negative electrons coming from the filament will be attracted over to the plate. The positive charge is obtained by connecting the battery marked "B" as shown.

The flow of electrons from the filament to the plate constitutes a flow of electric current. Unfortunately, in the beginning, before electrons were known, a certain direction of current flow was called positive and this happened to be in a direction contrary to the direction of electron flow. So a flow of electrons from the filament to the plate is the same thing as a flow of current from the plate to the filament. It is obvious that this current can flow only when the plate is charged positively and the tube acts as a valve.

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The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

ELECTRONS

In Radio Data Sheet 1-2 and 1-3 an introduction to the nature of electricity was given. The phenomena explained in those sheets dealt with the first evidence of electricity that was disclosd to the ancients. Since the discovery of these things many theories have been propounded in an attempt to explain what electricity is and whence it comes. Among these theories may be listed the ancient two-fluid theory, and the later one-fluid theory of Benjamin Franklin.

Both of these theories predicate the existence of a "fluid" as it is called which possess the electrical qualities. In the two-fluid theory two fluids are assumed, one possessing the characteristics of positive electricity, and the other those of negative electricity. An electric current constitutes a "flow" of these fluids.

In Franklin's theory only one fluid is assumed. Supposing that this is what we call positive electricity, a body possessing a negative charge would be supposed to have a deficiency of this fluid. A neutral body in the two-fluid theory is supposed to have an equal amount of positive and negative fluid. In the Franklin theory a certain amount of the fluid is necessary in a body to make it neutral by counterbalancing forces external to the body. If it has more than this amount it is positive and if less, it is negative.

Neither of these theories explain what electricity is, and neither of them contribute a great deal toward explaining electrical phenomena. The ELECTRON THEORY which has been developed of late years goes much further than these theories in explaining electrical phenomena, but, like the others, it does not offer an explanation of the ultimate nature of electricity.

It is similar to the theory of Franklin in assuming only one kind of electricity, with the exception that instead of a fluid it assumes a myriad of infinitesimal particles called ELECTRONS, which have a negative charge. These electrons may exist free or bound to a NUCLEUS. What the nucleus is, is not perfectly understood. It is known, however, that for equilibrium to exist, that is, for a body to be neutral or uncharged, a certain number of electrons must be bound to the nucleus of an atom. If, for any reason, one or more of these electrons become free and leave the atom, the atom is said to be positively charged. If the atom should take unto itself one or more extra electrons from somewhere, it is negatively charged.

(Continued on 1-5)

THE EXPERIMENTER, February, 1925 1-4

CUT ALONG PERFORATED LINES

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

ELECTRONS [Continued from 1-4]

Matter in the usual state is considered uncharged, or neutral. It is made up of myriads of atoms, the structure of the atoms, that is, the number of electrons contained in them, and the arrangement of the electrons determining chemical and physical properties of the atoms.

Various atoms are made up of various numbers of electrons. In a neutral atom the charge on the nucleus must be equal to the sum of the charges on all the electrons associated with it. The value of the positive charge on the nucleus is called the ATOMIC NUMBER of the elementary substance to which the atom belongs. If the atomic numbers of all the elements be arranged in numerical order, the arrangement will be the same as that of the atomic weights and chemical properties.

Electrons can be dislodged from atoms by heat or impact. The liberation by means of heat is the principle of the electron tube. There is assumed to be a certain SURFACE TENSION in the atom which prevents the electrons from escaping under ordinary conditions.

The electrons are assumed to be in continual motion about the nucleus of the atom at all times. Heat causes the velocity of the electrons in their orbits about the nucleus to increase, and if the increase is great enough the tangential velocity may become great enough, and the momentum of the electron become great enough, to break through this surface tension.

The amount of energy that must be expended by the electron in breaking through the surface is known as the ELECTRON EVAPORATION CONSTANT, of the substance. If this is divided by the charge on the electron, a quantity is obtained which is called the ELECTRON AFFINITY, or, when expressed in volts, the EQUIVALENT VOLTAGE.

The process of dislodgement of electrons in gases by impact produces IONIZATION. When free electrons pass through a gas, they collide with the gaseous atoms in their path giving up some of their energy to the atom struck. If this energy is sufficient, the electrons in the atom may acquire velocities sufficiently high to escape from the atom, leaving it positively charged. The gas is then ionized. This happens only when the energy is given up by the free electrons is greater than that corresponding to a certain critical voltage called the IONIZATION VOLTAGE. This is different for every gas.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE SPACE CHARGE IN ELECTRON TUBES

A definite relation exists between the number of electrons that are emitted from a filament of an electron tube and the temperature of the filament. The number also depends upon the material of which the filament is made. The relation is known as Richardson's formula. It is not necessary for most purposes to use the formula, but a discussion of the relation between the temperature of the filament and the electron flow is in order.

If we start with the filament temperature very low and gradually increase it by reducing the filament rheostat, the emission of electrons will gradually increase. Let us suppose that the positive charge on the plate is great enough to attract over to itself *all* the electrons as they are emitted from the filament.

As the temperature is increased a point will be reached beyond which no further increase in the electron flow to the plate can be obtained, that is, further increase in temperature will not result in further increase of current to the plate. This is called the "saturation" point of operation.

The reason for this is as follows: if we have a given temperature of the filament and a given voltage on the plate, there will always be a certain average number of electrons in the space between the filament plate. The presence of these electrons in the space causes the space to possess a negative charge.

As the temperature is increased and the electron flow increases, this "space charge" will increase, until a point is reached at which the space charge becomes as great as the attraction of the plate for the electrons. That is, the negative charge in the space has as great an effect as the positive charge of the plate. This space charge, being negative, prevents more electrons from coming into the space from the filament. Any more that attempt to come into the space are driven back into the filament whence they came. The only way to increase the current flow is to increase the plate voltage so that its effect will be greater than that of the space charge.

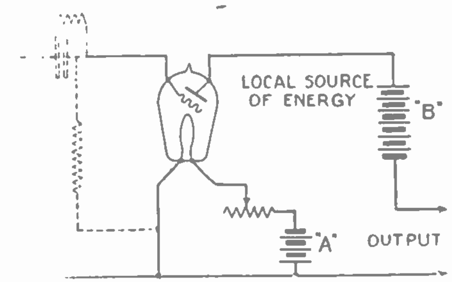
Looking at it the other way, if we have a constant filament temperature and gradually increase the plate voltage from a low value, a point will be reached beyond which the filament can emit no more electrons. Further increase in plate voltage will result in no increase in current.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

FUNDAMENTAL TUBE CIRCUIT

The electron tube as used in radio circuits as detectors or amplifiers has three electrodes—the grid, the plate and the filament. The incoming oscillations from the antenna or tuned circuits are impressed on the grid. The filament acts as the source of electron emission (3-2) furnishing a current in the plate circuit, which includes the local source of energy, the "B" battery. The input terminals of the tube are therefore the filament and grid, and the output terminals the filament and plate. Magnified reproductions of the oscillations on the grid occur in the plate circuit so that the tube acts as an amplifier, even though it may be acting at the same time as a detector.



The figure shows the arrangement. This arrangement must always be used, no matter what kind of circuit the tube is included in. If the tube is to be used as an amplifier the "B" voltage is generally higher than when it is to be used as a detector. For certain purposes a "C" battery is connected in the grid circuit. For purposes of detection a condenser and leak resistance is generally used. But in all cases the tube circuit itself is the same.

There are no set rules for determining the best values of battery voltages to use, or best values of grid-condnser and leak resistance. These vary with the make of tube and also vary from tube to tube of the same make. There are recommended values, however, which, on the average, will give best results, although considerable latitude is allowable. These values will be given in a table later on.

CUT ALONG PERFORATED LINES

Chemistry At Home

By Dr. E. Bade

Upper Row. Left and Center. Cleaning spoons in an aluminum dish, or in an ordinary one with a piece of aluminum in it by the addition of a little baking soda and salt. A few minutes of treatment brings the spoons out bright and clean. Right. A concentrated solution of aluminum sulphate and washing soda is made in a flask and used to clean discolored vessels.

Lower Row. Left. Oxalic acid made from sugar and nitric acid evolves choking fumes, which turned brown on contact with the air. Do not inhale them. After the conversion is complete, the solution is evaporated to dryness, producing such crystals as shown in the center lower illustration. The other photos show the cleaning of a tissue with oxalic acid and the removing of paint with a caustic alkali.

IT IS certainly peculiar how insidiously chemistry has penetrated into the kitchen. Of course, it is not recognized as such, but still it is there, and if it were not for the man behind the science, many of the labor-saving devices and processes almost universally employed would still be in the limbo of things undreamt of.

Take one of the simplest processes, that of cleaning clothes with the inaflmmable gasoline. This is the old process although it is still used today to some extent. At present we should use the non-inflammable liquid carbon tetrachloride which fills many of our hand fire extinguishers, so flame-repellant is it. The process of cleaning is the same as with gasoline, but the danger of fire has been taken from it.

Silverware should not be cleaned by rubbing and the use of abrasives, for this will gradually remove more and more silver as it is being polished; the silver thus removed is lost. It is far better to clean tarnished silver by a chemical action, the process used being easy to carry out and, besides, it does not consume any of the silver on the original silverware. Then, too, no tedious rubbing and polishing is required, provided the silverware is not tarnished too deeply.

In its simplest form the cleaning is accomplished in an aluminum tray or basin (be sure that the vessel is made of aluminum). Into this aluminum vessel pour approximately one, two, three or four quarts, according to the size of the pan, of boiling water. Now, for each quart of water used, add one teaspoonful each of baking soda (sodium bicarbonate) and of salt (sodium chloride). Stir until all is dissolved and then place the silverware in this liquid, taking care that the silver is completely covered by the water and that each individual piece of silverware is in contact with the aluminum pan. Leave the silverware approximately five minutes in the pan, then remove and dry and it will be found to be absolutely clean and bright.

An agateware or porcelain vessel may also be used, but then a small piece of aluminum must be placed in the pan and the silver must be kept in contact with the aluminum. The action, is, of course, the same in both cases.

The action that takes place is somewhat as follows: sodium hydroxide combines with the aluminum and liberates hydrogen, the hydrogen combines with the sulphur on the tarnish and passes off as hydrogen sulphide gas. The silver remains, and if any is dissolved by the reaction, it is again redeposited on the silverware so that no silver is lost.

Aluminum vessels, whether used in the home or in the laboratory often become coated with a brownish black deposit, which it is almost impossible to remove except through vigorous and continued rubbing, and even then many spots will still be found. It is entirely possible to remove this coating without elbow grease and at the same time do it more effectively and thoroughly. The discolored vessel is filled with water up to or slightly above the discoloration. Place the vessel on the stove and begin to heat the water. In the meanwhile a concentrated aqueous solution is prepared containing 9 parts by weight of aluminum sulphate, using the commercially pure substance, and 1 part by weight of sodium carbonate (washing soda). For a medium-sized pot holding about 2 quarts, a teaspoonful of this solution is added to the water. After the water has been brought to a boil, the blackish deposit will have disappeared.

One of the most efficient cleaners is oxalic acid a white crystal solid, organic in nature and soluble in water, which occurs, as a potassium salt, in rhubarb as well as in other plants. It is very poisonous and care should be exercised in handling it. Its greatest mportance in the household lies in its ability to decompose iron rust and inks containing it. It is for this reason that it is so universally used to remove such stains from cloth.

Many organic substances go over into oxalic acid on heating with nitric acid. When 90 cc of strong nitric acid are placed in a one-liter flask and are heated on a water bath, 25 grams of cane sugar are added to produce oxalic acid. Torrents of brown fumes of choking odor are produced as the reaction goes on, and the flask should therefore be removed from the water-bath and placed in the fume cupboard or out of doors just before the sugar is added. When the reaction has stopped, the liquid is evaporated on the water bath to one quarter of its volume, and is poured into a beaker and allowed to cool, when large, colorless, prismatic crystals of oxalic acid separate which melt at 101 degrees C.

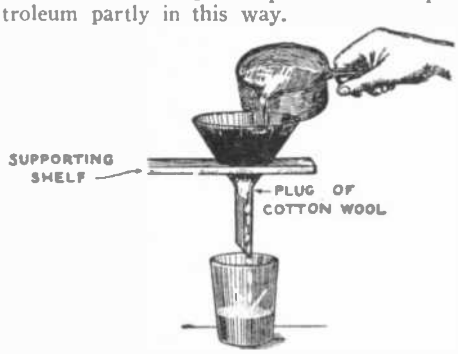
Iron rust stains on cotton, linen or paper are removed by moistening the spot with a

(Continued on page 285)

Experiments in Extraction and Odd Separations

By J. Edmund Woods
Member of the American Chemical Society

THE simple experiments described in a previous article do not by any means exhaust the known methods of separating one material from another. The latter are, in fact, so numerous that a description of them all would fill many complete issues of this magazine. A much used method, for example, of isolating one liquid from a mixture of liquids is fractional distillation, where a very volatile liquid is boiled out of a mixture at a temperature below the boiling points of the other constituents. Gasoline is separated from petroleum partly in this way.



Filtering a colored solution through bone black or other form of powdered carbon removes the coloring matter so that a clear solution filters through.

Another method takes advantage of the differences in the freezing points of several mixed liquids by cooling the mixture to a point where one member solidifies while the others remain liquid. Sometimes a solution is distilled under vacuum, which lowers the boiling points of its liquid constituents because their vapors then have less air pressure to overcome. This is done in concentrating sugar solution, as here it is important to boil off the water without subjecting the sugar to much heat.

Separations are further brought about by diffusion, which is based on the differences in the speed with which various particles travel. For example, a mixture of several gases such as hydrogen, oxygen and nitrogen, would seem exceedingly difficult to break up, yet we can put a porous partition of unglazed china in the vessel containing this mixture, and in a few minutes most of the hydrogen will be separated from the other two gases due to the high relative speed with which its molecules pass through this wall. The same thing can be done with liquids where, too, the particles are in constant motion.

Electrical separations are of great practical value. As an instance, if you make a solution of the green salt known as nickel chloride and place it in a pair of graphite rods which are connected to the terminals of a battery, the current passing through the solution will cause nickel to plate out on one of the rods, while chlorine gas collects in bubbles on the other and escapes into the air. In the same connection may be mentioned a galvanic process. If you dissolve copper sulphate in water, making a fairly strong solution, and then dip a clean knife into the liquid, a fine coating of copper will form on the steel. The polish of the blade will be impaired as an exact equivalent of iron will go into the solution.

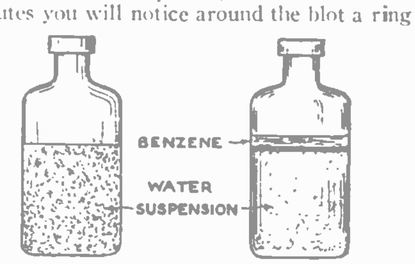
There are even magnetic methods of separating materials, as for example, in the concentrating of certain iron ores. The crushed ore in one type of machine is made to flow down a wooden chute near the bottom of which is a powerful electro-magnet. The dirt or gangue, as it is called, collects for the most part in a pile beyond the chute, but the particles of magnetic iron oxide are deflected by the magnet and fall in a heap by themselves. Dr. Cottrell's process for recovering metallic dust is now widely applied. Formerly the smoke-stacks of smelting and refining works carried off thousands of tons of valuable metal every year in the form of dust. By the Cottrell process this dust is now precipitated by static electricity before escaping from the stack and recovered, while the waste gases pass off into the atmosphere.

Speaking of precipitation brings to mind a host of chemical methods of separating mixtures, and of some rather uncommon physical separations used by the experimental chemist. By physical is meant a separation in which the materials separated do not undergo any change that destroys their identity.

Procure a small quantity of soot or fine charcoal, preferably powdered animal carbon or bone black. Place this in a good sized glass or metal funnel which has been loosely plugged with absorbent cotton so that it will retain the powder. Then fill a beaker with water colored with red ink or some vivid dye. Pour the colored solution through the charcoal filter, and as it slowly seeps through the bed of carbon, it will emerge as colorless as pure water. This is not only interesting but extremely practical, as the same thing is done on a large scale industrially when it is desired to decolorize a liquid. Sugar solutions are treated in this manner in the refinery.

The color removal depends on what we call adsorption, a term which must not be confused with absorption. When any object is dipped into a solution of some substance, there is a tendency for the dissolved material to collect around the surface of the object more than it does elsewhere in the solution. That is adsorption. Ordinarily the effect is too slight to be noticed, but when many thousand surfaces are presented to the solution, as was the case with the charcoal powder in this experiment, adsorption becomes a powerful factor. The dissolved dye simply concentrated around the charcoal particles and remained there while the water passed on. Charcoal will also remove ill-smelling or even poisonous gases from water or air that is filtered through it. The main feature of the gas masks which saved countless lives during the late war, was a canister filled with grains of charcoal made from peach pits and similar substances which took up the deadly fumes from the air as it was inhaled by the wearer.

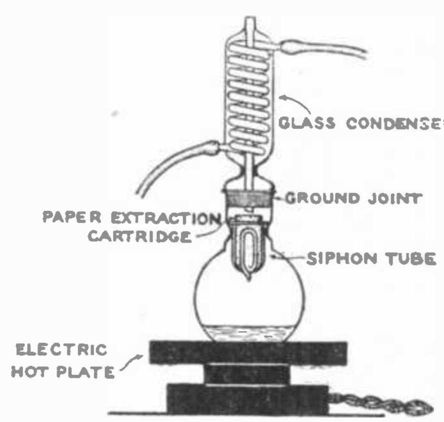
Another simple example of adsorption is seen when you spill ink on a piece of blotting paper. The ink spreads, but after a few minutes you will notice around the blot a ring



The figure on the left represents a suspension of clay and graphite in water. On the right the graphite is shown concentrated between the upper surface of the water and lower surface of the benzene to which it has adhered.

of moisture which is not colored. The surface of the myriad tiny fibres that comprise the blotting paper have adsorbed the colored particles of the ink without restricting the spread of the water in which the ink was dissolved.

Everyone knows the result of keeping apples, onions, or cabbages in the same compartment of a refrigerator with butter. The butter becomes flavored with the odor of the fruit or vegetable in a very short time. It is not so well known however, that this absorption of odors by fats has a commercial value in the extraction of perfumes from flowers. If you cover the surface of a shallow tray with pure lard and then add a layer of petals from some fragrant flower such as the rose or jasmine, the lard will absorb the



Type of standard extraction apparatus used particularly for inflammable solvents. The liquid boils when heated and its vapor is chilled to liquid again in the condenser above, dropping into the paper tube which holds the material to be extracted. When filled above the level of the siphon this tube discharges its liquid, with whatever material has been dissolved, into the flask below.

essential oil that gives the flower petals their fragrance. The process is called enfleurage, and in carrying it out many alternate layers of fat and petals are superimposed and the flower oil later recovered by dissolving it in cold alcohol. Cloths soaked in olive oil sometimes take the place of the solid fat.

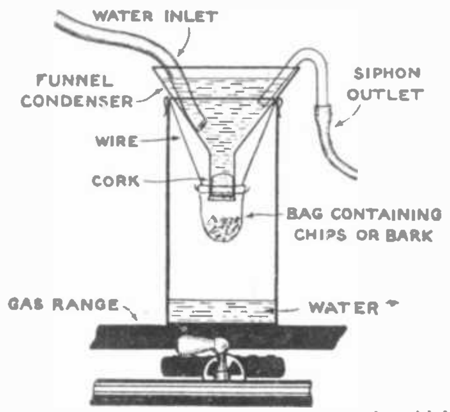
An interesting and unusual method of separation is illustrated in the following experiment. Mix equal quantities of powdered china clay and powdered graphite or some other form of carbon in pulverized form. On stirring the mixture in a considerable volume of water you will have a muddy gray suspension that will settle but little if at all. Now add about a cupful of benzine, gasoline or kerosene and shake the bottle well. When the two liquids separate, it will be seen that the benzene has carried up the powdered graphite with it, while the clay remains suspended in the water underneath. Many metallic ores are thus concentrated.

One of the most efficacious means of removing a particular ingredient from a complex mixture is by fluid extraction.

Suppose, for example, we wanted to extract the oil from a quantity of crushed cotton seeds by means of ether. The tea-ball arrangement would require too much time and too much ether, which is a costly solvent. A more efficient way would be to hang a bag containing the seeds above a small quantity of ether in a closed vessel, which is heated at the bottom and cooled at the top. The heat at the bottom would boil the ether, but its vapor on reaching the cold top would condense again to liquid and drop into the bag. While filtering through the bag, this fresh liquid would dissolve out some of the oil from the seeds and carry it to the bottom of the vessel. There the oil would remain while the ether kept boiling continuously repeating its evaporation and condensation. By this kind of extraction we can not only treat a great deal of material with very little solvent, but we can do so completely in the shortest time, because the solvent is always hot and purified by the distillation, so that it exerts its maximum dissolving power. The action is continuous—that is, there is always some ether boiling and some ether vapor condensing, and the extraction may go on steadily until all the oil has been transferred from the seeds to the bottom of the vessel.

The ordinary coffee percolator affords a homely illustration of practical extraction. Materials other than coffee can be treated in it also, but you are not advised to make this utensil do double duty between the kitchen and the laboratory. You might alienate your family's sympathy with chemistry, as few people care to see their cooking vessels used to expound scientific truths. The apparatus shown is simply constructed and effective.

Procure a tall can, the bottom of which is welded on without solder, so that the can may be heated over a flame. Set a large corked funnel in the can with a cotton bag attached by fine wire. The funnel is to serve as a condenser, and for that purpose it should have cold water circulating through it continuously. The illustration shows two tubes, one an inlet for cold water and the other a simple siphon for draining off the water as it gets hot. You can dispense with the tubes if you wish, merely dipping out the hot and adding cold water frequently. Place about 250 centimeters of water (the capacity of an ordinary drinking glass) in the bottom of the can, and fill the bag with the material to be extracted. There is a plentiful choice among the common materials of everyday use. You might take powdered oak bark from which hot water will extract the tannin used for making leather. Tannin is also present in tea leaves and gives the very bitter taste which is always identified with exceptionally strong tea.



Type of simple extraction apparatus in which the material to be extracted is suspended below a condenser formed of an ordinary funnel that sits in the mouth of a tall metal can.

A good subject for this experiment would be the extraction of sugar from raisins. Crush a small quantity of them so that the water will have ready access to their pulp, and place the macerated fruit in the bag. Put the can on the stove, heating it with a low flame so that the action will not be too rapid. Fill the funnel with cold water, and if you have arranged to let it circulate, the apparatus will require no further attention. The steam generated by the boiling water in the can will strike against the cold undersurface of the funnel and condense to water, which will flow down the stem of the funnel and drip into the bag. After an hour or so you will have a noticeably sweet solution in the bottom of the can, the sugar having been extracted from the raisins. The same apparatus may be employed with alcohol as the solvent in case you want to experiment with the extraction of oils from waste products, such as orange and lemon peels. In this case, however, great caution should be used to guard against the alcohol vapor catching fire.

Striking Experiments in Diffusion

By EARLE R. CALEY, B.Sc.

When liquids, gases or solids of different character are brought into contact with one another, they tend to pass into each other due to the motion of the molecules. This action is known as diffusion and the following simple experiments show this action in an unusual and easily observable manner.

Ex. I.—Illustrating Diffusion Between Solids

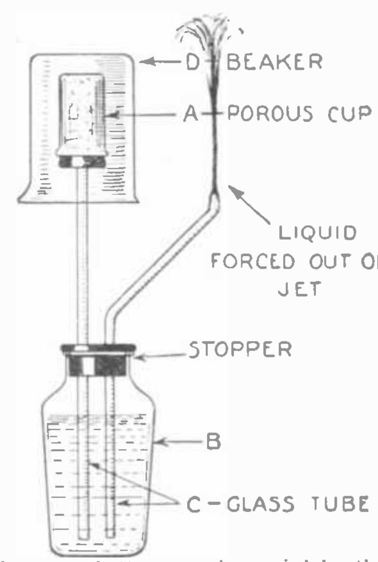
It is a well-known fact that solids as well as liquids and gases diffuse into one another. But diffusion between solids is a very slow process compared to that between gases and liquids and is, moreover, rather difficult to demonstrate experimentally. Plates of lead and gold in contact have been found to have diffused into each other after a lapse of some years.

The following experiment shows plainly the diffusion of solids into each other in a few weeks' time. A solution of gelatine in water is prepared by dissolving 4-5 grams of pure gelatine in 100 c.c. of water by boiling. This solution is then poured into a mould to harden. A convenient mould is an old beaker or petri dish. Another similar gelatine plate is also prepared and colored by placing a small amount of any soluble dye such as methylene blue in the boiling solution. The two gelatine disks thus obtained are placed in contact with each other and set under a bell jar in a quiet place where the process of diffusion can be watched. After the lapse of two or three weeks' time the colored dish will have diffused noticeably into the colorless one.

Ex. II.—A Patriotic Test Tube

A rather striking experiment on diffusion in which a test tube of subtances develops alternate bands of red, white and blue is due to Alexander, and is an excellent illustration of the different speed of ions in diffusion. A solution of agar-agar is prepared by boiling 1 gram of the dried material with 100 c.c. of distilled water until solution is complete. A very small amount of phenolpthalein indicator is added to the solution and then a very little dilute sodium hydroxide solution until the reaction is barely alkaline as shown by the pink color of the phenolpthalein. A very small amount of a solution of potassium ferrocyanide is also added. The agar-agar solution is then poured into a test tube and kept standing until it has become cold and jelly like. A few c.c.s. of a dilute solution of ferric chloride is then poured on top of the jelly.

The diffusing ferric ion soon forms an ever-widening band on top of the jelly due to the precipitation of ferric ferrocyanide, known in commerce as Prussian Blue. Below this blue band there is formed a colorless band due to the effect upon the indicator of the hydrochloric acid from the ferric chloride which has a higher rate of diffusion than the ferric ion. The tube, if properly made, exhibits equal bands of red, white and blue upon standing a short time.



A porous battery cup is carried by the end of a glass tube; it is tightly corked and the tube passes through a hole in the cork. The lower end of the tube passes through a hole in another tightly fitting cork in the neck of a bottle containing water. A second tube passes through the cork down into the water and has a jet at its outer end. On placing an inverted jar full of hydrogen or even of coal gas or water gas over the porous cup, a jet of water is expelled through the tube.

Ex. III.—The Diffusion of Liquids

Liquids diffuse much more rapidly than do solids and yet the process of diffusion is considerably slower than in the case of gases. The following simple experiment serves to illustrate the process of diffusion between liquids. A concentrated solution of copper sulphate is first prepared by dissolving 30 grams of blue vitriol crystals in 100 c.c. of hot water and allowing the solution to cool. A tall, narrow jar, such as a hydrometer jar or a 500 c.c. chemical graduate is then filled about three-fourths full of distilled water. The concentrated solution of copper sulphate is then introduced at the bottom of the jar in the following manner.

A piece of glass tubing of small bore is attached by means of a rubber connection to an ordinary glass funnel. By pouring the copper sulphate solution slowly into the funnel the concentrated solution can be placed at the bottom of the jar without mixing with the distilled water. By setting the prepared jar in a quiet place, the process of diffusion extending over several days can be observed easily.

Ex. IV.—Illustrating Diffusion of Gases

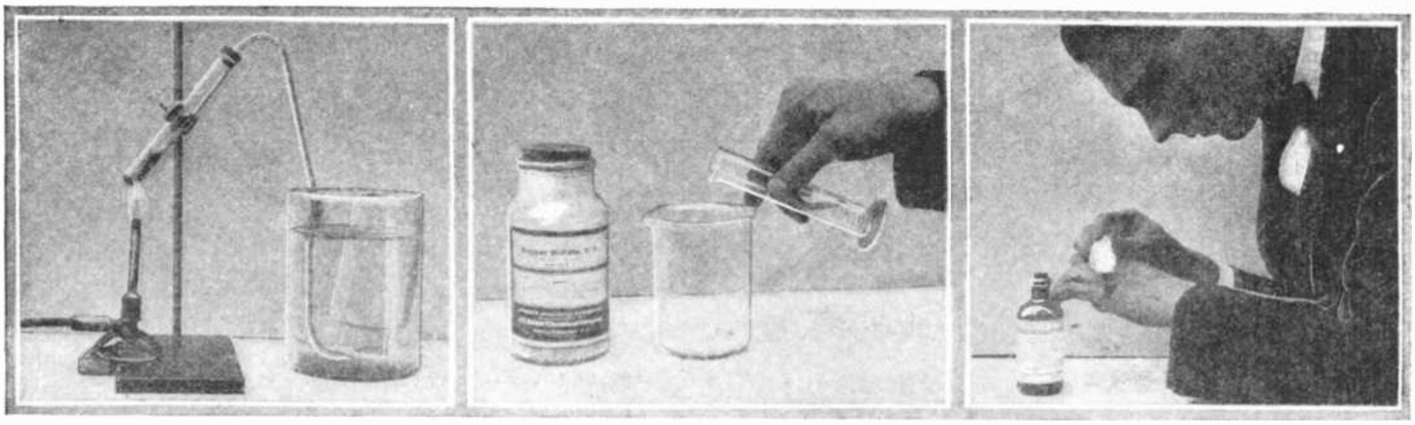
The pressure exerted by the diffusion of one gas into another can be illustrated by the apparatus shown in the illustration. This consists of a porous cup (A) such as used in battery jars, of the Bunsen type, closed tightly with a rubber stopper and supported upon the end of a piece of glass tubing about thirty inches in length. The end of this tube passes through a two-hole stopper closing the bottle (B) and extends nearly to the bottom of the same bottle. The other hole of the stopper receives a short glass tube (C) which is provided with a narrow jet upon its upper end. The bottle is nearly filled with water colored purple with a crystal or two of potassium permanganate.

When a beaker (D) filled with hydrogen gas is placed over the porous vessel in the position shown the hydrogen diffuses into the vessel at a greater rate than the air within diffuses out into the hydrogen. The resulting pressure is shown by the liquid in the bottle being forced out of the jet in the form of a miniature fountain. The hydrogen gas for this experiment may be mace in the usual manner by the action of dilute sulfuric acid upon zinc.

By diffusing gases through porous diaphragms or membranes a partial separation can be effected.

Experiments with Catalysts—Good Samaritans

By Raymond B. Wailes



Figures 1, 2 and 3 respectively, starting at the left, illustrate the manipulation in producing oxygen gas with manganese dioxide as a catalyst; the use of copper sulphate to promote the evolution of hydrogen gas; and the action of hydrogen binoxide on the red corpuscles of the blood.

IT is the little things in life which count. There are many little things in chemistry which count also, and count big, too. Iron will not rust in absolutely dry air. A small amount of water needs to be present to cause the oxidation of the iron to form the brown crumbly rust. Leaves would probably not be green and plants would probably die if it were not for a kind element, magnesium, wearing the costume of catalyst.

Catalysts are really helping hands. They promote a chemical reaction without entering into any combination. This enables them to keep the good deed going, almost forever. They assist, without the attention of a watchman or guardian.

Most of us have made oxygen gas by heating a mixture of potassium chlorate and manganese dioxide as shown in Fig. 1. The manganese dioxide here causes a more efficient production of oxygen gas by lowering the decomposition temperature of the chlorate of potash.

The production of hydrogen gas by allowing an acid such as sulphuric or hydrochloric acid to act upon metals such as zinc, often proceeds very slowly at first, scarcely any bubbles being seen, but if now several drops of copper sulphate solution or a piece of platinum foil are dropped into the metal and the acid, the evolution of hydrogen gas will be immediately quickened. The copper sulphate solution here precipitates out upon the zinc and this forms a miniature battery, with copper and zinc electrodes. The platinum plays the same role. Thus the production of hydrogen is speeded up.

We have all seen the bubbles of oxygen gas which are produced when hydrogen dioxide or "peroxide" as it is sometimes called, is allowed to drop into an open cut or wound. The red blood corpuscles cause a catalytic decomposition of the peroxide, which forms water and oxygen gas, the oxygen gas killing all disease-germs.

Another experiment which can be performed quite easily is the production of zinc iodide. At room temperature, zinc dust (powdered zinc) will not react with iodine crystals (not tincture of iodine), but a vivid chemical reaction which is entirely harmless ensues if but a drop of water is allowed to fall upon the mixture of iodine crystals and zinc dust. The water is best dropped on by means of a wash bottle (photo 4).

Starch can be turned into sugar by treating it with dilute acids. If ordinary corn starch is boiled with some dilute hydrochloric acid (use chemically pure acid, not commercial muriatic acid), glucose, which is one of the many sugars, will be formed. The acid here simply catalyzes the conversion of starch into sugar. If a bit of powdered marble or chalk is now added, the excess of acid is neutralized, and the resulting solution will be found to have a sweet taste, and glucose can be recovered from it.

But you do not have to use starch to make sugar. You can commence with wood, or cellulose as wood is termed, and treat this with an acid. Fig. 6 shows a method of doing this. A circle of filter paper, which is cellulose, is immersed in strong sulphuric acid for a short while, removed and then thoroughly washed in running water. If a drop of a weak solution of iodine (tincture of iodine can be used) is now touched to the paper, a blue color will be percieved. This coloration proves the presence of starch. This starch has been made from the cellulose filter paper by the aid of the acid, which acts as a catalyst. Sugar can be derived from this starch, if desired, but this step is rather difficult to carry out on the catalyzed filter paper.

A very pretty experiment is the preparation of oxalic acid from acetylene gas, using mercuric nitrate as a catalyst. This can be conveniently carried out in three Erlenmeyer flasks connected in series, the first serving as a gas generating vessel as shown in Fig. 7.

The first flask at the left end contains lumps of calcium carbide which is used in some types of bicycle and farmyard lamps. The separatory funnel inserted into this flask contains water. By opening the glass stopcock here, water may be gradually admitted to the carbide, which in turn generates acetylene gas. This acetylene gas now passes into the second flask which contains 3 parts of concentrated nitric acid and one part of water by volume.

About 5 or 10 grams of mercuric nitrate

Figues 4, 5, 6 and 7 illustrate the reaction between zinc and iodine upon the addition of water; the production of sugar from starch; then the production of starch from cellulose using a filter paper; and finally the manufacture of oxalic acid from acetylene. All of these seven experiments are very simple and interesting laboratory experiments.

are also placed in this 3:1 nitric acid mixture and the whole is shaken to dissolve the crystals. This mercuric nitrate acts as the catalyst.

The acetylene gas coming from the first flask should bubble through the mixture in the second flask. In doing so, dense red fumes of nitric oxides are formed which pass, together with unacted-upon acetylene, into the third flask, which also contains nitric acid and mercuric nitrate. Soon both flasks will be filled with the red fumes and the reaction will have slackened in the second flask. At this time, change the positions of the second and third flask, making the third the second and the second the third. The water must be kept dropping slowly upon the carbide to keep up the flow of acetylene gas.

When the reactions have quieted in both flasks, the whole apparatus should be disconnected. Crystals of oxalic acid will now be seen in the bottom of the second and third flasks. They can be filtered off, using as little water as possible, and washed with cold water, and used as such. The crystals are very poisonous.

Producing Ammonia from Air

By Earle R. Caley, B.Sc.

I. Introduction

IN recent years the question of the so-called fixation of nitrogen is one that has been attacked by chemists and successfully solved. Nitrogen is an element that is extremely essential to modern civilization. In countries where the population is dense and the soil intensively cultivated, as in modern Europe, nitrogen in a soluble form must be constantly supplied to the soil to replace that removed by plant life.

Many compounds of nitrogen, particularly nitric acid, are absolutely essential to modern existence. Without nitric acid the manufacture of high explosives could not be accomplished. Celluloid and many valuable drugs and dyes cannot be made without this valuable acid. In the past, nearly all nitrogen compounds have been obtained from Chili saltpetre, a crude form of sodium nitrate. The only known natural deposits of this substance are on certain desert regions on the west coast of South America. These deposits are being gradually but surely exhausted, a process that was greatly accelerated by the World War.

The problem of finding some other source of soluble nitrogen compounds had to be solved. The only other known large source of nitrogen is the air we breathe. We are submerged in an ocean of air consisting of four-fifths of that important element nitrogen. Yet this vast amount of nitrogen has never been used before by man for the reason that nitrogen in the form of a gas is comparatively useless. It must be combined or fixed with other elements and obtained in a combination to serve man properly. This problem of the "fixation of nitrogen" has been attacked by chemists the world over and there are many methods now known by which nitrogen may be taken from the air and converted into a soluble and useful form.

In the Birkeland-Emde process air is passed between flaming electric arcs and under the conditions that exist in the arc the two principal gases of the atmosphere, oxygen and nitrogen combine and form oxides of nitrogen which may be absorbed in water to ultimately form nitric acid.

In the famous Haber process, perfected in Germany during the war when the Germans were running short on nitrogen for explosives, hydrogen gas is made to combine with nitrogen gas from the air to form ammonia by passing the gases over metallic uranium under high pressure. The ammonia thus formed may be readily converted into other useful nitrogen compounds. Another process passes nitrogen over heated calcium carbide. None of these industrial processes can be successfully carried out, however, in the laboratory.

An interesting experimental method is described below by which the experimenter wishing to extract nitrogen from air and form nitrogen compounds, either as a demonstration or for his own satisfaction, may do so by a simple process requiring only a few pieces of ordinary chemical apparatus and several easily obtained substances.

II. A Simple Fixation Process

While nitrogen in the form of a gas is a very inert substance, at ordinary temperatures, at higher temperatures it possesses the property of directly uniting with a certain few metals forming compounds known as nitrides. If these latter compounds are then treated with water, ammonia in the form of a gas is given off and the hydroxide of the metal is formed. The ammonia gas thus formed may be then absorbed in water to form ammonium hydroxide, familiar to every household as a cleaning agent, or may be led into acid solutions to form other useful soluble nitrogen compounds such as ammonium chloride.

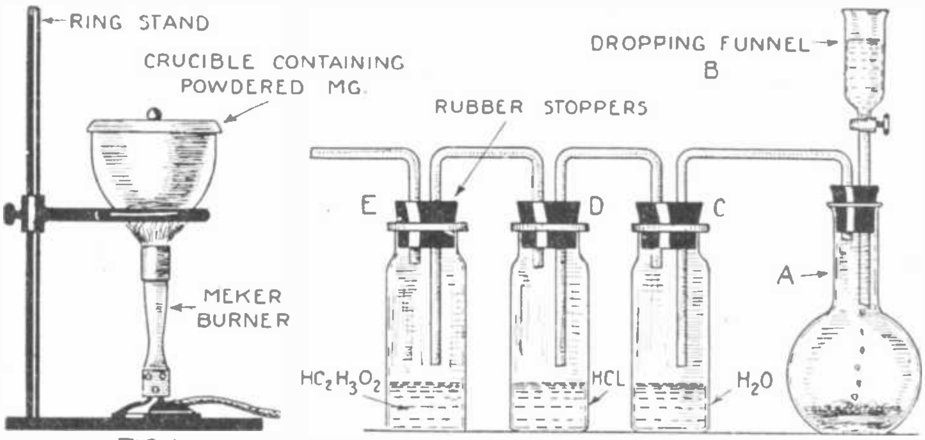


FIG. I FIG. 2

The Solvay process here illustrated by a very simple experiment, is one of the revolutionary chemical processes of the world, and has replaced in many places the Le Blanc process. Both manufacture carbonate of soda, so-called.

The most suitable metal to employ for extracting the nitrogen from the air is powdered magnesium, familiar enough as the essential constituent of flashlight powders. This metal in a powdered or granulated form may be readily obtained from any dealer in chemicals. Only a small quantity is required for the laboratory experiment. In chemical symbols the reaction between the magnesium, which is a white metal resembling zinc, and the nitrogen of the air is written thus:

$$3\ Mg + N_2 = Mg_3\ N_2$$

Magnesium + Nitrogen = Magnesium Nitride

When the nitride is treated with water the following reaction then occurs:

$$Mg_3\ N_2 + 6\ H_2O = 3\ Mg(OH)_2 + 2NH_3$$

Magnesium Nitride + Water = Magnesium Hydroxide + Ammonia

If the ammonia is absorbed in a hydrochloric acid solution the white solid salt ammonium chloride forms:

$$NH_3 + HCl = NH_4\ Cl$$

Ammonia + Hydrochloric Acid = Ammonium Chloride

If magnesium metal cannot be readily secured, powdered aluminum such as used for bronzing powder may be substituted. In this case some powdered carbon in the form of charcoal or lamp black must be mixed with the metal and ammonia freed from the metal by means of a caustic soda solution instead of water. The details of this instructive experiment are given below.

III. Experimental Part

The experiment as carried out with powdered magnesium will first be described and then the modifications necessary when employing aluminum will be given. The powdered metal is heated in a covered crucible by means of a strong gas burner for an hour to effect the combination between the nitrogen of the air and the metal. This operation is shown in Fig. I. Good-sized iron or porcelain crucibles with tightly fitting lids should be used. The powdered metal is packed to the top of the crucible and the cover firmly fitted on. A good plan, if an iron crucible is used, is to drill a small hole in the lid and seal the lid on with wet clay. The crucible and its contents must now be heated strongly. A Meker burner or a gas range fire will supply the needed amount of heat. After heating for an hour the crucible is cooled and the lid removed. The metallic powder will be seen to have completely changed in appearance. On the top there is a white powder, which is magnesium oxide, a compound of oxygen from the air and magnesium. Underneath will be found a yellow substance. This is magnesium nitride, the desired product.

The entire contents of the crucible are now emptied out and pulverized, preferably in a porcelain mortar. An equal quantity of dry sand is then mixed with the powder before it is transferred to the apparatus shown in Fig. II.

This apparatus is designed to allow water to act slowly on the mixture and for the collecting and absorbing of the ammonia gas evolved. (A) is an ordinary chemical flask having a capacity of around 500 c.c. A two-holed cork or rubber stopper is fitted in the neck of this and through one hole is passed the steam of an ordinary dropping funnel (B) while in the other is fitted a piece of bent glass tubing leading to the absorption bottles (C), (D), (E). In these bottles may be placed various substances to fix or absorb the ammonia gas. In the first may be placed water, in the second dilute hydrochloric acid in which will be formed a solution of ammonium chloride and in the third dilute acetic acid which will react to give a solution of ammonium acetate.

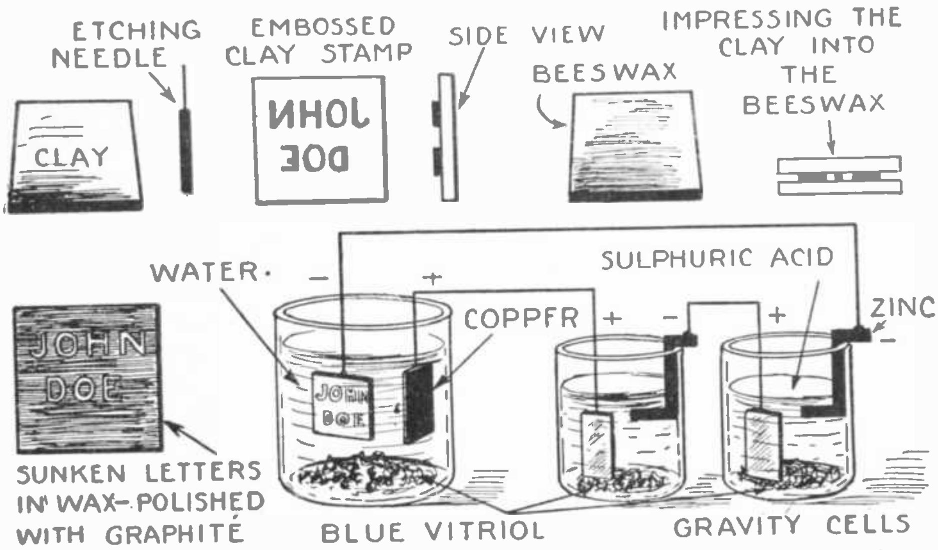
The tubes leading into the absorption bottles must in no case touch the surface of the liquids and are best placed a quarter of an inch above them. If the tubes were allowed to touch the surfaces of the liquids, these latter would be drawn back into the generating flask due to the solubility of the ammonia gas and thus spoil the experiment. The mixture of sand and metallic nitride is now placed in the generating flask with a small quantity of water in the dropping funnel. As soon as the water is allowed to drop on the mixture (this should be done slowly at first) a sudden reaction takes place and gaseous ammonia is evolved.

The water is allowed to drop on the solid until no further action is noticed. Toward the last a gentle heat applied to the flask serves to drive over the last portion of the gas. The absorption bottles may now be disconnected and the contents examined. In the bottle that contained water, the ammonia may at once be detected by its characteristic odor. The contents of the bottles that contained the acids should be evaporated in an evaporating dish until the white ammonia salts of the acids

(Continued on page 272)

How to Make an Electrotype Plate

By Clyde E. Volkers



The successive steps of an electrotyping process are illustrated above. An impression made in beeswax is electrotyped in a copper sulphate bath.

YOUR name and address or other desirable stamps for your own use may be made in the manner discribed here.

Electrotype plates made by electrolysis of copper salt are used in enormous quantity in book and general printing. Phonograph records can also be made from electrotypes.

Let us make a piece of type that we will find very practical. You have always wanted a stamp with which you could print your name and address in a few sceonds' time. Perhaps you have a phrase or sentence which you would like to be able to print by the hundred with a minimum of effort.

Making the First Mould of the Electrotype

First, secure some good clean clay. Mix it with water until it becomes a firm, yet plastic mass. Mould it into a block about five inches square and an inch in thickness. Make the surface perfectly smooth and level by rubbing and patting with a smooth board.

While the clay is plastic, carefully sketch on its surface the letters which you wish to print. Do this with the tip of a needle, the head of which has been pushed into the end of a pencil or round piece of wood of about the same size. Take great care in this work to obtain neat and reqular letters, equally spaced.

After your outline has been completed, cut the clay from around the letters, so that they will stand out in relief or raised above the rest of the clay about ⅛ inch. Smooth the letters carefully and fill any rough places or holes with more clay. Place in an oven and bake until hard.

Making the Second Mould

Melt some beeswax over a flame in a small pan so that it will form a layer on the bottom, about 3/10 of an inch thick; cool, and after it has hardened remove it carefully. Smooth its upper surface, and rub graphite (finely powdered) over the piece of wax.

Impressing the Clay Upon the Beeswax

Press tne raised letters of the clay into the beeswax to secure a good clean-cut impression of the letters. Remove the clay and dust more of the powdered graphite over the beeswax impression and around the lines and grooves of the letters. The copper deposit, later, depends on the care exercised here. Now polish the surface of the wax with a soft brush until the graphite appears black and shiny over all of the block of beeswax, and in the grooves of the letters. Attach a copper wire to the beeswax from the back and suspend the mould from the cathode or negative pole of a copper plating bath prepared as below.

Electroplating

Place some blue vitriol (copper sulphate) in a glass jar. Fill the jar half full of water and allow it to stand over night. Suspend in this solution a strip of copper having a surface equal to that of the beeswax form. Connect some dry cells, bichromate cells, or preferably, two gravity cells. Connect the positive pole of the batteries to the strip of copper in the electroplating solution; the negative pole to the beeswax form which is suspended in the jar of blue vitriol solution. The current from the battery causes copper to deposit on the graphite which is on the beeswax form. Allow a good deposit of copper to form. You may have to suspend more copper in the bath from the anode side. The solution does not lose its strength.

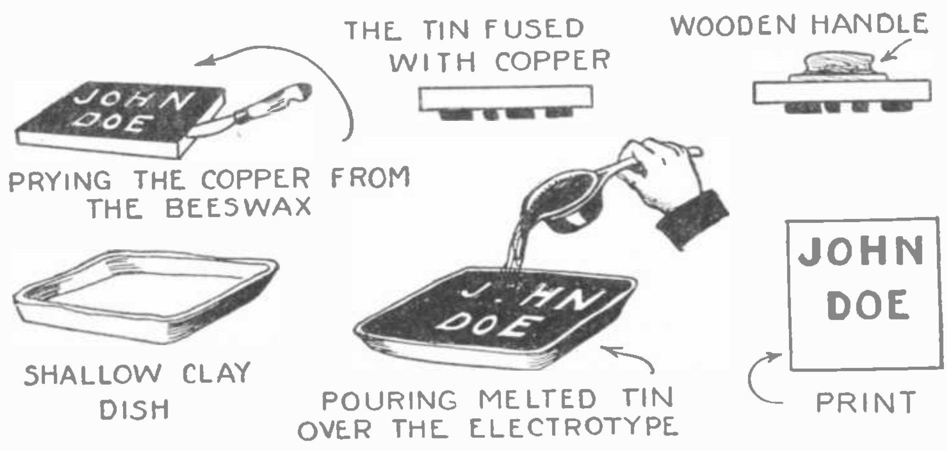
Making a Permanent Plate from the Copper Deposit

When a good layer of copper has collected upon the beeswax, remove and wash it carefully. Pry the copper layer from the beeswax and place it face up into a form of clay whose edges fit closely around the copper, and ¼ inch above it. The clay and copper are placed in a very hot oven until the clay has hardened. Melted tin is poured over the back of the copper in the form, until a layer of about ⅛ or ¼ of an inch in thickness is produced. After this has cooled, remove the electrotype. It is now ready to be inked and used as a stamp. Simply press the copper surface upon an inking pad and then make a copy on a piece of paper.

For convenience you may fasten a wooden handle into the back of the tin by drilling a small hole in wood and tin and inserting a small peg.

Other stamps may be made from any other embossed objects which will make an imprint in the beeswax.

Sometimes the beeswax is dusted over with finely powdered iron. The iron replaces the copper in the solution and a "strike" or thin deposit of copper is produced, which accelerates the subsequent deposition.

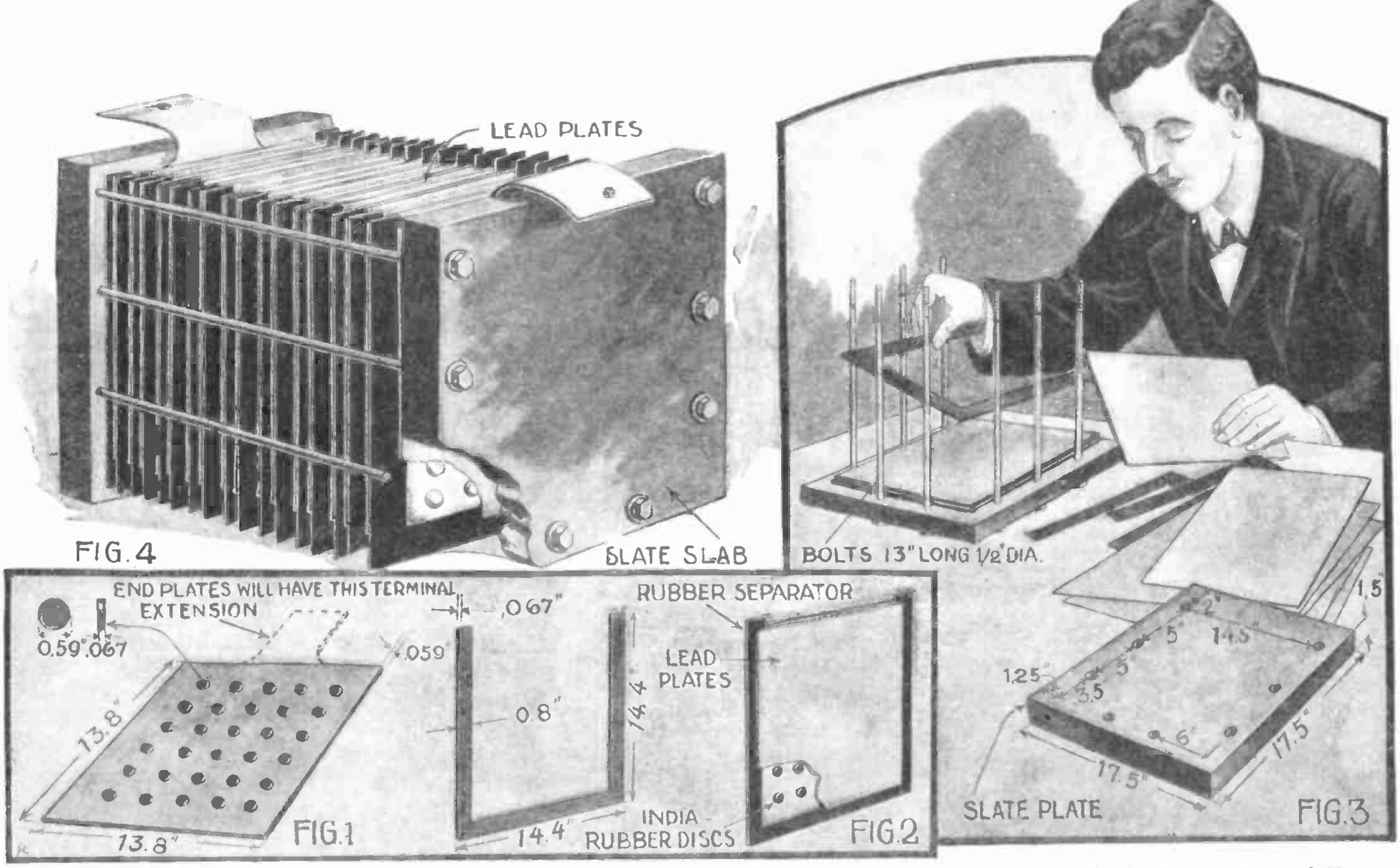


The sheet of electrotyping is separated from the beeswax and "backed" with melted tin to give the plate the necessary rigidity. A wooden handle mounted on the back completes this convenient stamp.

EXPERIMENTAL ELECTRICS

How To Make a 13,000 Ampere Storage Battery

By William Grunstein, E. E.



Despite its small size, the storage battery illustrated above can supply a current of 13,000 amperes. The battery consists of 70 cells using pure lead plates as electrodes. It is a storage battery of the Planté type. Its unusual feature is the extreme thinness of each cell. The effect of this is that the plates are very close together, giving very slight resistance. The distance between the electrodes is less than two millimeters (0.8 inch). The amateur experimenter will experience no difficulty in constructing the battery.

TWO coils, one on top of the other, are placed before you. The coils measure about 1 inch in diameter, and between them a piece of lead plate and a coin are placed. A switch is closed. One hundredth of a second later an automatic switch short-circuits the coils. They are separated, and to your surprise you find the coin impressed in intaglio in the cold lead plate!

You wonder how these small coils could exert such a terrific attractive force, a force of almost 3 tons, you are told. You trace the circuit and are disappointed to find not huge generators, but four storage batteries, each only 14 inches high, supplying current to the coils. You are bewildered and humbly turn to the demonstrator for explanation.

The latter with a smile of supreme satisfaction will tell you that these storage batteries were designed by R. L. Kapitza of the Royal Society, that they consist of plates of pure lead 13.8 inches square, and .059 inches thick separated by small hard rubber disks, and near the edges, by large U-shaped hard rubber separators, so that between each pair of plates a small cell .067 inches thick, is formed; the cells being filled with 30% sulphuric acid. (See Fig. 4.)

The demonstrator will oblige you with another spectacular experiment for which the batteries must be recharged. The four are connected in parallel and charged from a 110 volt source at 3 amperes. In less than four minutes they are disconnected, completely charged!

They are reconnected, two in parallel and the two groups in series. A piece of copper wire, No. 9 B & S gauge, is connected in place of coils. The switch is closed. A loud report and an intense flash like an explosion! When you recover your composure you find the copper wire has completely vanished. To your questioning and wondering glance the demonstrator nonchalantly replies that the copper wire drew 13,000 amperes from the battery. Amused by the baffled expression on your face, he explains that the battery has an extremely low resistance of .02 ohms, on account of the thinness of the layers of electrólyte, and can therefore supply energy at the rate of 1,000 kw. for a small fraction of a second.

If you are the dogged, intrepid experimenter we think you are, you will want to build one of these 13,000 ampere storage batteries despite the fact that its construction involves much labor and patience.

The battery used in the preceding experiments consists of four units. For each unit you will need 71 plates of chemically pure lead. Two of these plates are 17 x 13.8 x 0.5 inch. These are to be used as the end or terminal plates. The other plates are square 13.8 x 13.8 inches and .059 inch thick. To one side of each of these square plates and one of the terminal plates, 30 small India rubber disks are attached by means of India rubber solution. These disks are 0.59 inch in diameter and 0.67 inch thick. Dispose them regularly on the lead plates in a manner suggested in Fig. 1. These disks serve as separators between successive plates.

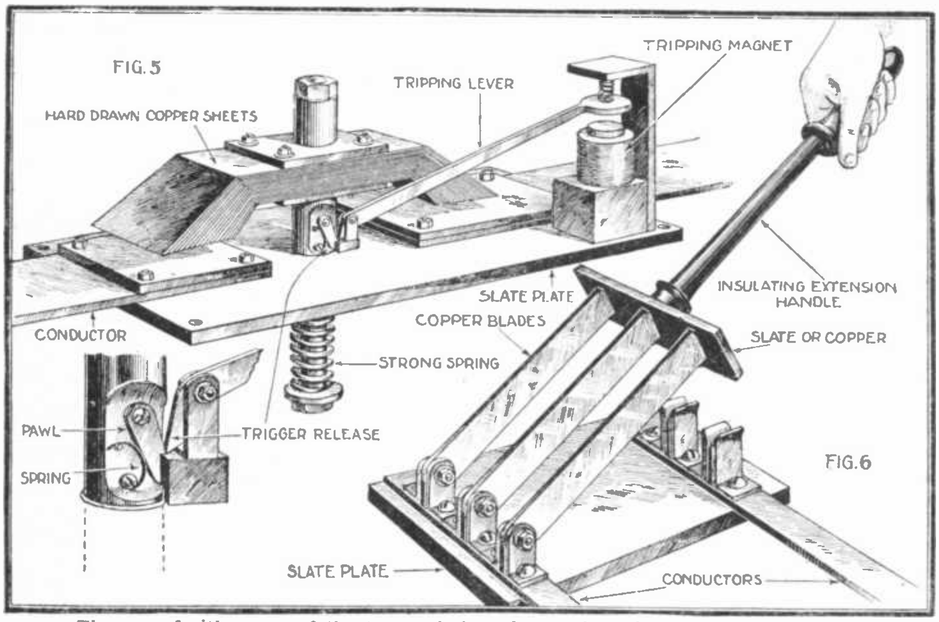
The plates are assembled to form a pile, with a set of rubber disks between each pair of plates. Besides these disks a U-shaped rubber separator, .067 inch thick, and somewhat larger than the plates, is placed between each pair. One of these separators is illustrated in Fig. 2, where the separator is also shown mounted between two plates. The arrangement there illustrated forms one cell of the battery, the walls of the cell being the two lead plates and the rubber separator.

The pile is clamped between two heavy pieces of slate 17.5 x 17.5 x 1.5 inches. Through these plates, eight ½" holes are drilled as indicated in Fig. 3. These holes drilled, the U-shaped separators cut, (70 of these will be needed for each unit) and the rubber disks mounted on the plates, you are now ready to assemble the battery unit. Place one of the slate plates with bolts passed through it upon a table. (Fig. 3.) On top of the slate, between the bolts, place one of the end plates with the rubber disk on top. Care must be taken that the lead plate does not touch the bolts. On top of this place the U-shaped separator and then another lead plate placed with the disks on top. Mount these alternate layers until all the 70 separators have been used. Then complete the pile with the other end plate, to which no rubber disks were attached. Pass the other slate end-plate over the bolts, and making certain that no lead plate touches the bolts, clamp the pile tight with nuts.

If the plates and washers were properly made the assembled unit (Fig. 4) will form 70 watertight cells. Each plate, except the end plates, serves as the negative electrode of one cell and the positive electrode of the adjacent cell, and at the same time is of course an extremely low resistance connector between successive cells. The battery unit consists therefore of 70 storage cells in series, which when filled to .9 of their depth with 30% sulphuric acid, will have a joint resistance of only 0.02 ohms.

To protect the slate and the bolts from the acid, they should be covered with a coat of tar varnish. The action of the acid on the rubber is considerable, necessitating a complete overhauling and cleaning at the end of a year. The India rubber in that time will have become badly deteriorated.

In the experiments described above four such units were used. The four units in parallel are charged at the rate of about 3 amperes. That is, on a 110 volt system a resistance of 37 ohms should be placed in series with the group of batteries. In charging, a very thin active layer is formed on the positive plate. With use this layer increases, causing a marked increase in the internal resistance of the battery. As a result, the rate of power output is decreased; the power obtained from the batteries might decrease in one year, by as much as 50%. When the battery is new, it will charge very rapidly, in 2 or 3 minutes, but in a year's time, the charging period will increase to 15 or 20 minutes.



The use of either one of the two switches shown above is recommended in connection with the Kapitza, 13,000-ampere storage battery. That shown in Fig. 5 is a remote control, spring actuated, magnetic-trigger release switch and has the advantage that the circuit can be closed by an operator located at a safe distance from the battery and the switch.

It is important that the battery should not be left discharged for long periods. If left in this condition for three days its resistance will be increased so much that only one-fourth of its initial power is obtained.

Caution! It is best to keep at a safe distance from the batteries. Some cells of the battery might be suddenly punctured and acid might splash out of them. This action is probably due to inordinate increase in the active layer on the plate. The layer breaking off, "shorts" the cell which in this condition is continuously discharging, resulting in the sulfating of the plates. The resistance will increase rapidly at most points of the cell and as a result the current will concentrate at points of low resistance. The designer of these batteries, Mr. R. L. Kapitza, has noted some cases, where holes of 1/8 to 3/4 inch, were burnt in some plates of a battery.

For discharge, the batteries are connected in series parallel, *i. e.*, to units in parallel and the two groups in series. All connections between battery units and other apparatus must be made with copper strips having a cross-section area equal at least to that of No. 0000 B & S wire (.1662 sq. in.). It is imperative to have broad and tight contacts, either bolted or soldered. All contact surfaces should have an area of at least 1 square inch. A very convenient conductor is a copper strip 1/16" by 1" in cross-section. Conductors so shaped are bent without great difficulty and form broad contacts when bolted or soldered in lap joint.

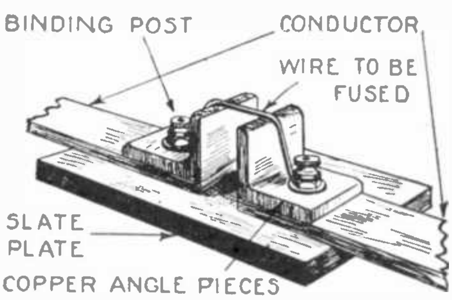


FIG. 7

The Kapitza battery will fuse a No. 9 copper wire with a violent explosion, completely vaporizing and perhaps disintegrating the copper. For these fusing experiments a fuse apparatus such as that shown above can be used.

The switch is the most vital part of the circuit and special care must be exercised in its construction. It is preferable to use a spring-actuated, magnetic-trigger-release switch such as that shown in Fig. 5. This switch was designed for the special needs of the Kapitza battery by Mr. E. I. Laurmann. As shown in the illustration, contact between the two large copper blocks is made by a set of hard-drawn copper sheets mounted on a rod, the lower end of which carries a stiff spring which draws the rod downward. To open the switch the rod is drawn up until the small pawl engages the edge of the metal block and retains the switch in the open position. Adjacent to this pawl is a long tripping lever whose further end is suspended over a strong electromagnet. The latter is connected to a battery of dry cells through a push button. The pressure of this button energizes the coil which attracts the tripping lever and this trips the pawl. Immediately the rod is drawn down and the luminated copper connectors bear down on the copper terminal blocks. The manifest advantage of this switch is its rapid action and its remote control. The operator with the push button may be located at a distance where he does not run the risk of receiving burns from arcing contacts.

Should the experimenter find the construction of such switch beyond his means, he can, by the exercise of greater care in operation, employ a large single throw switch with several blades in parallel. A switch of this type is illustrated in Fig. 6. A long insulating handle is mounted on the switch to enable the operator to close the switch without bringing his hand dangerously near the contacts which, if the switch is not quickly closed, are apt to arc. The exact dimensions of the switch are not important so long as the experimenter will make certain that at no part of the circuit is the conductor cross-section less than about 0.2 sq. in.

Caution! Great care must be exercised when experimenting with the Kapitza batteries. Currents of the order of 10,000 amperes cause dangerous arcing at poor contacts. *Switches must be closed swiftly* and not before the operator has made certain that arcing at the switch or at the fuse block, will not endanger his hands or face.

The fuse block is illustrated in Fig. 7. It is of very simple construction, comprising two copper angle pieces provided with binding posts. Note that, since the thin wire connected between the posts will fuse only between the two blocks, the binding posts are not subject to arcing.

With this last piece constructed, the equipment is complete. The circuit is shown diagramatically in Fig. 8B arranged for the fusing of wire, using the remote control switch. It will be remembered that the Kapitza batteries accumulate very little energy at full charge, and must be recharged after each fusing experiment. In charging connect as shown in Fig. 8A.

The experiments in fusing can be varied by the use of wires of different metals, and different sizes. If properly timed, instantaneous photographs of the arcs produced in fusing would form an interesting study. As to the experiments with the coils, described at the beginning of this article, the amateur experimenter would there encounter great difficulty and we would advise him to limit his study to fusing which in itself offers ample opportunity for striking and instructive experiments.

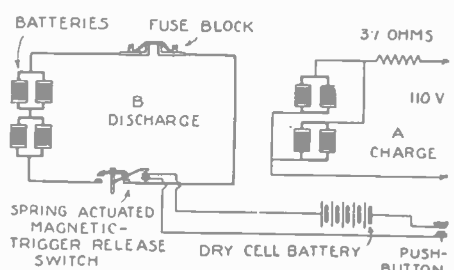
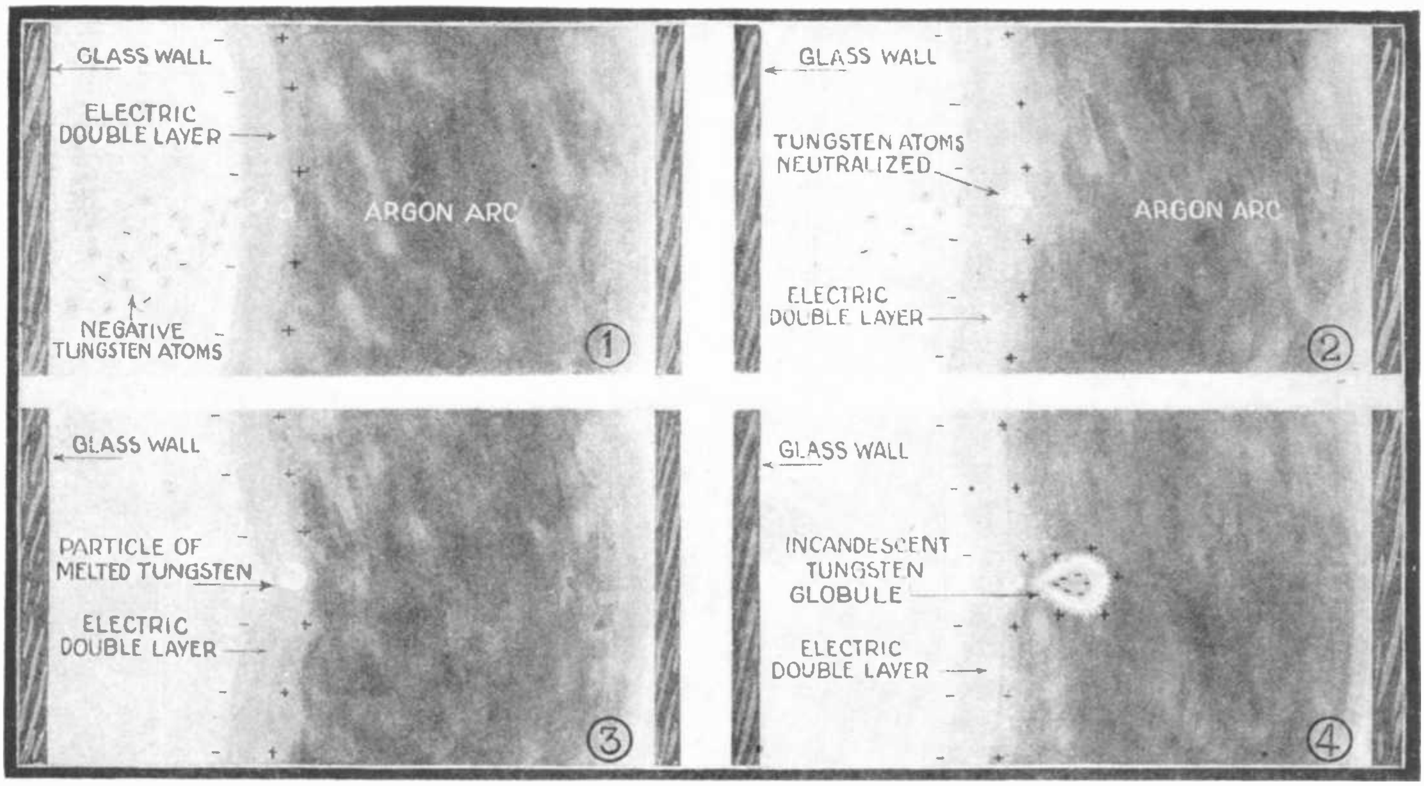


FIG 8

In discharging (B) the Kapitza battery to obtain a 13,000-ampere current four units are connected in series-parallel as shown in (B) above. In charging (A) the batteries are connected in parallel and charged through a resistance of 37 ohms from a 110 volt source.

Ball Lightning Made in the Laboratory

(Continued from page 237)



In a tube filled with argon gas small globules of liquid fire have been formed, which bear a strong resemblance to ball lightning. A magnet draws the argon arc to one side of the tube and negatively charged tungsten atoms emitted by a filament move into the arc (Fig. 1). Near the edge of the arc they cross a region called the electric double layer bearing opposite charges on the two sides. Here the atoms lose their charge and collect in groups (Fig. 2). The neutral tungsten atoms thus form small masses of liquid tungsten on the border of the arc, and the layer of negative charges bends into the arc (Fig. 3). This indentation continues until becoming very sharp the tungsten globule becomes detached and forms a rapidly moving miniature ball lightning (Fig. 4).

bright blue flashes are sent up the vertical stem.

This spectacular and beautiful electrical discharge which gives promise of leading to a greater understanding of vacuum phenomena was produced in the research laboratories of the General Electric Company, by Dr. Irving Langmuir, C. G. Found and A. F. Dittner, prominent American physicists.

And yet at first glance the apparatus in which these curious phenomena take place seems to differ only in shape from the ordinary two electrode vacuum tube, and essentially is similar to the argon-filled tungar rectifying bulb. Fig. 2 shows a sectional view of it. The large glass cylinder is 15 cm. (5.9 inches) long and 10 cm. (3.9 inches) diameter, and contains a single loop tungsten filament at each end. To this cylinder is welded a slender glass tube 50 cm. (20 inches) long and 3 cm. (1.2 inch) in diameter at the upper end of which a disc electrode is mounted.

Now the filament is supplied with current at a low potential and is brought to incandescence at a very high temperature, about 2,500° C. (4,432° F.). Then 250 volts are applied between the plate and the filament, but as yet no glow appears in the tube. The ionization in the tube is insufficient, but can be much increased by approaching a terminal of a high frequency coil to the glass tube. This done, an electric arc of the characteristic argon color appears in the tube. The arc draws one ampere and the potential from plate to filament drops to 25 volts.

Nothing unusual is involved in this action, but let the filament circuit be opened for only one-half second and a sequence of most remarkable electrical phenomena ensues. The momentary decrease in filament temperature causes a rise in the voltage across the arc by reducing for an instant the electronic emission from the filament. The voltage, rising to about 100, causes a sputtering of the filament and small quantities of tungsten are shot into the arc. Though the tungsten so emitted is only about .000,001 grams, its effects are astonishing. The arc which before the "sputtering of tungsten" filled the tube and was insensible to the influence of a magnetic field, now detaches itself from the walls and can be attracted or repelled by a permanent magnet held near the tube.

The arc now has an altered appearance. It has a central reddish core, which bears a positive charge and is about 1 cm. in diameter. In this red column positively charged argon atoms are moving and vibrating under the influence of the electric field between the plate and the filament. Immediately surrounding this region is a thin dark space, and beyond this a bright yellow sheath of glowing gas. This sheath is negatively charged and gradually disappears, the central part of the arc increasing in size until it almost fills the tube. In place of the yellow "skin" a thin layer of negative charges remains. This, together with a positive layer around the reddish arc, forms what is called an "electric double layer"; that is, two invisible sheaths extremely close to each other, the inner one bearing a positive while the outer a negative space charge.

If an ordinary horseshoe magnet is brought near the tube, the arc is deflected, as is any conductor carrying a similar current. At the same time the yellow skin appears on the opposite side of the arc on the side not in contact with the wall.

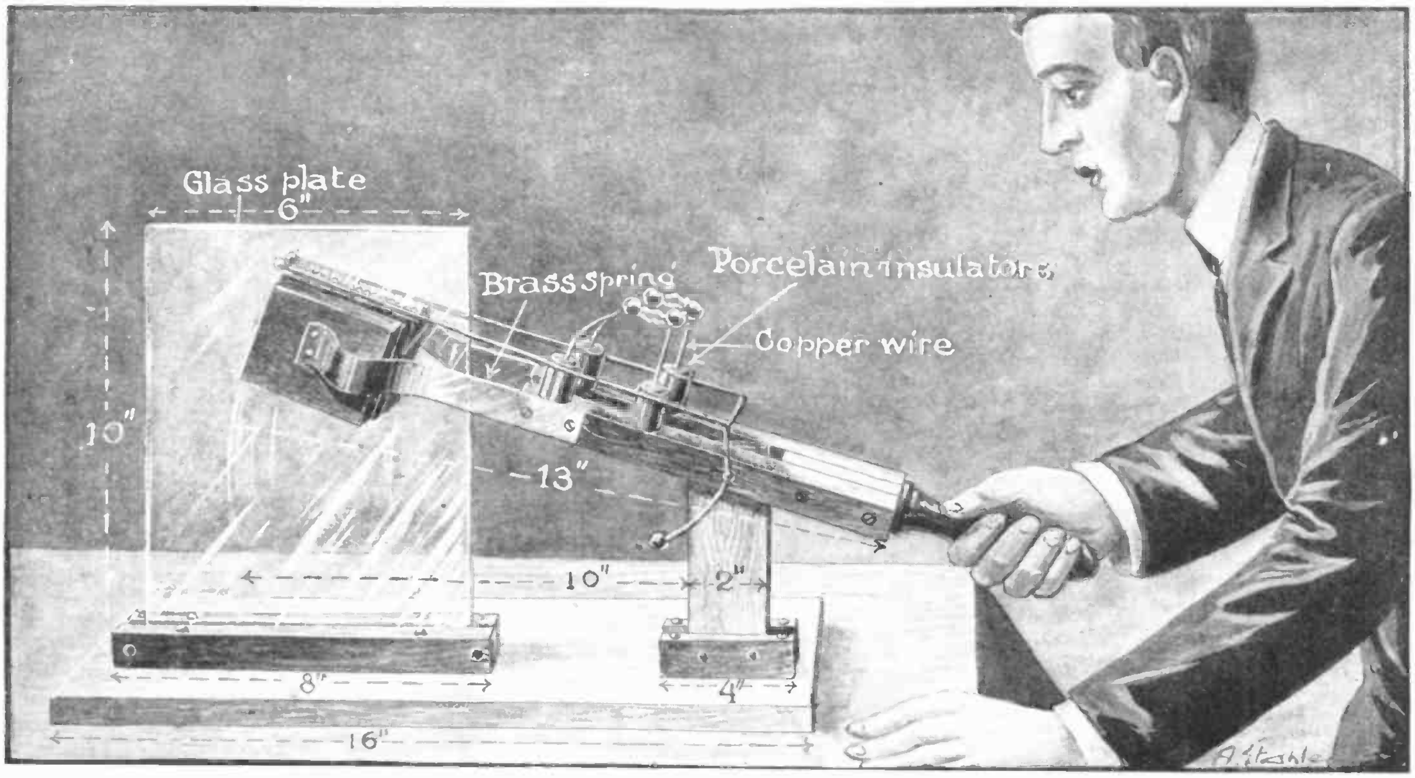
As the magnet is brought nearer, the yellow skin becomes brighter and thinner, and curiously begins to act like a liquid. Slowly, tiny droplets of golden yellow liquid fire are formed. They move along the surface, only to break away and fall, molten spheres of bright white light into the arc. By regulating the intensity of the magnetic field, these droplets or globules ranging from a few tenths mm. up to 5 or 6 mm. in diameter (about the size of a pea) can be made to form slowly and detach themselves singly from the skin of the arc. By proper combination and longitudinal and transverse fields the globules may often be made to move upwards or downwards in the arc parallel to its axis for distances up to 5 or 10 cm., 2 to 4 inches. Under certain conditions the globules have been observed to move very slowly so that their motions through the arc could be easily followed by the unaided eye. But more often they move with the velocity of about a foot per second, and thus appear as brilliant lines or filamentary streamers. See Fig. 3 where several streamers with nearly parallel paths are shown.

These streamers are formed by the influence of the magnetic field, and vary in appearance with the magnitude of the current flowing through the arc. If this current is varied, the motion of the streamers will be correspondingly affected. Thus, by superimposing an alternating current on the direct current fed to the anode, that is, the disc electrode, the streamers or individual globules will move in a sinusoidal path. That is, they will appear as a sine wave, which is characteristic of alternating currents. The streamers will reproduce accurately the wave shape of the current even

(Continued on page 284)

Novel Frictional Electric Machine

By F. E. Andrews

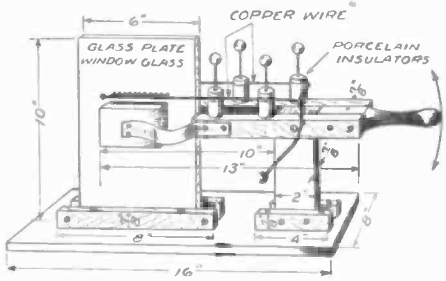


The static generator illustrated above is a variation on the frictional electric machine. In pumping the handle up and down the cushions covered with a coating of amalgam rub against a glass plate. Metallic collectors conduct the charge to the terminals.

THE illustration shows a modification of the old-fashioned frictional electrical machine. This was the predecessor of the Holz machine, as the latter was the predecessor of the Wimshurst machine of today.

There were two ways of constructing the frictional machines. In one a cylinder was rotated against which a cushion rubbed in order to produce excitation. In another a disc of glass rotated, rubbing against cushions as it turned.

The machine we illustrate is simplicity itself and is an interesting version of the old time machines. A piece of plate glass is supported in a vertical position and a pair of leather faced cushions carried by a forked carrier press against its sides. Immediately above the cushions there are a pair of rods with a number of points projecting towards the glass, which is the collector, one rod on each side. These collectors connect with insulated vertical bars of brass with balls on the top, the old fashioned prime conductors. Cushions, collectors and prime conductors move up and down as the handle is raised and lowered pump-fashion. The handle is pumped up and down and the prime conductors are supposed to collect the static electricity excited by the friction and to charge the prime conductors.



The illustration shows the details of the frictional electric machine described above with full dimensions.

The cushion or rubber is to be made of leather and it is well to coat it with an amalgam composed of four parts of mercury, eight of zinc and two of tin. The zinc is first melted. the tin is added and the mixture is stirred. A wooden box lined inside with chalk contains the mercury previously heated, and the tin-zinc alloy is poured into it. A lid is put on the box and it is violently shaken until the amalgam becomes cool. It is pulverized in a mortar. for it is very brittle, and is said to become almost soft. It is then mixed with a little vaseline and spread upon the surface of the leather.

How Our Readers Voted

WE have received many hundred votes expressing our readers' views as to the different departments of THE EXPERIMENTER, in answer to our request embodied in the printed coupon. Incidentally, we were somewhat flattered by the fact that a number of our readers would not use the coupon, because they felt that this would deface their copies, which they wished to preserve. This is peculiarly gratifying, for one of the sad things about an editor's work is that it is apt to be so ephemeral, that he is working only for the day.

It is fair to say that the editors should be impartial and should not indulge in personal preference for one section or the other. But we are only human. and it is pleasant to find our section *Experimental Electrics* with ten per cent. of the votes for, and only one-quarter of one per cent. of the votes against it, heading the list. We have worked hard on this section and feel that it presents an admirable view of what is being done in absolutely experimental work by electricians great and small—for this section is not restricted to the great scientists only, but when good work is done we put it in, irrespective of the personality of the experimenter.

How and Why is a close second. a shade under ten per cent. in its favor, and a small fraction of one per cent. against it. The *Junior Experimenter* and *Chemical Experimenter* begin the descent. although they are each of them close to nine per cent. in favor, and a very few per cent. against.

The Result

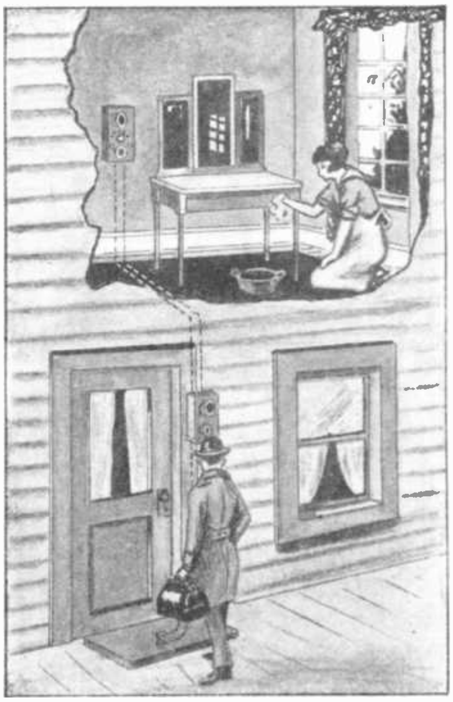
VOTES FOR		VOTES AGAINST	
Experimental Electrics	982	Experimental Electrics	10
How and Why	978	How and Why	34
Junior Experimenter	894	Junior Experimenter	92
Chemical Experimenter	869	Prize Contests	115
General Section	866	New Things Electric	153
Prize Contests	835	Chemical Experimenter	156
Radio Experimenter	793	General Section	171
Elec-tricks	790	Radio Experimenter	187
New Things Electric	751	Elec-tricks	190
Motor Electrics	597	Motor Electrics	344
Fiction Stories	566	Latest Elec. Patents	351
Latest Elec. Patents	561	Short-Circuits	362
Short-Circuits	540	Fiction Stories	371
	10,022		2,536

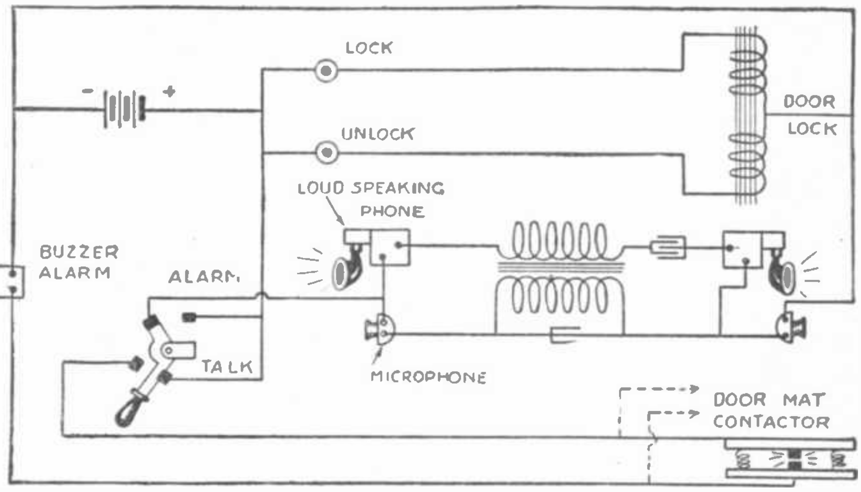
The General Section ranks almost exactly the same as the *Chemical Experimenter*, eight and one-half per cent. for and seven per cent. against. *Prize Contests, Radio Experimenter, Elec-tricks* and *New Things Electric* are all very close; the last named is the lowest, with seven and one-half per cent. approval, and six per cent. against. *Motor Electrics* comes a little low, with six per cent. approval and fourteen per cent. of votes against it. *Fiction, Latest Electrical Patents* and *Short Circuits* are all grouped together, with close on six per cent. approval and fourteen per cent. disapproval.

It must be remembered that the above, like income taxes, can be figured in various ways. Thus, every vote against, to be fairly expressed should be divided by four, as only one-fourth of the votes in favor were cast against the departments; in other words, every vote against is four times too large as calculated here. The basis for this point of view is that for each thousand votes for our different sections there were only 250 votes against.

It is a poor thing for a person to be satisfied with doing their best; they should always aspire to do more than their best. Yet the result of this very interesting contest and the tenor of the vast majority of the numerous letters received are such that we feel that THE EXPERIMENTER has reached a very high standard and we certainly propose to maintain it. We hope that our correspondents will become contributors, so that our readers will know what other experimenters are doing.

Domestic Signal System





This is a very ingenious system of connections and alarm, as well as of local telephone connection for protecting a house. The critical connection is made when the door mat is stepped upon; this gives warning to anybody upstairs or in any room of the house that someone is at the door. Above are shown the connections, all fully designated.

THE old adage that every man's house is his castle has been superseded when the busy housewife spends a portion of her time walking to the front door to answer seekers of alms, itinerant merchants, canvassers, questionable or unwelcome callers, house riflers besides, the possible depredations of burglars and sneak thieves during the night.

This signal system provides a valuable step-saver, as well as a positive protection.

The apparatus is primarily actuated by the closing of contacts located under doormats, steps, in hallways, back porches or elsewhere. Pressure upon the mat causes the closing of an alarm circuit, ringing either bell or buzzer, or illuminating a lamp in bedrooms.

A switch is manipulated, which cuts off the alarm signal and cuts in a telephone circuit employing loud speaking receivers, therefore it is unnecessary to hold a receiver to the ear to listen to speech transmitted from interior to exterior, or vice versa. It is only necessary to stand close to the instrument to render speech transmission and reception possible.

Upon inquiry from within, the caller states the importance of his call, and if acceptable to the household, a button is pressed momentarily and an electric lock unfastens the door bolt. Utilizing the electric lock, there is absolutely no possibility of the same lock being picked by burglars or sneak thieves.

The lock solenoid is wound in two sections, with double circuit, rendering it possible to either lock, or unlock the door by the momentary pressing of the labeled push buttons. The circuit is fool-proof, easy to wire, and will operate on a battery of dry cells.

The telephone circuit is composed of a simple series of two microphones, battery and primary of an induction coil (with shunt condenser if required), and a secondary (receiver) circuit of induction coil secondary, large series condenser and two loud speaking receivers, all connected in shunt to the units, exclusive of the battery in the primary or microphone circuit.

After the caller has either been turned away or has been admitted and already left, the door is locked by the proper push button and the control switch is restored to the alarm position, which then renders the apparatus sensitive to the presence of intruders or following callers.

The applications of this signal system are many. Contactors may be placed at distant points to guard against intrusion at those points. An additional improvement may be added to the alarm signal circuit so as to guard against rain or fire—thus rendering the apparatus, as a whole, sensitive to callers, intruders and the destructive forces of nature.

A rain alarm, constructed by the writer, has shown remarkable efficiency and is illustrated in Fig. 2, wherein replaceable units are made up of the following: A sheet of tar paper two feet square, surmounted by a piece of wire cloth or screen of approximately the same size. A layer of salt is strewn upon the screen, sufficient to prevent metallic contact between it (the lower screen) and another sheet of wire cloth placed upon the dry salt layer.

Falling of rain upon the salt dissolves the latter and forms contact between the two screen sheets, leading to battery and signal unit. When one unit has been "used," another can be inserted at once, thus providing uninterrupted service.

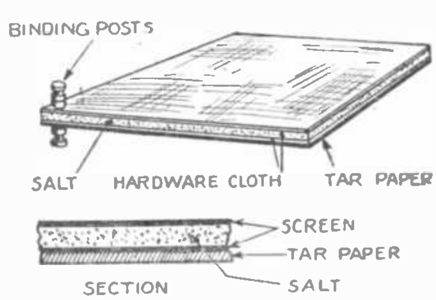
Thermostats have been described heretofore in PRACTICAL ELECTRICS in variety.

THE TELEDACTYL

Feeling over a distance by Radio—in other words, projecting your hand over distances of hundreds of miles—may seem impossible, but the author, Mr. Hugo Gernsback, in the current issue of SCIENCE AND INVENTION, shows how it can be accomplished by means already available today. Imagine a doctor feeling a patient's pulse although both are separated by a thousand miles or more!

ELECTRICAL ARTICLES APPEARING IN FEBRUARY "SCIENCE AND INVENTION"

"Shipwrecked" on the Stage By A. P. Peck
The Radio Teledactyl By H. Gernsback
Portable Electrocardiograph Measures Heart Currents
Harmless X-Rays—"Cold Light" for Surgery
Everyday Chemistry By Raymond B. Wailes
How We Digest Food By Ismar Ginsberg, B.Sc., Chem. Eng.
Building a Motor Speedster—with full detailed working drawings By George Arthur Luers, Automobile Engr.
A 100 Ft. Antenna Mast By Fred A. Parsons, 2ABM
A Low Loss Broadcast Receiver By Frank Frimerman, 2FZ
Three Extra Good Circuits
Radio "Questions and Answers" As Well As Science "Questions and Answers"



Very effective rain contact which will give a very low resistance connection with the first drops of rain. There is a large area of salt which will diminish the resistance materially. This is part of the above system.

Insulating Paint

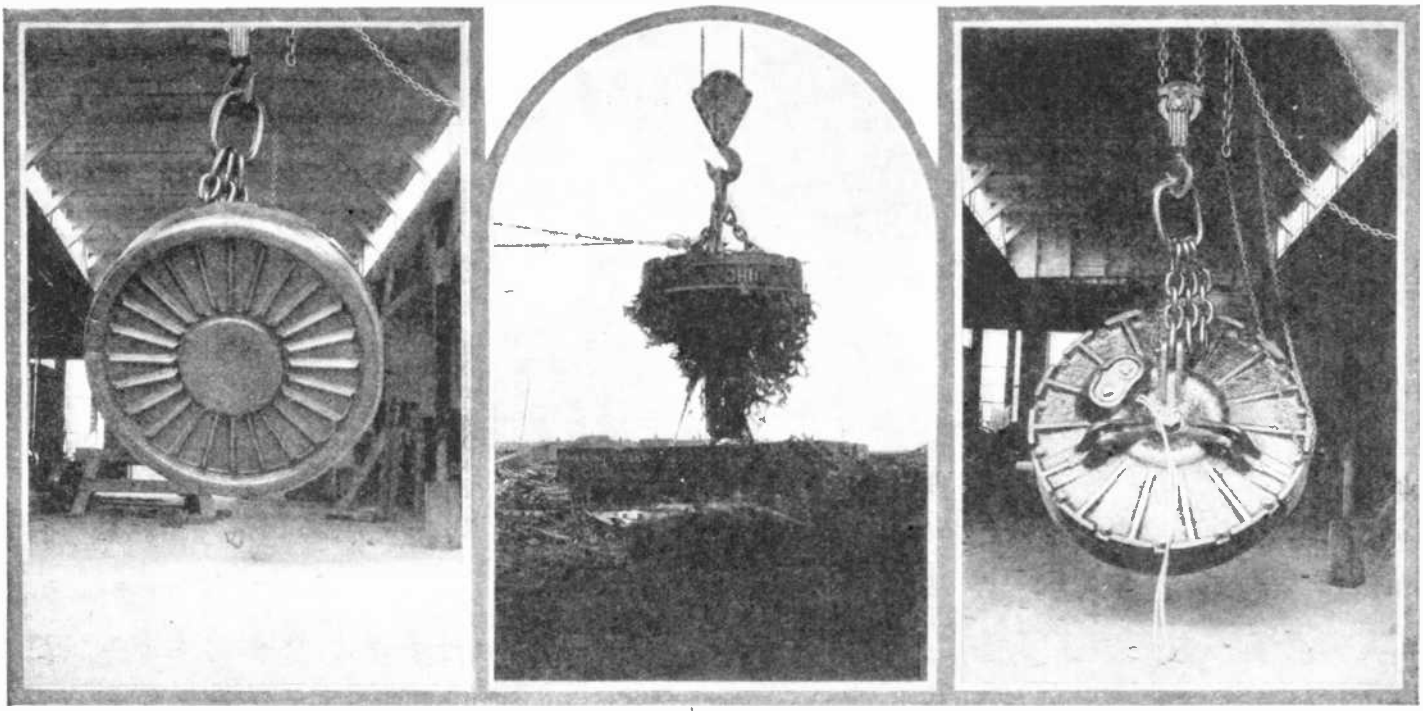
THE amateur electrician is often in need of some kind of a paint which has good insulating qualities. Ordinary paint does not meet this requirement because of the oil which it contains.

A very good insulating paint can be made very easily by any amateur of materials that are to be found in almost any household. All that is required is some denatured or wood alcohol and an old Victor phonograph record, either one you do not care for or one that has been broken. Place a small quantity of alcohol in a glass or other receptacle and break the record into it in small pieces. The desired consistency can be acquired by adding more alcohol or record, as the case may be. Allow it to stand for four or five hours to permit the alcohol to thoroughly dissolve the record. This paint dries very quickly requiring from one-quarter to one-half hour, which is a very desirable feature.

Contributed by LLOYD PHELPS.

Practical Hints and Data for Building Electromagnets

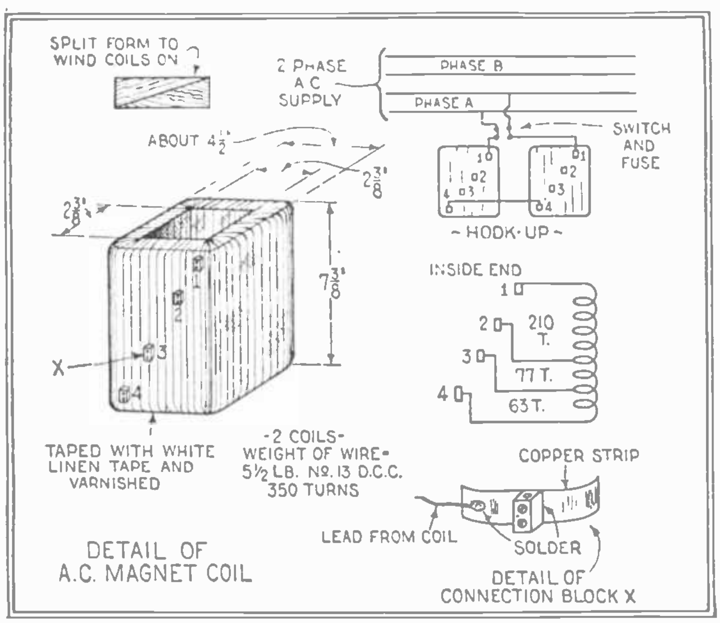
By H. Winfield Secor
Associate Member, A.I.E.E.

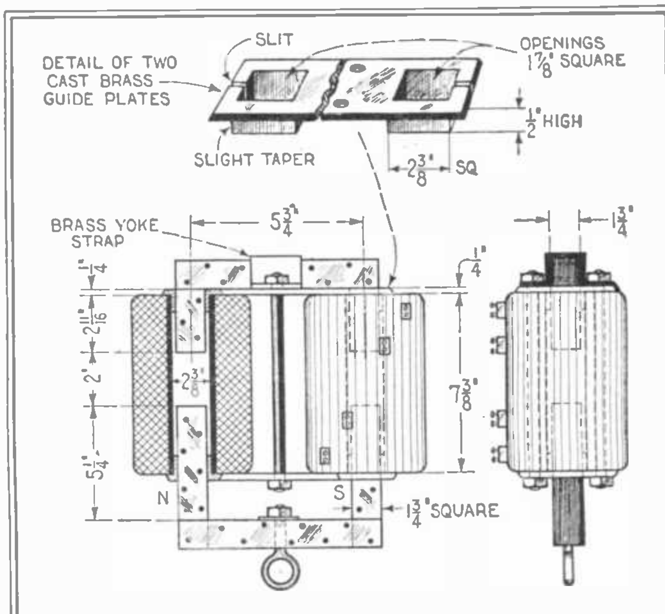


This huge electro-magnet will lift tons of iron without the necessity of tying the load with any bond other than the magnetic lines of force set up by the coils of the magnet. The bottom and top views are shown at left and right respectively.

One thing to be remembered in building electromagnets, no matter whether large or small, is to get the greatest number of turns of wire possible in the most compact space, and as near to the iron core as possible. The data given for the magnets and solenoids above is from the writer's own notebook, and these magnets were calculated and actually built, giving the pulls mentioned in the descriptions. It is a good general rule to observe, at least for small and medium sized electromagnets, to make the depth of the winding not over one and a half times the diameter of the core. In some cases the winding may be a little deeper, and in other cases a little shallower than this. In building solenoids it will be found best to place the cores in the lathe and either turn or file them quite smooth, and always smear a little oil or vaseline on them, so that they slide freely in the brass or copper tubes within the magnetizing coil.

Where slower action is desired in the case of the solenoid, a trick often used by inventors is to utilize the piston-like action of the core sliding within the brass tube, to produce a dash pot. To do this the core should fit the tube quite accurately and the air compressed behind the core is allowed to escape through an adjustable valve in the rear stop core or yoke, this arrangement consisting merely of a hole drilled axially through the stop core, and the size of the hole being varied with a cone tipped screw. Fig. 7-C shows an oil dash pot attached to solenoid on a motor starter. The slow movement of the dash pot piston in the cylinder which is filled with a light grade engine oil, is regulated by a small valve in the piston or in some cases, simply by having a small hole drilled through the piston. In other cases where a very slow motion is desired, the solenoid draws the piston through the cylinder, the oil escaping around the piston as it dragged forward. The descent of the solenoid core with its attached dash pot piston and rheostat contact brushes is accomplished by the weight of this part of the whole mechanism in the average case, or it may be augmented by springs or other arrangements.





Details for the construction of an A. C. magnet coil are illustrated above. The apparatus is in effect a double solenoid. The coils are tapped at several points and the intensity of their magnetic fields is thus adjustable. Note the full dimensions quoted on the illustration.

The present article refers to a bipolar solenoid for 20-pound lift through a 2-inch range, to operate on 220 volts, 60 cycle, alternating current, suitable for elevator brake service, etc.

This tractive A. C. lifting magnet has a laminated or built-up sheet iron core, yoke and armature, of the dimensions given in the drawing, Fig. (?). Ordinary stovepipe iron is satisfactory, but regular annealed transformer silicon steel (sheet) is preferable. Each sheet should have a coat of thin shellac varnish before the assembling. After piling up the core-sheets they may be clamped and drilled for riveting, using ¼-inch iron rivets. The outside ends of the holes are best countersunk so that the rivet ends can be upset into the conical holes so formed, resulting in a flat core surface. It is best to cut out the iron laminations in a U-shape, as it is somewhat troublesome to interleave and rivet the iron sheets at the corners sufficiently tight to withstand the strains of repeated action.

The two magnet coils are clamped together with the yoke member by means of two ½-inch brass bolts, although iron bolts may be used. Two brass castings in the form of guide plates (A) are best used to hold the coils in place and to provide openings through which the armature cores can slide. It is best to arrange the armature member to slide up and down on a good-sized central stem or guide post, this not being shown for the sake of simplifying the drawing. Otherwise the armature will have a tendency to oscillate and jam when being pulled upward. Slits about one inch wide should be cut clean through the one side of each brass guide ring where it encircles the core, or else these will heat up, due to powerful currents being produced in them by induction.

Each coil is wound on a form about 2⅝ inches square, thus leaving room for tape, etc., in finishing up the coil. Each coil comprises 350 turns (5½ lbs.) No. 13 D.C.C. magnet wire, wound evenly in layers. Make the wooden core in two sections, split diagonally, so as to facilitate the removal of the coil when finished. Wind several layers of empire cloth or oiled linen around the form, tie one end of the wire on the lathe face-plate and start winding the first layer. Wind on 210 turns and then solder fast the tap connection for lug No. 2.

Insulation is very important in these A.C. windings, and if they are not to be impregnated with some good varnish or insulating compound, place two layers of oiled linen between each layer and thoroughly shellac the wire as you wind. The succeeding layers are tapered off, or shortened, as the coil builds up, and holding it in form itself without recourse to a spool. Thus about six layers will be required, depending upon the closeness of winding, etc. It is well to run binding string in here and there to help tie and hold the coil after it is fully wound. The finished coil is well taped, first with oiled linen tape and then with white linen tape, giving this a coat of black asphaltum finally.

Switchboard for Experimenter's Laboratory

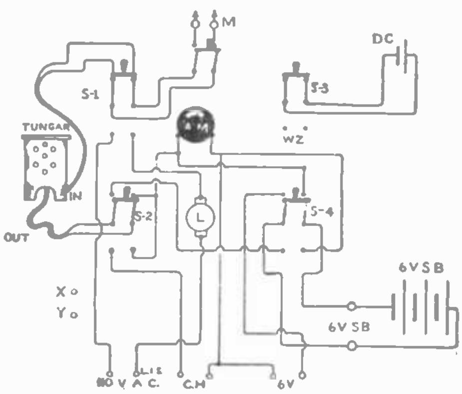
By Raymond B Wailes

THE main item in the experimenter's laboratory should be a serviceable switchboard. But how many could we find if a census were taken of the undergraduate and experimental world? Not many.

Here is a real honest-to-goodness switchboard which is more than a toy; more than a panel for a couple of Little Hustler motors and dry cells. It can be made into just what you want it—one of the amateur class or one of the near-professional type. Wire it to suit yourself as you may desire, or use either of the wiring diagrams.

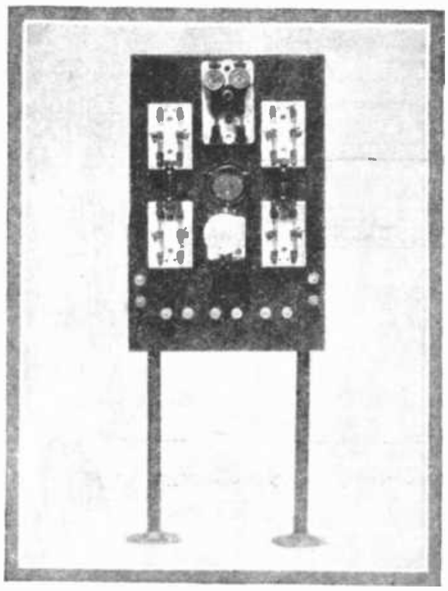
The panel is of wood. Now don't rave! The 110 fresh volts, alternating circuit which were socked to Fanny in the September issue of PRACTICAL ELECTRICS will not leak through the grains and play hide and seek over the sap markings to any appreciable extent.

A suitable size for the panel is 12 x 18 inches. Seven-eighths dressed stock is very serviceable The supports are made of half-inch iron pipe, 29 inches long and terminating in wall flanges which serve admirably as feet for the legs. Screw holes are incorporated in these wall flanges so that you can mount the switchboard on your laboratory bench top. Ordinary pipe clamps or sheet U straps can be used on the back of the panel to secure the panel to the legs.



The illustration above is a diagrammatic view of a switchboard designed to be used in charging storage batteries by means of the tungar rectifier. This switchboard also embraces the features of the one shown at the right

Fig. 1 shows how the switchboard can be wired and modified for dry battery or storage battery current. Some experimenters have no access to 110 volts and operate their devices with low voltage sources. The switch at the top of Fig. 1 controls this low voltage or battery current, and can be considered the main switch. When this switch is in the left position, the lamp (L) is in series with the source and consequently the source of current at binding posts (E) will be that of the battery with a lamp in series with it. This is useful in testing.



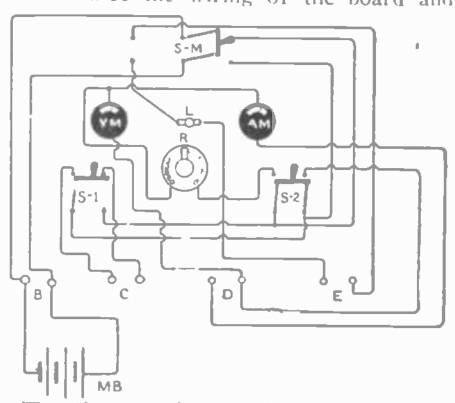
This switchboard, which has every appearance of an efficient laboratory type, can be readily constructed by the experimenter. It is adaptable to a variety of uses. However, the panel is of wood and therefore the use of the switchboard should be limited to low voltages.

With the switch to the right and switch (S-1) in, the whole of the battery current is ready to be delivered at binding posts (C). With switch (S-M) still to the right and switch (S-2) up, or on, the rheostat, voltmeter and ammeter are all connected and will regulate and indicate the character of the current delivered at posts (D) The battery is connected to binding posts (B).

Fig. 2 is that used by the writer with 110 volts A.C. The main switch is at (M). Smitch (S-1) connects the tungar rectifier with the house system. With the tungar operating and switch (S-2) thrown down, the binding posts (CH) will deliver rectified pulsating current passing through ammeter connected in the line. If the switch (S-2) is thrown upward, the Tungar operating (with S-1 up), and (S-4) is thrown down, the storage battery connected at (6VSB) will be on charge, with the ammeter in series. This battery can be the family radio battery.

Throwing (S-4) upwards connects the six-volt storage battery with the ammeter in series, with posts (6V). Switch (S-1) thrown down connects the lamp in series with the binding posts (LIS). A single dry cell can be connected to switch (S-3), and either pair of jaws of this switch led to the spare binding posts (X) and (Y) if desired. A single dry cell is useful in certain tests such as the completeness of a circuit in small parts as a galvanometer coil. The reserve jaws on (S-3) can be used when any special occasion arises.

Of course the wiring of the board and the instruments mounted upon it will vary with the needs of the experimenter, but the mechanical construction of the switchboard can always be used. Perhaps a tungar will not be used; perhaps an electrolyte rectifier will be installed on a shelf below or in the rear of the panel; a watt-hour meter may be installed; a field rheostat added; a circuit breaker incorporated; an overload relay used; the switchboard described is readily adaptable to these new items.



The diagram of connections for a switchboard to be used in connection with a storage battery supply is shown above. This switchboard provides a readily controlled power supply for the laboratory.

Building a Magneto Generator

By Hans Konwiczka

OUR first requirement is a strong magnet to develop a field of force. It is hard to get a good permanent magnate of proper form, so we will use an electromagnet excited by a battery. The most important parts are the following:

The magnet, the armature, the commutator, the shaft, the brushes, the baseboard, with the receptacles for the magnet and for the shaft bearings, the electrodes, the terminals.

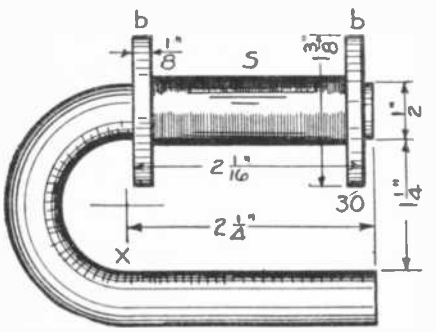


FIG. 1

Complete data for the construction of the pole pieces of a simple generator are given in this illustration. Two wooden spools wound with the suitable wire are mounted on each leg of the bent soft iron bar.

1. *The Field Magnet*

Out of a round iron bar of one-half inch diameter we make a so-called horseshoe magnet of the form shown here. The two straight legs are 2¼ inches long and 1¼ inches separated from one another. Both the end surfaces must be perfectly true. We can harden the magnet to a certain extent if we wish, so that it will retain some residual magnetism. For each leg of the magnet a wooden bobbin or spool (S) is provided. Each spool is a small fraction of an inch shorter than the magnet legs; they are about 2 1/16 inches long.

The two discs are 3/32 inch thick and 1⅜ inches in diameter; the thickness of the body of the spool must be as little as possible so as to bring the iron core and the windings close together. The two bobbins are now wound with S.C.C. magnet wire from 24 mils to 34 mils thick. They are wound full and this must be done so carefully that the wire of an outside layer will not find its way beneath that of the one under it. The two spools are wound as full as possible, one right-handed and one left-handed. A piece of wire eight inches long is left free at each end of each winding to be used in the connection put on later.

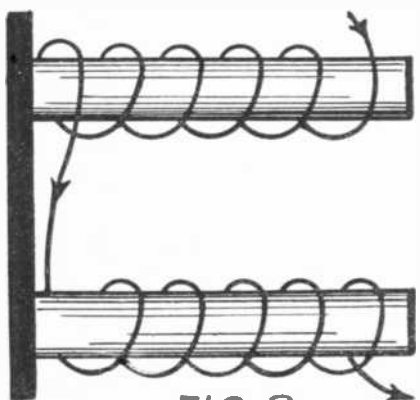


FIG. 2

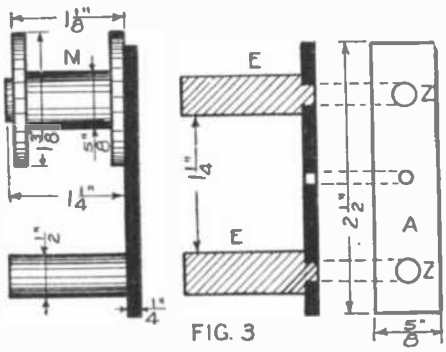
In order to have a north and south pole facing the armature the coils in Fig. 1 should be wound in the directions indicated above. Note that the two coils are oppositely wound.

The two bobbins are now thrust upon the legs of the magnet, so that the iron thereof projects only one-eighth inch or less. It will be remembered that the windings are to be in opposite directions.

2. *The Armature*

The armature is also an electromagnet but of a different form than the field magnet. For the armature we have to use thoroughly annealed iron, so as to do away with any chance of residual magnetism, because in the armature the current has to change direction with great frequency and to carry out this action the natural or residual magnetism must be at an absolute minimum.

Through a thin iron plate (Fig. 3) 2/32 to 4/32 inch thick, 2½ inches long and ⅝ inch wide two holes (zz) are bored, for riveting in two iron cores, (EE) of the same material as we use for the magnet, in other words, of ½ inch round iron. Excluding the extension for riveting, each of these cores is 1¼ inches long, and they are exactly at the same distance from each other as the core of the magnet, namely, 1¼ inches. For each of them there is a smaller bobbin (M), 1⅜ inches diameter and 1⅛ inches long, so that here 3/32 inch of the iron projects. The discs at the end of the spool and the wood of the body are made as thin as possible so as to hold the greatest quantity of wire.

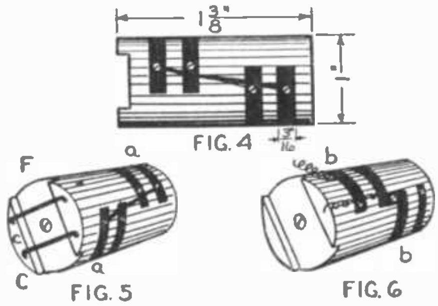


No intricate problems are involved in the winding of this armature. Two spools with iron cores and an iron strip make up this unique armature core.

At (O) there is a hole in the thin iron through which the shaft of the armature passes. The bobbins are wound exactly as for the magnet but we use much thinner wire. Each is wound full with S.C.C. wire eight inches thick. Here again care must be taken that the windings are put on in opposite directions. Here too, for each end of the wire, there is a piece 4 to 8 inches long left free for subsequent connections. It will take from 400 to 475 feet of the thinner wire to wind the two spools, while the magnet spools with their thicker wire will need only from 250 to 325 feet. We must be very careful not to break the thin armature wire as we wind it on the spool. Next to the armature the shaft receives the connection.

3. *The Commutator.*

This consists of a wooden cylinder, Figs. 4 to 6, of 1 inch diameter and 1⅜ inches long. The central hole must be accurately placed. On the cylinder are secured four strips of thin brass, 3/32 inch wide and of such a length that they extend a little more than half way around the circumference of the cylinder. These strips are spaced equidistant one from the other, and screwed down fast and connected two and two—the two inner ones to each other and the two outer ones to each other, as shown in Figs. 4, 5 and 6. The two inner strips (b, b) can be made of one piece which will take care of their electric connections. The two outer strips (a, a), Fig. 5, are connected by thin copper wire which is bedded in a rather deep groove so as not to touch the thin plates (b, b). Paraffined paper is placed over the portion of the wire that goes under the strips (b, b). The commutator is now thrust upon the shaft.



Commutator of this generator is constructed of a small wooden cylinder and a few strips of copper or brass. It is a commutator of unusual form but also of unusual simplicity.

4. *The Shaft.*

is made of an iron or brass wire 3⅝ inches long and about ⅛ inch thick. The thinner portions, acting as bearings at the end, are each 3/16 inch long. At the one end of the commutator there is a groove (F), Fig. 5, cut out, which closely fits the cross piece of the armature when it also is in position on the shaft. Clamps of wire go over the cross piece holding it in the groove. (C, C), Fig. 5, show these clamps.

The bobbins are next placed upon the armature and connected together so as to bring the winding in opposite directions, one clockwise and the other anti-clockwise. The ends of the windings are now completed, one pair to the two outside strips of the commutator and the other pair to the inner strips. As a direct connection would interfere with the action of the two brushes yet to be installed, the connecting wire must be carried in a deep groove under the outer strips to the inner one. It must be secured so that it cannot move. It is a good plan to fill the groove with hot paraffin after the wire has been placed in

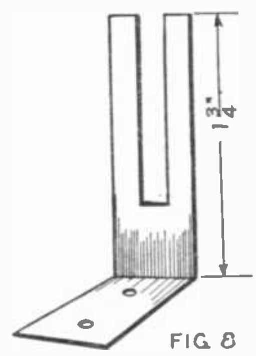


Fig. 7 is a drawing of the armature shaft, one end of which carries the two-coil unit shown in Fig. 3. The brushes to be used in connections with the commutators shown in Figs. 4, 5 and 6 are constructed as shown in Fig. 8.

it and secured and connect it to the commutator strips. The commutator along with the armature must have a very tight fit on the shaft. If the hole has been bored too large the centering of the commutator and armature will be interfered with.

5. *The Brushes*

To take the electricity from the apparatus we require brushes, Fig. 8. These are made out of very thin, spring-tempered brass strips. They are cut at one end into fork shapes and the two prongs

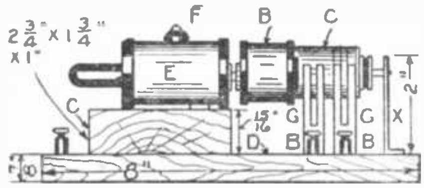


FIG. 9

A side view of the assembled magneto generator is shown above. The armature is rotated by means of the pulley at the right end of the apparatus.

of the fork are as far apart from one another as are the inner and outer strips on the commutator. The brushes, which have forked ends, alternate with each other in resting upon an inner and outer strip, as is clearly shown in Fig. 9 (G, G). Each of these brushes has also a clamp-screw (B, B), which later will receive the ends of the circuit wire. The brushes must be so long that the rubber for the commutator—

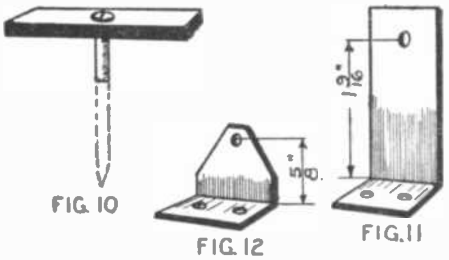


FIG. 10 FIG. 12 FIG. 11

Fig. 10: A retaining strap to hold the field coils in place. Figs. 11 and 12: Bearings supporting the armature shaft. None of the usual bearing troubles will be involved in the use of the bearings shown here.

the forked ends, in other words—will project about 1¾ inches from the angle.

6. *Baseboard with Magnet Support and Bearings*

The baseboard (B), Fig. 9, is made out of hardwood and may be of two dimensions, one so that it can receive the apparatus alone, or else that it can accommodate the apparatus and auxiliaries, including the drive wheel. In the first case we need a board 8 inches long, 4 inches wide and ⅝ inch thick. The board will present

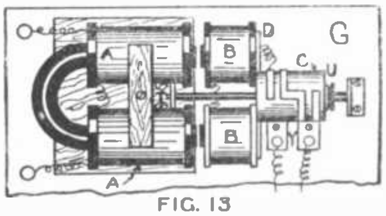


FIG. 13

This plan view of the magneto generator shows the disposition of all the parts very clearly. The terminals at left are for the field exciting current while those at the right are the out-put terminals.

a good appearance if made of mahogany or walnut. If we put the auxiliary parts on the same baseboard, which we do not recommend especially, as we need it also for other apparatus, the baseboard must have a length of at least 16 to 20 inches. It may be ⅞ inch thick.

To raise the magnets to the proper level we need a block (C), Fig. 9, made of hardwood; this block is 2¾ inches wide, 3¼ inches long and 15/16 inch thick. It screws from below to the baseboard, or is glued thereto. A very effective fastening may be given it by the use of dowels. A bolt and cross-piece (F), Fig. 9, hold the magnet down to the block. The bolt and cross-piece are also shown in Fig. 10. The magnets must be attached to the block so that the pole ends project a few sixteenths beyond the edge of the wood, then the rotating armature will not rub against it.

To get the armature into its position we must have two supports for the bearings. The longer supporting piece (X), Fig. 9, is screwed directly to the baseboard and is 2 inches high. The bottom, bent to an angle, is screwed down through two holes to the

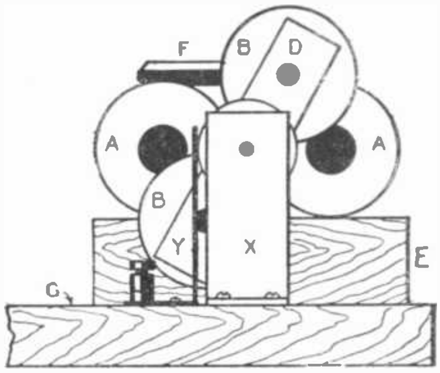


FIG. 14

The front view of the generator illustrated above shows the armature in rotation. The voltage induced in the coils varies as the armature rotates, being a maximum when the armature is horizontal.

wood, and the thickness of this bottom or foot is not included in the two inches. This support is made of heavy brass plate in the neighborhood of one-sixteenth inch in thickness. The hole for the shaft is a little over 1½ inches above the surface of the baseboard. As is shown clearly in Fig 9, the armature must be carried at such a height that as it revolves the bobbins carrying the windings do not rub on the baseboard nor against the faces of the poles, if all is true and squared up. The armature core-ends should accurately face the ends of the poles of the field. Fig. 11 shows the high bearing support.

The second bearing pedestal is screwed down to the b' ck and therefore must be shorter by the thickness of that block than the other one. It contains the hole for the shaft to pass through, which must, naturally, be at the same level as the hole in the other bearing, so as to keep the shaft perfectly horizontal. If everything is carried out exactly as described, this hole will be ⅝ inch above the surface of the block. The form of the bearings must be as shown in Fig. 12, or otherwise it would not fit in between the bobbins of the magnet. It is made of the same stock as the bearing (X), Fig. 9. The apparatus is now finished. Fig. 9 gives a side view. Fig. 13 gives a view seen from above. Fig. 14 is the front view. From these three the exact layout can be understood.

Similar parts are designated in both diagrams with the same letters: (G) is the baseboard; (E) is the magnet block; (A, A) the magnet with its bobbins; (B, B) is the armature; (D) is the armature yoke; (Y) shows the brushes, with the binding posts; (U) is a little wheel of lead or brass, which has a groove so as to be secured to the driving apparatus, as it is to be driven by a belt.

7. *The Electrodes*

We must make electrodes for the machine such as are shown in Fig. 15, in order to be able to feel the electricity generated.

8. *Driving Mechanism*

We can put on a crank if we desire and turn the shaft by hand, but as this work is very tedious we use a driving mechanism to get a current which can really be felt. The driving mechanism consists of a large wheel that is turned with its fixed shaft, belted to the small pulley (U) of the generator, so as to impart motion to the arma-

FIG. 15

Two electrodes of the type shown above, connected to the terminals of the magneto, can be used in taking "electric vibrating" treatment. The shock received through the electrodes can be varied by altering the speed of the driving wheel.

ture. Fig. 13. The larger the driving wheel the faster proportionately does the little wheel (U) turn. If we take for the driving apparatus a wheel of one foot diameter and for the little wheel a one-half inch diameter each turn of the large wheel will make the little wheel turn 24 times, which

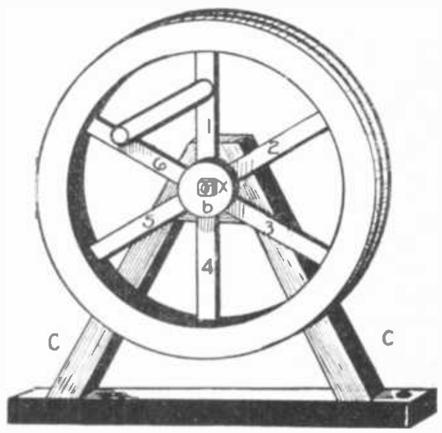


FIG. 16

To drive the armature at high speed the armature pulley is belted to this large driving wheel, which is manually rotated. The driving wheel together with the magneto can be mounted on a large base forming a single portable unit.

is a rather impressive speed. We can easily obtain a speed of rotation up to 1,600 turns per minute.

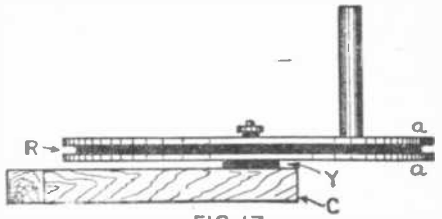


FIG. 17

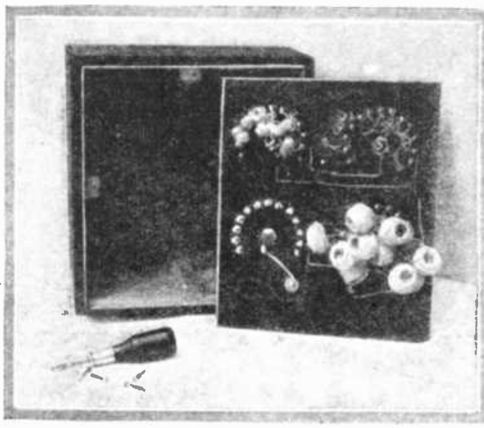
The figure shows the end view of the driving wheel. The wheel is not rigidly connected to its shaft but turns easily upon it.

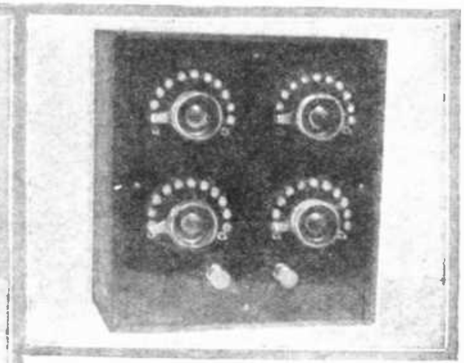
Out of thin veneering we cut a wheel with six spokes, Fig. 16, which may have an outer diameter of 12 inches. In that case the inner diameter will be 8¾ inches. The spokes are each 1½ inches wide. We then cut two rings or half rings with 12-inch inner diameter and outer diameter of 12½ inches. These rings or half rings (A, A), Fig. 17, we glue on both sides of the drive-wheel, so as to provide a groove (R) to hold the belt. A handle, Figs. 16 and 17, is fastened to one of the spokes. Out of the same wood as the two outer rings we cut two discs (b, b), Fig. 16, which we glue to the hub of the wheel to give the shaft a better bearing.

Experimenter's Resistance Box

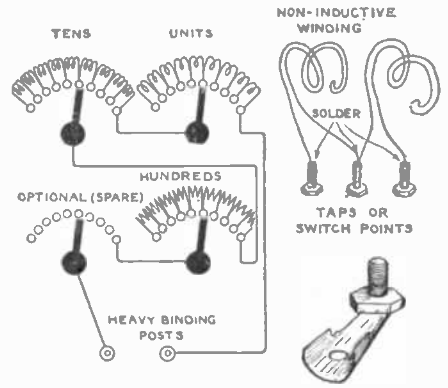
By RAYMOND B. WAILES

PERHAPS the high cost of a resistance box has kept this instrument out of the experimenter's laboratory. Such an instrument is very frequently required. A highly accurate instrument of this type can be made at a cost of about ten dollars, and each succeeding instrument for about two dollars.





The resistance box here illustrated will form a welcome addition to the equipment of most experimenters. The electrical circuit is illustrated at the right.



The instrument proper is housed in a radio cabinet of the flat variety. A box 7¾ x 8¾ x 3¾ inches deep was used by the writer. A hard rubber or bakelite panel is a necessity, for it will prevent much current leakage, and the current is going to be measured by a sensitive galvanometer.

With the design incorporated in the author's instrument, as high as 1,100 ohms in steps of one ohm can be obtained across the two binding posts. In other words, one ohm, 723, 724, 725, 1,000, 1,001 or any number of ohms less than 1,110 can be obtained. A spare switch with spare points will enable one to add to the instrument ten 1,000-ohm coils so that 11,110 ohms can be obtained. The coils or various resistances are obtained by rotating the switch arms.

The greatest loss in such a home-made instrument is due to the inaccuracy in measuring the wire for the coils, also loss between the rotating switch arms and the contact or switch points. Care in measuring the wire and triple laminations on the switch arms will reduce these factors, however. It is best to use flat, broad-headed switch points. The writer chose No. 30 B. & S. D. C. C. advance resistance wire for his resistance coils. The temperature coefficient of electrical resistivity of this wire is negligible. One thousand feet of this wire weighs about a third of a pound and its resistance at 75 degrees Fahrenheit is 2,940 ohms, so that a third of a pound will make two resistance boxes similar to the author's. The wire is made by the Driver-Harris Company, of Harrison, N. J.

Ten one-ohm coils should be made. Each one-ohm coil is made by measuring off *exactly* four and five thirty-seconds of an inch of this No. 30 B. & S. D. C. C. advance wire. One ohm is really four and three thirty-seconds of an inch, but two thirty-seconds more are allowed to provide a one thirty-second of an inch for soldering at each end, the soldering having for all practical purposes no resistance.

The ten 10-ohm coils are made by using three feet and four and four-fifths inches of the same wire for each ten-ohm coil, this length of wire being very nearly of 10 ohms resistance. The ten 100-ohm coils are made with 340.1 feet of the same double-covered cotton advance wire.

In winding the coils, they should be wound non-inductively. To do this, double the wire, but do not cut. Now beginning with the closed end, wind the two leads of wire until the free ends are reached, making a coil having about a quarter of an inch air core. All coils should be made in this manner. The coils should now be soldered to the switch points which have been mounted with their rotating switches, on the panel. Use only resin core solder or use resin as a flux for this operation, as a zinc chloride or "killed" acid soldering solution will spatter up on the application of the soldering iron, and the highly conductive zinc chloride will fall between the switch points and cause a serious leakage. The zinc chloride is very hygroscopic, so don't think that it will dry and become an insulator.

Lugs should not be used on the switch points. Oxidation will set in between them and their contacting switch points and cause an added resistance error, especially if the resistance box is subjected to gases from chemical operations.

The coils and switches are wired virtually in series as shown in the diagram. The spare switch points and switch can be used for additional resistance coils such as 1,000-ohm units, if desired. It is not possible to wind 1,000-ohm coils with this advance wire and still have a fair degree of accuracy. The experimenter can utilize magnet coils, obtained either from discarded telephone receivers or purchased at a low price. The resistances of these are known.

The operation of the instrument is very simple. To obtain one ohm across the binding posts, turn all switches to zero, or to the left (right in the diagram). Now move the "unit" switch one switch point to the right, thus placing one 1-ohm coil in circuit. If, say, 711 ohms are required for any purpose, move the "hundreds" switch to the eighth switch point (the first point is "off"), the "tens" switch to the second switch point and the "units" switch to the second switch point. Of course, using a Wheatstone or slide wire bridge, the resistance box is made one arm of the bridge and adjusted until the galvanometer gives zero deflection in the regular operation.

"Listening In" for the Stars

By WILLIAM GRUNSTEIN, E. E.

IT is well known that light waves are but one species of a large genus of electromagnetic radiations. These radiations embrace a vast range from the 0.0000000001 meter long Roentgen rays to the Hertzian or radio waves of thousands of meters wave length. Over this extensive range our visual organs are sensitive to only the narrow band of radiations comprised in the visible spectrum. For the perception of other radiations we are obliged to have recourse to indirect means such as the fluorescent screens rendering the impinging X-rays indirectly visible, or radio receiving apparatus reducing the energy of long "wireless" waves to audible form.

It appears then, that the eyes aided by powerful telescopes are well adapted for the purposes of the astronomy which deals with the motion of celestial bodies. Yet the inaccuracies of the eye necessitated the employ of the photographic plate for important observations. But this again is a cumbersome process for in taking records the data must be delayed until plates are developed. This method is therefore out of question in the determination, for instance, of the time by observing the position of a star.

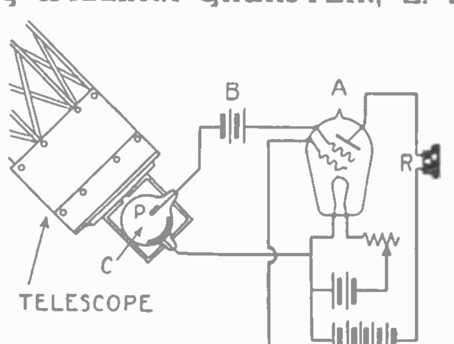


FIG. 1

In the Paris Observatory a photoelectric cell attached to a telescope trained on a certain part of the sky announces the arrival of stars at this predetermined point by impressing a weak photoelectric current on the grid of an amplifying tube.

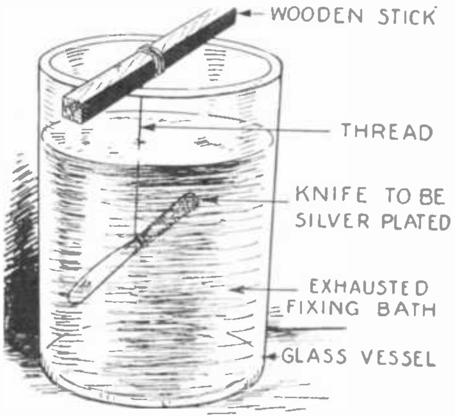
Well, says the ingenious astronomer, if we cannot see accurately the star arriving at the observed position, why not hear it? The question seems absurd, for we have no evidence of sound waves traveling through interstellar space. It recalls to us the myth of the old Greek, Pythagoras, who, it was said, heard the musical vibrations of celestial "spheres." However, the astronomers of the Paris Observatory, without reverting to the fantasms of Ancient Greece, are now "listening in" for the stars, using a first rate "hook-up" without aerials and are

(*Continued on page 284*)

Silverplating without Battery or Solutions

By C. A. Oldroyd.

METAL articles can be silverplated if they are hung in a photographer's exhausted fixing bath. Such a bath is rich in silver salts that have been dissolved out of the films of plates and prints.



By a process of chemical replacement metallic objects immersed in an exhausted solution of photographers' fixing bath will be covered by a thin deposit of silver. The action may take some hours.

The article to be plated is suspended in the solution by a thin thread, and in a few hours, a thin coating of silver will have been deposited.

A similar method can be used for recovering the silver out of old fixing baths. Brass strips are hung in the solution, and from time to time the deposit is scraped off when sufficiently thick.

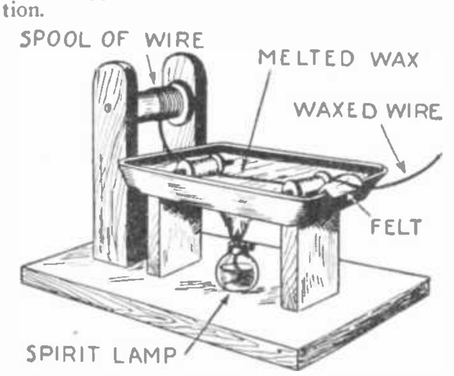
Chemical works are good buyers of such recovered silver. Fairly large quantities can be secured if the exhausted fixing baths of professional photographers are treated in the way suggested above.

Wire Waxer

By Charles Field

HAVING occasion to wind some coils, I found that the wires would lie better in place if they were waxed with paraffin.

To do the waxing, I constructed a very simple apparatus, as shown in the illustration.



A tray of melted paraffin wax is used to coat a wire drawn through it with wax. Two spools are journalled to keep the wire immersed as it is rapidly drawn through the solution. A bit of felt wipes off the excess of wax.

A baseboard 12 or 15 inches long has two standards on it, carrying a movable shaft, on which the spool of wire can be placed. In front of these two standards is a rectangular pan, and spools are mounted on shafts near the opposite bottom corners of the pan. This is for the wax.

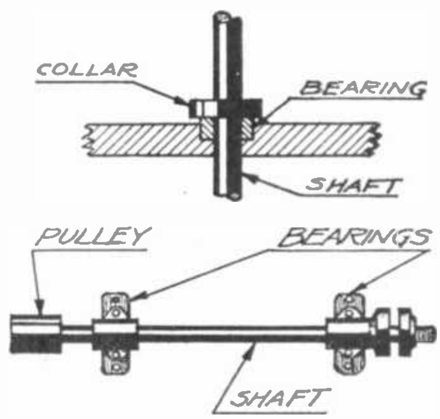
The pan is carried on wire supports so that an alcohol lamp can be placed beneath. Paraffin is melted in it after the end of the wire has been drawn under the two spools and out the further end. Now as the wire is drawn out, it comes out with a coating of wax, and in order to prevent an excess, a felt rubber is fastened near the outer edge of the pan, which rubs off the excess of wax, which runs back into the dish.

Making a Power Saw

By Willis Jones

A POWER saw is very essential to the experimenter, but far beyond the reach of some pocketbooks. In my workshop I needed one so badly that I decided to make one, which I did and it has proved very successful.

Starting out with about ten dollars, I first visited a junk shop and succeeded in getting an old Delco generator and a rusty saw mandrel for five dollars.



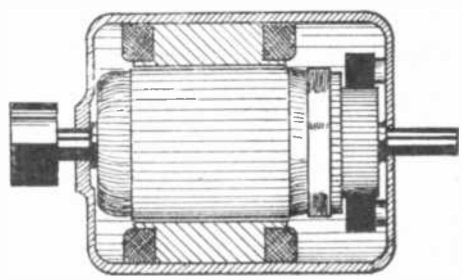
Very easily constructed bearings to be used in connection with the circular power saw. The bearings form the vital part of any rotating machine.

When I arrived home and examined the generator I found that outside of some rust and a few broken connections on the armature it was all right, that is there were no field or armature coils burnt out, otherwise I would have had to replace the defective coil with a new one, no easy task.

After cleaning the generator thoroughly and soldering the loose connections together it ran finely; after this I soaked the saw mandrel in kerosene until I succeeded in getting nearly all the rust off it, then oiled it with machine oil.

The generator was one of the third brush kind; I removed the third brush and used that lead as one of the power line terminals; on account of this being a generator the field coils have a lot of small wire on them. This need not be taken off, but by using the right voltage excellent results will be obtained. This one runs on A.C. or D.C. at a voltage of about 30; with D.C. only a rheostat is needed, with A.C. a transformer is needed, with a capacity of 275 watts and voltage 30 to 35.

If the field coils are connected in parallel to each other the voltage can be reduced, but it will take a higher amperage. With this connection, fairly good results may be obtained by using a 9 cell (18) volts storage battery of about 150 ampere-hours' capacity. To use any voltage lower than this, say 12 volts, the small wire must be taken off and heavy substituted, for the lower the voltage, the higher the amperes must be to produce a given amount of power. The armature of this generator had No. 16 wire on it. So in order to use a 12-volt battery successfully on this motor, which produces a little over ¼ horse power, a wire about the size of No. 5 or 6 would have to be wound on the fields. This takes a heavy amperage, so the battery would have to be a powerful one to supply this heavy current. This motor

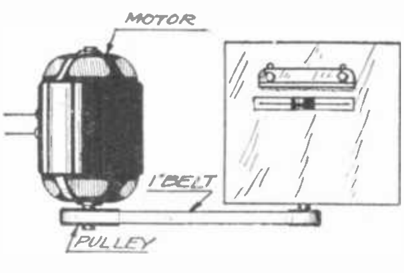


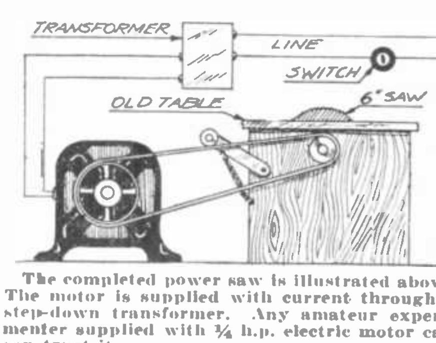
The diagram shows the interior of a direct current dynamo which can be used as a motor to drive a circular power saw.

takes about 250 watts and runs at about 80 to 85% efficiency. The field coils are in series with the armature which produces a high speed such as is needed for a saw.

The mandrel is mounted on an old table very securely, the pulley being 2" in diameter with a 2" or 3" face; the motor pulley is about 4" in diameter with a 3" face; 8 feet of 1" leather belting finishes the job. Never try the motor on the full house voltage, the fuses will blow and the motor will be ruined. Do not buy an automobile starter as they are no good for this work unless rewound, which is quite an expense, if not a nuisance. The cost was as follows:

Motor and mandrel	$ 5.00
6" saw	1.75
8 feet of leather belting	1.50
1 pulley	1.00
Miscellaneous	1.00
	$10.25



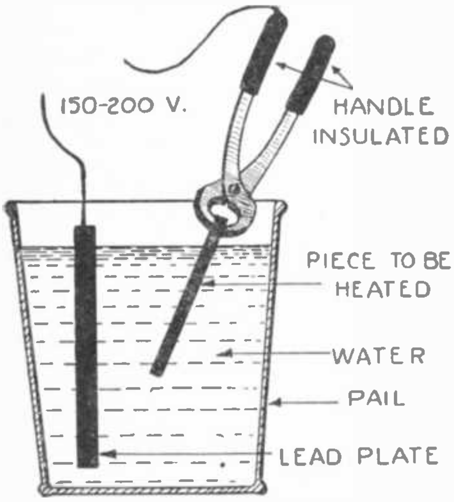


The completed power saw is illustrated above. The motor is supplied with current through a step-down transformer. Any amateur experimenter supplied with ¼ h.p. electric motor can construct it.

Heating Metals Under Water

THE following is a striking method of electrically heating metals for the purpose of working them.

If a pail of water, in which is dissolved some common washing soda, has immersed



A blacksmith brought iron to a red heat by immersing it in water. The iron and the pail were connected to a 200-volt supply.

in it a lead plate which is connected to the positive terminal of a 150 or 200 volt electric circuit, it gives all the necessary apparatus for quickly heating iron. The metal to be heated is grasped in tongs which are electrically connected to the negative terminal of the electric circuit, the handles of the tongs being insulated.

When the metal is plunged into the pail of water, it is quickly brought to a white heat and may then be withdrawn and worked on the anvil or welded to another piece of heated iron by the ordinary blacksmith's method. Any metal may be heated by this process, but welding can be performed only on those metals which, like wrought iron, can be welded by the blacksmith.

The heating of the metal when it is plunged into the water is apparently caused by an electric arc which is set up around the submerged metal on account of its becoming surrounded by a coating of hydrogen gas in the form of minute bubbles. The amount of current used varies from a few amperes to many hundreds, depending upon the size of the metal to be heated.

It produces a remarkable sensation to see a piece of metal which is dipped into a pail of water come quickly to a blinding heat; and, when held in another pair of tongs (not connected to electric circuit) to see the same piece of metal again dipped into the same water for the purpose of cooling it.

Contributed by R. A. GOEPFRICH.

Renewing Dry Cells

WHEN dry cells are worn out, they are usually thrown away and replaced by new ones. As the life of the ordinary cell is comparatively short, it becomes an expensive proposition to do any amount of experimenting with them.

To make use of these discarded cells, it will first be necessary to remove all the active, or rather inactive material, and clean the zinc case by sandpapering the interior bright. The carbon electrode should be cleaned by boiling in water.

Re-line the zinc case with a layer or two of heavy blotting paper, and pour in a half inch layer of sand in the bottom. Put the carbon in its place in the center and force in around it a paste made as follows:

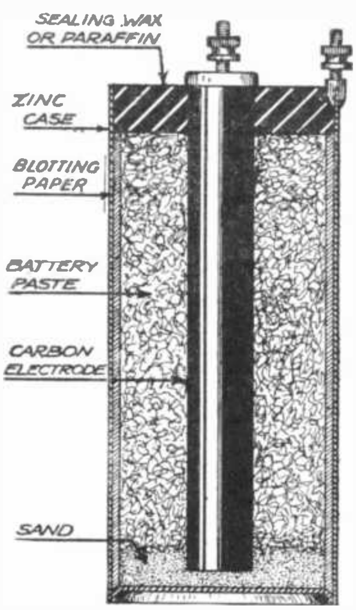
Dissolve ½ lb. of zinc chloride and ½ lb. of sal ammoniac in a quart of water, distilled if it is possible to obtain it. Make a stiff paste of equal parts of powdered manganese and powdered carbon and the above solution.

The blotting paper lining in the zinc case should be soaked with the same solution before the paste is put in.

If the cell will not be used for large currents, some inert material such as broken porcelain, sawdust, etc., may be used to fill the case and thus cut down the expense of renewing the cell.

After the paste is leveled, seal the cell with paraffin or ordinary sealing wax. The cell is now as good as new and will last fully as long as a new one with the same service.

Contributed by C. H. OSTERMEIER.

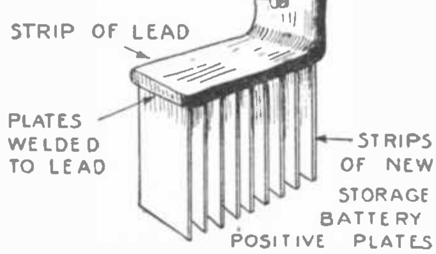


It is within the reach of every amateur experimenter to build dry cells, as satisfactory as new ones, using the electrodes of exhausted cells. The diagram shows one such renewed cell in cross-section.

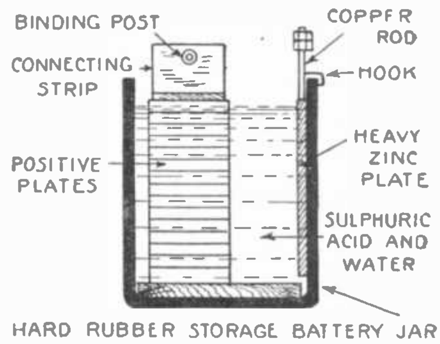
High Voltage Cell

THE average electrical experimenter, if he is fortunate enough to possess a storage battery, will not use it enough to keep it in good condition. A storage battery must be kept charged or it will soon be ruined. A battery which would not deteriorate when sitting idle in the laboratory would be just the thing for the experimenter and the radio fan.

To construct such a battery, procure some storage battery positive plates—new ones if the expense is justified, but old ones will do if the active material is still adhering firmly. Cut these up into strips about one and a quarter inches wide and as long as the original plates are wide. Clean one end of each strip and burn to the end a strip of lead to hold the plates rigidly together and



A low resistance and permanent connection is made between the set of positive plates used in the high voltage cell by welding these plates to a long strip of lead.



A primary cell having for its elements positive storage battery plates and a zinc plate will supply currents of one to two hundred amperes at a potential of 2½ volts. This is an unusually high voltage for a primary cell.

to connect them electrically, as shown. When burning the plates together, place strips of cardboard between them and tie with cord to make it easy to handle them. A box may be formed of plaster of paris or some such material around the tops of the plates and connecting strips, and very hot lead is poured into the space between the plates to weld them together. The pieces of cardboard are then removed to allow the electrolyte to circulate freely between the plates.

The other element of the cell is made of zinc. A plate of zinc about one-fourth inch thick is best. The thicker and larger the plate, the longer it will last and the greater will be the capacty of the cell. Amalgamate the zinc by cleaning with sulphuric acid and rubbing with mercury. A binding post in the shape of a threaded copper rod is fastened to it and a hook provided so that the whole may be readily removed from the solution when the cell is not in use. A binding post should also be mounted on the lead connecting strip of the other element to facilitate connections.

An old hard rubber storage battery jar is ideal for the container. These may be obtained for the asking at most garages. If a wooden box is constructed to hold the jar, the latter will not be so easily broken.

The solution is made by pouring one part of sulphuric acid into three or four parts of water. If a higher internal resistance is desired the solution may be made weaker—if a lower resistance is wanted, it may be made stronger in acid.

The constructor of this cell will be surprised at its voltage and ampere-hour capacity. The voltage is around two and one-half volts due to the use of the zinc electrode, and currents of one to two hundred amperes may be obtained. If the zinc plate is made large enough the batterey will furnish "juice" until all the active material on the positive plates is gone, when it will have to be recharged. After it is charged, the electrolyte should be renewed with fresh acid.

When the cell is not in use the zinc should be taken out of the solution. No action will go on when it is removed and it may be left out for an indefinite period and still be good when it is desired to use the cell. An ordinary storage battery would not stand such treatment.

Three of these cells made and mounted in a storage battery box, will form a battery which is far superior to the regular storage battery for intermittent use, and the voltage of the battery will be somewhat higher.

A School Made Telegraph

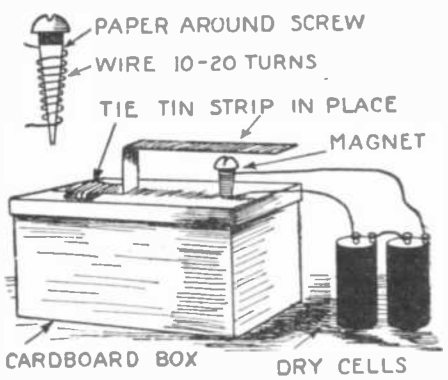
By Clyde E. Volkers

ONE day I happened to visit a school where a lady teacher was attempting to explain the principles of the electric telegraph to her class in science. She had nothing to work with—no apparatus with the exception of a few scraps of wire and two or three old, dry cells which still had a little "juice" left in them. The pupils could not see an instrument in operation and did not seem to understand it thoroughly.

We finally made a telegraph out of material secured some place in the room.

First, a screw was removed from one of the desks. (Don't tell the school board, it was returned.) This served as the core of the magnet. A piece of paper was wrapped around the screw and several feet of the scraps of wire were connected and wrapped around it. A strip of tin about four inches long and a quarter of an inch in width, was cut from an old tin fruit can which some time or other had held a specimen that a youngster had brought in. This was bent as shown in the illustration and tied to the top of a cardboard box so that the tin was in a horizontal position above the screw which had been pushed into the top of the box. One wire was connected to the cells, the other was used as a key to make a contact with the other terminal of the cells and to operate the sounder.

It is needless to say that those pupils understood the electric telegraph and that many made for themselves an instrument at home.



All you need to demonstrate the action of the electric telegraph is a cardboard box, a wood screw, a strip of tin, a few lengths of wire, a dry cell, and ingenuity.

The Mystic Motor

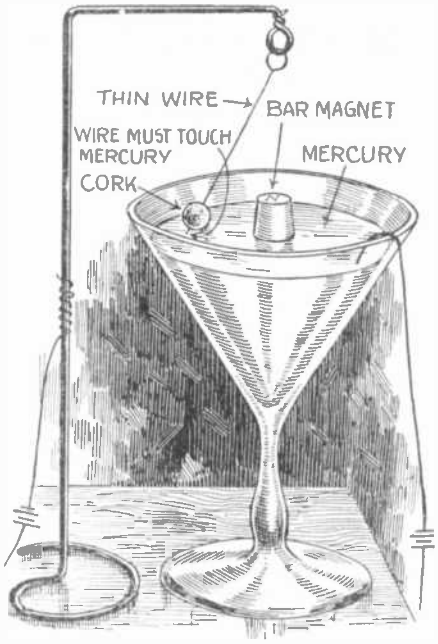
By Arthur A. Blumenfeld

THE arrangement of apparatus for the "Mystic Motor" is as follows:

A bar magnet with its north pole pointing upwards is fastened to the bottom of a wine glass with sealing wax. The top of the magnet should be level with the top of the glass. Then fill the glass almost to the top with mercury. Next build up a stand of heavy wire and suspend from it a thin wire so that it can move freely in all directions. Then attach a cork to the bottom of the thin wire and place the stand over the wine glass as shown in the illustration. The thin wire must make contact with the mercury in all positions. Then arrange another wire so that it makes contact with the mercury and the apparatus is ready.

Connect the positive end of a dry cell or better still a few Daniel cells, arranged in parallel, to the loose wire making contact with the mercury, and connect the negative end to the wire stand. The suspended wire will then begin to turn about the bar magnet and will do so as long as current continues.

This is due to the lines of force around the bar magnet and the thin wire.



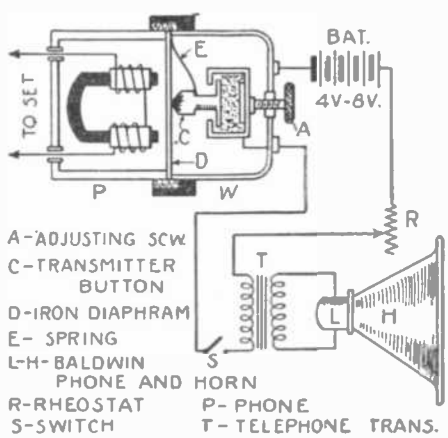
By an experiment similar to that illustrated above Faraday discovered the principles of the electric motor. Current passes through a wire partly immersed in mercury and by reacting with the field of the bar magnet causes the wire to rotate about the latter.

Efficient Loud Speaker

AN efficient, easily constructed loud speaker for the amateur is illustrated in the accompanying diagram. The principle involved is that of a microphone relay or sound intensifier. Excellent results were secured by the writer with this loud speaker, unusual tone volume with surprisingly little distortion being obtained by careful adjustment.

The diaphragm of a microphone transmitter is removed and the transmitter is then mounted with one 3,000-ohm receiver so that the transmitter button (C) is in contact with the iron diaphragm (D) of the receiver. The pressure of the transmitter button on the diaphragm may be varied by the adjusting screw (A) until best results are obtained. A battery of from two to eight volts is in series with the microphone, a rheostat to regulate the voltage, and one side of a telephone transformer (T).

During the reception of audible signals the vibration of the diaphragm (D) causes a much greater vibration of the diaphragm of the receiver (L), due to the larger volume of current flowing through the mi-



The illustration shows an unusually efficient form of a microphonic relay. The arrangement simply provides for the combination of a 3000 ohm receiver with a transmitter button.

crophone circuit. Loud speakers of a similar nature have been suggested in which the diaphragm of the receiver is connected by a metal rod or cord to the diaphragm of the transmitter, but due to inertia losses the results were usually disappointing. However, in the loud speaker here illustrated the diaphragm is common to both receiver and transmitter circuits, and a relay of a similar nature has been successfully used by the Marconi Company in transoceanic communication.

The only difficulty that may be experienced is in initial adjustment, in which care must be exercised not to create too much pressure of the transmitter button on the diaphragm of the receiver which would quench its vibration and produce a minimum variation in the resistance of the microphone circuit. The voltage should be increased until the "frying point" of the microphone is reached.

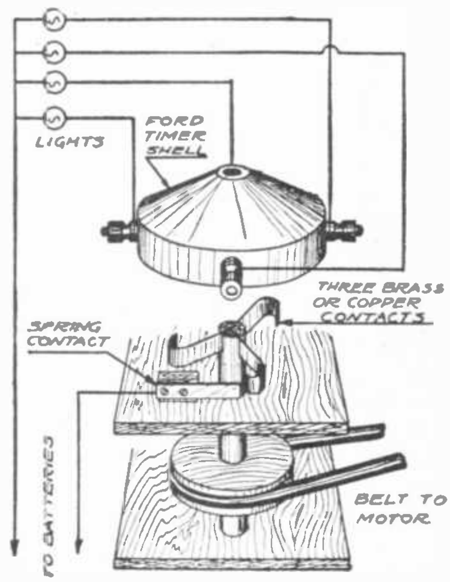
This loud speaker may be neatly mounted in a cabinet, its appearance limited only by the builder's ingenuity and materials, and it will prove a valuable and creditable addition to any receiving set.

Contributed by Theodore E. Keller.

Simple Flasher for Christmas Tree

By R. H. Kasper

A SIMPLE flasher for the Christmas tree can easily be made from an old automobile commutator shell, and a motor for driving the rotor. The rotor consists



An old automobile timer to which a system of lights is connected, as illustrated, provides a very simple and effective flasher for Christmas tree lamps.

of a metal shaft, the upper end of which contains three slots (made by a hacksaw) into which spring contacts of copper or brass are fastened. The whole assembly is mounted on a box or board, a sleeve bearing being supplied for the rotor shaft.

The wiring is done as shown. One side of the lights is connected to a line which goes to the battery or other source of current. The other side of the battery or source of current is connected to a brush of either spring brass or copper, which makes contact with the rotor shaft. From the four terminals of the shell, wires run to the respective rows of lights.

Though this arrangement permits the use of only four rows of lights, the color combinations are more varied. There are three brushes (spaced 120 degrees apart) carrying current to four commutator segments (spaced 90 degrees apart), the contacts made in this manner will produce an ever changing array of color.

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

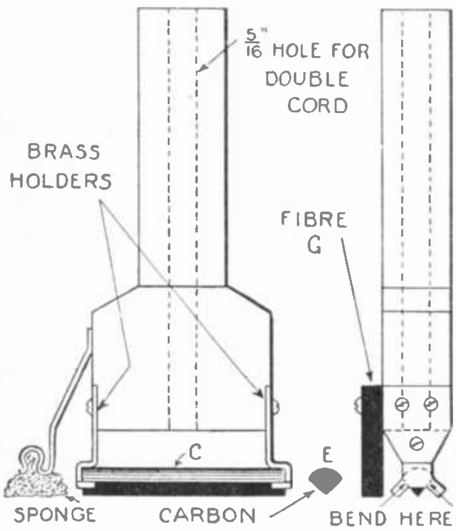
First Prize, $25	Second Prize, $15	Third Prize, $10
Aurelio Rivera, L. V. M., Hotel, 705½ King St., Seattle, Wash.	Roscoe Betts, Arcadia, Nebr.	Philippe A. Judd, 1525 Tenth St., Portsmouth, Ohio

First Prize
Electric Glass Cutter

By Aurelie Rivera

GLASS cutters on the market today comprise a hard steel roller of small diameter or else are the time-honored glazier's diamond fitted to suitable handles.

The illustration shows the construction of an electrical glass cutter that has no respect for thick glass plates. There is a heating



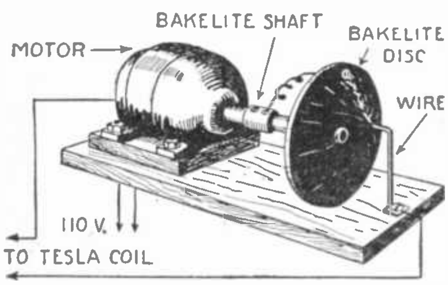
A piece of carbon from a flashlight battery kept at incandescence is used to cut glass. A small wet sponge follows after the incandescent element.

element, C, made out of an old flashlight carbon. It is fitted so that it will have an edge. E shows its cross-section. It is held in place by holders H_1 and H_2. H_1 shows the construction of these holders. To these holders, the terminals of a double fleible cord that passes through the center of the handle are connected. The slide, G, is placed on the left side. It may be hard wood or fibre.

The device works by virtue of the unequal contraction of the heated glass upon sudden cooling. As the cutter is drawn along, the sponge, S, follows it and cools the path which the red hot carbon heating element has traversed.

Second Prize
Window Attraction

By Roscoe Betts



A disc which may be an old phonograph record is turned by a motor, a bolt near its periphery connected to the motor shaft, is a whirling electrode. A Tesla coil discharge strikes across and gives a beautiful effect.

THIS instrument consists of an insulating disc cut from bakelite, hard rubber, glass or even cardboard (the former being the best) mounted on a bakelite shaft which in turn is connected to the shaft of a motor.

Near the edge of the disc is mounted a small machine bolt or other metal electrode, which is connected by a wire to the metal shaft of the motor, these being the terminal parts for one side of a high frequency circuit.

The other side of the H. F. Circuit consists of a stiff wire mounted in front of the disc as shown.

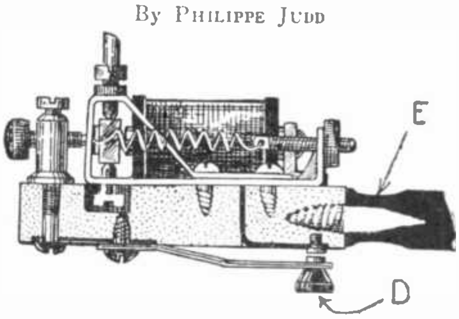
It is intended that a high frequency spark shall jump from the stationary electrode to the bolt on the disc.

Whether the disc be rotated rapidly or slowly, a very odd effect will be produced.

If several rotating electrodes be placed on the disc a "cone of fire" may be produced or troboscopic effects may be devised.

Third Prize
Electric Vibrator

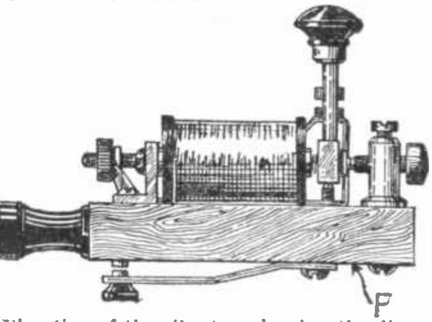
By Philippe Judd



The sectional view of an electric health vibrator made from a discarded bell. Note the attachment for handle on the right.

> **$50 IN PRIZES**
>
> A special prize contest for Junior Electricians and Electrical Experimenters will be held each month. There will be three monthly prizes as follows:
>
> | | |
> |---|---|
> | First Prize | $25.00 in gold |
> | Second Prize | $15.00 in gold |
> | Third Prize | $10.00 in gold |
> | Total | $50.00 in gold |
>
> This department desires particularly to publish new and original ideas on how to make things electrical, new electrical wrinkles and ideas that are of benefit to the user of electricity, be he a householder, business man, or in a factory.
>
> There are dozens of valuable little stunts and ideas that we young men run across every month, and we mean to publish these for the benefit of all electrical experimenters.
>
> This prize contest is open to everyone. All prizes will be paid upon publication. If two contestants submit the same idea, both will receive the same prize.
>
> Address, *Editor, Electrical Wrinkle Contest*, in care of this publication. Contest closes on the 15th of each month of issue.

THE accompanying illustrations show the metamorphosis of an old electrical bell into a modern electric vibrator. The bell should be one of the larger sizes, so that the vibrator when assembled will be capable of withstanding reasonably rough usage. The bell is disassembled as only those parts necessary for its actual movements, *i.e.*, the magnets, vibrating armature, and contacts, are to be used in the vibrator.



Elevation of the vibrator, showing the disposition of parts; the handle is shown in part at the left.

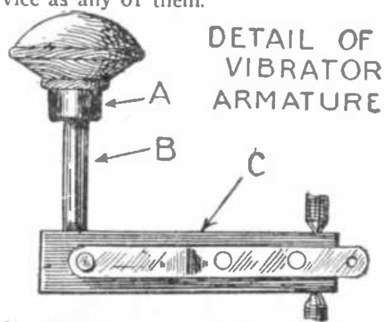
The shape and size of the wooden base, F, will depend upon the type and size of the bell used. It should, however, be sufficiently substantial to withstand the usage to which it will be subjected. A handle, E, is fastened to one end of the base, by means of a large wood screw, from which the head has been cut to form a shank.

Before assembling the parts on their new base, a hole is drilled and tapped in the free end of the armature, C, to take the short, brass rod, B, which is threaded at both ends. This shaft need not be over 2½ inches long, its diameter, of course, being controlled by the thickness of the armature.

The wooden knob, A, serves as the applicator of the instrument. Some of the moulded bakelite knobs, such as on radio apparatus, serve admirably for this purpose.

The switch, D, is of the key type and consists of a strip of 1/16 inch spring brass, ½ inch by 3 inches, fitted with contact points and the applicator knob. It is so placed on the back of the base as to be conveniently operated by a slight pressure from the thumb of the hand holding the instrument.

The vibrator may be operated with dry cells, although a small step-down transformer in a 110v. A.C. line gives better results. The instrument is used in the same way that the commercial vibrators are, and, if carefully constructed, will give as good service as any of them.



The vibrator and armature operated by the electro-magnet of the bell in order to give the desired massage.

What Some of Our Readers Say

Old Memories

Editor, EXPERIMENTER:

The second number of "THE EXPERIMENTER" has been on the newsstands here for a couple of weeks.

I have read both numbers of the new publication and it is just like meeting a long lost and sadly missed friend.

It was away back in November, 1917, that I purchased my first copy of the "*Electrical Experimenter*". I was a sophomore in high school then and an embryo radio bug.

None of us amateurs of those days can ever forget how the old "E. E." guided our destinies in wireless when it looked as if Congressman Alexander was to have his way and we were to be silenced.

Those years went fast and finally "our own" magazine came out under a new name and brought with it a companion known as the "*Radio Amateur News*," and how that new one grew!

But both could not take the place of the one that had been.

I drifted away from radio in 1921 in pursuit of a higher education and became a licensed pharmacist the next year.

And now comes the new "EXPERIMENTER" bringing with it old memories of sharp cold nights with the phones on your ears listening in on the chatter of the lumber schooners plugging up and down the coast, time from old "NPG" at Mare Island and—oh, what's the use—you've been through it and you know the old days before C.W.

THE EXPERIMENTER has come back and I'm going with the best magazine of its kind back to the days of amateur radio.

In other words THE EXPERIMENTER could not be better and we are sure glad to have it back.

Sincerely yours,
RALPH W. DEMORO.

A Young Chemist Is Our Ardent Reader

Editor, EXPERIMENTER:

I have forgotten to write to you since the time I sent my joke; page 597, Scientific Humor, of Oct. 1924, "*Science and Invention*." I have received the check of "only one dollar."

A reporter of "*Science and Invention*," I am also an ardent reader of "THE EXPERIMENTER." I like to "read" and "look over" something about science, inventions and chemistry.

My brother and I have a Chemical "lab." of our own, including about fifty-three (53) chemical reagents. My brother goes to night textile, studying Elementary Chemistry (2nd year). So, now no doubt, you wonder (?) why we buy "*Science and Invention*" and "THE EXPERIMENTER" magazines.

Yours truly,
Lowell, Mass. LESTER KAPALA.

Thinks It It The Best Magazine He Has Ever Read

Editor, EXPERIMENTER:

The first issue of your excellent publication has been received and I think it is the best magazine I have ever read and I am sure many other experimenters will say the same. It is the very thing I have been wishing and waiting for, but please don't ruin it, by putting too many pictures in it.

On the enclosed voting coupon there are some things which I have marked off, not because I do not like them, but because I think they could better give their space to something else.

Very truly yours,
New Orleans, La. WM. N. TULLER.

Hopes We Will Keep Up Our High Standard

Editor, EXPERIMENTER:

I purchased one of the first editions of THE EXPERIMENTER and would fill out the voting coupon if it were not placed where I would have to cut out a radio hook-up diagram to get the coupon. That will be my first criticism. All coupons and articles for clipping should be placed where it will not be necessary to cut out good reading matter to use them.

Television is especially interesting and you can help a great deal by telling all you know about it.

Keep such articles as practical hints and data on building magnets coming and don't hesitate to put in the formulas. I have books that waste a page telling of a formula that is too deep for the average student. But I would rather have the formula and advance to it than to go through life in ignorance.

Thanks for the detailed information on the Tesla High Frequency Resonator.

Chemistry is one of the most valuable sciences in the world so don't slight it.

Junior Experimenter and Elec-Tricks are of value and instructive.

In short I like the entire magazine and hope you will keep up the high standard and not hesitate to include formulas and detailed information.

Very truly yours,
Arkansas City, Kansas. ARTHUR HOLLAND.

A Problem From A Reader

$10.00 Prize for Its Solution

The communication printed below asks for the solution of a problem. The diagram is supplied by the writer. The EXPERIMENTER offers ten dollars gold as a prize for the best solution. If more than one reader solves it in the same way and such is decided to be the best way, a prize of ten dollars will be given to each of the successful competitors.

The competition closes at 12 noon, February 28, 1925.

Mr. H. Gernsback,
Editor EXPERIMENTER:

Sure am glad to see the EXPERIMENTER back on the stands again, and while I read your other magazines I really did miss our little paper. Hope the old readers will rally back and support it again.

I have a little problem which may not be of enough interest to publish, so am enclosing stamps to the amount of 25c for a mail reply. I operate a machine which needs various attentions within an hour. I would like to have a bell ring when each operation is completed, taking "time out" until same is accomplished, then starting machine up again, resetting bell circuit and starting clock again. I hope the drawing is understandable and that you can suggest some means of rigging same up to use.

CECIL MANNERS.

The Problem

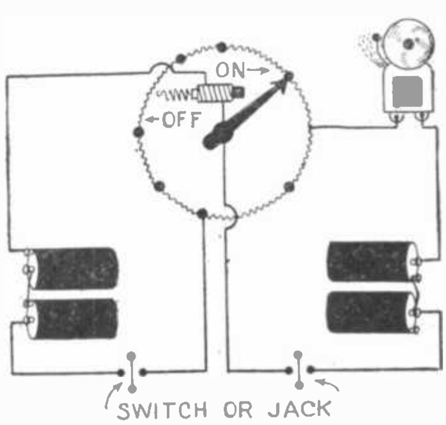
Machine operation is completed, hand touches "stop" which closes bell circuit, ringing bell, also same contact has stopped the clock with magnet.

Operator has opened bell circuit, thus stopping bell ringing, and goes to work, several minutes to accomplish.

Operator is ready to start up again—closes bell circuit and opens clock circuit, releasing magnet device.

FINE! BUT! The bell starts ringing because hand is still on stop and will continue to ring for ¼ minute or until hand passes "stop"; clock also refuses to start for same reason.

PROBLEM? How can clock circuit be opened and closed so as to be ready for next stop, and how can bell circuit be opened and partly closed again and ready for "stop"? *See illustration below.*



This is a suggestion which tells how not to do it. Read our correspondent's query and see if you can do it for him.

Thinks We Couldn't Have Made a Better Change

Editor, EXPERIMENTER:

I think the magazine is fine and I do not believe you could have made a better change in the magazine. It sure helps a student in laboratory and experimental work.

I am taking the "Electrical Engineering Course" in the International Correspondence Schools, and I have got a good many ideas from this magazine.

I prefer Electrical and Chemistry work but radio articles in the magaizne will help boost it along with some.

Yours truly,
Ottumwa, Iowa. LESLIE THOMPSON.

"We Have Improved With Leaps and Bounds"

Editor, EXPERIMENTER:

I think your magazine has improved with leaps and bounds and I like it better than "Practical Electrics." I have not taken your magazine because I never heard of it till a few weeks ago. Now I get it regularly every month.

Wishing you success,
Lawrence, Mass. NOBLE G. BRACE.

"Your Achievement"

Editor, EXPERIMENTER:

I cannot give your achievement too much praise. Until I saw "THE EXPERIMENTER" I thought that "*Science and Invention*" came as near my ideal as possible, but although I will patronize *Science and Invention*, "THE EXPERIMENTER" just "fills the bill." As I did not wish to cut my copy I have placed my ballot below.

So you see I am *very* much in favor of your magazine.

Yours truly,
Lexington, Kentucky. J. RICHARD HAYNES.

Signs Himself "A Loyal Reader"

Editor, EXPERIMENTER:

Desiring to vote and yet not wanting to cut the coupon out of my magazine, I'm sending my vote by letter.

I've been reading "Practical Electrics" for a long time and have been entering into your contests, but when you decided to change the original policy of the publication and add Chemistry and Radio articles, I was overjoyed.

I like all of the electrical contests and the fiction stories but I do think that we should have some chemical contests so as to create interest in that branch of experimentation. Try one and see if it is not very popular.

A loyal reader,
Clemson College, S. C. F. W KINAN.

Wind Electric Plants, Motors and Dynamos

Editor, EXPERIMENTER:

I am a subscriber to your valued magazine and your decision to change the name and scope to embrace more subjects very good.

Will say that I have always been interested in articles on wind electric plants, construction of motors and dynamos, etc.

Please accept my best wishes in getting the magazine under the new name.

Yours truly,
Ballinger, Texas. E. L. MIKA.

Could Not Praise It Too Highly

Editor, EXPERIMENTER:

I got the first issue of "THE EXPERIMENTER" today, and it sure is a dandy. I am sure going to take it all the time. I do not think one could praise it too highly. I like the Chemical Experimenter best of the departments. Keep it up and full of pep.

Yours for success,
Los Animas, Colorado. RAYMOND TRACY.

It Fills the Bill

Editor, EXPERIMENTER:

Just a line to tell you that I certainly like your new publication, THE EXPERIMENTER. It certainly fills the bill better than *Science and Invention*, at least with me.

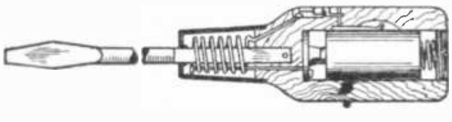
I saw the voting coupon, but instead of using it, I am going to tell you my opinions. I don't want to say anything against any part or department of the magazine, for they are all fine, and while some may not interest me quite as much as others, still the part that I don't care quite so much for may be the only thing others like. So I will hold my peace on dislikes. But as to my especial likes, Experimental Electrics, Experimental Chemistry, and the general news section are my favorites.

I also like your "Short Circuit" department. Some of the cartoons and verses are pretty good, at least to one having had previous experiences of that sort.

Yours for a better (still) EXPERIMENTER.
Seattle, Wash. CARLYLE WEISS.

Latest Electrical Patents

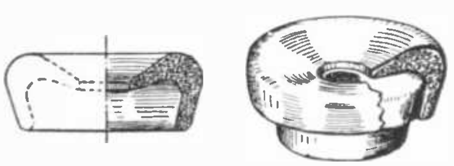
Magnetic Screw Driver



A dry cell and electromagnet are mounted inside the handle of the screw driver. The pressure of a button on the handle closes the electrical circuit and energizes the coil which renders the screw driver blade magnetic. By releasing the button the screws retained by the screw driver ceases to adhere.

Patent No. 1,516,042 issued to H. R. Hines, Warsaw, Ind.

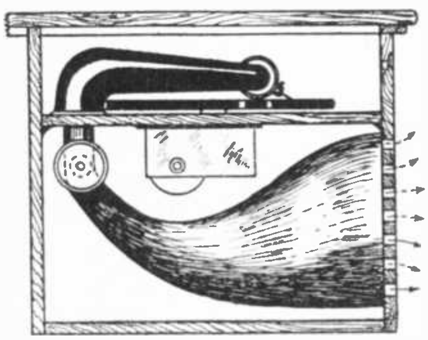
Radio Receiver Ear-Cushion



No radio fan who listens in with earphones need suffer from swollen ears any longer. The ear-cushion shown above made of soft, spongy rubber and easily mounted on the receiver entirely eliminates the objectionable pressure of hard rubbr earphones.

Patent No. 1,514,152 issued to Hugo Gernsback, New York City.

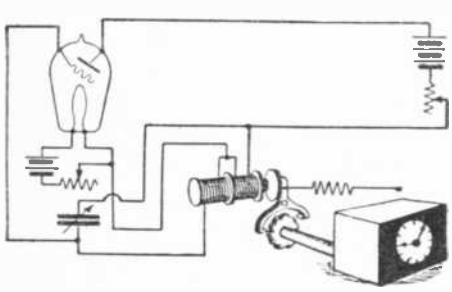
Radio-Phonograph



By means of an ingenious combination of a phonograph and a radio phone receiver an inventor constructs the radio phonograph which, while making a permanent record of incoming messages, renders these messages immediately audible through the horn of the phonograph. To repeat a message the radio phone receiver is disconnected from the circuit, and the phonograph set in operation.

Patent 1,508,726 issued to I. Shapiro, Denver, Colorado.

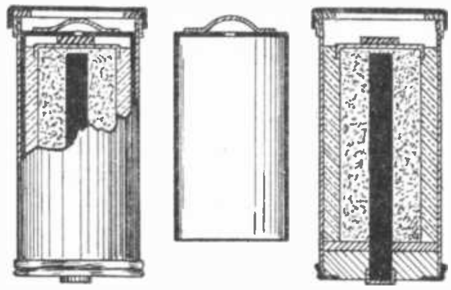
Vacuum Tube Chronometer



In the grid and plate circuit of an oscillating vacuum tube two coils mounted on the same core are connected. The coils actuate the escapement wheel of a clock whose regularity is thus assured by the constancy of oscillation in the tube.

Patent No. 1,574,751 issued to P. I. Wold, East Orange, N. J.

A Non-Deteriorating Dry Cell



Since due to local action many dry cells deteriorate even before they are sold, an inventor proposes a battery whose zinc or negative element is sold separately and inserted into the cell when the latter is put into service. The illustration shows the separate cell and zinc element and the two assembled together.

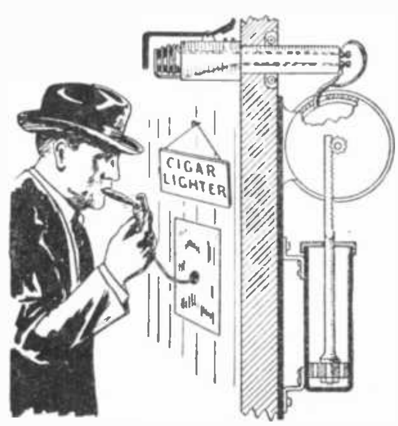
Patent No. 1,515,652 issued to H. F. French and R. C. Venner, Fremont, Ohio.

Electric Water Heater

The novel electric water heater illustrated above is extremely simple. It consists of a rigid insulator cylinder which contains a heating resistance, and which terminates in a standard male thread fitting an ordinary lamp socket. If the heater is used on the table it can be connected to a distant lamp socket by means of an extension cord.

Patent 1,504,944 issued to S. E. Cook, Lincoln, Nebraska.

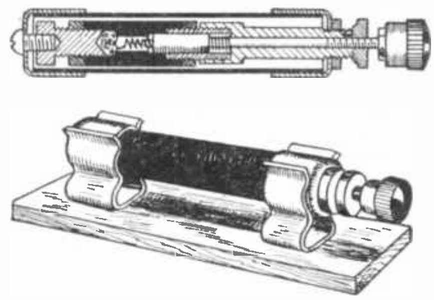
Electric Cigar Lighter



A coil of wire is heated to incandescence by a current conducted by a wire on a drum. The drum, by means of a rack and pinion, is controlled by a dash pot. The cigar lighter when withdrawn unwinds the wire and lifting the shield which protects the coil completes the circuit and the lighter is heated. After release, the drum slowly winds the wire up.

Patent No. 1,516,255 issued to G. J. Fogel, and D. Damberg, Seattle, Wash.

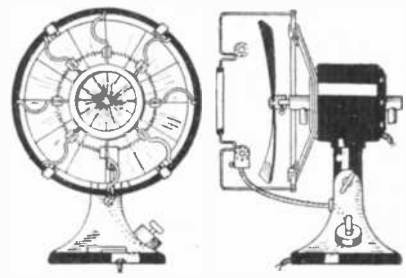
A Compact Detector



This detector whose construction is evident from the cross-sectional drawing above, is very rigidly constructed, and provided with the usual means for delicately adjusting the detector. Its appearance as well as its mounting resembles that of the ordinary cartridge fuse.

Patent No. 1,515,994 issued to A. W. Bowman, Winthrop, Mass.

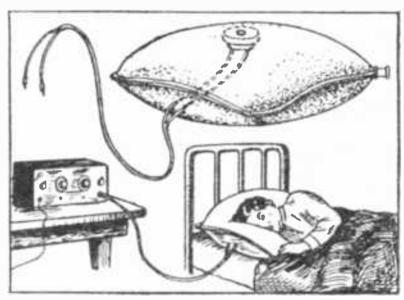
Combination Fan and Heater



A heating coil mounted on the frame work in front of the fan blades and supplied from the same source as the fan motor converts the electric fan into an electric heater. The fan blades serve as heat reflectors.

Patent No. 1,515,731 issued to E. P. Cole, Chicago, Ill.

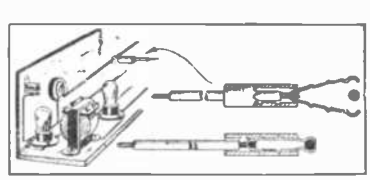
A Pillow Telephone



People confined to their beds who cannot bear the pressure of the regular phones against the ears will find a welcome relief in this pillow telephone which enables them to listen to radio or ordinary telephone conversation in a reclining position.

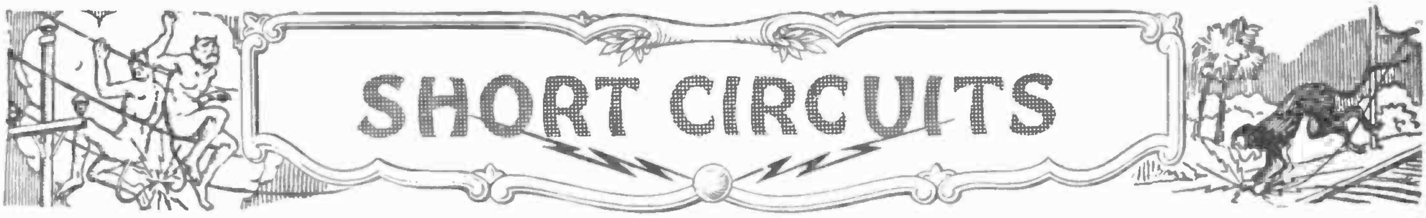
Patent No. 1,515,467 issued to Charles Henry Draving, Phila. Pa.

Wire Connector



This device offers a ready means for making connections to circuit terminals or to any part of a conductor. A pair of wire tongs normally distended are clamped around the conductor when the insulating tube is slipped over the tongs. Connection can be made to live wires without danger.

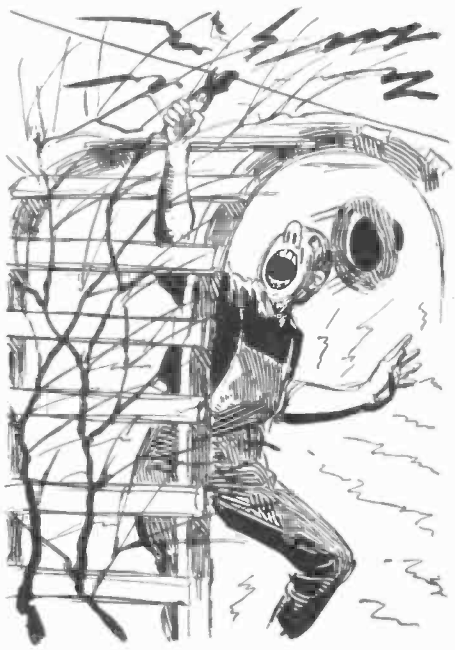
Patent No. 1,515,860 issued to Alonzo Howard, Chicago, Ill.



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!

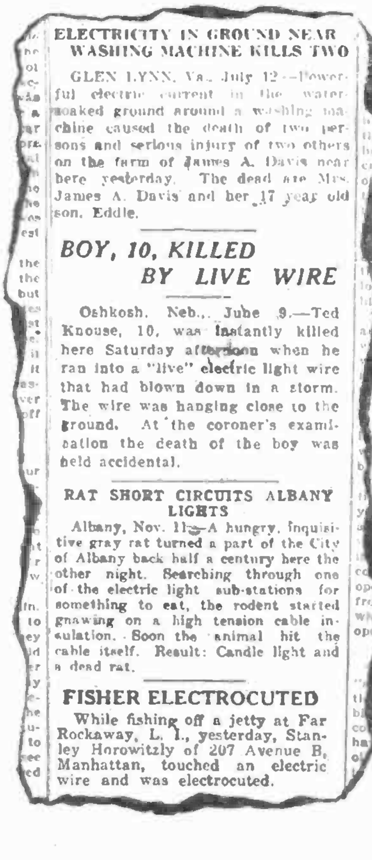
Beneath this ground
Lies Daniel McBright
He put in a fuse
Without a light.

This stone marks the grave
Of Fireman Bett
He jerked a wire
While his feet were wet.



Cold is this tomb
Of Sandy McPine
Whose shears snipped
A wire for a vine.

This grave was made
For Izaak Von Snod
Whose steel fish pole
Formed a lightning rod.



ELECTRICITY IN GROUND NEAR WASHING MACHINE KILLS TWO

GLEN LYNN, Va., July 12.—Powerful electric current in the water-soaked ground around a washing machine caused the death of two persons and serious injury of two others on the farm of James A. Davis near here yesterday. The dead are Mrs. James A. Davis and her 17 year old son, Eddie.

BOY, 10, KILLED BY LIVE WIRE

Oshkosh, Neb., June 9.—Ted Knouse, 10, was instantly killed here Saturday afternoon when he ran into a "live" electric light wire that had blown down in a storm. The wire was hanging close to the ground. At the coroner's examination the death of the boy was held accidental.

RAT SHORT CIRCUITS ALBANY LIGHTS

Albany, Nov. 11.—A hungry, inquisitive gray rat turned a part of the City of Albany back half a century here the other night. Searching through one of the electric light sub-stations for something to eat, the rodent started gnawing on a high tension cable insulation. Soon the animal hit the cable itself. Result: Candle light and a dead rat.

FISHER ELECTROCUTED

While fishing off a jetty at Far Rockaway, L. I., yesterday, Stanley Horowitzly of 207 Avenue B, Manhattan, touched an electric wire and was electrocuted.

Beneath this sod
Is Algernon Frick.
Who, with wire kite line
Did Franklin's trick.

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

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

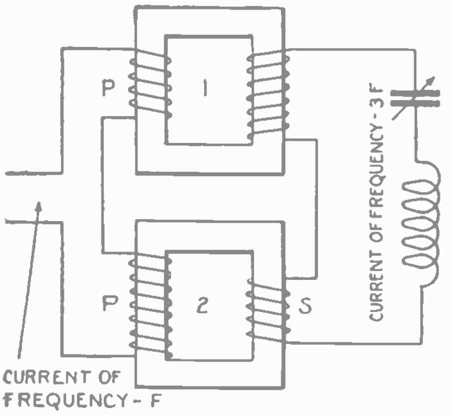
Kindly oblige us by making your letter as short as possible.

Frequency Transformers

(492) H. I. Lever, New York City, asks:

Q. 1. What are frequency transformers?

A. 1. Frequency transformers as the name indicates are devices for changing the frequencies of electrical currents. There are numerous types of such machines, but two



Two transformers connected as shown above will supply a secondary current of three times the frequency of the primary current. The secondary circuit is tuned to improve the operation.

general classes may be distinguished: 1. Dynamic and static frequency transformers. One example of the former class is the familiar induction motor. A current of a certain frequency is sent through the stator of such a machine and an electromotive force of a lower frequency is induced in the rotor. By varying the speed of the rotor the frequency of the secondary current is varied.

The second type of frequency transformer is of greater interest to the amateur. One form of it is illustrated in the accompanying diagram. When an alternating current is sent through the primary of a transformer the secondary current will show the presence of a strong third harmonic. The secondary currents will have different wave forms depending on the intensity of the magnetizing force on the core of the transformer. By opposing the currents due to a weak magnetizing force to those due to a strong one, the third harmonic is accentuated.

Thus in the figure the primary of transformer 1 is wound with a few turns while that of 2 is wound with more turns and the secondaries are so wound and connected that the currents of the fundamental frequency annul each other, leaving only the currents of the third harmonic. The secondary circuit is tuned to this third harmonic in radio work. By this means energy supplied to the primary side with a 10,000 cycle current will induce a 30,000 cycle current in the secondary circuit.

Electronic Conduction

(493) Paul Weiss, New York City, writes:

Q. 1. Will you please explain the electron theory of metallic conduction.

A. 1. According to the electron theory electricity is corpuscular in nature. That is, it consists of small indivisible charges called electrons. All atoms contain such electrons bound to a central nucleus. In metals, however, there are large quantities of such charges or electrons freely roaming through the spaces between the atoms. The motion of theses electrons is normally irregular, but if a difference of potential is established between two points of a metallic conductor an electric force will be exerted on all electrons between these points, and under the influence of this electric field these electrons acquire a component of velocity in the direction of the electric force. The result will be a flow in one direction of these electrons. The electrons being negatively charged their flow in one direction will constitute an electric current in the opposite direction.

Electrical Resonance

(494) Mr. Michael Nadel, Toronto, Canada, asks:

Q. 1. What is meant by electrical resonance?

A. 1. That condition in an alternating current circuit in which the capacitive reactance is exactly equal to the inductive reactance is designated as resonance. Reactance is a property of A.C. circuits which opposes the flow of current without causing loss of energy. While the resistance of a circuit causes a loss of power, reactance merely stores this energy in one instant and returns it to the source in the next. Thus reactance periodically accumulates and discharges energy. Inductive coils and condensers have large reactances and when such apparatus

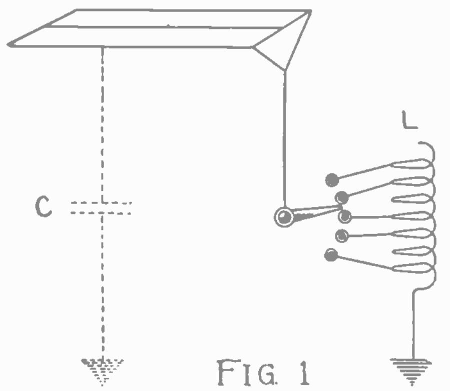


FIG 1

A tuned aerial circuit is in electrical series resonance with the oscillations received by it. In this condition the reactance of the tuning coil L and that of the antenna capacity neutralize each other and thus reduce the impedance of the antenna circuit to a minimum for the frequency for which it is tuned.

is included in a circuit the latter is said to be reactive.

Inductive reactance increases in proportion as the frequencyy of the current increases, while capacitive reactance decreases in proportion as the frequency is increased. Therefore for any circuit with capacity and inductance (as a radio tuning circuit) there is some value of frequency for which the capacitive and inductive reactances are exactly equal. This is the resonant frequency of the circuit. Now, inductive and capacitive reactances are opposite in tendency to resist the current, and in a resonant circuit, therefore, they annul each other. The reactance of a resonant circuit is, then, zero and the current is limited only by the resistance.

Resonance is directly involved in the tuning of a radio circuit. The operator merely varies the inductive and capacitive reactance until the circuit is in resonance for the

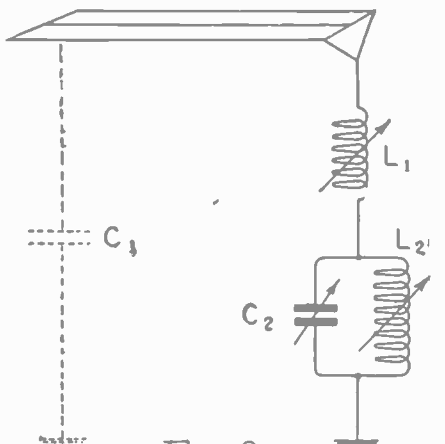


FIG. 2.

A case of parallel resonance is illustrated by the circuit C2 L2. The peculiarity of such circuit is that when tuned to resonance for a certain frequency its impedance to currents of that frequency becomes infinite and theoretically no current of that frequency can pass through the circuit. This characteristic renders such circuits useful in eliminating interference of a particular wave-length.

frequency of the oscillations emitted by the transmitting station which the operator desires to "pick up".

Q. 2. What are series and parallel resonances?

A. 2. These are merely the resonances obtaining in series and a parallel circuits, respectively. Fig. 1 indicates a case of series resonance. It represents the antenna circuit of a radio receiving station, the circuit being completely by the capacity of the antenna with respect to the ground. The radio waves induce an emf. into the antenna but the reactance of the circuit being very high, no appreciable current flows through the circuit. The operator now tunes the circuit by adjusting the coil L until maximum loudness of the signal is obtained. At this point the inductive reactance is exactly equal to the capacitive reactance, and resonance is established.

In Fig. 2 a parallel circuit containing inductance and capacity in the respective branches is shown. We saw that in series circuits the current is maximum when the circuit is resonant to the frequency of the current considered. In parallel circuits, however, resonance to any frequency will reduce all currents of that frequency to zero. Thus in Fig. 2, if the parallel circuit C_2L_2 is tuned to resonance to waves of 300 meters, that is to a frequency 10,000,000 cycles per second, no current of that frequency can pass through the antenna circuit. So that by the arrangement shown, any undesirable wave-lengths can be cut out. This circuit is especially useful where it is desired to eliminate interference from powerful local stations. The circuit C_3L_3 is tuned to the wave-length of this station and then the antenna circuit is tuned by means of L_1, to any desired frequency without interference from the local stations.

Nickeling Without Battery

(493)—P. R. Cook, Williams, Ariz., asks:

Q. 1.—Please give full details for nickel plating without a battery.

A. 1.—Nickeling without battery can only be applied to metals susceptible of replacing nickel in its solutions.

The surface of the object to be nickeled is cleaned in dilute hydrochloric or sulphuric acid and rinsed off in pure water. The bath is made by mixing one part of commercial zinc chloride at 48 degrees B. and two parts of a solution of double nickel-ammonium sulphate saturated in the cold. Bring the liquid to ebullition and immerse in it the object on a zinc hook, and leave for about half an hour.

Work vs. Force in the Electromagnet

(494)—H. B., Manhattan, N. Y., asks:

Q. 1.—Does a current passing through the coils of an electromagnet, the latter sustaining a weight, do any work?

A. 1.—"Doing work" is a commonly used expression for exerting energy. Energy is the product of coulombs by volts (in practical electric units) and the rate of expenditure of energy is expressed in volt-amperes, which are watts. The watts expended in the magnet coils are not affected by the core of the armature or attraction for and sustaining of the armature. If the circuit of the magnet coils were of no resistance, no power would be expended on it and it would still energize the magnet. We quote from our contemporary, the *Electrical Review* of London:

"The difficulty encountered by our correspondent is due to the nature of electro-magnectic pull and its resemblance to muscular pull. It is almost as wearing to hold up a bag of flour as it is to lift it, and the electromagnet consumes power, from the electric circuit, while maintaining its pull without lifting. Let him translate the problem into a 'permanent magnet' pull and then he will see that 'work' is done only during the movement of his plunger. If he winds his pole pieces with wire connected to a galvanometer he will observe a swing during each movement of his plunger, although no battery be in circuit. A similar action takes place in the electromagnet, giving rise to an electromotive force opposed to the battery during inward motion of his plunger. The battery's effort to overcome this small e.m.f. is the only useful work done by the battery—after it has established the magnetic flux equivalent to that of a permanent steel magnet. In pulling out the plunger, he will send a current in the reverse direction through the coil—assisting the battery."

Storage Battery Plates

(495)—Robert B. Bridge, Bartlett, Texas, asks:

Q. 1.—I have some lead grids for radio "B" batteries which need new paste in them. Can the active element be removed from new or serviceable lead battery plates and made into paste to fill lead grids of another battery?

A. 1.—No. In treating new plates with active material it is necessary to scrape the plates perfectly clean, after which the paste is applied. The paste then sets, becoming very hard and brittle and securely adhering to the lead plates. This hardened active material, if removed, will be in powdery form and cannot be made again into a workable paste. New active material should be used in forming the plates of your batteries. Then the paste will set like plaster of Paris.

Q. 2.—What are the ingredients and proportions of each constituent for use in making active material for the positive and negative plates of a lead storage battery?

A. 2.—You will need a quantity of red lead (Pb_3O_4), a quantity of litharge, or yellow oxide of lead (PbO), sulphuric acid and distilled water. The positive plates are filled with a thick paste, made up of red lead and sulphuric acid, diluted with distilled water beforehand to a specific gravity of 1.275. The red lead paste, which will be a dull red color, should be of such consistency as to spread smoothly into all the interstices of the grids so that they will be uniformly filled, and smooth on both sides. The level of the paste should not be higher than the surrounding ribs. As each grid is filled set it carefully aside to harden.

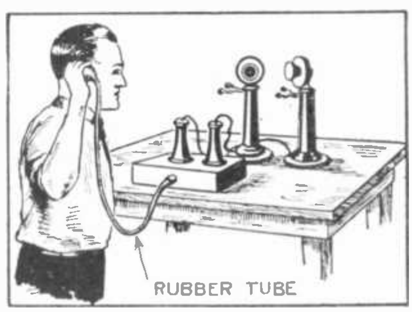
The negative plates are made in exactly the same way, except that the paste used is made up of litharge and electrolyte. This paste is a bright yellow in color. Only a small quantity of each paste, about enough for one plate, should be made at one time, as it hardens quickly like plaster of Paris, as said above, and must be used quickly. The assembled batteries should be charged at normal rate for 20 or 30 hours to form the plates. A more detailed description appeared in the May, 1922, issue of this magazine.

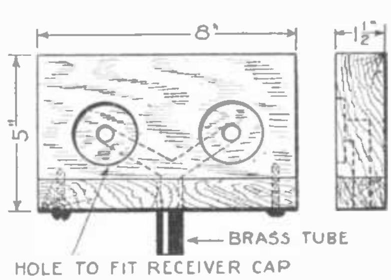
Dual Telephone

(496)—B. G. Reiss, Pittsburgh, Pa., asks:

Q. 1.—Is there any way in which I can connect the receiving end of two telephones into one telephone receiver and use both telephones at the same time? In other words, I want to read news items over both phones to two parties at the same time, and if either party misses a word I want him to say he missed it so that I can repeat and then proceed with the message. While reading these messages I must have one hand and one ear free.

A. 1.—Although it would be possible to interconnect the two phones to one receiver, we do not advise tampering with the instruments. In our illustrations we show a simple accessory that may suit your requirements. A wooden block of the dimensions shown is cut out and drilled with holes as shown. It will be necessary to make the block in two parts in order to drill the proper holes. The two large circles indicate recesses in which the receivers are placed.





How to make two telephone receivers do your work; a headphone or even a full headset may be used in connection therewith.

The other holes conduct the sound to a rubber tube that is attached to the block by means of a brass tube tightly fitted in the front hole. Although an ordinary stethoscope may be used, if you require one ear free an ordinary rubber tube with an enlarged opening will suffice. With this arrangement it is simply necessary to place the two receivers of the telephones on the sound block, which will enable sounds from both receivers to be heard through the one rubber tube, and the operator can talk into both microphones at once so that both parties can hear. Thus no changes are required in the telephones and either can be used independently.

Spectrum of X-rays

(497)—T. Golden, New York City, asks:

Q. 1.—What is meant by an X-ray spectrograph?

A. 1.—X-rays are of different wave-lengths, depending on the amount of energy expended in their emission in the X-ray tube. W. H. Bragg, an English physicist, has devised a means for the separation of a complex X-ray beam into its elements of various wave-lengths, in a manner similar to that used in ordinary spectroscopy. The X-rays being of extremely short wave-length could not be diffracted by the ordinary diffraction grating. Diffraction gratings are glass plates engraved with a very large number of delicate lines, sometimes more than 2,000 per inch, which when light passes through them produce effects similar to that occasioned by the ordinary prism. Since no grating could be made fine enough to satisfy the requirements of X-rays recourse was had to the "natural grating" in crystals. The very regular arrangement of the atoms in the molecules in a crystal made the X-ray spectrometer possible. The X-ray impinging on an atom is reflected. By using the proper angle of incidence the rays reflected from various atoms in the crystal could be made to re-enforce, the direction of this re-enforcement being different for different wave-lengths. In other words, the X-ray spectrometer by altering the position of the crystal with reference to the incident beam of X-rays measures the angle of reflection corresponding to the various components of the beam. The wave-lengths are then obtained from this data by computation.

Corona Discharge

(498)—T. Finck, New York City, asks:

Q. 1.—What is the cause of corona discharge?

A. 1.—Due to the radio-active substances normally present in the crust of the earth, the atmosphere contains a small quantity of ions. Normally these ions perform an irregular motion, but are not present in sufficient quantity to render the air conductive. When a high potential is applied to a transmission line a powerful electrostatic field is set up between the line and the ground return. This field accelerates the ion and imparts to it a great kinetic energy. Upon colliding with a molecule the ion gives up some of this energy to the latter, and in consequence the molecule itself becomes charged and is brought under the influence of the electric field. The number of ions in the air thus becomes multiplied (a process called ionization by collision), and if the field is strong enough a density of ionization is reached which will cause a true definite ionization current to flow. The result is a loss of energy from the transmission system. If the line potential is raised, a subdued violet glow will appear at the surface of the transmission line. This is the corona.

Q. 2. Why is the glow limited to the immediate vicinity of the line?

A. 2. The glow occurs where the density of ionization is greatest, and this in turn is at the place where the potential gradient is a maximum. The potential gradient between two conductors is maximum at the surface of the conductors and becomes zero half way between them.

Foucault Currents

(499) Eliseo Vivas, Caracas, Venezuela, asks:

Q. 1. What is meant by Foucault currents?

A. 1. Foucault currents are more generally known as eddy currents. These are currents due to electromotive forces induced in conductors and circulating or eddying often inside the material of the iron cores of magnets or armatures without supplying the main circuit with power. They are present in all electrical apparatus operating on alternating currents and are especiallyy important in transformers and alternators. In these machines the eddy currentts are induced in the iron pole pieces, yokes and transformer cores, causing an increase in the temperature of the machines as a result of electrical energy converted into heat energy by these local currents. It is to reduce this harmful effect that the magnetic circuits of such machines are made up of laminated iron. The laminations reduce the path of the eddy currents and thus considerably reduce the heating resulting from them.

Q. 2. Are these currents of practical use?

A. 2. Eddy currents have found important application in the high-frequency furnace. In these furnaces the material to be heated, if non-conducting, is placed in a crucible made of some conducting material such as graphite. The crucible is surrounded by a large coil through which rapidly alternating, that is, high-frequency currents circulate. These currents induce in the crucible very large eddy currents which cause the crucible to heat up. Temperatures of a very high degree can be achieved in this manner. If the material to be heated is a conductor, such as iron or copper, a crucible of non-conducting material is used. The Foucault currents in the contents of the crucible doing the heating.

Chemical Nomenclature Potassium Bichromate

(500) John Zerega, Pottsville, Pa., asks:

Q. 1. Why is potassium bichromate so called? It seems to me that a title of that name, containing two anhydrides of chromium trioxide, should have hydrogen in it of two hydroxyl radicals, just as sodium bisulphite has an atom of hydrogen to justify its title of bisulphate.

A. 1. In chemistry there are a certain number of terms justified by long usage which are not absolutely correct, such as carbonic oxide, often used for carbon monoxide, while carbonic acid gas is never called carbonic oxide, although that would be its strictly correct name.

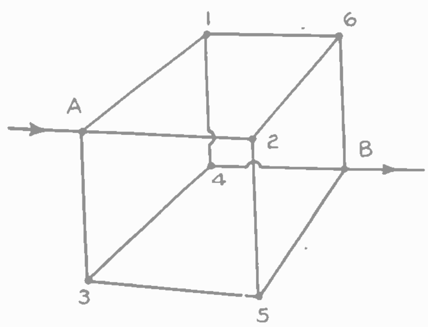
In its chemical relations, chromium trioxide, which figures as an anhydride of an acid, seems to have little or no affinity for water. In potassium bichromate there are represented two chromic acid anhydrides; each of them is dyadic. So we should anticipate finding the equivalent of four monad atoms in it, two of hydrogen. The absence of hydrogen occasions a certain amount of incorrectness in the name of bichromate. The formula which the name potassium bichromate indicates should be K H Cr O_4—but like the boy and the elephant, "there ain't no such animal."

A Test Question

From our German contemporary *Radio* we translated the following:

The following example presupposes familiarity with Ohm's laws. The combined resistance of a number of individual resistances in circuit with each other we know is equal to the sum of their resistances, with the reciprocal of the sum of the reciprocals of the resistances of parallel conductors gives the resistance of them all combined.

In the figure given here a cube is outlined by conductors and each side is equal to the other in all respects. Each side line has a resistance of one ohm. The question now is to determine what the resistance between (A) and (B) is. Simple as the example seems in attempting to calculate it one will come upon very considerable difficulties and it would be very interesting to us to receive information as to experiences with this calculation by our readers.



This is a difficult problem simple as it looks. The bogey is three hours.

Producing Ammonia from the Air

(*Continued from page 251*)

are seen as solids, thus showing in a tangible form a solid salt obtained from the colorless and invisible air.

In case powdered aluminum is used instead of the magnesium the following changes in the above process must be observed. The powdered metal must be thoroughly mixed with 1/15 of its weight of powdered charcoal or lamp black and packed into a crucible as before, care being taken to fit the lid firmly on. The crucible must be heated more strongly than before, best to a good red heat.

When the crucible and its contents are red hot, the mixture in the crucible is ignited by directing a blowpipe flame on the top of the substances. The mixture will ignite and glow strongly throughout. The crucible and its contents are then cooled, broken up and mixed with sand as before. Instead of using water to free the ammonia, as when magnesium was used, a 20% solution of caustic soda is employed in the dropping funnel. The contents of the flask are boiled in this case to obtain a good flow of ammonia gas. The solutions in the absorption bottles are then examined as before.

While magnesium gives the most satisfactory results in this experiment both methods are sure to work if all directions are carefully followed and cannot fail to give satisfactory and instructive results.

The production of ammonia from the air is more properly termed the fixation of atmospheric nitrogen.

Tuned Radio Frequency Circuits

(*Continued from page 244*)

Resistance Coupled Tuned RF Circuit

Resistance coupled amplifiers at wavelengths below 600 meters give very poor results, but if we use a tuned circuit in place of the usual grid leaks, much better results are obtained. Such a circuit is depicted at Fig. 8. The variable resistances may be variable grid leaks. They should be adjusted so that the circuit does not oscillate at any wave-length. This circuit has not been fully developed as yet, but it has promising possibilities.

Tuned Reflex Circuit

Fig. 9 shows an experimental circuit that combines tuned radio frequency amplification, regeneration, detection and audio amplification. The first RF transformer may be the one shown at B, Fig. 10. The second one may be any standard low-loss three circuit tuner having primary, secondary and tickler windings. The secondary is tapped as shown. An audio transformer is used for reflexing the audio currents into the second tube. Loud speaker results are obtained from this circuit.

Experimental Detector and Two Stage Amplifier

(*Continued from page 232*)

in its circuit, until very soon a condition of equilibrium is attained and a constant plate current flows. Under ordinary conditions, the turning on of the filament current will cause the set to start oscillating, without touching any other controls.

The greatest cause of burnt-out filaments can be attributed to excessive filament current. All standard tubes are rated according to their filament voltage and current, these values affording maximum output and life at the same time allowing a wide factor of safety. During operation, the filament is constantly getting thinner, so that its resistance increases. This increase of resistance automatically decreases the filament current. Again, the rate of electronic migration from the filament depends directly on the temperature of the filament which in turn depends on the current. Since the current has decreased, the rate of this electronic migration also decreases, and our tube may stop oscillating or may do so at a different frequency. If we leave the rheostat alone, our signals become weak and the next impulse is to boost the current by decreasing the resistance. By so doing, the temperature of the filament attains the previous value, but since the size of the filament has decreased, the actual number of electrons leaving the filament decreases appreciably. Thus it becomes again necessary to increase the filament current still higher by increasing the voltage. But by this means, we endanger the life of the tube. The most feasible way of overcoming this obstacle is to raise the plate voltage slightly, according to the best value that the characteristic curve affords. It is thus best to operate the filament at constant voltage. Above this constant value, a slight increase in potential boosting the current in direct proportion, causes a very marked increase in filament volatilization or disintegration and the filament will be placed in a very precarious condition. After a 10 per cent. reduction in diameter of the filament, the life of a tube is practically over.

The Ark of the Covenant

(Continued from page 235)

"Possibly. The only concrete thing about it is the cabin—which might be the gondola of a dirigible."

"And the blue wall, Jimmy—the blue wall? Some effect of alcohol on the eyes, maybe?"

"Maybe," I agreed. "Unless—unless what he saw was the side of the airship——"

"Could an airship venture so low?"

"How can I tell, Dan? If the crooks came out of an airship at all, it would be less likely to be spotted if it came as low as possible over the area of operations, where all the inhabitants were unconscious. The higher it remained, the wider the field from which it was visible. You've got to remember that the Metallurgical is only a little less high than the Woolworth, and that the few overhead cables still in existence are well under roof height. Say your supposed airship had a width of just under thirty metres — there's nothing to stop it from nestling in Broadway."

Dan let out a chuckle.

"Columbus! This is deep stuff, Jimmy. We'll have to do a lot of sleuthing before we're through."

"I'll tell you what, Dan. I'm going to get Dick Schuyler on the phone, and ask him to join us tonight at Hazeldene. With the old man and Milliken we'll have a fine old council of war—a regular powwow."

"Has Dickie any sense?"

"You bet you," said I. "Dickie not only has sense, but he knows more about lighter-than-air machines than I do. I don't favor that sort of flying at all."

In the Chemist's Laboratory

When we arrived at Dan's laboratory, he went off to see his research merchants who had been working on the tarnished gold. I didn't go with him, being on the phone to Dick Schuyler. I was lucky enough to find my man at home with his squadron, and he fell in with the idea of joining the party at Hazeldene.

"I'd like to come across on your new bus, Jimmy," he said, "but I'm on duty again at five in the morning. I'll fly over on my own bus if you can berth her for me."

"Tons of room, Dick," I told him.

"When do you start for Hazeldene?"

"At seven from the Battery stage."

"Right," said he. "I'll start with you."

"Very well, old son," I said. "We'll wait for you at the other end."

I heard a splutter come over the phone.

"Now what the devil do you mean by that, Jimmy Boon?" Dick demanded. "I have to inform you that my bus is the quickest thing in the service."

"Can she do five hundred per?" I asked casually.

"Good Lord!" he yelled. "Can the *Merlin?*"

"Start at seven and see for yourself," said I, and rung off.

Dan came back just then, but had no discovery to report.

"My fellows are in the air," he said. "That locket and coin of yours have got them going. There seems to be the faintest trace of radio-activity filming the gold, but they have not determined what it is yet. I've indicated new tests, and they'll work late on them. The thing's a puzzle."

He went off to pack a kit-bag, and while I waited I ran through some newspapers we had bought on the way up town. The columns were crammed with talk of the robbery, and it was evident that business was badly jolted. Every paper spoke of the "panic" on Wall Street, of the run on the branches of the banks, and none of them could make head or tail of the radium mystery. Since the passing of the Personal Liberty Laws, which restored to Americans the right, among other things, to drink when and where they liked, and what they liked, the newspapers had not shown such scare lines. But in all the mass of written stuff there was not a single helpful word.

The phone buzzer went, and I found my father at the other end of the wire.

IV

Lord Almeric Plauscarden of the Bank of England

"Say—is that you, Jimmy? Your father speaking. Is that new plane of yours up to picking a passenger off a liner which is now thirty-six hours away from Sandy Hook?"

"That'll be about fifteen hundred kilometres away—eh?"

The old man swore.

"Durn your new-fangled measures son," he said. "I make it nine hundred American miles——"

"Same thing. When do you want him to be in New York?"

"Could you land him at the Battery at ten to-morrow?"

"Yes. I can pick him—or her—up in good time for that."

"I said 'him,' Jimmy. Lord Almeric Plauscarden, deputy governor of the Bank of England, it is. He's on the *Parnassic* due off Sandy Hook on Wednesday morning."

"Right. I'll do it."

"Thank you son. I'll radio him to expect you—when?"

"Just before six to-morrow morning."

"Good. See you at the Battery presently."

If the old man had patted me on the back physically, he would have pleased me less. There was something in the casual way he had proposed the trip, a certainty of my straight answer, that made me feel good and chesty. I'm sure if I had said no, he'd have taken it as casually.

The feeling had not worn off when Dan Lamont came back with a small kit-bag in his hand.

"What's the smug contentment for, Jimmy?" he asked. "Have you just heard that the President has resigned and that you've been offered the job?"

I told him, and his eyes lightened up.

"Say, Jimmy," he pleaded, like any kid, "I'm coming with you, old man—you're taking me with you, aren't you?"

"It means starting about three in the morning, Dan."

"That doesn't matter, Jimmy. I'd like to come along——"

I said he could, and he danced a little breakdown to show how pleased he was. Dan Lamont's an awful kid in some ways, for all his high position in the scientific world.

We drove down to the Battery in good time, and waited to see the *Merlin* come in. Dan's man drove the roadster away, and presently my father arrived. Dick Schuyler had his seaplane moored a little way along, and he waved his hand.

In a little time I spotted my bus like a dot in the clouds, as Milliken came speeding across Brooklyn, before turning north into the Upper Bay. He was flying good and high, and to an outsider seemed to be overshooting the point for making a safe angle.

I took a look out of the corner of my eye at Dickie Schuyler, and he was standing up in the cockpit of his boat, yelling to attract my attention.

"What's the matter, Dickie?" I yelled.

"That your boat?"

"Yes."

"That fellow's going to crash her—too steep an angle!"

I waved my hand serenely, and he dropped back into his seat to watch, open-mouthed. I fancy he expected to see Milliken turn back or spiral to the right height for planing into the landing-place, but he stood up to watch again when the *Merlin* began her hovering flight down.

My father touched my arm.

"That's something new, Jimmy?" he asked.

He just patted me on the shoulder.

The *Merlin* touched the water about twenty yards out, and taxied slowly up to the jetty. The landing-stage crew turned her, and we all got aboard, Milliken giving up the pilot seat to me. I waved my hand to Dickie Schuyler to show that I was ready, and we both took off together. In that particular flight we didn't go much above four hundred kilometres per, but we left the police boat well behind. In fact, the *Merlin* was berthed and we were all on the jetty waiting when Dickie landed.

"You've got some bus, Jimmy," was all he said at that time—but he had a lot to say later on.

This projected trip out to the *Parnassic* knocked my idea of making Milliken one of the council of war clean on the head. I might have trusted another of my fellows to go over the *Merlin* preparatory to the flight, but I knew that Milliken would not let anyone else do it. An extra gasoline tank had to be shipped and fixed with new connections, and the job wanted a sure hand.

Milliken promised that everything would be ready by three o'clock, and picked out a squad of the more skilled mechanics to do the work. He took it for granted that he would come with me on the flight, and I knew that it would be useless to argue with him, but he agreed to take a bit of sleep when the job of fixing the extra tank was well in hand. So I had to leave it at that.

We had to let Dick Schuyler get off his opinions of the *Merlin* at dinner before we could fall to discussing the robberies seriously. And I am afraid that the dinner was unduly prolonged before I satisfied his curiosity by the aid of a whole thick pad of scribbling paper. The funny thing was that neither the banker nor the man of science seemed to be bored by the arguments. Dan and my father were as

The Ark of the Covenant

(*Continued from page 273*)

keen as a mustard box.

When at length we had the *Merlin* thoroughly explained, we were ready for coffee and other drinks in the smoking room, and there Dan and I put forward our theory of the robbery.

V

Discussing a Theory

"Pinkerton & Co.," said Dick. "I'm pleased to meet you. I often wondered who you were. Well, well—so you're only you, after all!"

"Don't you think it's feasible?" I demanded.

"Ah, if you come to feasible—it's just feasible, Mr. Pinkerton—or are you the Co.?"

"I wish you'd quit kidding, Dickie," I said. "Do you consider the notion reasonable?"

"Reasonable? Mr. Pinkerton, I——"

Then Danny and I both set on him.

"I'll be good—I'll be very good!" he yelled presently. "Shur-rup, Jimmy! Stop it! I'll be good!"

We let him go, and after telling us that we were a couple of thugs, he became very sound on weights and gases and hot air of that sort. He had the latest statistics about dirigibles at his finger-tips.

"I think you may discount the Finn's blue-wall idea. It would be very dangerous for a dirigible of any size worth talking about to come down so near the buildings. On a night like last night, with the wind there was, there would always be a good deal of drift, and a dirigible is not the sort of thing you can push away from a wall, as you do a ship's boat from a quayside.

"I'm inclined to agree with you," Dick went on, "that the Wall Street robberies are linked up with the gasoline and store affairs in Newark. The dope links them up. But why drag in an airship to explain the possibility of the job being done by one gang—to explain the need for the gasoline? I can't see an airship dropping down on Newark and not being spotted. You've worked out that one four-thousand-kilo truck could handle the gold?"

"That's right," I said.

"How far is the gasoline station from the bay side?"

"Not far, but it stands on a canal running into Newark Bay."

"That will do my business," Dick said triumphantly. "Suppose we just put a jolly old motor-ship—not big—say about twenty tons—alongside our nice little gasoline station. On land, we have our four-thousand-kilo truck. The motor-ship drifts down to the gasoline station, and whangs in the dope—gas, or whatever it is, then proceeds to run a pipe up to the tank. It takes its fuel. In the meantime the gang with the truck is operating on Schomberg's Stores. When that is done, the truck moves off across the Hudson by the Cortlandt Street Ferry, which runs all night. It drops its dope in Broadway and down Wall Street. The gang bursts the bank and collects the goods, and off out of the district to a private wharf, say, on the Jersey City side of Newark Bay, to where the jolly little motor-ship has swum over. The little lugger is loaded with the booty, and drops down either side of Richmond—and there you are!"

"Now, do you know," said Dan Lamont, "that's a very pretty story, Dickie—and very well told, too! But how do you get over the fact that all the automobile engines stopped in the doped district?"

"Ours is a special automobile, ours is! Maybe it's an electrically-driven truck——"

"It now appears," my father interposed, "that the street cars down Broadway were stopped below Post Office Square, nobody knows how."

We all turned to stare at him, for we had almost forgotten his presence, he was so silent. Dan was the first to recover.

"That washes out your electric truck, Dickie," he said.

"You can have your airship," Dick said. "When you get crooks that can dope a whole district, stop automobiles and electric cars, spread stickfast, so to speak, on all movement for two hours over an area of a square kilometer—what's to prevent them having an airship that can nestle down on Broadway? Have your airship—but do think tenderly of my little motor-luggage. I was so fond of it."

The Cabin in the Air

"What do you think of it, Mr. Boon?" Dan asked my father.

"I think the difficulty of concentrating, and of getting away undetected, points to an approach from an unexpected quarter—so I say the air. The Finn's dream is too exact to be alcohol. It's simple. Just a cabin coming down from the air—then a blue wall—and some noises that to my layman ear sound uncommonly like machinery. No alcohol dream that. So I say the air. Seems to me that whatever theory you try to develop, you always get about half-way with it. But I have a hunch that the solution will be found in the air. Dick showed more surprise over Jimmy's new seaplane than over the whole robbery. Why?"

"Because Jimmy has evolved a new principle, sir," said Dick.

"Well, Jimmy hasn't got the monopoly of brains in the world. Maybe somebody's evolved a new principle for dirigibles," said the old man. "I'm going to have one more drink. Then I'm going to bed. And if for once I may play the heavy father, I'll advise you all to do the same. Seven hours from now, Jimmy has got to be six hundred miles out at sea."

"So have I," said Dan Lamont proudly.

We all had another drink, and the old man told us exactly how he got on the long green in four and holed out with a handsome putt for a five.

CHAPTER FIVE

I

It was three o'clock on the Tuesday morning, and Dan Lamont and myself were standing in the porch of Hazeldene with my father. The roadster was purring out on the avenue. The old man had the flimsy of a radio message in his hand.

"Lord Almeric will be ready for you, and asks that you will pick up an extra passenger if possible," he said, "most likely his secretary. Can you do it?"

"Sure," I replied. "That will be all right. Did he say anything about the ship's probable position at six o'clock?"

"No. Here's his message—you'd better have it. And here's a note I have written to Lord Almeric.

"You'd better have an automobile waiting for him and his secretary at the Battery from nine o'clock. We may make good time—it is fine flying weather. You'll be all right with Didcot on the *Seven* going across, dad. Well, so long!"

"So long, son! 'Morning, Dan!" my father said. "Look after yourselves. You're fixed all right for food?"

"Milliken is sure to have everything fixed," I told him.

Just then Dick Schuyler, in a dressing-gown, came out of the house.

"I've just been through to headquarters," he said. "There isn't much ice about, and flying conditions are good, Jimmy. You should pick the *Parnassic* up in no time."

"Thanks, old man. Well, so long!"

We roared down to the sheds in quick time, and found the *Merlin* afloat and ready, shining like silver under the arcs. Milliken had everything prepared, from extra

(*Continued on page 276*)

Funnel Dissolves Chemicals

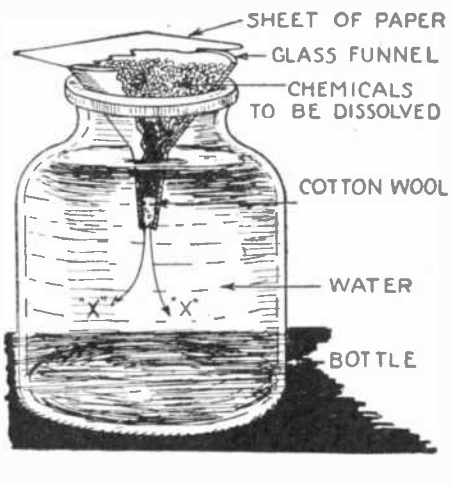
By C. A. Oldroyd

CHEMICALS can be dissolved very quickly, and the resulting solution filtered at the same time, by the plan shown in the illustration.

The water in which the chemicals are to be dissolved is contained in a large wide-necked glass jar. Into the mouth of the jar a glass funnel is placed, the funnel stem is filled with two small bits of cotton-wool, and above the latter, the chemical to be dissolved is placed.

As the water penetrates the cotton wool, it soon reaches the chemical, and dissolves it, the heavier solution sinks to the bottom of the jar, and its place is taken by fresh water. (See arrows "X".)

In a very short time, the whole of the chemical will be dissolved, the cotton wool pads will have retained all impurities, such as dirt, grit, wood splinters, etc. If a sheet



of paper is placed over the funnel, no dust can settle on the chemicals, once they are in the funnel.

Photographic solutions such as hypo, etc., can be prepared with this device in a much shorter time than by placing the crystals in the jar, together with some water, and shaking the whole from time to time.

The increase of specific gravity of a liquid due to its dissolving any substance is utilized here. As the substance goes into solution the specific gravity of the solution is increased and a current descends from the funnel.

A similar method is sometimes used to dissolve the contents of a crucible. It may be used in many cases where salts tightly lodged in a vessel are to be dissolved. The vessel is completely immersed in water and inverted. The same kind of current is set up and solution quickly is effected.

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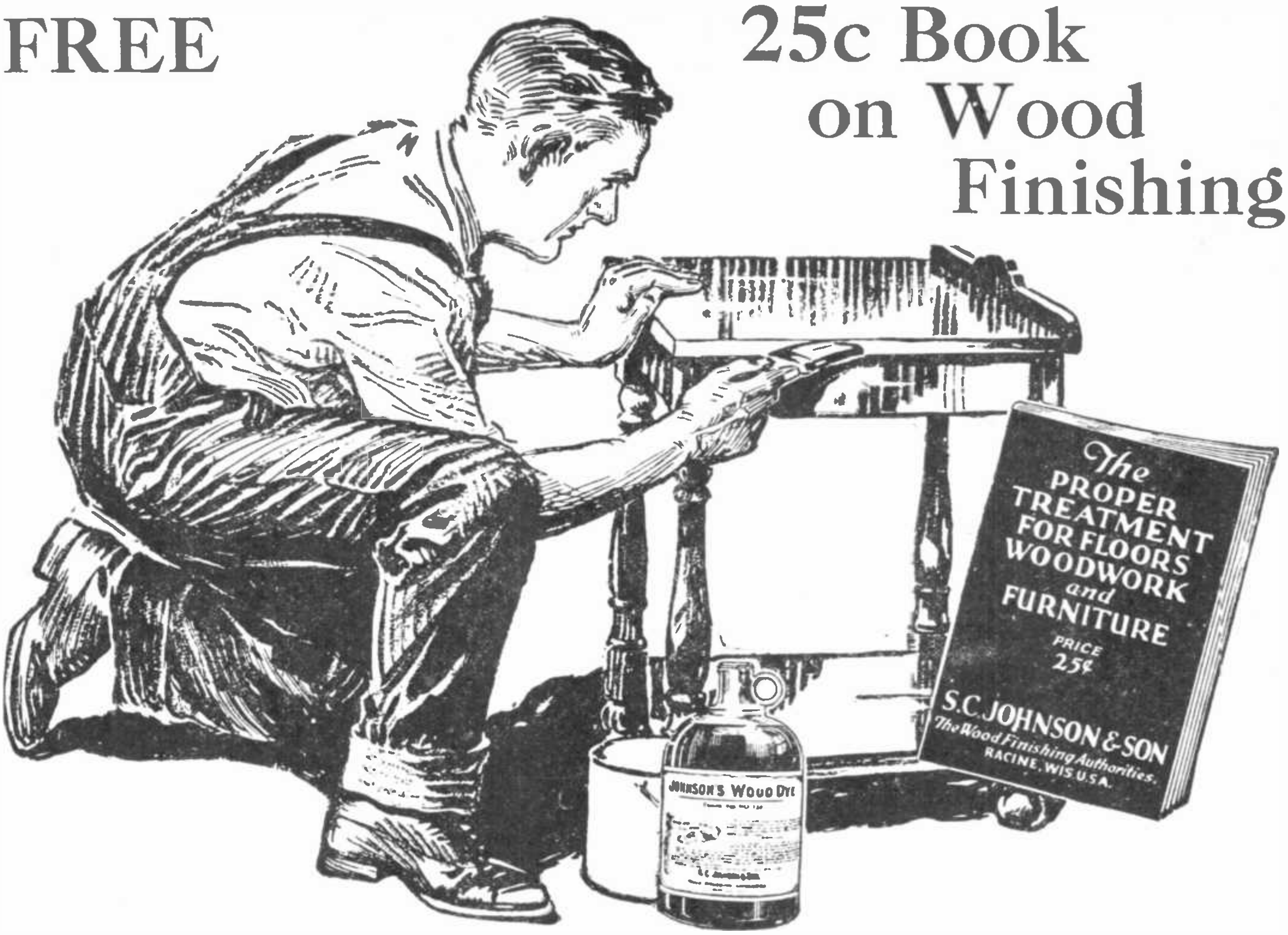

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No. 120 *Fumed Oak*	No. 178 *Brown Flemish*
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The Ark of the Covenant

(*Continued from page 274*)

wraps and food for the passengers, down to easy chairs in the cabin, and the fixing of the tank had been done in very workmanlike fashion. We were good for three thousand kilometers.

A Long Airplane Trip

We took off at 3:15, and I laid the course on a point or two north of east, quickly bringing the *Merlin* up to a steady four hundred kilometers the hour. It was reckoned that we should sight the *Parnassic* at a point six hundred and fifty kilometers east of Cape Cod, and two hundred and fifty south of Halifax, which gave us a thousand-odd kilometers of an outward voyage.

It would have been easy that morning to fly by the stars, they were so clean and bright. Their light was reflected in a dusky sheen off the sea below. To the north the Great Dipper was poised on the end of his handle. What clouds there were about were the merest wisps, and there wasn't a trace of fog.

Danny, wrapped as if for a journey to the North Pole, sat at my side, a little behind where I was in the pilot's seat, and he leaned forward in interested silence to watch every move of my hands, but his eyes were shining with delight at his adventure. The murmur of the silenced engine came to us on a beautiful liquid note which showed clearly how thoroughly Milliken and his men had done their work. That excellent artificer sat on the floor at Danny's feet and leaned against the side of the cabin, his head cocked sideways to listen intently to the voice of the engine. There was nothing to do, for the *Merlin* was flying like an angel.

The lights of steamer after steamer appeared faintly on the skyline, neared, and passed under us out of sight. On our port bow the coastwise lights winked and glowed, until at last Nantucket fell far astern, and in less than an hour's flying we had passed to the south of Cape Cod. When the clock on the control-board showed 4:15, I turned to Milliken.

Picking Up a Liner by Wireless

"Let down the aerial," I said, "and see if we can pick up the *Parnassic*."

It was characteristic of the man that he knew the call and the wave-length without having to ask, and it was without any comment but a quick nod that he lowered the aerial and fixed the receiver to his ears. In a minute the cabin was filled with the blatter of the radio.

"PNC! PNC! PNC!"

He waited a little and repeated the call, then suddenly switched to the open receiver of the radiophone. A strange voice issued from the box and filled the cabin.

"There's something the matter with the *Parnassic's* wireless," said the voice," gone phut, or something. Who's calling her, anyhow?"

"This is the seaplane *Merlin*," said Milliken. "Who are you?"

"British steamship, *Maramba*," the voice replied. "Where are you?" Milliken looked at me.

"Two hundred kilometers or so due east of Cape Cod," I told him, and he repeated it into the transmitter.

"Looking for the *Parnassic?*"

"That's the notion," said Milliken.

"She should be somewhere round 43° north, 60° west. I say, there's something the matter in this blinking ocean this morning—ghostses or something—gives you the creeps. Well, cheerio, *Merlin!*" said the English voice. "Is it cold up there?"

"Not a bit of it, thanks," said Milliken. "Cheerio, *Maramba!*"

"Cheerio and good luck!"

Milliken looked to me for instructions.

"Wait fifteen minutes, Milliken, and try her again," I told him. He pulled up the aerial, and almost without thinking what I was doing I opened the throttle. The hand of the speed-dial went steadily round to 450, as the *Merlin* lunged forward with a keener note.

"What's that glow that comes and goes on the horizon away to the left?" asked Danny, when fifteen minutes had elapsed.

"It must be the light on Cape Sable," I said, with a look at the height register, which showed we were three thousand odd meters above sea level. "About a hundred and sixty kilometers away."

Milliken was letting down the aerial again, and soon the radio once more was splutter-ing its "PNC! PNC! PNC!" But save for the steady song of the engine, no sound greeted our ears. Milliken tried again, and again, without result. An uneasy feeling took hold of me.

"Haul in the aerial, Milliken," I said. "I'm going to let her go full out. Clamp the telephone receiver to your ears, Dan."

Milliken spun the drum round, and turned to help Dan with the cap-receivers, which would cut out all noise except what could come through the phone, and then he did the same for me. When we were all fixed, I opened the cut-out, and gave the *Merlin* full throttle. The dial hand jerked round to five hundred kilometers and stayed put, for that was the limit of its register—but I knew we were going well over the five hundred.

It was now fifteen minutes to five, and a cold grey had crept into the horizon ahead. Steadily, steadily, as we sped into the dawn, the light paled into silver and primrose, the floor of the sea passed from dull blue into a living purple flecked with green and silver. Minutes passed, the hand of the clock on the control-board dragging heavily, and again I felt that curious alertness of perception which I had experienced on and after the flight of the day before. It was more than alertness. It was an anticipation of things that were about to happen.

And now, with the coming of the light, visibility decreased as a haze began to grow over the face of the sea. We dropped on a long angle to fifteen hundred meters. Here and there, the sea was dotted with steamers which, though visible to us, must have been out of sight of each other. These we could see were freighters and small liners.

All three of us in the cabin of the Merlin were staring ahead, expecting to sight the great mass of the *Parnassic* at any moment, for the time was now well past five o'clock. As far as one could judge, we were nearing the position where the liner could be expected, but the haze below us was thickening quickly and, every minute, was lessening our range of vision. Soon it would mean casting circles in search.

Suddenly Milliken touched me lightly on the shoulder and pointed. Ahead of us, four masts and three funnels pierced the mist. I throttled down and whipped into the silencer, then hovered down into a steep angle. We were over the ship in a few seconds.

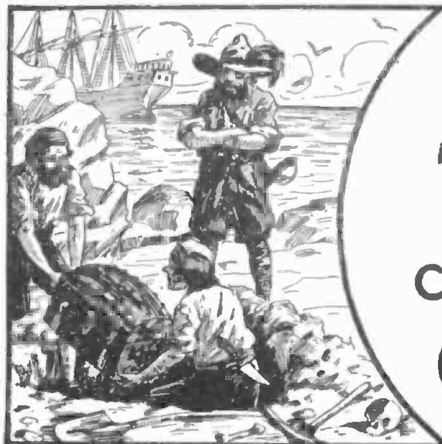
"There's something the matter there, Mr. Boon," said Milliken. "There's no way on her, and she's rolling, broadside on."

"My God!" cried Dan Lamont. "She has been abandoned!"

II

The Abandoned Ship. The *Parnassic*

There was something terrifying in the helplessness of the great liner. Broadside to the rollers, she lay sluggishly, swaying and veering amongst the oily hummocks, and about her was the silence of death itself. Not a soul stirred on her decks, and the thin wisp of steam that curled from one of



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I have not written since I received the big set. I can still say that it far exceeded my anticipations. Since I have been studying with your school I have been appointed chemist for the Scranton Coal Co. testing all the coal and ash by proximate analysis. The lessons are helping me wonderfully, and the interesting way in which they are written makes me wait patiently for each lesson.—MORLAIS COUZENS.

I wish to express my appreciation of your prompt reply to my letter and to the recommendation to the General Electric Co. I intend to start the student engineering course at the works. This is somewhat along electrical lines, but the fact that I had a recommendation from a reliable school no doubt had considerable influence in helping me to secure the job.—H. VAN BENTHUYSEN.

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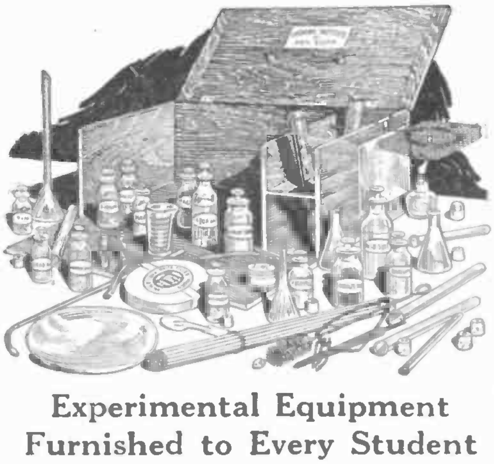
Thanking you for your lessons, which I find not only clear and concise, but wonderfully interesting. I am—ROBT. H. TRAYLOR.

I received employment in the Consolidated Gas. Co. I appreciate very much the good service of the school when a recommendation was asked for.—JOS. DECKER.



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The Ark of the Covenant

(*Continued from page 276*)

her smoke-stacks was the only thing about her that moved.

I know that my hands were shaking on the joy-stick, and it was all I could do to master the sick feeling that was creeping over me. We circled round her as slowly as we could, and coming as close as we dared.

"Look!" I said. "There are dead men lying on the bridge!"

"God in Heaven!" Dan Lamont cried, white to the lips. "What can have happened to them?"

"I don't know," I muttered, "but we'll find out."

I swung the *Merlin* closer still to the liner.

"What are you going to do, sir?" Milliken cried apprehensively.

I am going to put the *Merlin* aboard her, if I can."

"You'll smash her, sir!"

"Maybe," I said madly, "but we're going aboard."

"Don't try it, sir! For God's sake, don't try it!"

"Shut up, Milliken!" I said crossly—then realizing that he wasn't thinking of his own skin, but of his beloved *Merlin*, I grinned at him feebly. "It's all right, Milliken. I won't do anything rash. Let's reconnoitre."

It was out of the question to try and bring the *Merlin* alongside the heaving freeboard of the liner. We would have had our wings smashed for a certainty. Nor was there space available to land on any of the decks, cluttered as they were with ventilators and deck-gear. The only likely place to bring her aboard was on what appeared to be a long stretch of canvas covering the promenade deck astern, and it was a question if that would take her weight. Fortunately, there was no cordage much aft of the jigger-mast, except for one stay coming down to the stern-post, and all halyards were reeved close to the mast. A ventilator or two pierced the awning.

Though it was a terribly risky thing to attempt with the ship rolling as she did, it was the only chance, and I told Milliken what I proposed to do.

"All right, Mr. Boon," he said. "There's nothing else for it—if we are to get aboard. I don't blame you."

"What about you, Dan?" I asked. "It's a hundred to one you'll be smashed or spilled into the sea."

"That's all right, Jimmy. Go ahead with it."

"I'll get down on the floats, Mr. Boon," said Milliken; "might be handy to brace her if she topples."

He fetched out a length of rope and cut it in two, then, taking off his coat, he slid through the hatch to the port-side float.

Getting Aboard the *Parnassic*

I was depending on the *Merlin's* power of hovering to pull the thing off, so I took her up a bit to one side astern of the ship, gauging the distance to miss that after stay. The ship, rolling horridly, came up to meet us. We were over the awning, then it veered from under us—I thought we'd missed it, when—back it swung—slowly. I flicked the rudder round to bring us into line with the ridge of the awning. We landed with a grinding shudder, then heeled sideways as if we'd never right. I had quite made up my mind that we were going to crash over on our back in the sea below—but after a sickening moment or two of suspense we righted!

Dan, flat on the floor, with his head poked out of the hatch, let out a yell.

"By Christopher, Jimmy!" he shouted. "Did you see that?"

"What?"

"Milliken! Oh, you Milliken!"

It was Milliken who had saved us. Lying on the float, he had seized hold of one of the ventilators as we settled, and, with those amazingly powerful arms of his outstretched, had braced us as we toppled, otherwise we would have crashed overboard. Few men living could have done it. When I got down on top of the awning, my mechanic was composedly tying one of the float struts to the ventilator, and a very white face was all he showed of the superhuman effort he had put out.

"Not much damage done, Mr. Boon," he said quietly. "Except that the starboard float has sprung a bit, I think."

"Good for you, Milliken," was all the thanks I dared give him for saving our lives. "You stopped us from going overboard."

Luckily for us, the canvas of the awning was stretched over stout boards, strongly supported, and these were sufficient to take the weight of the seaplane. Milliken lashed the opposite strut to another ventilator, and we all climbed down to the deck.

A Paralyzed Crew

The ship still was held by that awful silence, unbroken save for the lap-lapping of the sea about her, and I fancy all three of us were gripped by a sense of overwhelming awe as we went down the companionway, making for the gangway swung across the after well. From the gangway we saw, down below us, a number of seamen sprawled inertly in the scuppers and about the hatch. We called down to them, but they did not stir, and our voices, unnaturally thin, came back to us in eery echoes from the open hold.

"Let's take the bridge first," I said.

We ran up the ladders to the lower bridge, and in the chart-room we saw an officer lying on the floor in a heap. Dan went into the chart-room, while Milliken followed me to the upper bridge. Here we found two officers huddled behind the high canvas dodger, and on the wheelhouse behind, two seamen lay together, one of them face downwards with his arm rove through a quadrant of the wheel.

It was as if the ship had been struck by a sudden plague. I don't know how Milliken felt about it, for his ugly old face was a mask of stolid calm, but shivers were running up and down my spine. I kneeled beside the officer next to me.

"He's breathing, Milliken!" I cried, and I gently shook the supine figure by the shoulders, but with a sigh the man only settled back more closely against the rails.

"Try the other man," I told Milliken.

My mechanic stepped over, and gently raised the officer—he was the chief—into a sitting position against his knee. The man opened his eyes and blinked at us, then with amazing suddenness was wide awake.

"What the hell?" he said, and staggered to his feet. "Who are you? What are you doing on the bridge? Get off the brid—" His gaze fell on his brother officer. "Here! What have you been doing to Barr? You've killed him!"

He was a huge man, and he made a move towards me with a look that was not very pleasant.

"Don't be silly," I said, as quietly as I might. "He's asleep—the same as you have been."

"What's the matter with the ship? God! She's adrift! What——" He stared at us, and passed his hand over his head. "Lord! I remember now—but it was dark then——"

The Captain of the *Parnassic*

Meantime Milliken had managed to waken the younger man, and just then Dan came up the ladder with the officer who had been lying on the floor of the chart-room. Only by his braided cap could one tell he was the captain, for he was in pyjamas with a thick blanket-coat over them.

Build the Set you have dreamed of

TROPADYNE SUPERADIO OUTFIT

Superior to Super-Heterodyne

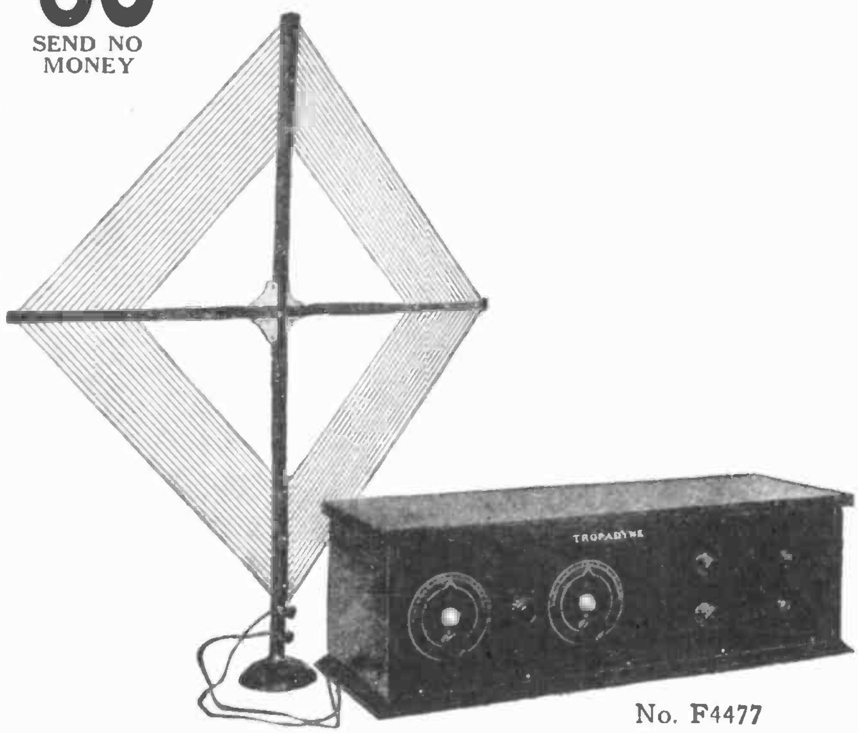
$60.50

SEND NO MONEY

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

The outfit advertised here is complete, as listed below, everything needed is included, down to the last screw. The charts, blueprints, directions and photos furnished are so complete and explicit that anyone can build this set and have it working within a few hours. There is nothing additional to buy except the necessary batteries and tubes. Price includes mahogany cabinet and folding loop aerial.

You can pay $150 or more for an outfit, or $200 or more for a set, but you cannot possibly buy a better set than this one.



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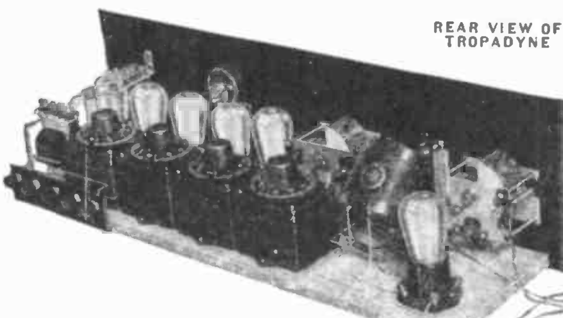
Your Money Refunded if this set does not satisfy you in all respects—if after 5 days' fair trial you do not proclaim the TROPADYNE the best radio set you ever listened to.



REAR VIEW OF TROPADYNE

Note These Important Features:

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

LOOP RECEPTION—Outside aerial not to be used with this set—the complete loop is included in outfit.

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

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

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

ECONOMY and SIMPLICITY—This is not a reflex, yet six tubes do the work for which other sets require eight to ten.

The Editor of the Radio News

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

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

Complete List of Parts:

4 *RICO* Tropaformers; 1 Standard Variocoupler; 2 *Certified* Low Loss 23-plate Condensers; 1 *Calibrated* Transformer; 2 Jacks; 3 Fixed Condensers; 6 Bakelite Sockets; 2 Vernier Dials; 1 Rheostat; 1 Potentiometer; 1 7x24 Panel; 1 7x24 Mahogany Cabinet and Baseboard; 40 ft. Bus Bar Wire; 1 Folding Loop Aerial; 1 Grid Leak and Mounting; Binding Posts; Flexible Wire; 1 Bakelite Binding Post Strip; 4 doz. Screws; Full Directions.

RADIO SPECIALTY COMPANY, 98S PARK PLACE, NEW YORK

Tropadyne Gets Europe!

"Received 2BD, Aberdeen, on November 25th. Results good, except noises. 11:30 to 11:40 talk, from 11:40 to 12:00 piano number. Piano number good, talk poor. Used Tropadyne Circuit."

J. ZIMMER, 157 James St., Newark, N. J.

The above has been verified by "RADIO NEWS"

SEE OUR 2-PAGE AD ON PAGES 1378 and 1379 RADIO NEWS

Exp. 2

SEND NO MONEY

RADIO SPECIALTY CO., 98S Park Place, New York, N. Y.

Please send at once one complete Tropadyne Superadio Outfit as advertised in February Experimenter. I will pay postman or expressman $60.50 upon arrival.

NAME ....

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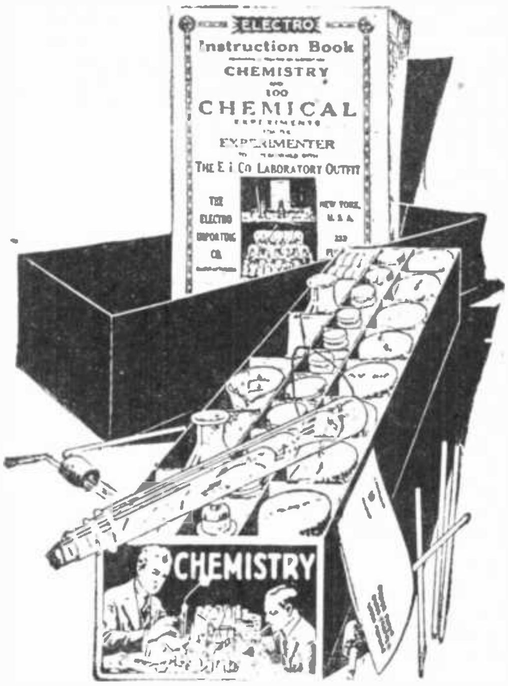
A Chemistry Laboratory for $7.00

Think of it, fellows! Here is a *real* chemistry outfit with regular chemical apparatus that performs those fascinating, actual chemical experiments. This outfit is not a toy, put up merely to amuse, but a practical laboratory set, with all the chemicals, apparata and reagents necessary to perform real work and to teach the beginner all the secrets of inorganic chemistry.



DESCRIPTION OF THE OUTFIT

The outfit consists of 44 Chemicals and Reagents all C. P. put up in appropriate wooden boxes, glass bottles, and hermetically closed jars. The acids are put up in glass bottles with ground-in glass stoppers, and there is a sufficient quantity of chemicals supplied (mostly one to two ounces) to make dozens of experiments with each.

The apparatus furnished are all of the best obtainable make and of standard laboratory size and shape.

The Instruction Book is a real Chemistry Course for the Beginner. Some of the Contents are: *Division of Matter*: This is a Treatise on Elementary Chemistry and deals with the theory of the Elements, Molecules and Atoms, etc. *Chemical Nomenclature*: This explains in simple language the derivation of the chemical names of the elements and their compounds. There is a chapter on *Laboratory Operations; Glass Working; First Aid; Fire Extinguishers; Experimenters' Aphorisms*, etc.

A good part of the book is devoted to Weights and Measures. The Metric System, The English System and the U. S. System are fully explained.

The following tables are furnished: Symbols and Atomic Weights of the Elements; Measures of Weights, Volume, Capacity and Length; per cent solutions; Conversion of Measure expressed in parts; poisons and their antidotes; technical and common name of chemical substances; formulas for cleaning various substances, etc., etc.

Among the 100 *Experiments are:*

How to make chemical tricks; How to make invisible and magic inks; How to test flour; How to test soil; How to make chlorine gas and smoke (German War Gas); How to bleach cloth and flowers; How to produce Oxygen and Hydrogen; How to make chemical colors; How to test Acids and Alkalies and hundreds of interesting hints and formulas.

Complete, $7.00 **Sh. Wght., 10 lbs.** **(Shipped by Express only)**

(We guarantee shipment within 24 hours after your order is received)

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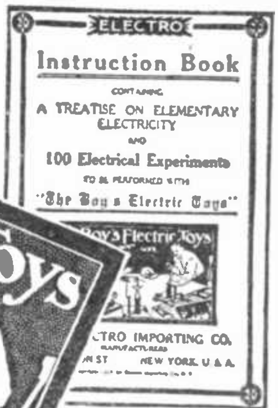
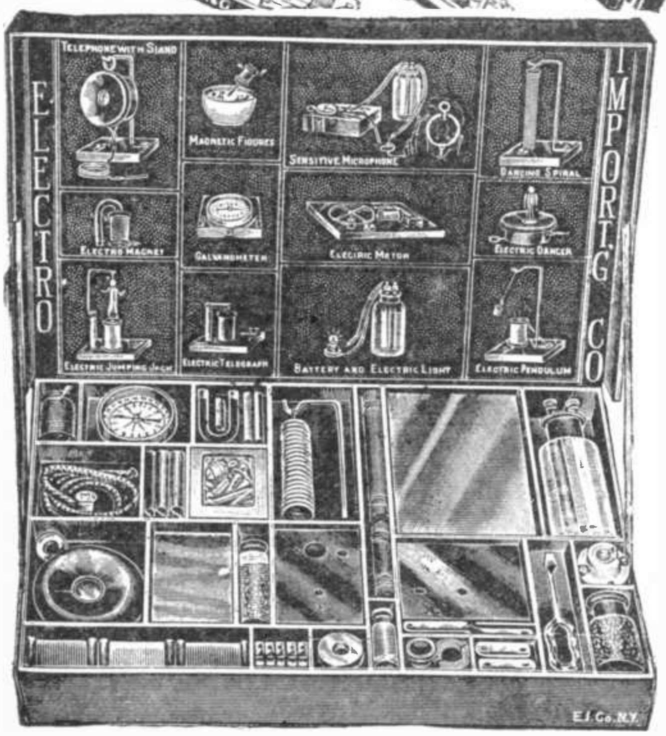


Every Fellow Wants the

BOY'S ELECTRIC TOYS



The Boy's Electric Toys contains: Enough material to make and complete over twenty-five different electrical apparatus without any other tools except a screwdriver furnished with the outfit. Student's chromic plunge battery, compass-galvanometer, solenoid, telephone receiver, electric lamp, etc. Enough various parts, wire, etc., are furnished to make the following apparatus:

Electromagnet, electric cannon, magnetic pictures, dancing spiral, electric hammer, galvanometer, voltmeter, hook for telephone receiver, condenser, sensitive microphone, short distance wireless telephone, test storage battery, shocking coil, complete telegraph set, electric riveting machine, electric buzzer, dancing fishes, singing telephones, mysterious dancing man, electric jumping jack, magnetic geometric figures, rheostat, erratic pendulum, electric butterfly, thermo-electric motor, visual telegraph, etc., etc.

With the instruction book we furnish one hundred experiments that can be made with this outfit, nearly all of these being illustrated with superb illustrations. No other materials, goods or supplies are necessary.

The outfit contains 114 *separate pieces of material and* 24 *pieces of finished articles ready to use at once.*

The size over all of the outfit is 14 x 9 x 2¼. Shipping weight 8 pounds.

"The Boy's Electric Toys" outfit as described, $7.00. Immediate shipment.

SEND NO MONEY

We have so much confidence in these sets that we desire to ship either one to you by express C.O.D. with the privilege of inspection. In other words, we ship on approval. It does not cost you one cent to take a good look at whichever outfit you want, and see if it comes up to your expectations. If it does, pay the express man $7.00, plus express charges. If not, you need not accept it, and we will pay the return charges as well.

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Please send me by express THE CHEMICAL LABORATORY. If I don't like it I need not accept it. If I want it I only pay $7.00 plus the few cents express charge.

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Exp—2-25

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Please send me by express THE BOY'S ELECTRIC TOYS. If I don't like it I need not accept it. If I want it I only pay $7.00 plus the few cents express charge.

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Exp—2-25

The Ark of the Covenant

(Continued from page 278)

"What's the matter, Mr. Boscence?" he demanded wildly. "It is two hours since we hove to—just before six bells in the middle watch—I've been asleep—or unconscious. This gentleman—what has happened to the ship?"

"I don't rightly know, sir," the chief said, passing his hand over his head bewilderedly. "There's something queer here ——"

The captain stuck out his wh[illegible] torpedo beard.

"Get some way on the ship. Ring down—" He whirled round to the wheelhouse as he spoke, and broke off. "For the love of God—look at the steersmen! What's come over the ship?"

I nodded to Milliken, who ran into the caboose and woke the seamen quite easily.

Dan looked at me in a dazed sort of way.

"Jimmy!" he gasped. "It's Wall Street all over again! You'd better explain to the captain."

"Where do you come from?" the captain demanded. "How do you get aboard my ship? You're not passengers."

"You're Commodore Sir Peter Weatherly, aren't you, sir? I asked.

"That's me, he snapped.

"I'm James Boon, Sir Peter," I explained "I've come out on my seaplane, the *Merlin*, to take Lord Almeric Pluscarden on shore We found your ship adrift, and I managed to land my machine on your awning aft there. The whole ship has been doped, sir."

"Ring down to the engine-room, can't you, Boscence?" the commodore said to his second in command, ignoring me. "We must have some way on her."

"I have done so, sir," the bewildered chief officer replied. "I get no bell back from them."

"If I might suggest something, Sir Peter," I ventured. "Let my mechanic, Milliken go round with your officer here," indicating the younger man, "and waken up the crew."

For a moment he stared at me as though trying to collect his thoughts, then he nodded briskly.

"Do that, Barr," he ordered. "Wake the crew—though what on earth they should be asleep for beats me. And you, young man—Mr. Boon, you say you are—perhaps you'll explain as much as you can of this business."

"This is my friend, Mr. Dan Lamont," I said. "He will bear out what I tell you, sir. But first, let me ask you to walk to where you can look into the after well——"

"Come along, then—this way!"

He led the way down to the boat deck, and made for the rail over the well.

"God in Heaven!" he exclaimed. "My men! Are they dead?"

"No, sir," said Dan. "I imagine they're asleep as you have been. They'll waken easily."

"Come to my cabin, gentlemen," said the sailor. "I'm all adrift. I simply can't understand this thing at all."

I must say that I admired the grip he had of himself, and his acceptance of what must have been a bewildering situation. He was alert and business-like as he led the way back to the lower bridge.

"Mr. Boscence," he called up to the chief officer. "The first thing to do is to get some way on the ship. Give Mr. Barr a hail, and tell him to turn out all the engine-room staff not on duty, and to send them down to—to wake their fellows. Tell them not to interfere with any of the passengers who may be on deck or in the saloons. Pass the word to such of the crew as may be stirring. Do you understand?"

"Aye, sir!"

The Radio Union

The Radio Purchaser and Radio Dealer in an Association for Mutual Benefit

Under the auspices of "Radio News," the World's Leading Radio Magazine, an association has been formed, having for its object, the bringing together of consumer and merchant, in a way that will permit every radio owner to save money on his purchases.

The Radio Union is a mutual benefit association of radio stores and radio enthusiasts. Every member store agrees to give a discount on every sale made to individual members. The member stores will benefit because our members will patronize those stores at which they obtain a discount on their purchases—the individual members benefit because they will save money on every radio purchase, and eventually on purchases made for all other necessities, such as groceries, clothing, jewelry, automobile supplies, drugs, furniture, etc., etc.

Every live radio dealer has been invited to join The Radio Union, and contracts stipulating the discounts that will be allowed on members' purchases are pouring in from every city in this country. Eventually invitations will be sent to stores selling all classes of merchandise, in your town, so that very shortly you can make large savings, not only on your radio purchases, but on everything else you or your family buy. The list of membership stores will be sent to every enrolled member.

The dues for membership will be $5.00, entitling you to life membership, guaranteeing you against any further dues or assessments, and entitling you to a discount on every purchase you or any of your immediate family make in a membership store.

We want 50,000 charter members. To these first we offer a membership at only $2.00—a saving of $3.00. Remember this is the only cost—there are no dues or assessments that you will ever have to pay. All you must do to obtain your discounts from member stores is to send us once a month, or oftener if you wish, the bills or sales slips for purchases made from member stores. These bills will be verified by the stores from which the goods were purchased and they will remit the discounts to us. These savings we forward to you after deducting a small charge for our operating expenses and overhead.

You have everything to gain by becoming a member in this Radio Union and can save $3.00 by joining now as a charter member. A single purchase will more than make up the small fee of $2.00 which you pay to join the Association.

DO IT TODAY

Remember the regular Membership fee will be $5.00 hereafter.

Fill out the application blank, and mail it today with your remittance.

Officers and Directors

The personnel of the Officers and Directors of The Radio Union Inc. is quite sufficient to guarantee the success of the new association. The Officers and Directors are Messrs. Hugo and Sidney Gernsback and Mr. R. W. DeMott, the owners of the Experimenter Publishing Company, the publishers of Radio News, Science and Invention, The Experimenter, and Motor Camper & Tourist. These great magazines, with their tremendous circulation, at the disposal of The Radio Union, assure an overwhelming success to the new organization.

APPLICATION FOR MEMBERSHIP

THE RADIO UNION, INC., 53 Park Place, New York City, N. Y.

Gentlemen—Enclosed you will find Two Dollars ($2.00) for charter Membership fee in The Radio Union, Inc.

I understand this payment entitles me to a Life Membership and to a discount on every purchase I make in a membership store, list of which you will forward.

NAME .... STREET ....

TOWN .... STATE ....

The Ark of the Covenants

(Continued from page 281)

He turned to Dan and myself.

"You'll forgive my lack of courtesy in your welcome, I am sure. You were not expected to appear in circumstances such as these. Come with me, please. We won't go to my cabin. I must look after the ship. You can tell me what you know as we go along."

We followed him below, but when we came to the smoking-saloon, and found there a number of passengers huddled like dead men round the card tables, or sprawled out on the floor, it was too much for the captain.

"It is no use. I must get the hang of the thing first of all," he said. "You'll have to tell me what it means. This morning at three o'clock I was called out of my bunk by word that a red riding-light was floating on the sea ahead. I turned out, and was immediately met by a message that had come over the wireless phone. It came from the U. S. battleship *Argonne*—or was supposed to come from her: 'Heave to immediately. Danger.' I passed the word to the bridge to obey the order, and made to follow. I had no sooner reached the chart-room—I wanted my binoculars—when—well—the next thing I remember is being spoken to by this young man—Lamont, did you say? That's my side of it. Now, as clearly and as quickly as you can—what do you know?"

With as few words as I could, I told him about Wall Street, of the mysterious sleep, and how the thieves had got away with two and a half millions in gold.

"There was something about that came over the wireless yesterday," said the captain. "It's a very mysterious thing. You say that the folk around Wall Street were chloroformed—or whatever it is—just as we've been?"

"Exactly, sir."

"Then—by thunder!—they've been after the specie I'm carrying—a half million sterling in gold!"

III

The Gold on the *Parnassic* Stolen

He darted off through the saloon doorway, and down the alleyway, Dan and I close to his heels. He stopped at a cabin labelled, "Purser," and banged on it, trying the handle at the same time. A fat little man opened the door, and blinked sleepily at us.

"Quick, Strachan!" yelled the captain. "The second key of the strong-room! Hurry, man!"

"What's the matter, sir?"

"Damn it, man! Don't argue! Put on some clothes and bring the key of the strong-room as fast as you can. Hurry!"

He turned and barged past us back the way he had come, and up a companionway, Dan and I tagging after him. We followed him into his suite, beyond which was the strong-room. He needn't have worried about the key. Right in the middle of the steel door was a yawning hole, through which we saw, in a brilliant blaze of electric light, the disorder of smashed wooden cases.

"Piracy, by God!" gasped Sir Peter. "Piracy on the high seas—and on my ship! It can't have been done from aboard the ship—they'd never get away with that weight of gold—half a million!"

"Florins?" asked Dan.

"Florins be damned!" said the captain. "Ten-florin pieces. Sovereigns!"[1]

[1] In 1929, when Britain and the U. S. A. adopted the metric system for weights and measures, the florin of 100 farthlings became the British unit of money in a new decimal coinage.

Engineers Association Opens Way to Big-Pay Electrical Jobs For 500 Young Men!

Shortage of available trained men for big-pay electrical jobs has prompted the Associated Electrical Engineers to undertake, at their headquarters in Chicago, a unique training enterprise designed to supply the needed man-power. A new method, originated by their engineers, is reported to combine actual electrical practice and training in a way that enables any young man, with or without education, to become a trained Electrical Expert within 12 months, with earning capacity of $10 to $15 a day. By confining the training entirely to practical electrical work, they have cut down the time required to only one hour per day. A complete outfit of practical equipment is supplied, so that the necessary experience may be gained in training. 500 young men are to be admitted, and a number of places are still open. Any young man of good standing with a desire to better himself, is invited to write, at once, to the Associated Electrical Engineers, Dept. 425, at 537 South Dearborn St., Chicago, Ill.

Ball Lightning Made in the Laboratory

(Continued from page 255)

at frequencies up to 1,000 cycles. A similar effect is produced by using alternating current for heating the filament. In either case the globule streamer assumes a wave motion, traveling across the arc in beautifully sharp curves, rather than in straight lines.

If the arc current is maintained, this effect continues for hours before the minute portion of tungsten ceases to act. The effect can then be brought back by again cutting out the filament current for a moment and thus sputtering another trace of tungsten into the argon vapor. If the arc current is shut off for about 40 seconds, the effect disappears—the tungsten has been deposited and the streamer discharge will not start again until more of the metal has been sputtered from the filament.

According to this theory, tungsten atoms, negatively charged, roam about in the spaces outside the arc. These atoms entering the "electric double layer" lose their charge and collect on the positive sheath, forming small globules. At these points on the double layer the negative sheath is indented, and when sufficient tungsten accumulates, this indentation becomes sharp and will extend into the arc until the globules tear away. By the nature of their formation the globules will thus have a positive sheath on the outside and a negative sheath on the inside; an arrangement the reverse of that found in the arc proper.

These glowing detached globules seem to have characteristics similar in many respects to those that have been described as belonging to ball lighting. It is perhaps not certain that ball lighting is anything more than a psychological phenomenon, but if it has objective reality, it may possibly be due to causes similar to those which give rise to the globules described above. The ions of a highly ionized gas, such as the electrified atmosphere, recombine on solid particles forming small spheres, the solid particles being retained within the ball by their charges and the electric field being retained at the surface of the ball. This theory is very effectively supported by the marked resemblance between ball lightning and the globules of liquid fire produced in Dr. Langmuir's experiments.

Listening in for the Stars

(Continued from page 262)

ceiving CW of about 0.0000006 meters. Of course these waves are not radiated by stellar radio transmitting stations, but are just commonplace light waves, whose energy, through the relay action of a photoelectric cell, is rendered audible.

A photoelectric cell of the type shown in C, Fig. 1, is trained by the aid of a powerful telescope on the position in the sky at which a star is to be observed. When the star reaches this position the feeble light rays emitted by it impinge on a film of potassium with which one side of the cell is coated. These rays excite the atoms of potassium to such an extent that the latter emit electrons. The electrode (P) in the cell is charged to a positive potential by the battery (B) and in consequence the electrons emitted by the potassium are attracted by the electrode.

The flow of electrons from the potassium to the electrode (P) constitutes a feeble electric current which charges grid (1) in the amplifier tube (A). Another grid (2) is used to reduce the space charge to a convenient normal value, at which the variations in the charge on grid (1) are best amplified. The amplified current is then passed through the telephone receiver (R). Thus the position of the star is instantly announced by a sound in the receiver.

It may be of interest to consider in this connection a question raised by one of our readers endowed with more curiosity than information concerning radio. "Since light rays are merely short electromagnetic vibrations," writes our correspondent, "why cannot a radio circuit be designed which will receive light waves in exactly the same manner as ordinary 'wireless' waves are received today?" Our answer to this interesting question is that while such radio circuit can be designed the execution of the design would be a physical impossibility. For the reception of waves of yellow light, for instance, a circuit provided with a capacity of only 1 microfarad would have to have an inductance not exceeding 0.000,000,000,000,000,0000.09 microhenry. To reduce the inductance of an electrical circuit to such low value is manifestly impossible.

Chemistry at Home

(*Continued from page 247*)

solution of oxalic acid in water. It is possible to use a concentrated solution, but then the place moistened must be thoroughly washed with pure water after the stain has disappeared or the fibre of the material will suffer. Stains of iron rust on marble and tile are removed in the same way, or, better still, by making in a tumbler a paste, consisting of one teaspoon of oxalic acid, half a teaspoon of antimony trichloride and sufficient water to make a paste. Leave this paste on the stain for a day or two and the discoloration will disappear. Many of the stains with which wood is colored are also removed by bleaching with oxalic acid, but in order to do this effectively, the acid solution must be quite warm.

Paints of all kinds are most readily removed from furniture with some strong caustic such as sodium or potassium hydroxide. Here the caustic does not actually remove the paint or varnish, but rather loosens it. Such a paint remover is made of a mixture of various chemicals, which, although not particularly pleasant to work with, is extremely effective when correctly applied. To 16 parts of water glass (sodium silicate) add 2 parts of ammonia and mix. To this solution 1 part of sodium hydroxide is added and dissolved. Before using see that the whole is thoroughly mixed. Brush this mixture on the painted work which is to be removed and let it remain until the paint has softened. When using a brush be sure to clean thoroughly with warm water before putting it away. The softened paint can be removed by scraping.

Trying Out the "Beam"

The Government are going to co-operate with the Marconi Company in the trial of powerful "Beam" stations, for communication with South Africa, India, Canada, and Australia. By means of a reflector which partially surrounds the transmitting aerial, a fraction of the outgoing energy is concentrated into a "beam" directed towards the receiving station which receives some of the energy formerly broadcast in all directions.

Wireless "Power"

Experimental tests are being carried out at Southend and Leigh-on-Sea, England, with a device by which it is claimed electric power can be wirelessly transmitted through space. The transmission of power differs radically from the operations of radio. This is not fully realized by the "General."

Many men fail in building their Radio sets because of some trivial error that could easily have been corrected before it was too late. The E. I. Company has compiled a book that will help you avoid all the common pitfalls while building your Radio sets. PRICE 25c.

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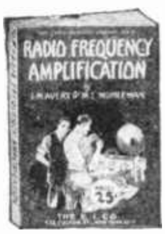
Book No. 3



Distance lends enchantment—and its the Radio Frequency Amplification that brings in the distance on your Radio Receiver. If you contemplate adding any Radio Frequency to your set you will want this book at your side. PRICE 25c.

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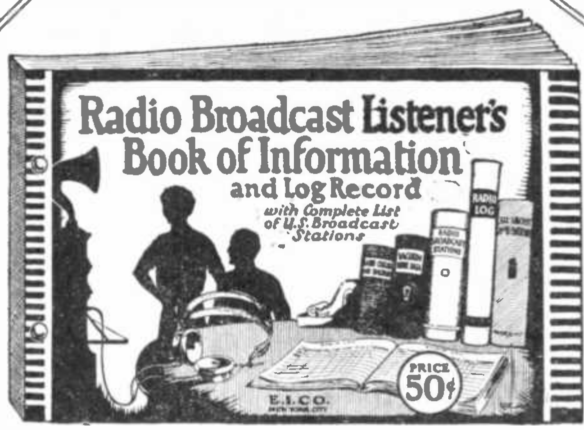
The complete set of E. I. Company Books shown on this page make up a library that covers practically every important detail of Radio Receiving Sets. The low cost of the complete set as compared with the amount of valuable information contained in it is the Reason why many Radio Set builders have a complete library at home that is constantly referred to. Size of each book is 7 ½ inches by 5 ¼ inches, contains 52 pages and printed with a handsome two-color cover. You can obtain these books separately or all together from your Radio Dealer or by writing to us direct enclosing the price of each book.



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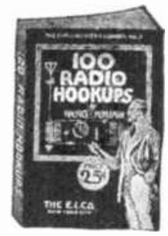

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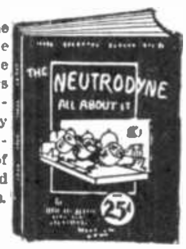

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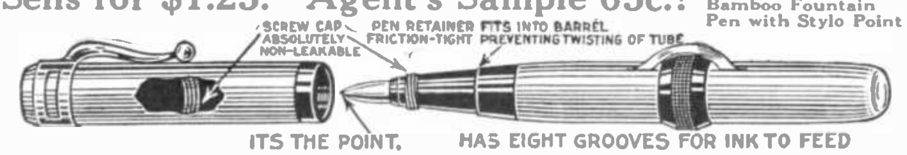

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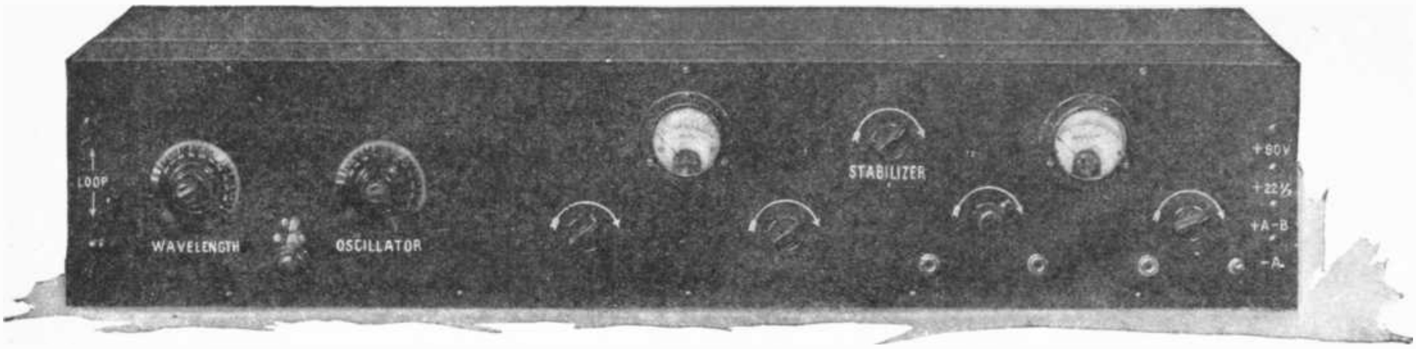

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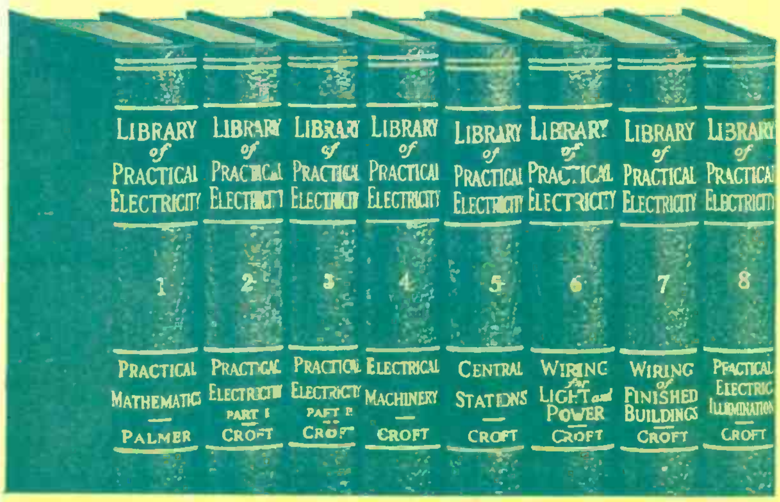

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