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The EXPERIMENTER

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LIGHT BY ELECTROLYSIS. This is a futuristic article with suggestions for the possibility of producing cold light.

LABORATORY MANIPULATION. Another article in this series, giving the elementary view of laboratory manipulations, so much neglected in the text books.

HOW TO MAKE A RING ARMATURE DYNAMO. A most interesting description of a Gramme ring armature dynamo, a specially interesting type.

MAKING A MERCURY VAPOR ULTRA-VIOLET LAMP. One of Mr. Wailes' articles, attractive as usual from their appeal to the experimenter of limited facilities.

EXPERIMENTER'S GLASS-BLOWING TOOLS. This is a valuable sequel to Mr. Caley's article on the manipulation of glass, giving various apparatus to be used in making apparatus for experiments.

CONSTRUCTING A RADIO "B" BATTERY. This article will interest our great army of radio enthusiasts, with its many illustrations and full description. It is a storage battery using six-inch test tubes for cells.

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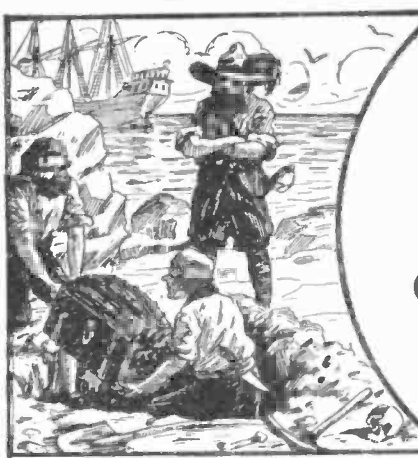

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Volume 4
No. 5

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

March
1925

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

Efficiency in Experimenting

By Hugo Gernsback

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

EXPERIMENTATION is a most peculiar subject. Ninety-five per cent. of experimenters, who have started out experimenting purely as a hobby, sooner or later find that some of their experiments can and will be capitalized. The experience and knowledge gained from experimenting will leave its mark upon you whether you desire it or not. An experiment that you performed five or ten years ago may be the cause of bringing riches to you.

In other words, experimenting, even if done as a hobby, is never without final results. For in no matter what business or in what endeavor you find yourself, sooner or later your experimental work will hark back.

If we admit this much in the premises, it behooves us to regard experimentation as something more than a hobby, even though it may be only a hobby with you at present. Experimenting, no matter in what line, should always be taken most seriously, and if we accept this once, it follows that our experimenting should be done in an efficient and workright manner.

There is nothing more destructive and time-consuming than haphazard experimenting. While, of course, one may gain experience by just performing certain experiments, this will never do in the end, particularly when it is realized that better and more interesting experiments can be made by applying efficiency.

Now efficiency in experimenting lies in two directions. In the first place, as the writer has pointed out in previous editorials, before starting to experiment, one should know exactly what to do before starting. Everything should be ready, so that no useless time will be expended in running around for materials, but this, of course, is repetition, as the writer has mentioned this before.

And this is not what this editorial is concerned with. The real efficiency in experimenting lies deeper, and must be looked for elsewhere. It can be expressed in the one word: **Information.** If you wish to make an experiment just for the sake of the experiment, well and good, but even here you must have some information about it. You must have read something about the particular experiment in a book. You may have heard about it in some other manner, or you may have thought of the experiment yourself, considering it original, and it is this last phase that is not only most elusive, but lures you into wasting a lot of your valuable time.

It should be understood right here that very few experiments are original. Nearly every one you can think of, with mighty rare exceptions, has been made by some one else.

So the writer says,—particularly when you come to think of what you regard as an original idea: do not start to buy expensive materials and waste a good deal of time in starting a difficult experiment, before you have secured all the information on the subject you can. Things most illuminating will crop up during such an investigation, and nine times out of ten, by looking up records of experiments previously made by others, you will become convinced that your original idea was not half as original as you thought.

How to get such information? Of course there are text books and books treating on similar subjects. These should be studied carefully, and thoroughly, and notes should be made on any subject pertaining to the experiment under consideration. If you cannot get all the information from your own books, then a trip to the library will often prove most interesting. Once you get to know how public libraries index various material it will then be an easy matter to collect all the necessary data you are after.

The next records, and the most important ones, are patent files. Only the very large libraries have such files. Where it is impossible to visit personally such a library, the next best thing is to write to the Patent Office in Washington, asking them how many patents there are in the particular class of work in which you are interested. The Patent Office, as a rule, will tell you how many patents there have been issued on such-and-such an art in various classes and sub-classes. Copies of these patents cost 10c apiece, and it is often cheaper to spend a few dollars in this direction, and get real information, than to spend much larger amounts in making the experiments first, only later to find out that some one else long ago went over the same ground.

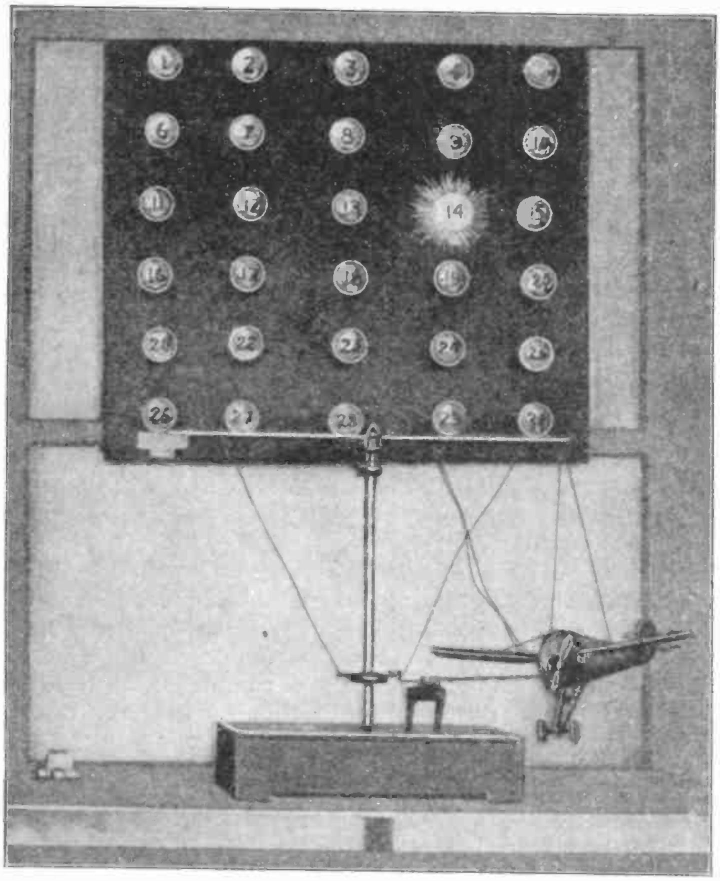
If you have exhausted every available source of information, such as text books, libraries and Patent Office, this does not mean that you have obtained all of the information. Some technical magazine may have published something on the subject that is not filed in the average library, and of which even the Patent Office may not have a record, because not everything is patented.

Suppose you are interested in some particular scientific problem, and all the above-cited avenues of information do not prove fruitful. The next best thing that can be done is to write a letter to the editors of a number of technical periodicals, asking them if they can give you some light on the subject. Of course it is not necessary to divulge your idea, but you can write upon the subject just the same. You will find that the editors of such publications often can give you information not otherwise available.

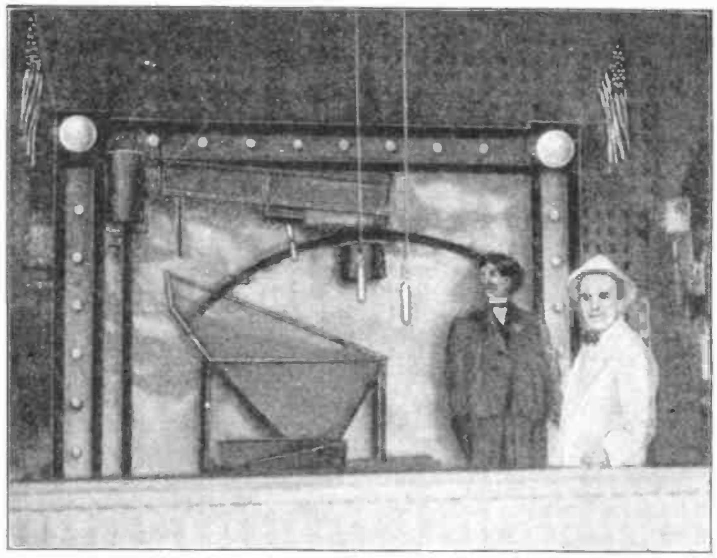
Then, after you have accumulated all of the information available, you can go ahead with a clear conscience, and by using your references intelligently, you will be able not only to save days and weeks of work, but a large amount of money as well. And, you will get to your goal in record time. This is Efficiency in experimenting.

Electric Games of Chance

By Geo. R. Holmes, A.I.E.E.

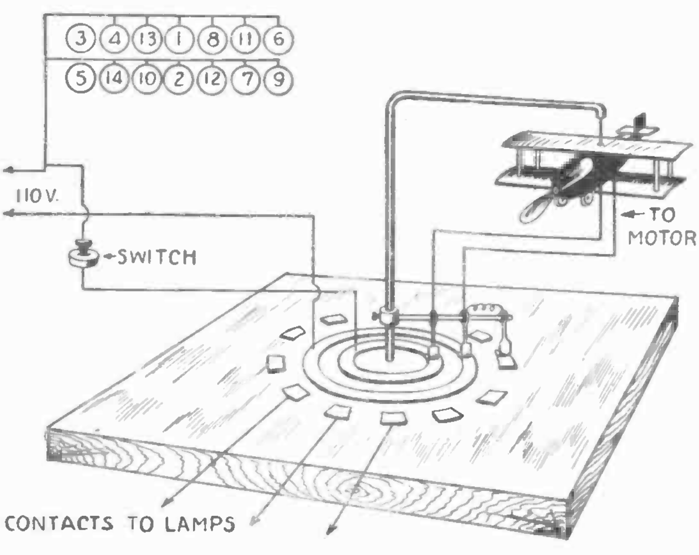


A miniature airplane on an arm moves in a circle. A brush makes contact with successive segments on the axle each connected to a different numbered lamp. The lamp which remains illuminated after the airplane has stopped carries the prize winning number.

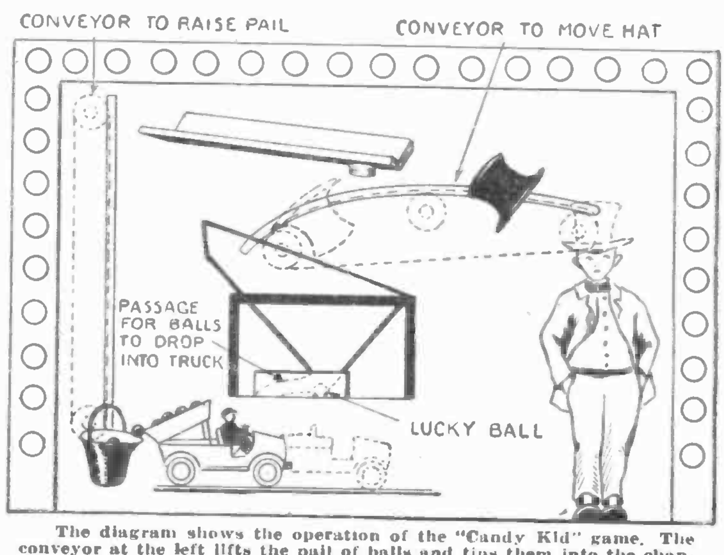


The "Candy Kid" accomplishes the selection of one out of a number of balls. A silk hat automatically removed from the head of the figure receives a number of balls and tips them into the hopper where one of these is lodged in a cavity and the rest roll by into a small cart. The retained ball carries the lucky number.

NO longer does the verbose, loud, exhorting bally-ho of the pitchman, at county fair or seaside resort, with his spinning wheel of chance, induce a gullible public to recklessly plunge with its nickels and dimes. For the days of Barnum's, "There's a fool born every minute and one to catch him" policy are on the wane, and if one desires to make a living this way he must give the public their money's worth.



The operation of the airplane game is illustrated diagramatically above. In operation the switch is closed to start the airplane and having given it sufficient momentum the switch is opened and the airplane allowed to "coast" to rest.



The diagram shows the operation of the "Candy Kid" game. The conveyor at the left lifts the pail of balls and tips them into the channel at the top. At the same moment the conveyor at the right carries the silk hat under the opening of this channel. Having received the balls the hat is carried by the conveyor to the hopper into which the balls are tipped.

Flying Aeroplane

In this game switches along the stand control the stopping and starting of an aeroplane suspended on an arm from an upright support. Current to a motor starts the propeller which drives the aeroplane around in a circle. Brushes attached to the bottom go over segments, thereby closing the circuits to different numbered lamps. When the current from the motor is shut off and the airplane comes to rest, one lamp will remain lit—the winner.

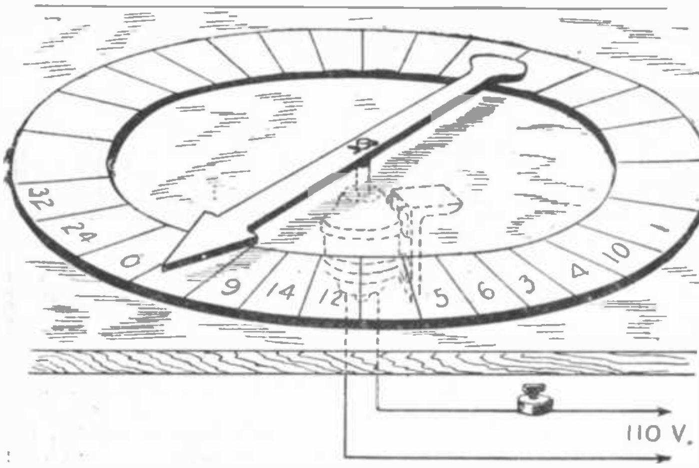
The "Candy Kid"

This consists of a large display front in which many mechanical operations are controlled by an electric motor. Players choose numbers on the board at the front of the stand. For each number on the board there is a ball, bearing a corresponding number. All the balls are in a small auto at the bottom of the device on the left side at the beginning of each play. When everything is ready this auto is mechanically tipped over and all the balls roll into a basket. The basket is then raised automatcally by a chain to the top of the device on the left side and the balls are thrown into an incline alley. They then roll down the incline.

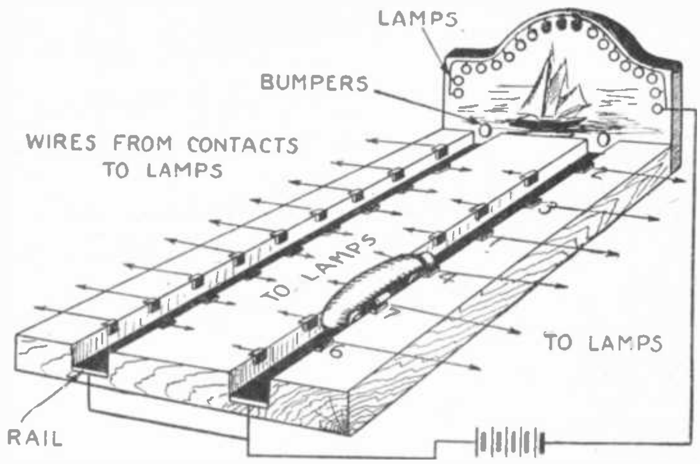
As one of the players pulls one of the strings hanging above the stand, the figure at the right raises its hand. Then the hat on its head automatically comes off, turns over, and travels until it rests under the incline just where the balls are above. A pull on another string and the slot in the bottom of the incline comes open, the balls drop into the hat, which then turns over again, dropping the balls down another incline. The first ball that runs out into a groove at the front is the winner.

Spinning Arrow

This last is a variation of the regulation wheel so that it comes above suspicion from those who might be well read on the exposé



A large wooden arrow rotated by the action of an electrically driven propeller carries a brush and an electromagnet on its underside. The brush and the magnet move over iron segments. Each player has his own switch which he tries to close at the instant the magnet passes over the corresponding segment. When this succeeds the attraction between the magnet and the iron segment will cause the arrow to stop and point to the winning number.



This is another game built on a war motive. Rolling over a conducting rail to which one terminal of the battery is connected, the steel torpedo as it is pushed forward and rebounds from the bumpers, makes successive contacts with segments connected to numbered lamps. The lamp which remains lit after the torpedo stops announces the lucky number.

of pitchmen's tricks. The numbered disc is suspended horizontally and the arrow usually spun by the operator is run by an electric motor placed underneath in full view. Switches on the stand again play a part in its control. The motor is started or stopped at will by any player and comes to rest over a number.

The Electric Arrow

Shown in the cut above. A large, ornamental arrow is delicately balanced on a pivot in the center of the tent and festooned with electric lights of various colors. Near the pointed end of the arrow there is an electric motor on the shaft of which is mounted a small aeroplane propeller. Switches at various points on the circular table around the tent control this motor which can be started or stopped at will be any of the patrons. Spaces on this table indicated the first names of the gentler sex. One chooses the name of his fairest, deposits his dime and when all the players are set to the number of twenty-four, the operator asks one to snap the switch and start the arrow spinning. At another given signal someone else snaps a switch and the arrow starts to slow down.

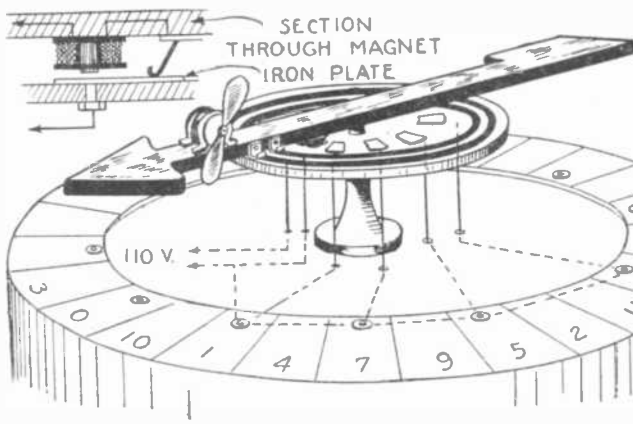
It will be seen that this is an electro-scientific development of the old spinning arrow of church fairs.

Then the fun and skill start. Each player has a push button. As the arrow slows down, there is a brush which travels over twenty-four contacts, one at a time. Each player endeavors to time the pressing of his push button so that the brush will make contact and close a circuit which will actuate a large electro-magnet under the arrow and in turn be attracted to a strip of iron and so retard the arrow. There are twenty-four such strips of iron. Needless to say, one gets plenty of thumb exercise until the arrow stops at a winner.

The Submarine Attack

This device, shown above, is also an exclusive electric game. At the backboard is shown a fleet of battleships and over the tops of them a row of numbered electric flashlight lamps. Two torpedoes are used on a horizontal board which move in grooved slots so that they cannot slip out.

The player pushes one of these towards the battleships, and, when it hits, there is a rebound. On the rebound, as the torpedo comes back, it makes contact with segments in the groove lighting up different numbered lamps. The numbers are staggered so that they do not follow in consecutive order, either on the edge of the groove or on the backboard. To win one of the major prizes the torpedo must stop at five, ten or fifteen. With careful attention to the strength of the push given the torpedo, it is easy to judge when it will stop on one of the coveted numbers when it rolls back.



This game is extremely simple and the electric motor is used merely to start the arrow spinning. The switch open, the arrow is allowed to come to rest, the prize winning number being indicated by the arrow.

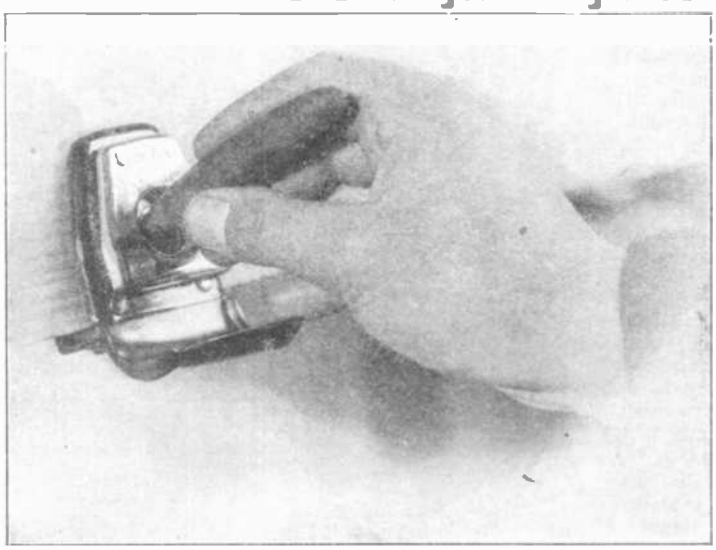
Automobilist's Cigar Lighter

We illustrate a very interesting electric cigar and cigarette lighter for the dash-board on automobiles.

There are no winding cables, reels, or inside switches. The lighter consists essentially of a base which fits against the instrument-board of the car. An extension at the base forms a spark catcher and ash-tray, a large heat-unit mounted on a mica plate near the top of this base. A spring hinged cover which contains the automatic switch and has at its center a hole through which the heat-unit is visible.

When the cover is pressed forward with the finger-tips, the heat-unit instantly flashes to a bright red heat. Touching the end of cigar to the heat-unit lights it in not over five seconds.

It is so designed that anyone can install it in a few minutes without drilling holes or using special tools. Universal mounting brackets make it fit practically any instrument-board.



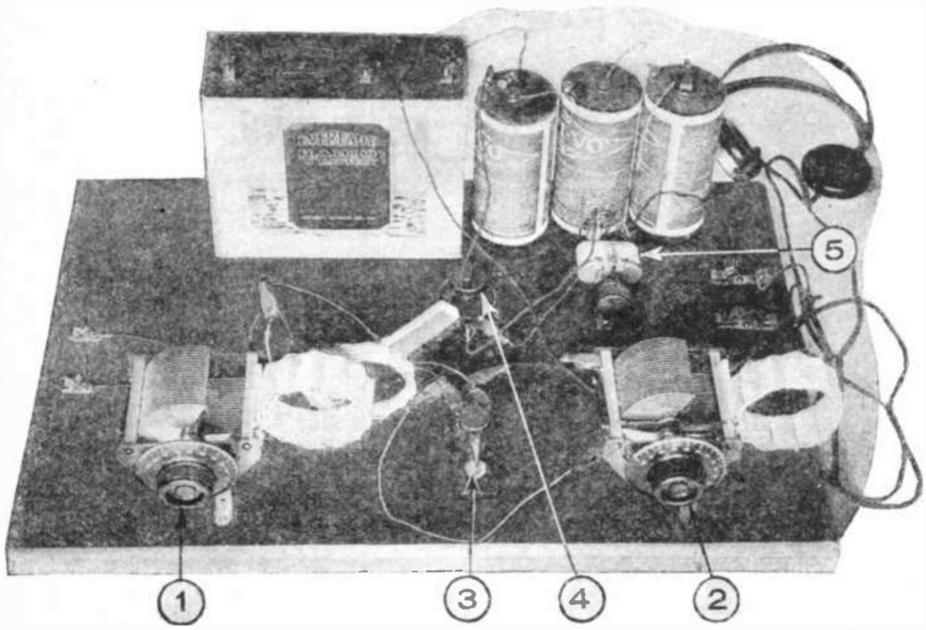
The cigar-lighter carried on the dash-board of a car has a lid, which is closed. The closing opens the circuit. To light a cigar the lid is dropped which closes the circuit and the heating element becomes red hot and will light a cigar in a few seconds.

One feature of this lighter is that it has no cord and no movable parts except the lid, and that is hinged fast. The lid operates as the handle of a switch; dropping it is like opening a circuit by a single pole switch, the switch mechanism, of course, not affecting the person using it. The mere fact that it can be so readily attached will make it attractive to automobilists not over fond of cutting up their dashboards and making complicated connections. With beauty cases for the fair sex, telephones for communication with the chauffeur from the interior, lamps for lighting the inside compartment of the body and a heater for the same, the every-day automobile is becoming a luxurious affair.

EXPERIMENTAL RADIO

Conducted by Clyde J. Fitch

Oscillating Crystals



Apparatus used for making experiments with oscillating crystals—1 and 2 are tuning condensers on which are mounted the low loss coils; 3 is the zincite crystal detector; 4 is the potentiometer and 5 the variable resistance.

DO CRYSTALS usually oscillate? The distance records made by some experimenters with crystal detectors seem to indicate that this cannot be attributed entirely to freak conditions. One explanation is that the distant stations are picked up on the crystal receiver from re-radiation of a local regenerative set. In this case the regenerative receiver acts as a relay station. This may happen in many cases, but quite often experimenters in remote sections of the country and operators at sea make extraordinary distance records with simple crystal sets. It appears, therefore, that some form of regeneration must take place in the crystal circuit.

Oscillating crystals were investigated as far back as 1906 by many well known radio experimenters. Recently a Russian engineer succeeded in making practical uses of oscillating crystals. Under certain conditions the usual crystal detector can be made to oscillate at any frequency now used in radio transmission, the same as the vacuum tube oscillates. This would indicate that regenerative amplification may take place in a crystal receiver under proper conditions. Many of the distance records made may be explained with this assumption. Regeneration accidentally occurred which had the effect of lowering the antenna resistance and making it more susceptible to weak signals. Had the antenna coupling been very loose and if good low-loss instruments were used, no doubt regenerative crystal receivers would have been in use long ago.

Some crystals produce stronger oscillations than others. Among the numerous contacts studied are pyrite-carbon, chalcopyrite-zinc, galena-carbon, or zincite-carbon and zincite-steel. The zincite-carbon and zincite-steel contacts seem to be the best producers of strong oscillations. The construction of the contact is similar to that of the ordinary crystal detector.

Lists of parts required:

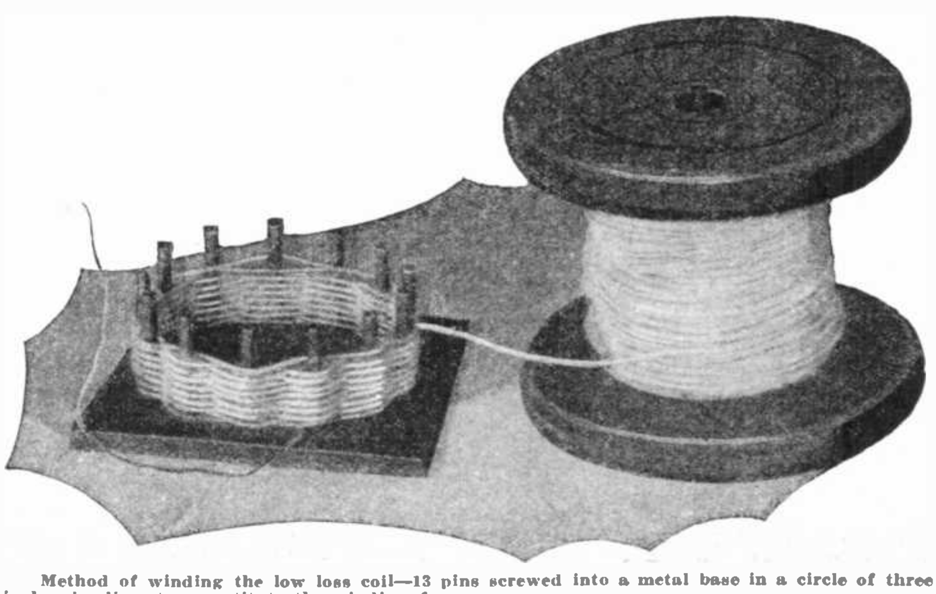
1 *Rasco* Crystodyne Detector.
2 Low loss 43-plate variable condensers. .001 mfd. capacity.
2 Low loss coils made as described in the text.
4 1,500 turn honeycomb coils.
1 *Pacent* 400-ohm potentiometer.
1 *Bradleyohm* No. 10
1 3-point switch.
1 *CRL* 3,000-ohm variable resistance.
1 Tapped B battery and 3 dry cells.

The zincite crystals may be selected, but it has been proved by experiment that even a poor crystal is made much better if it is fused in an arc, and scraped to remove the outside black layer which is not a good conductor. One may also break the crystal and use the inside surface. It is necessary to fuse the crystal in the votaic arc surrounded with binoxide or peroxide of manganese to prevent its reduction to metallic zinc.

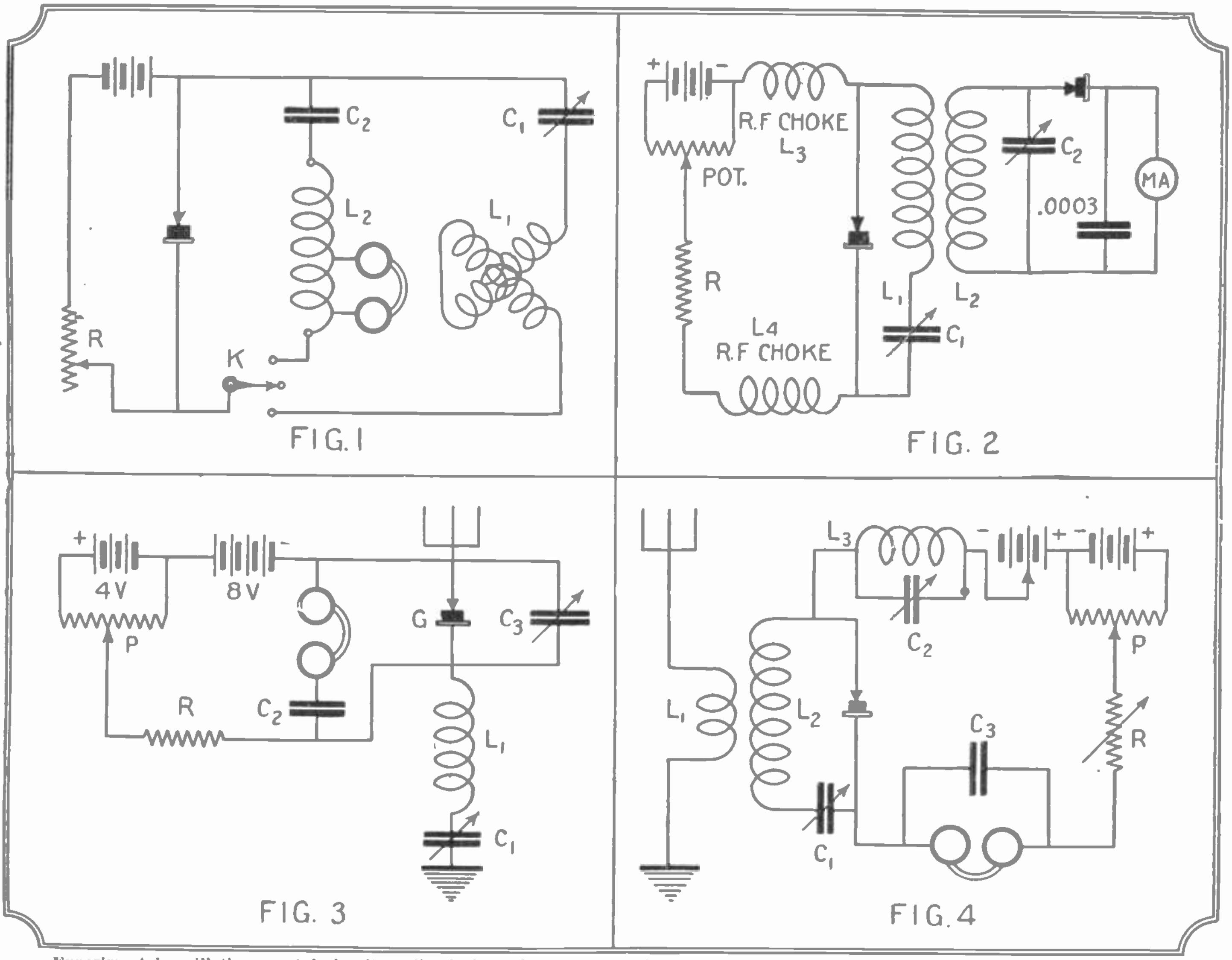
The illustration (Fig. 5) shows a hook-up board built for experimenting and investigating oscillating crystals. The instruments required for these experiments are given in the list. As the crystal is a very feeble generator, it was decided at the start to use instruments having absolutely the lowest possible losses. Low-loss coils were made for the radio frequency circuits. These coils are clearly illustrated. Fig. 6 shows the method used for winding these coils. Thirteen steel pins are screwed to a metal base in a circle 3¼ inches in diameter. The pins are ⅛ inch in diameter and are spaced evenly. No. 16 D.C.C. wire was used for the coils. The wire is wound over one pin and under the next, as the illustration shows. After the coil is wound it is removed and securely tied with string.

Two coils, each of 30 turns, should be made. They are mounted directly on the low-loss 43-plate variable condensers with the connecting leads as short as possible. The coils are fastened to the condensers by means of radio cement placed on the celluloid insulating strip of the condenser. The wire of the coil is so large that when soldered to the condenser terminals it securely holds the coil in place.

Another form of low-loss coil which the experimenter can easily wind is depicted in Fig. 7. A bakelite or other hard tube is covered with four or five layers of wax paper, and the wire is wound over the paper. Before winding, three strips of gummed



Method of winding the low loss coil—13 pins screwed into a metal base in a circle of three inches in diameter constitute the winding form.



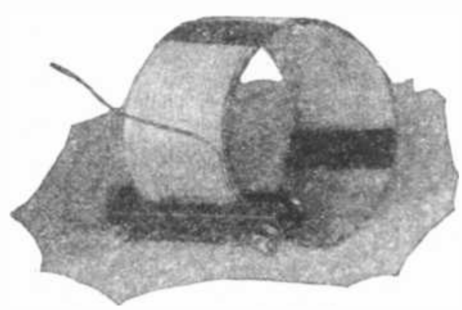
Experimental oscillating crystal circuits. Fig. 1 shows how either radio or audio frequencies may be generated depending upon the position of switch K. Fig. 2 is for generating radio frequencies of short wave-lengths. Figs. 3 and 4 show circuits for receiving continuous waves.

paper should be placed over the waxed paper so that they can be folded over the finished coil and hold the turns in place. The coil is then slipped off and clamped with two strips of hard rubber, as shown.

The experimenter should first get the crystal oscillating at audio frequencies before he attempts to make it oscillate at radio frequencies. Such a circuit, known as the cristodyne circuit, is shown in Fig. 1. The battery used may be composed of dry cells, such as a "B" battery, providing its internal resistance is not too great. The voltage to apply to the crystal is generally between five and 30 volts, depending upon its quality. The resistance (R) should be about 3,000 ohms and it should be variable. L2C2 is the audio frequency oscillating circuit. (L2) may consist of four 1,500-turn honeycomb coils connected in series with a tap at the center of the headrest. (C2) is a fixed condenser having a capacity from ¼ to 2 mfd. (L1C1) is the radio frequency circuit. Although (L1) in the illustration indicates a variometer the experimenter may use the low-loss coil described instead. (C1) is a 43-plate condenser. It has been observed that the crystal produces stronger currents when the ratio of capacity to inductance is large. Hence it is advisable to use large condensers and small coils. By means of switch (K) either the audio or the radio frequency circuit may be connected to the crystal.

It is best to use low resistance phones of about 300 ohms, although good results were obtained from a pair of 2,000 ohm ones. By connecting the circuit L2C2 and by varying the battery voltage and resistance (R) audio frequency oscillations are produced which are heard in the phones. Of course, the proper contact point on the crystal must be found. Once this is found and the oscillations are produced, the switch (K) may be thrown to the radio frequency circuit (L1C1) and the crystal will be in the proper condition to generate radio frequency oscillations. It is reported that in Russia many radio experimenters have succeeded in communicating by radiophone over a distance of one mile, using the crystal as the generator of radio frequency currents and also as the receiver.

Fig. 2 shows a better circuit for producing radio frequency oscillations. It has been possible with this circuit to produce oscillations having a wave-length of 25 meters, which means a frequency of 12,000,000 cycles per second. For this extremely



Another form of low loss coil which the experimenter can easily wind. It is self-supporting except for two strips of gummed paper and the hard rubber clamps.

high frequency the resistance (R) has a value of 2,300 ohms. The coil (L1) is 2¼ inches in diameter and is composed of seven turns of No. 12 copper wire. The variable condenser (C1) has a value of .0003 mfd. L3 and L4 are radio frequency choke coils. To measure the wave-length a special wavemeter was used, composed of the coil (L2), which is 2¼ inches in diameter, and consists of a single turn of No. 12 copper wire, shunted by a variable condenser C2 of .006 mfd. capacity. A galena crystal detector is connected in series with a microammeter having a scale of 0 to 100, allowing the operator to find the resonant point.

For the reception of radio code signals and radio telephony, the circuit shown in Fig. 3 may be used. In this circuit oscillations are produced directly in the aerial, and once the crystal is oscillating, CW signals may be heard. By proper adjustment of the potentiometer (P), the crystal may be brought to a point just before oscillations start, and broadcast stations may be amplified considerably by regeneration. As the aerial is directly connected to the crystal, the tuning will be broad, and it will be difficult to get the crystal to oscillate on account of the large amount of energy absorbed by the aerial. To overcome these disadvantages the circuit shown in Fig. 4 was developed. This is the circuit shown in the illustration of the hook-up board. The aerial is loosely coupled to the oscillating circuit. Instead of using radio frequency chokes, as shown in Fig. 2, a tuned circuit (L3C2) is connected in series with the battery lead to keep the radio frequency currents from circulating through the battery.

Getting On the Air

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

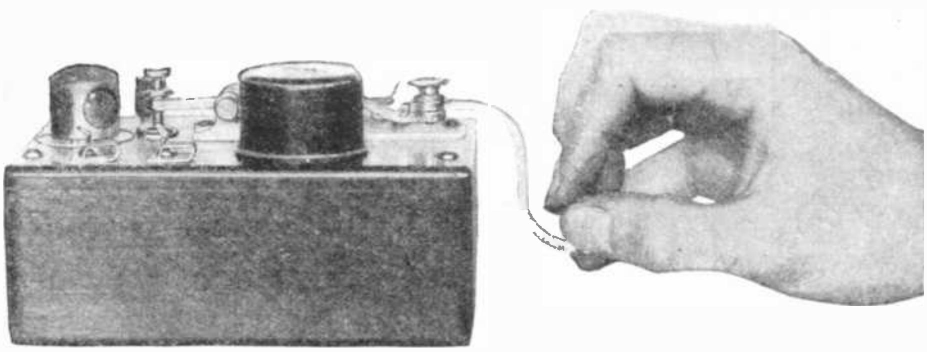


Fig. 3. The correct position for holding a telegraph key when transmitting code. Note that the entire arm and not the fingers should be used for operating the key.

HOW many of the thousands of broadcast listeners of today realize the greater amount of pleasure that the amateur is getting out of radio than they themselves obtain by hearing the broadcast programs? Daily more and more broadcast listeners have come to see the amateur's point of view, and many of them are entering into the amateur game with a zest. In this and a few succeeding issues of this magazine, the writer will explain for the benefit of those who have never been interested in amateur radio, what it is, how to get into the game in the best way, and also describe in detail the construction of an amateur transmitting and receiving station.

Those broadcast listeners who read this article and who are not acquainted with amateur radio will need a little explaining. An amateur is one who is interested in radio not only as a hobby, but as a study. It is he who has virtually given the broadcast listener every piece of apparatus in use today. Amateurs have conducted much experimental work which has resulted in improved and more efficient receivers. In every broadcasting station you will find one or more such on the operating staff. They are also connected with every large radio manufacturing company, usually in high engineering capacities. From this you will immediately see that the real amateurs are not the little boys with the spark coils who make a lot of noise and accomplish little, but are serious-minded men of all ages. They include representatives of practically every known profession and business and they derive immense enjoyment and benefit therefrom.

Aside from what a person can get out of radio when studied from the amateur standpoint, the one great object of amateur radio is to promote co-operation and render services to others. This, in a large measure, is accomplished by the relaying of messages by the stations, the procedure for which will be described in a future article.

All amateurs quickly learn to consider the feelings of others. The broadcast listener with a simplified and unselective set, who has his programs interfered with by code stations, immediately "goes up into the air" and calls down the wrath of the powers that be on that "kid that is always interfering with the music." However, the "kid" or amateur is not always the one that causes this interference. Commercial and government stations handling traffic far more important than any broadcast program could ever be, are often the cause of interference. If the broadcast listener would only acquaint himself with the workings of both the commercial and amateur stations, he would soon learn tolerance and respect for the traffic carried on by the operators of these stations.

We are pleased to present to our readers the first of several articles dealing with amateur radio that will appear in this department. These interesting articles by Mr. Peck will take the reader through the various steps of the amateur game from the learning of the code and obtaining a license, to the installation of a complete short-wave transmitting and receiving station. Valuable hints to the radio experimenter will be found in every article.

The Code

We will consider the first step necessary for taking up this most fascinating of all hobbies. The first thing to do is to learn the code which is reproduced herewith.

A	. —	S	. . .
B	— . . .	T	—
C	— . — .	U	. . —
D	— . .	V	. . . —
E	.	W	— —
F	. . — .	X	— . —
G	— — .	Y	— —
H	. . . .	Z	. — .
I	. .	1	— — —
J	. — — —	2	. . — — .
K	— . —	3	. — —
L	. — . .	4	. . . . —
M	— —	5	. . . . .
N	— .	6	— . . . .
O	— — —	7	— — . . .
P	. — — .	8	— — — . .
Q	— — . —	9	— — — — .
R	— .	0	— — — — —

The continental code used in wireless telegraphy. This code differs slightly from the Morse code used in line telegraphy.

In order to properly memorize the code so that it will be of use and so that speed can be attained in transmitting and receiving, the code must not be visualized in dots and dashes, but the sound of the symbol for each letter should be visualized so that it will be connected instantly with that letter when it is heard without conscious thinking. For instance, do not memorize the letter A as being symbolized by dot dash, but memorize it as dit dah. These sounds resemble somewhat those heard during reception and instead of having a visual record of each letter, you will obtain a mental record.

Practice Sets

When practicing the code, it is necessary to have some kind of a practice set. The simplest type is illustrated in Fig. 1. This consists of a key, a buzzer, and one or two dry cells. They are connected up as shown and pressing of the key will cause the buzzer to sound. An army type of practice set is shown in Fig. 2. At first you should practice making dots and dashes so that each dot and each dash will be of uniform lengths. A dash should be approximately equal to three dots in duration of time.

The key that you select may be the one that you will use in the future in your transmitting set. Therefore, it is well to buy a good one in the first place. For low-powered sets, ordinary telegraph keys such as used by telegraph operators will be amply sufficient and they are usually quite well made. However, if you contemplate installing a high-powdered set of, say, 50-watts power or more, a larger key with heavy contacts should be purchased. In either event the method of manipulating the key will be the same. Grasp the key as illustrated in Fig. 3, raising the first and second fingers on the top of the knob, the thumb on one edge and slightly underneath and the third finger on the opposite edge also slightly underneath. In this way, the thumb and third finger can assist the spring of the key in bringing the lever back to the normal position, while the first and second fingers press the knob and close the contacts, forming the characters. When practicing the code, place the key so that the elbow can rest on the table and grasp the knob as illustrated. The wrist should be elevated from the table and the entire arm should be used for operating the key. Do not try to use the fingers alone as the muscles will soon become stiffened and will not operate the key properly. Using the entire arm may seem somewhat awkward at first, but after the key has been manipulated for some length of time, this position will become natural and will become much less tiring than the other.

Before practicing, the key should be adjusted, so that it will work best and will suit your individual requirements. The rear adjusting screw should be so placed that the contacts will be open about ⅛th inch. The front screw which regulates the tension of the spring should then be adjusted until the lever closes the contacts with the required amount of effort. This tension will be different for each operator and must be adjusted to your own particular characteristics.

For persons who must learn the code alone, either the practice set illustrated in Fig. 1 or those in Figs. 2 or 4 may be used. The last one is somewhat better as it more nearly simulates radio messages. The phones are placed on the head and the key manipulated to form the characters. In any practicing, the buzzer should be adjusted to give as high pitched a note as possible and still be smooth in operation because the high pitched note is easiest to read. The contacts must not stick, as otherwise practice will be greatly interfered with.

Practicing the code alone is not the best method of attaining speed in operation as one cannot actually practice receiving until he has the receiving set, and then he will

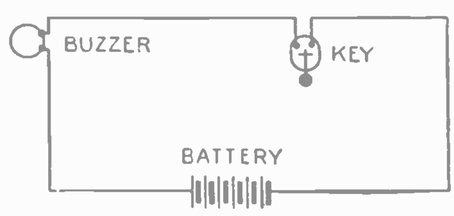


FIG. 1

Diagram of a simple practice set comprising a key, buzzer and battery.

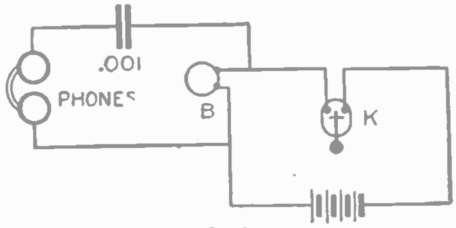


FIG. 4.

A simple code practice set using telephone receivers. By wearing the receivers a more realistic effect of the code is produced.

usually find that most of the stations received are transmitting too fast for him. The best plan is to get some other beginner to practice at the same time or else to prevail upon some amateur friend to instruct in reception. In this case, a practice set such as illustrated in Fig. 5 will be needed so that the operators may be located in different rooms. This will eliminate any tendency toward verbal conversation that would seriously interfere with the practicing. Here two keys, two buzzers and two sets of phones will be required. The phones are optional as in the single practice set, although they are desirable. With an arrangement such as shown, actual two-way communication can be carried on, and you can practice both transmitting and reception alternately so as to obtain the greatest proficiency possible.

The one thing to remember in practicing the code is to start off slowly and not to try to break speed records the first evening that you practice. Accuracy and consistent sending is to be far more desired than speed. Form your characters perfectly, keeping all dots, all dashes and all spaces of uniform lengths respectively. At first you may be able to send only a few letters a minute, but as you progress, your speed will automatically pick up until finally you will surprise yourself by finding that you are able to transmit and receive ten words a minute. In quoting speeds, it is always considered that each word is the equivalent of five letters.

Licenses

A speed of 10 words per minute is necessary for obtaining an amateur radio operator's license. You also have to be familiar with the radio laws of the United States which are given in the booklet entitled, "Radio Communication Laws of the United States," which may be obtained from the Government Printing Office at Washington, D. C., for the sum of 15c, not stamps. A copy of this book should be obtained and carefully read.

Licenses for amateur transmission are issued free of charge by the United States Government. Examinations are given at central points in every radio district. You can find your examination point from the following list:

First District: Headquarters at the Custom House, Boston, Mass. This district comprises the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

Second District: Headquarters at the Custom House, New York, N. Y. This district comprises the States of New York (county of New York, Staten Island, Long Island, and the counties on the Hudson River to and including Schenectady, Albany and Rensselaer) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson and Ocean).

Third District: Headquarters at the Custom House, Baltimore, Md. This district comprises the States of New Jersey (all counties not included in second district), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains and Franklin county), Delaware, Maryland: Virginia, and the District of Columbia.

Fourth District: Headquarters at the Custom House, Savannah, Ga. This district comprises the States of North Carolina, South Carolina, Georgia, Florida and the territory of Porto Rico.

Fifth District: Headquarters at the Custom House, New Orleans, La. This district comprises the States of Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Oklahoma and New Mexico.

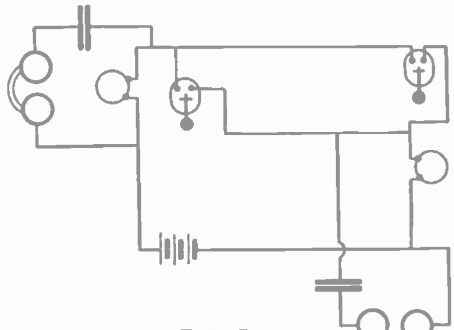


FIG. 5

A double code practice set enabling two persons to transmit messages to each other.

Sixth District: Headquarters at the Custom House, San Francisco, Calif. This district comprises the States of California, Nevada, Utah, Arizona and the territory of Hawaii.

Seventh District: Headquarters at the Federal Building, Seattle, Washington. This district comprises the States of Oregon, Washington, Idaho, Montana, Wyoming and the Territory of Alaska.

Eighth District: Headquarters at the Custom House, Detroit, Michigan. This district comprises the States of New York (all counties not included in second district), Pennsylvania (all counties not included in third district), West Virginia, Ohio and Michigan (lower peninsula).

Ninth District: Headquarters at the Custom House, Chicago, Illinois. This district comprises the States of Indiana, Illinois, Wisconsin, Michigan (upper peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota and North Dakota.

If you are situated too far from an examining point, a second grade license will be issued upon application to the radio inspector, and upon presentation of sufficient evidence that you are acquainted with radio communication laws and that you are capable of receiving at a speed of 10 words per minute. Two licenses are always required, one for the operator and one for the station. The station license can be obtained by mail from the radio inspector.

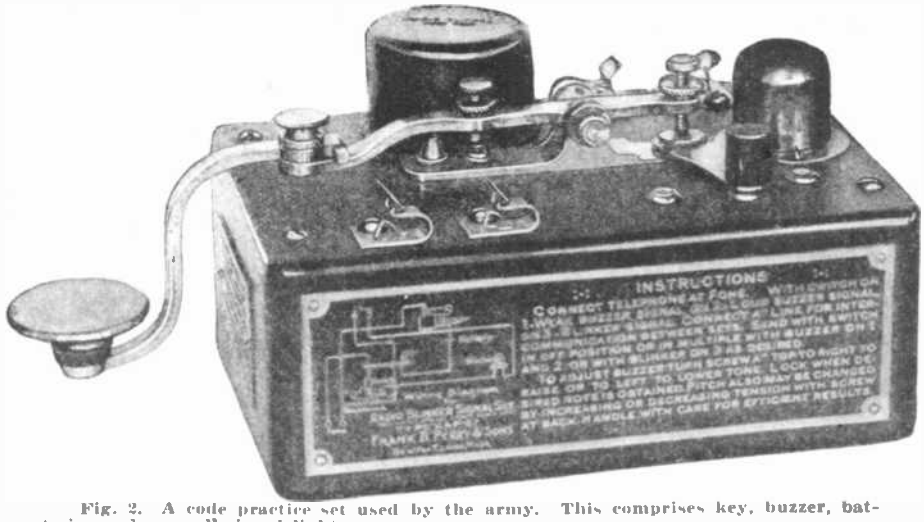


Fig. 2. A code practice set used by the army. This comprises key, buzzer, batteries and a small signal light.

Electric Light Radio Set

PROVIDED you live in a house with direct current, you may easily connect the receiver illustrated and, at the same time, be using the light furnished by the bulb which acts as a rectifier to the incoming radio waves.

All that are needed are the following apparatus:

One tuning coil
One 23-plate variable condenser.
One radio head-set.
One strip of tinfoil.
One electric light bulb.

After the set is wired according to the diagram, switch on the light and start tuning in. A crystal set would work louder, but this set works efficiently.

The set may be further simplified by using the 110-volt line for the aerial. In this case, the tuning coil should be connected in series with the lamp, as shown in Fig. 2.

Contributed by ALBERT W. SMALL.

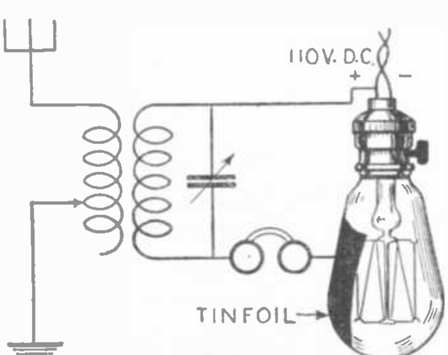


FIG. 1

A radio receiver in which the electric light bulb coated with tinfoil acts as a detector or rectifier of the high frequency currents.

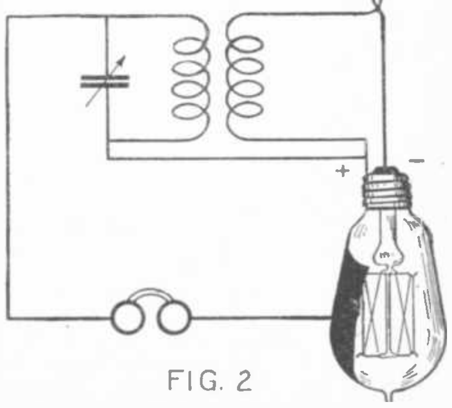


FIG. 2

A similar circuit in which the lamp not only acts as the detector, but the 110-volt line is used for the aerial.

Tuned Radio Frequency Circuits

By Clyde J. Fitch

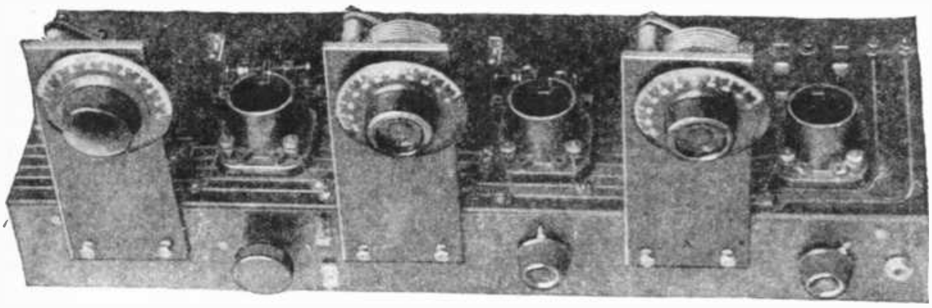


Fig. 6. An experimental tuned radio frequency set employing two stages of amplification and detector. The simplicity of wiring made possible by using the ready-wired base makes it ideal for the experimnter.

PURSUING our descriptions of tuned radio frequency circuits we are pleased to present a new form of hook-up board that should appeal to radio experimenters. This board is illustrated in Fig. 6 and the connections are shown in Fig. 1. It is made from a Durad base. This base is of insulating material. In it are embedded five wires for the battery connections. A number of holes drilled along each wire allow for connections at various places. These connections are easily made with the small bolts and washers furnished with the board.

A short panel is mounted on the bottom of the board on which are placed a potentiometer, telephone jack and two 30-ohm rheostats. Small insulation strips support the three .00035 mfd. variable condensers as shown. On the board are mounted three vacuum tube sockets, two small neutralizing condensers, and a detector grid condenser and leak. A number of Fahnestock clips allow for connecting different coils and for trying different circuits. As the illustration Fig. 1 shows, the wiring of this test set is very simple.

The photograph Fig. 7 shows an experimental five-tube receiver employing two stages of tuned radio amplification, detector, and two stages of audio amplification. This board is similar to the one described in the February issue, except that it includes the two audio stages and has two tuning condensers controlled by one knob. It will enable the experimenter to test the comparative efficiency of one dial and multiple dial control units. The parts required for this apparatus are given in the list.

Simultaneous tests at a number of western universities have recently been made to test the comparative efficiency of one dial and multiple dial tuning control for radio receivers. As a result of these tests, it can now be authoritatively stated that one dial control is not only far simpler and easier to operate, but that it is actually more selective and accurate in logging.

A somewhat similar state of mind obtained in the early days of the automobile business. It is safe to say that automobiles would never have become the universal utility that they are today if the control had not been simplified to the point where anybody—man, woman, or child—can make the car go without knowing or caring what is under the hood. Radio is passing through a phase that is strongly analogous.

There are only two things that the broadcast listener has any interest in varying in his receiver. These are the volume and the total capacity or tuning of the set. The volume control is a comparatively simple matter, being merely a matter of controlling the current supplied to the tubes, and the rheostats, once set, ordinarily require only occasional adjustment, especially if an adjustable horn is used.

The variation of capacity, or tuning, as everybody knows, depends primarily on the action of the variable condensers. In all of the popular circuits which combine selectivity with range and volume, such as tuned radio frequency, the Neutrodyne and the Super-Heterodyne, there is a definite fixed relation between the required capacity of each of the condensers. The problem of one-dial control resolves itself into mounting all the condensers on a single shaft so that this constant relation can be taken care of in one operation.

Fig. 2 shows a five-tube circuit with a two-dial tuning control. Condensers C and C1 are operated by the one control dial. Across the condenser C1 a small variable condenser C2 is connected, which is used for fine adjustments to compensate for inaccuracies in the construction of the larger condensers. The condenser C3 tunes the detector cricuit separately. Of course, the experimenter may devise some means of mechanically connecting this condenser to the others so that all may be tuned with the one dial. In some cases it is better to tune C1 and C3 with one dial and tune the antenna circuit L2-C with a separate dial.

Parts Used in Five-Tube, Two-Dial Set

1 *National Airphone*, single dial control, double condenser unit.
1 .00035 mfd. single variable condenser.
3 Low loss coils.
1 Grid condenser and leak.
5 *Cutler-Hammer* vacuum tube sockets.
1 *Mar-Co* audio transformer.
1 *Pacent* audioformer.
1 *Pacent* six-ohm rheostat.
2 *Pacent* 30-ohm rheostats.
1 *Pacent* single circuit jack.
1 Baseboard, 12x36x½ inches.

This particular circuit is of interest in that regeneration may be controlled by means of the 30-ohm filament rheostat that controls the filament current of the first tube. The coils should be so designated that the first tube will oscillate with normal filament current. In other words, the primary coil L5 should have very few turns, about four, so that tube No. 2 will not oscillate. Primary L3 may have about 10 turns so that tube No. 1 will oscillate with normal filament current. By controlling the filament current with the 30-ohm rheostat the oscillations are easily controlled. The antenna coil L1 also may have 10 turns.

The experimenter will note that, when gearing three condensers to one control dial, if one condenser is slightly out of alignment, the efficiency for DX reception is poor. It is, therefore, well to use small vernier condensers, separately controlled, across each of the larger condensers to compensate for inaccuracies. The single control set is then no longer single control, as the small vernier condensers must be adjusted.

Another way of accomplishing the same result is to use broadly tuned circuits so that an extremely fine adjustment is not required. Fig. 3 shows a four-tube circuit that is somewhat broad in tuning and only requires one dial for the three tuning condensers and only one small vernier control knob for condenser C2. Broad tuning is effected by means of the crystal detector. In addition, this detector gives much better tone quality than a vacuum tube detector. In this circuit the three primary coils, L1, L3 and L5, may each have 10 turns. The secondary coils have approximately 60 turns. Oscillations are controlled by the 30-ohm filament rheostat connected to the first tube.

Single dial control of two or more tuned circuits is not restricted to radio frequency

(*Continued on page* 350)

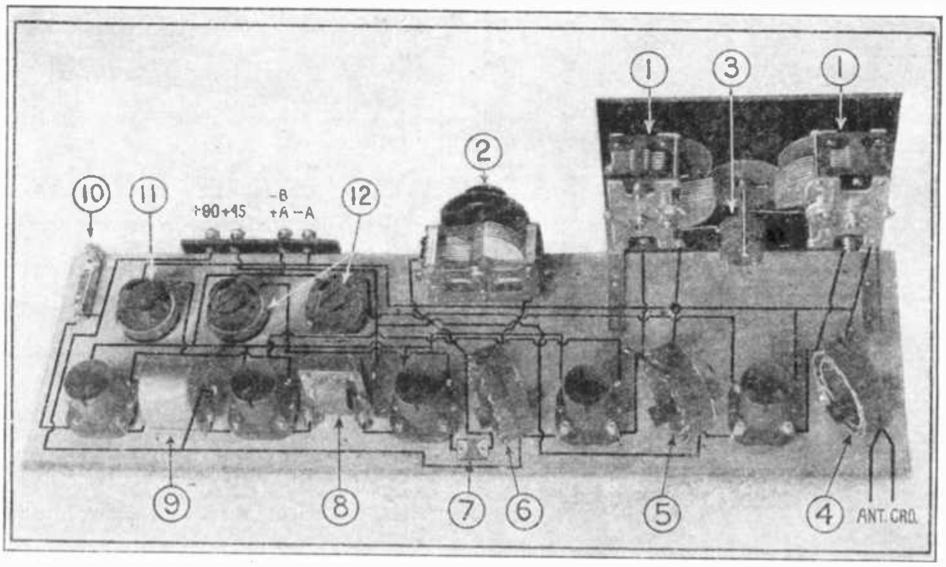


Fig. 7. An experimental five-tube receiver in which two of the tuned circuits are controlled by one dial. The condensers (1) are geared to one dial. The condenser (2) is controlled separately. (3) is a small venier condenser for fine adjustments. (4), (5) and (6) are the low loss coils. (7) is the grid condenser and leak. (8) and (9) are audio transformers. (10) is the jack, (11) the six-ohm rheostat and (12) the 30-ohm rheostats.

Tuned Radio Frequency Circuits

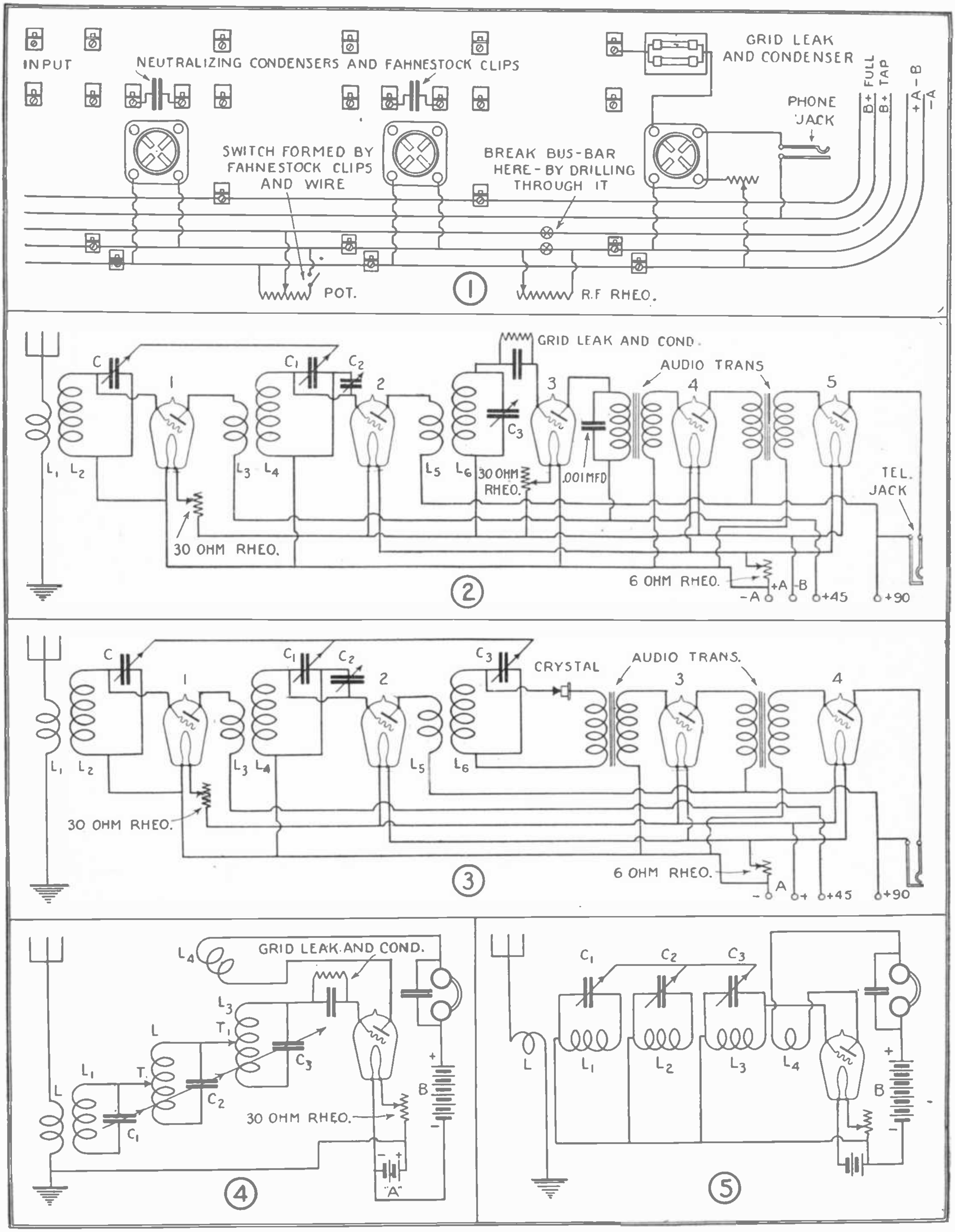


Fig. 1. Circuit diagram of the experimental set shown in Fig 6. Note the simplicity of the connections. The tuning condensers are not shown as they are connected in the circuit with flexible clip leads. Fig. 2. Diagram of the apparatus shown in Fig. 7. The two condensers C and C¹ are controlled by one dial. Fig. 3. A four-tube single control set using a crystal detector. Fig. 4. A single control super-selective one-tube regenerative set. Fig. 5. A similar set in which the three tuned circuits are in inductive relation with each other.

Two Electrode Vacuum Tube Amplifiers

By W. B. Arvin

THE ever versatile vacuum tube again comes to the experimenter's aid, in this case through the agency of the filament. In some recent experiments it was found that the filament of the ordinary low filament current tube, such as the 199 type, has a characteristic curve for amplification just as the grid possesses one. And strangely enough, there are positions upon it, in which an amplification factor of 1 to 9 or 10 may be obtained.

The idea was brought to mind in looking over some old telephone experiments wherein an engineer used a two electrode valve as a telephone repeater. He placed the secondary of a transformer in series with the filament battery supply and attached the primary to the microphone or transmitter. The modulations of the battery supply had a decided effect upon the heat of the filament and so produced a like change in the plate current.

To investigate this effect, meters, batteries and tube were hooked up according to the diagram in Fig. 1 and readings were taken. The rheostat was adjusted and the filament current was raised in steps of one milli-ampere through the filament. With each of these readings a corresponding notation of the voltage across the filament was made. The resulting change in the plate current was measured and the curve plotted.

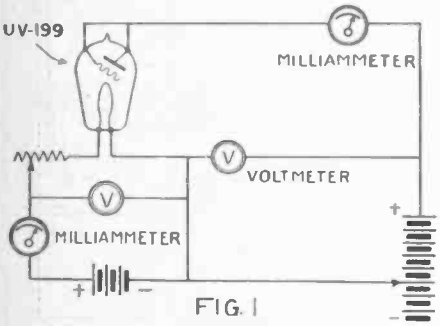


FIG. 1

Method of connecting the meters, batteries, and tube for plotting the characteristic curve shown in Fig. 2.

The amplification curve is shown at Fig. 2. A study of this graph will show that there are positions which will produce an amplification of ten to one. As in the case of the ordinary use of the tube, care must be taken to place the tube in operation at this point, which means that the heating supply of the filament must be so adjusted as to bring the "no signal" position of the device to the bottom of the strongest amplification portion of the curve.

It must be remembered that this is a power device and all calculations are made in *watts*. The situation is entirely different from the ordinary conditions which obtain when using the grid of the tube to make changes in the plate current, in which case the device is primarily sensitive to potentials only. It will be noted that the axes of the curve are plate and filament watts.

It was found most practical to use a resistance of the carbon pressure type in making the adjustment in the filament circuit in taking the readings. With it, the necessary small changes could be made in the supply, for the proper minute changes could not be obtained with the ordinary wire type.

Particular adaptation was made to the amplification of low frequency currents. In telegraph work, either wire or radio, the system gives excellent results. It operates best, however, where the changes are not of high frequency; forty cycles or less being ideal for proper results.

An English adaptation has already been made of the system using it to assist in the modulation of a one tube transmitter. Sex-

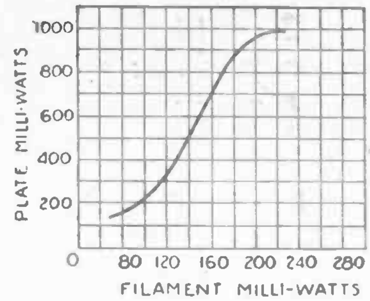


FIG 2

Curve showing the relation of plate watts to filament watts of a UV-199 with plate and grid connected together. A plate voltage of 90 was used.

ton O'Connor, an experimenter of some note, vouches for the circuit and its operation. The circuit is shown at Fig. 3. Only one tube is used in the circuit and it is used both as oscillator and modulator. Note how the grid circuit is used after the accepted fashion for the generation of the carrier wave and how the current variations from the microphone are impressed both upon the grid and the filament.

The experimenter will at once see applications for this system, since it provides him with a second means of controlling the output of the vacuum tube without resorting to the usual system of impressing two frequencies on the grid as in the reflex circuit.

The idea is a bit futuristic, for most of the amateur fraternity, but yet, there is a possibility. We speak of the use of this tube as a synchronizer in a television scheme, for the transmission of pictures. In the majority of plans put forward so far, some form of timing gear is necessary which will keep the two stations—the one transmitting the picture and the second reproducing it—in perfect step or synchronism during the period that the picture is coming through. This is an extremely important step in most of the apparatus, and the idea of using this tube with a low frequency on the filament is suggested to the experimenter.

Another adaptation may be made in the form of a relay for very weak telegraph currents. This use is of course obvious and is offered merely to give the worker an idea of the selectiveness of the apparatus, or rather the range over which it is best suited. In the preliminary tests, it was found that the best output was obtainable with frequencies up to forty cycles. But with proper care, in spite of the seeming sluggishness of the filament, it may be used as an amplifier of audio currents at the frequencies of the speaking voice, if sufficient care is taken in the selection of the amplification point and the tube used.

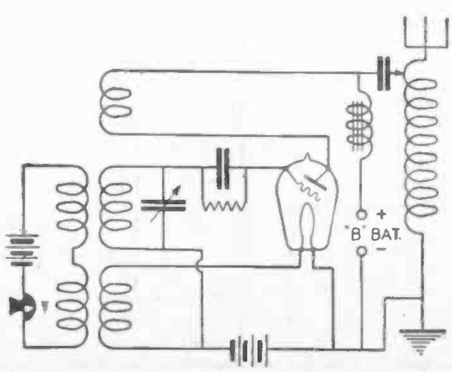


FIG 3

A transmitter circuit in which both the filament temperature and grid potential act as the controlling electrodes of the plate current.

And here is a point worth noting. It is generally known that the tube industries have standardized their product. In spite of this fact, all of them are not the same as regards the emission of the filament for a given amount of current passed through it. For this reason it is logical to note that each tube will have to be treated differently as to point of best operation. Some will work excellently in the manner described here, while others will give results of a mediocre nature only.

The use of the 199 type was stressed in the beginning. It is useless to reiterate except as a means of adding an explanation of the vagaries of the operation of several tubes of the same type. Their efficiency and emission at low currents depends upon the coating of oxide applied to the filament. This is put on in several coats and can hardly be made exactly the same in the case of every tube, hence the deviation from a given characteristic, so far as the filament is concerned.

This arrangement was used in a telegraph line where the resistance was exceptionally large on account of the temporary nature of the connections and line. By using the tube as shown in the above circuit-diagrams and feeding the output to a relay in the line, good communication was carried

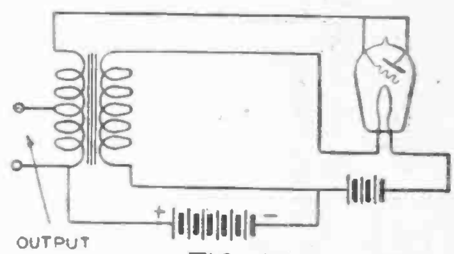


FIG. 4

The two element tube as an oscillator. Note that the filament acts as the controlling electrode of the plate current.

on for some time, where it would have been impossible except for the addition of the tube.

One of the handiest adaptations of the arrangement is that shown in Fig. 4. Many times around the laboratory a small alternating current at a reasonably steady frequency is desired. The tube arranged as shown can be used for such work by placing the transformer in the circuit. The primary of the instrument is placed in the filament circuit in series with the A battery which furnishes the current for both the transformer and the filament. The plate and grid are connected together in the original manner and are hooked up to the plate in series with the B battery. If best results are desired a third winding may be used for the output of the arrangement.

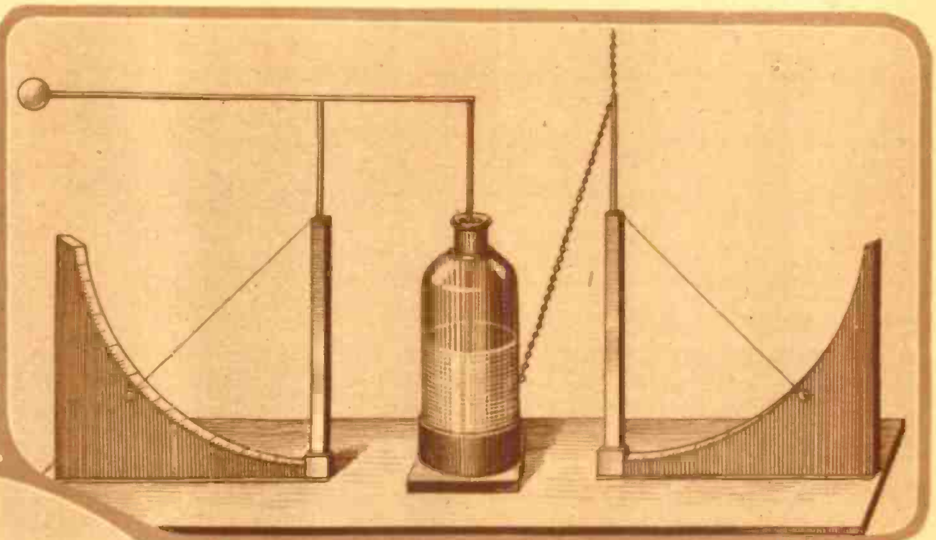
An ordinary telephone transformer may be used, or the experimenter may build his own. The frequency generated will, of course, depend upon the constants of the transformer and the remainder of the circuit. If the telephone instrument is used the third winding may be placed directly on the outside of the secondary. An iron core must be used in any case.

Audio or sub-audio frequencies may be produced by this means. A receiving arrangement may be used in the process of manufacture to roughly determine the frequency. After the arrangement is placed in operation, a fairly good standard of low frequency may be had by comparing the note generated by this means with a standard tuning fork and makin gthe oscillator produce a note of the same pitch as the fork.

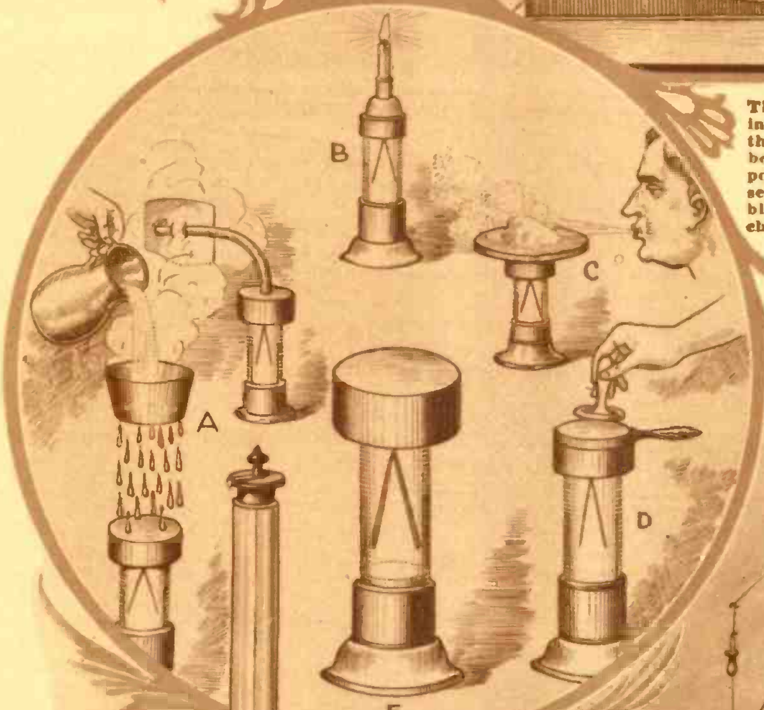
Historic Experiments

Number 5

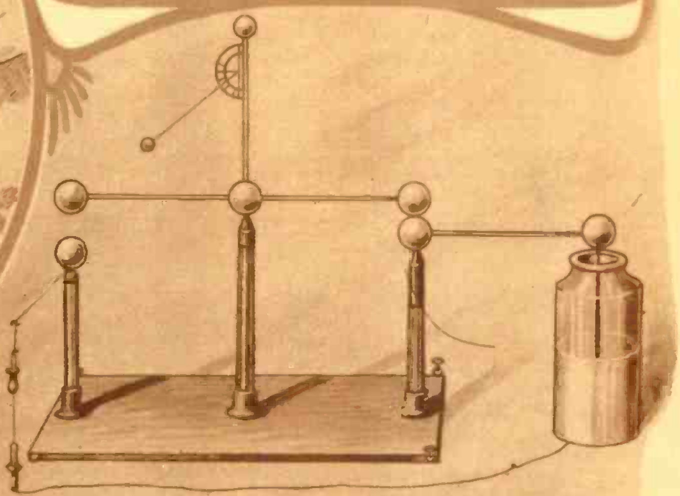
Early Electrometers

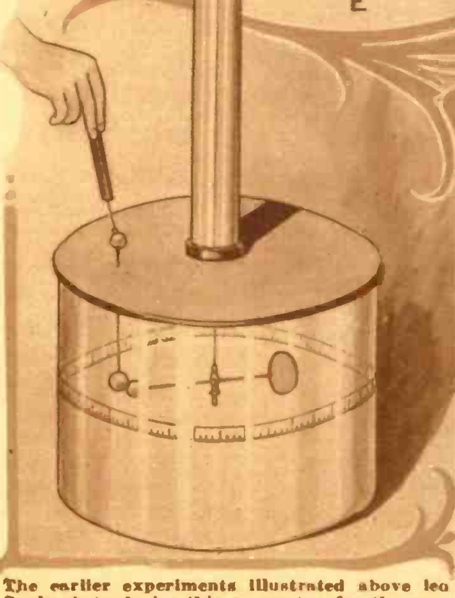


One of the earliest electrical measuring instruments was Richmond's Gnomon shown at the left. The device indicates the charge in the Leyden jar by the degree of deflection of the pith ball suspended by a silk thread. Richmond invented this in 1752. In 1753 he connected the apparatus to a lightning rod to measure atmospheric charges and was killed by a discharge of the apparatus through his body.



The electroscope illustrated at the left was invented by Volta in 1733 and was the subject of numerous experiments during the eighteenth century: A, water passing over hot coal will bear a negative charge, while the steam so produced will be positive. B, setting a candle on the electroscope increases the sensitivity, it is claimed by old experimenters. C, chalk powder blown off the electroscope imparts to the latter an electric charge. D, sudden separation of two metal plates after contact leaves both plates charged.





The earlier experiments illustrated above led Coulomb to devise this apparatus for the purpose of measuring the force exerted by two charged bodies upon each other.

UNTIL any field of knowledge is developed to a stage where it lends itself to quantitative treatment it can hardly be called a science. So with electricity. In its earlier stages when curious scholars were interested merely in studying and demonstrating its marvels, electricity was but the object of fashionable interest. In preceding issues of THE EXPERIMENTER we illustrated the electrical experiments of this period. On this page we show early attempts at measuring electrical quantities so as to express them in numbers. Electricity has been called a science of measurements.

Number seems curiously related to human psychology. When we have reduced a phenomenon to numerical expressions, we have a feeling of certainty, a feeling of thorough acquaintance with it. Nature seems to be intimately associated in our minds with number and rhythm. Even the symbols of higher mathematics do not at first convince the student as numbers do.

So these early experimenters, whose researches we illustrate on this page, were answering a fundamental appeal of their minds, in developing a quantitative theory of electricity. Among these was the English experimenter Cuthbertson, whose electrometer illustrated immediately above closely resembles that of Richmond's at the top of the page. After him came Coulomb, the French scientist, who, by his torsion apparatus shown at left, discovered the fundamental electrical law that two electrically charged bodies exert a force upon each other which is directly proportional to the charges and inversely proportional to the square of the distance between them. This established it as an action radiating like light from a charged center.

The Ark of the Covenant

By Victor MacClure

[What Has Gone Before]

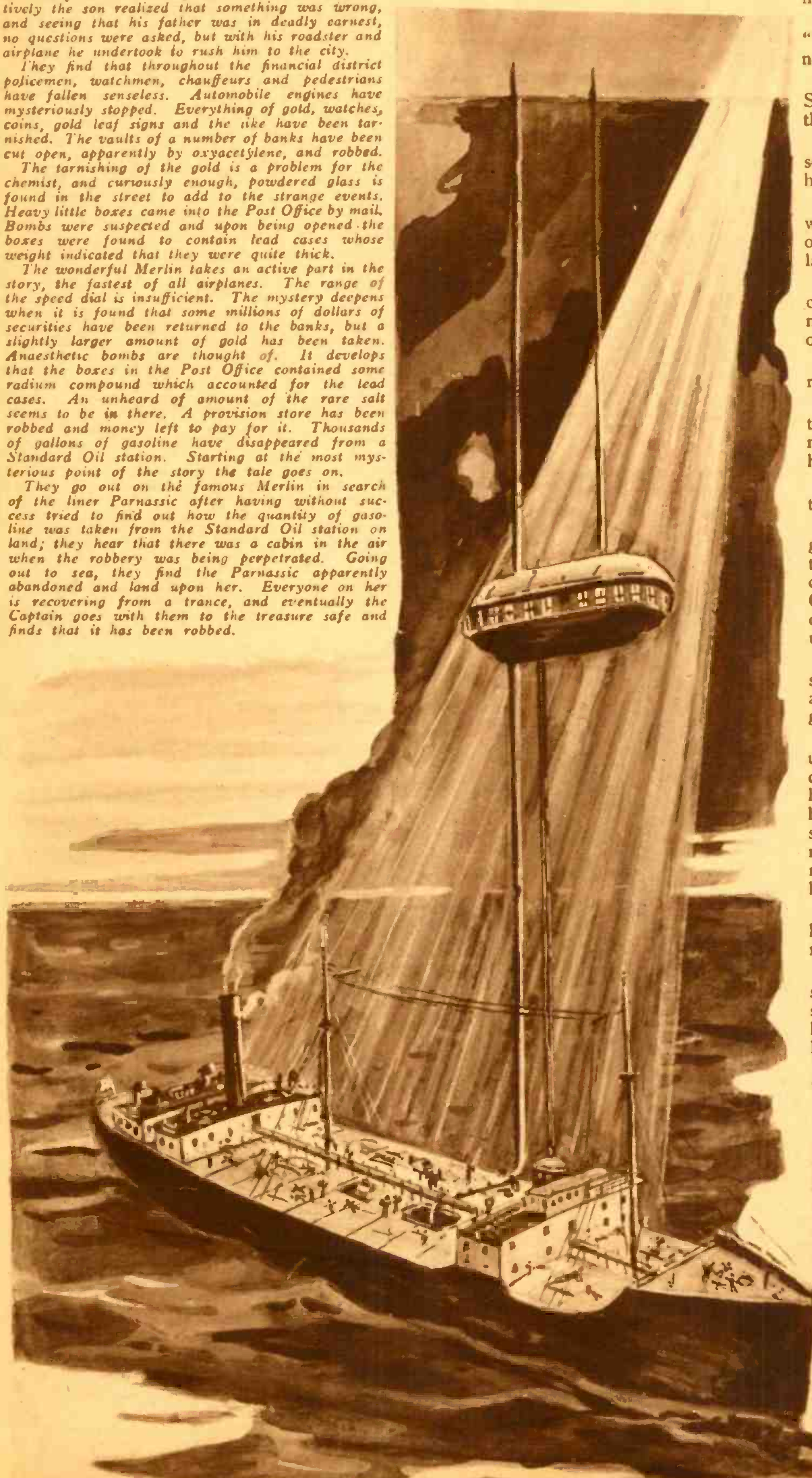
A number of New York banks have been robbed. The time is near the end of this century. The President of one of the banks stands by his son's bedside early in the morning and wakes him. Instinctively the son realized that something was wrong, and seeing that his father was in deadly earnest, no questions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

They go out on the famous Merlin in search of the liner Parnassic after having without success tried to find out how the quantity of gasoline was taken from the Standard Oil station on land; they hear that there was a cabin in the air when the robbery was being perpetrated. Going out to sea, they find the Parnassic apparently abandoned and land upon her. Everyone on her is recovering from a trance, and eventually the Captain goes with them to the treasure safe and finds that it has been robbed.



"Y. S. oil-carrying steamer, Westbury. We were slowed down by a riding light ahead of us and a message came from the battleship Argonne, telling us to heave to because of danger ahead. Since then we don't know a dern thing of anything, except that our forrard tank is short of three thousand litres of the highest grade aviation spirit by the gauge. Yes, sir. And there ain't a man on the ship, sir, that can say what was doin' in the last two hours."

LORD ALMERIC PLUSCARDEN

"Phew! Nearly two and a half million in American dollars," I said—the British florin standing at that time at 2.42—"just about as much as they got out of Wall Street!"

"Tell me, Mr. Boon," said the Captain. "When you sighted us, was there any craft near us?"

"Nothing within forty kilometers of you, Sir Peter—and certainly nothing up to doing that distance in the hour."

"That cuts out an hour, leaving one for some craft to do the job in. They must have been damned smart!"

Just then the purser came running in, and when he saw the strong-room door, he let out a wail of despair. Sir Peter cut the lamentations short.

"Step down to Lord Almeric Pluscarden's cabin, Strachan," he said. "My compliments to him, and will he come here at once?"

"But the strong-room, sir!—the strong-room! It has been broken into!"

"Dammit, Strachan!" the captain said testily. "We can see that. Kindly take my message to Lord Almeric. Crying won't help us."

He turned to a telephone on the wall of the cabin.

"Lucky the exchange is automatic," he said grimly, "or I wouldn't be able to get through to my bridge, I suppose. That you, Boscence? Any report from the engine-room. Good! Now the first morning watch will come on duty, and be relieved at eight as usual. Carry on!

"The engine-room reports a good head of steam," he turned to us and said. "The automatic oil feed in the stoke-hold has been going on all the time. Ah, the engines!"

We felt the vibration of the ship's engines under our feet as Lord Almeric Pluscarden came into the cabin. I had expected somehow to see an elderly man, probably white-haired and rubicund, but the newcomer was a slenderly built, dark-skinned, dark-haired man, apparently of about forty-odd, alert in manner, and athletic-looking. I found out later that he was close on sixty.

"Hullo! What has happened, Weatherly?" he asked at once, when he saw the ravished strong-room.

"I'm damned if I know, Lord Almeric," said the captain, with a finger pointed at the spoiled door, "but that's the chief thing that has happened. How it came about—well—here's your pilot, Mr. Boon, and his friend, Mr. Lamont. They've got a story that'll take your breath away."

"Kind of you to put your machine at my disposal, Mr. Boon," said Lord Almeric. "I'm afraid you've had a cold flight. Very sporting of you to accompany him, Mr. Lamont. I'm grateful to you both. And now—this story?"

Between us Dan and I told of the Wall Street robberies, of our theories, and of our coming to the *Parnassic*. Lord Almeric asked a shrewd question or two, then Sir Peter gave a fuller account of the stopping of the ship.

"I am very much a layman in aeronautical matters," Lord Almeric said when we had finished, "and I do not know if there are any other points to be made for or against your idea of the airship—beyond those you make yourselves. I must say you put a fair case, which is considerably strengthened by this act of piracy. Whatever may be the mode of operation, we are certainly faced by a remarkable organization. But I should not, if I were you, Weatherly, dismiss the possibility of the gold still remaining on the ship. I suggest that a thorough search be made of the ship and of the passengers' baggage. You will not, of course, except my luggage from examination——"

"Surely, Lord Almeric—" the captain protested.

"I insist," said the other, "and I am sure that Miss Torrance will say the same. Miss Torrance," he explained to me—"if you can take her—is your other passenger, my niece and secretary."

"Only too glad, Lord Almeric," said I, a little taken aback at the idea of carrying a woman. "But I'm afraid we damaged the starboard float getting aboard, and if we have to come down on the way back—well—it'll be a bit inconvenient. We'll get wet, at least."

"You don't anticipate a forced descent, Mr. Boon?"

"No," I said, "but you never know your luck. Then there's the difficulty of taking off from the awning——"

"Bless my soul," said Lord Almeric, "you don't me to say that you put your seaplane aboard on the awning?"

"I did—and I'm afraid I've ripped off some of your canvas, Sir Peter, in doing it."

"I'll worry about that, young man," the captain said, "when somebody has ripped a slab off the strong-room door, and ripped five million florins off my ship!"

He glared at the damaged door, tugging his little beard the while as if to drag from it some solution of the mystery.

"Fifty years I've been at sea," he said thickly, "man and boy, and, by thunder, I've never come across anything like it! It's bewildering—exasperating—God, it's heartbreaking! On my ship—Lord Almeric—on my ship! The disgrace of it!"

"Peter Weatherly," his lordship said, with something that was good to hear in his voice, "this piracy concerns me, as a governor of the Bank of England, very nearly—and I can tell you that for my own part not one atom of blame attaches to you."

"But I stopped the ship, my lord, and gave the blighters their chance!"

"For Heaven's sake, Peter," Lord Almeric said in an altered tone—equally good to hear—"get the ridiculous notion out of your head that anybody is going to pick a bone with you over anything you've done!"

He went over and put a hand on the sailor's shoulder to shake him.

"Be assured, old friend," he said. "It will take more than this to shake the clean record of fifty years!"

"But it's such an exasperating thing! It leaves a fellow helpless! I'm going through the ship with a fine sieve presently, but I feel it in my bones that whoever has swiped the kopecks has got clean away. Still, it has to be done. We can't leave anything to chance."

"That is right," said Lord Almeric. "And now, I suppose I'd better be getting a start made. I shall put what you say to Miss Torrance, Mr. Boon—but if I know anything of her, it won't deter her from joining us. But you must have some breakfast——"

"There's plenty to eat on the *Merlin*, Lord Almeric," said I, "and if the lady is coming, and won't mind picnicking for once—why, we'll get away as soon as Sir Peter will permit us."

"I shall have to go over your boat for form's sake," said Sir Peter. "Come along. I'll do it now, and then we'll see what we can do to get you off without mishap."

IV

The Crew of the Parnassic Restored

It was difficult to imagine, when we were on deck again, that only half an hour gone the ship had been peopled by folk apparently dead. The seamen were washing the decks and going about their ordinary work pretty much as if nothing had happened. If there was a tendency to get to work in pairs, it was nothing to notice, and the demeanour of the men spoke well for the discipline Sir Peter kept on his ship.

"By thunder, young fellow," said the captain, when he saw how the seaplane lay, "you're not lacking in nerve! It must have been a ticklish business." And he added vulgarly: "She's as snug as a bug in a rug!"

"It'll be a job to get her off," said I. "I hope you won't mind putting on a few of your hands to turn her, sir?"

"As many as you want," he said, "or as many as the awning will hold and bear the weigh of. I'll take a look inside—so that I can give you clearance papers——"

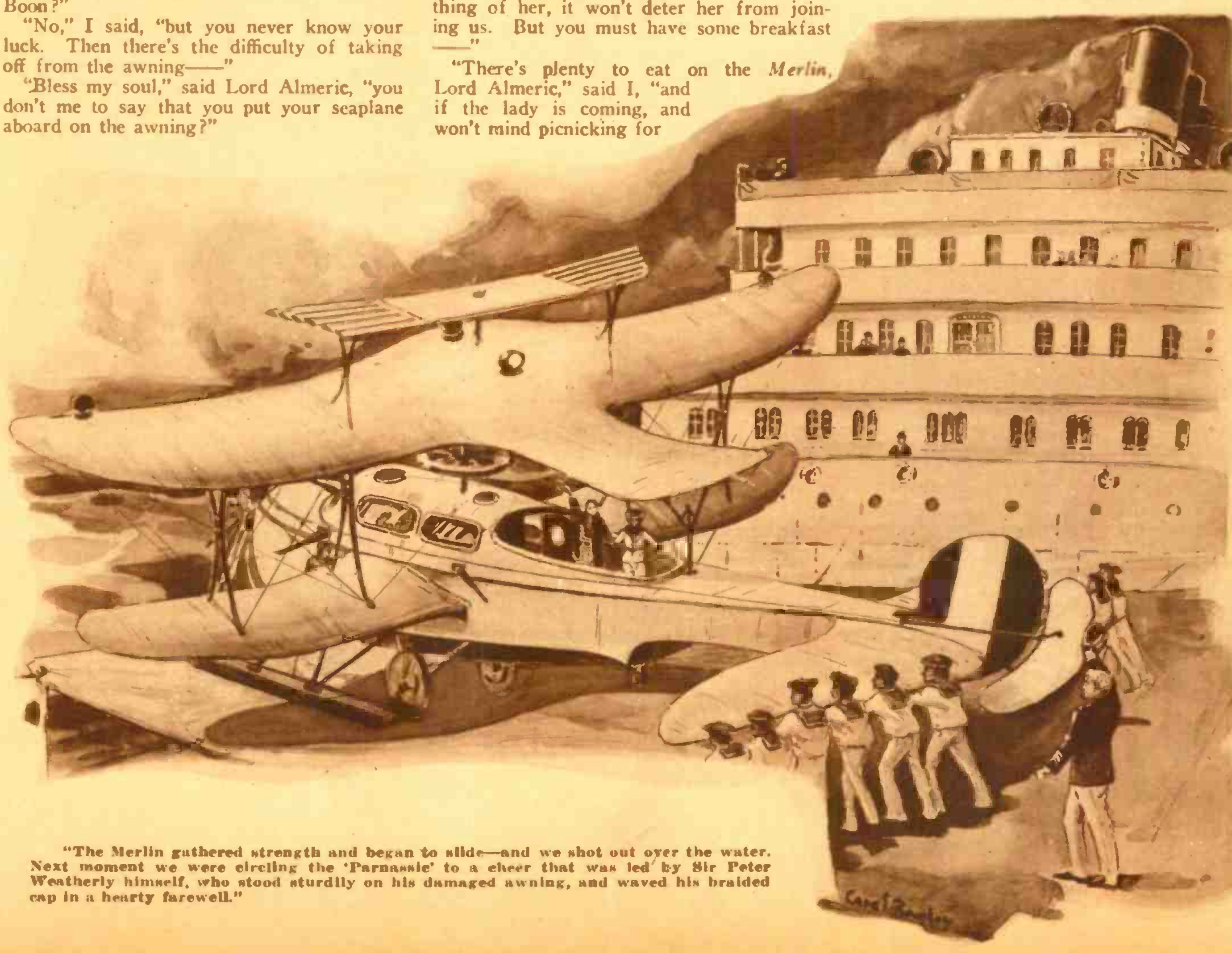
He went up into the body of the machine, while I had a look at what Milliken was doing. Stout fellow that he is, he had rousted out the ship's smith, and together they had patched up the float where the aluminum had parted from the framework. If a little cockled, the float was as seaworthy as ever.

Sir Peter came down from the cabin, and opened the floats.

"I have to do it," he apologized, "for your sake as well as my own."

"That's all right, sir—and if when you get

(*Continued on page* 344)



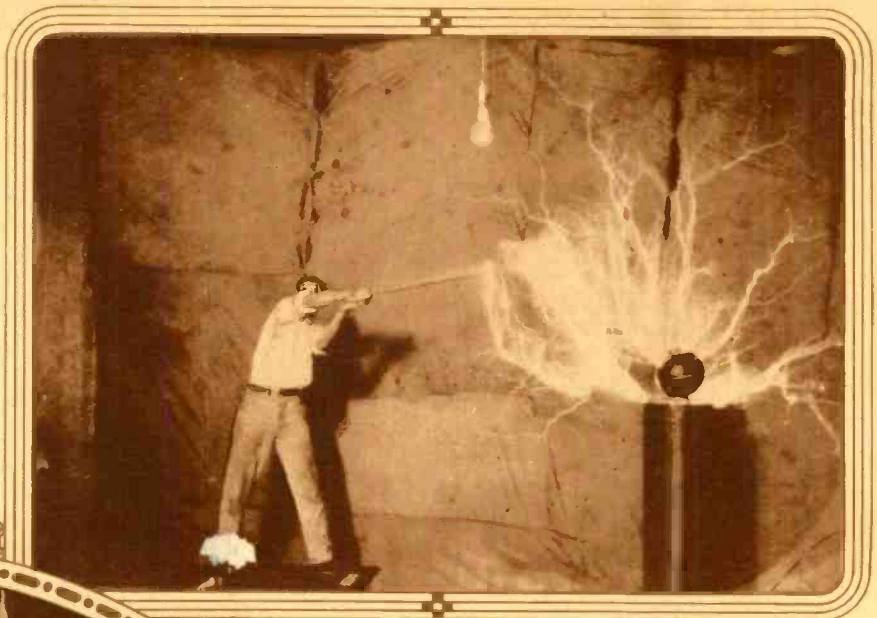
"The Merlin gathered strength and began to slide—and we shot out over the water. Next moment we were circling the 'Parnassic' to a cheer that was led by Sir Peter Weatherly himself, who stood sturdily on his damaged awning, and waved his braided cap in a hearty farewell."

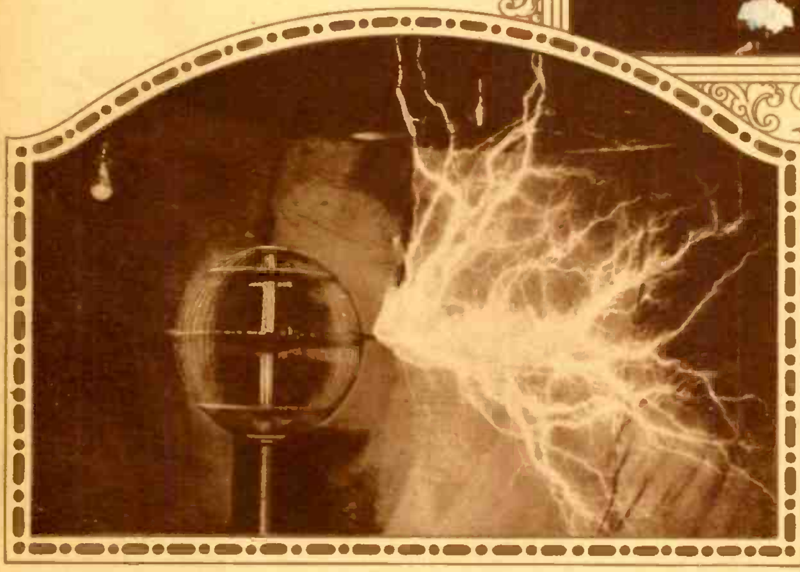
High Voltage Experiments

By Lester Reukema

Instructor of Electrical Engineering at the University of California.

The intensity of the spark testifies to the magnitude of the current which the man in the picture at right draws from the coil. A sabre held in the hand receives the discharge from a 40 K.W. high frequency coil.





Terrifying as the discharge above appears, it can yet pass over a man's body without harm because of its extremely high frequency, which prevents its penetration into the system.

The torch bearer below stands in a basin of salt water connected to the Tesla coil. The torch is a strand of wire from which powerful sparks shoot into the air.

These concentrated sparks are the most difficult to bear, and unless the hair is thoroughly wet, it is apt to be burnt by the sparks.

IN OLDEN days, before science had, by explaining the causes of the physical phenomena surrounding us, robbed them of the mystery and awe with which earlier people invested them, the lightning was held in dread as the most spectacular demonstration of the power and majesty of the gods. Today the mystery and awe have given way to knowledge, and the electricity which manifested itself only as the dreaded lightning has been tamed and become man's most valued servant. Yet lightning still remains the most spectacular phenomenon in nature. The vivid glare flashing across the sky is a thing of most exquisite beauty; the crashing thunder echoing from every hill thrills with its suggestion of mighty power. And, indeed, although a flash of lightning consumes but a few hundred watt-hours of energy, it represents for an instant several thousand millions of kilowatts of power, since this energy is expended in a few millionths of a second.

Largely to study the destructive effects of lightning, the Tesla coil has been developed into the impulse oscillator which may be said to produce lightning artificially. Once in each year the engineering students of the University of California act as hosts to the rest of the students on the campus and to others interested in such work. And the impulse oscillator takes up its role of entertainer and producer of spectacular displays.

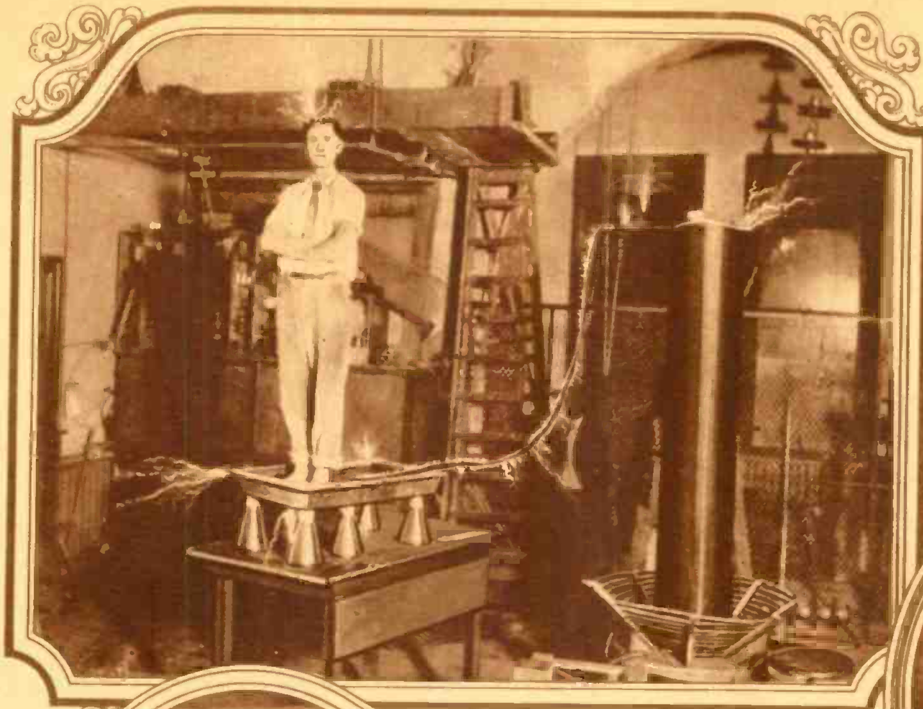
The discharge from the ball, as shown, is a beautiful sight, writhing tongues of violet flame shooting out from the spherical surface, branching and twisting in all directions like angry serpents. As one watches, certain of the flames succeed in hitting the walls or ceiling 10 or 11 feet away, changing instantly to dazzling white power arcs. And all of the while, the display is accompanied by a cracking, explosive roar. Thunder on a small scale. The discharge over 11 feet in length, from the wire cage represents a potential of about 1,500,000 volts.

At this voltage the energy will tear its way through or around any kind of insulation which may be placed in its path. Wooden planks are set afire almost instantly, glass and porcelain are punctured, even marble cannot hold back the energy. It would seem as though such a bolt must mean sure and instant death to anyone so unfortunate as to be hit by it. Yet, due to the high frequency of the discharge, there is no danger whatever, if certain simple precautions are observed. Thus some pictures

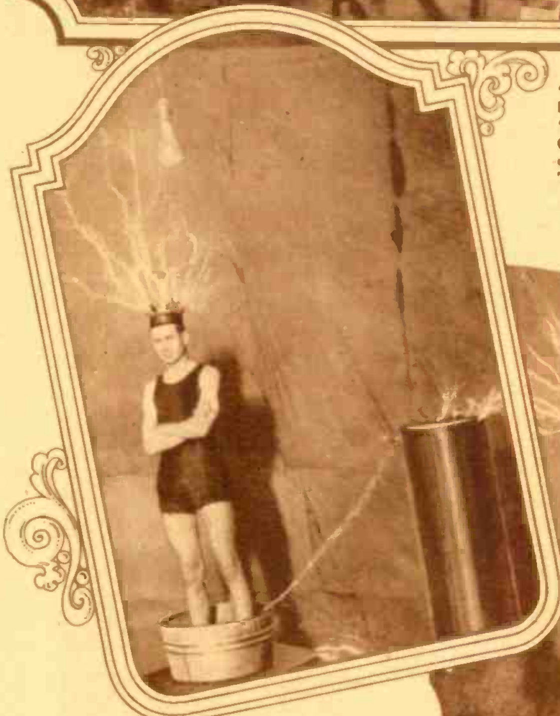
(Continued on page 342)

Playing with Lightning

(See also opposite page)



The man above is taking a 40 kw. high frequency discharge from the Tesla coil at the University of California. The coil used in these experiments is seven feet high. The current passes over the surface of the body only.

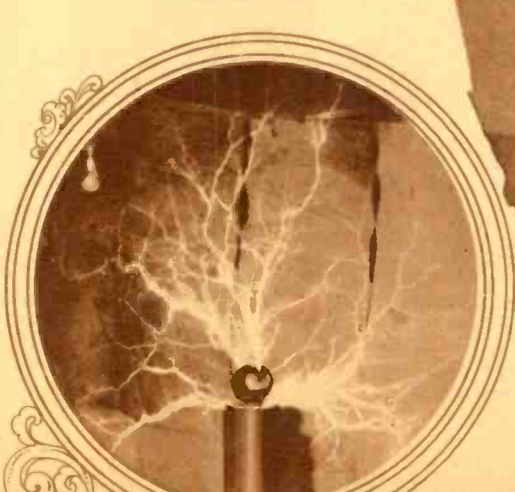


The gentleman above is enjoying a salt water tub bath. It is claimed by the author that no man ever got a bigger kick out of his bath than the one illustrated here.

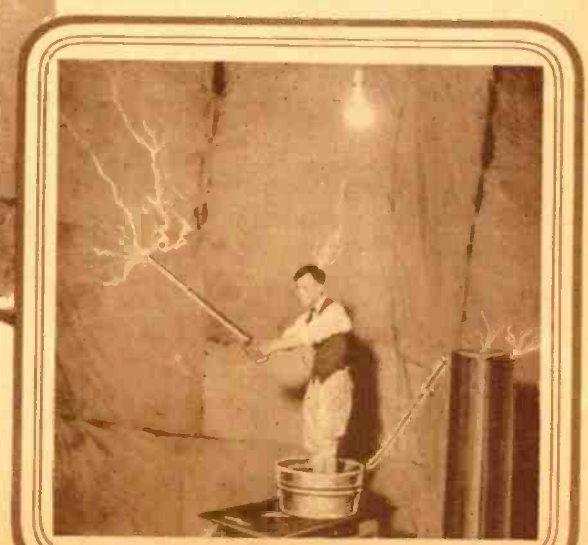
The sparks emitted by the arms of the small rotor at the left impart to it a spectacular motion. The Tesla coil is connected to the salt water bath in which the man stands.

An intense high frequency current passing over the body of the man shown below, discharges at the tips of the sabre which he holds.

The discharge above is radiated from a metal crown worn on the head. The use of this crown eliminates the danger of burning the hair.

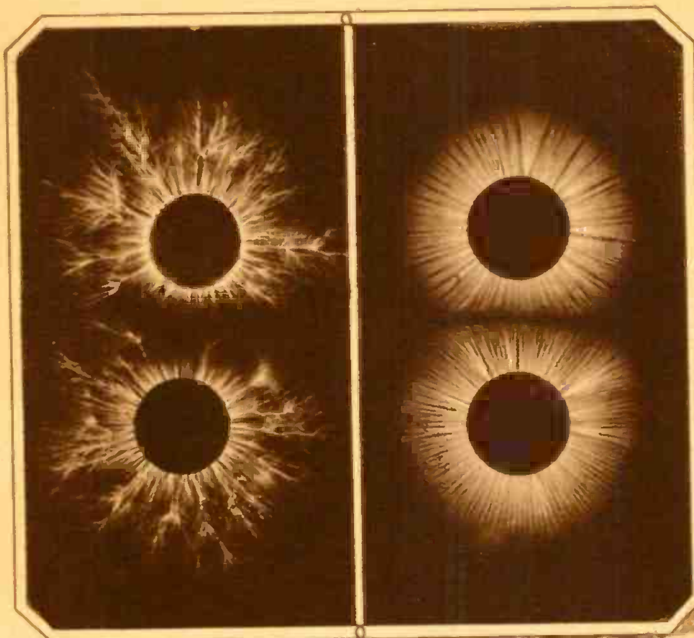


The terminal of the large Tesla coil in full action is shown at left. Some of the sparks are more than eight feet long.

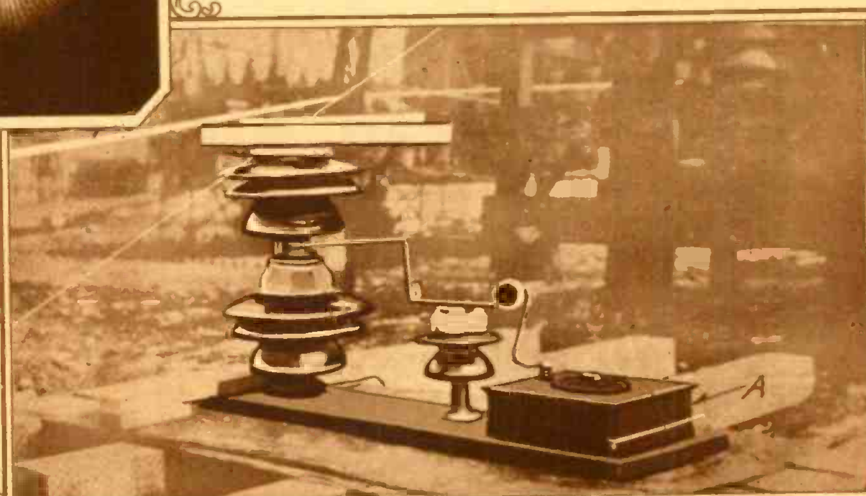


The Klydonograph

The Instrument that Sees and Records Electrical Surges of 0.000,005 Second Duration by the Photographic Plate

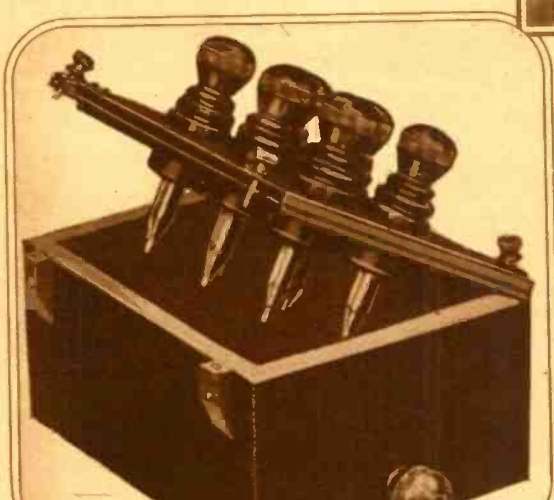


The illustration at left shows photographs taken of the corona glow on an electrode connected to a transmission line in which a momentary surge of electrical current occurred. The dark circles show the cross-section of the conductor and the radiations from them are corona discharges which, while invisible to the eye, can affect a photographic plate.

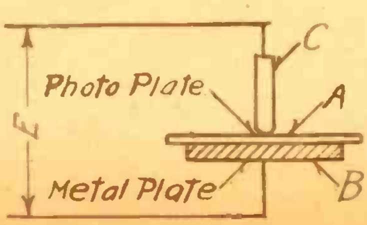


The photograph at the right shows the klydonograph (A) connected to a transmission line. The klydonograph is merely a dark box in which a cylindrical electrode connected to the transmission line is in contact with a photographic plate which is resting on the other electrode of the instrument.

A multi-electrode klydonograph is shown below. In operation the photographic plate is placed in the bottom of the box, and upon closing the lid the electrodes assume their appropriate positions with respect to the plate.



The diagram shows the operation of the klydonograph. Between the electrodes B and C the photographic plate A is placed. The corona discharge occurring between the two electrodes is recorded on the plate.

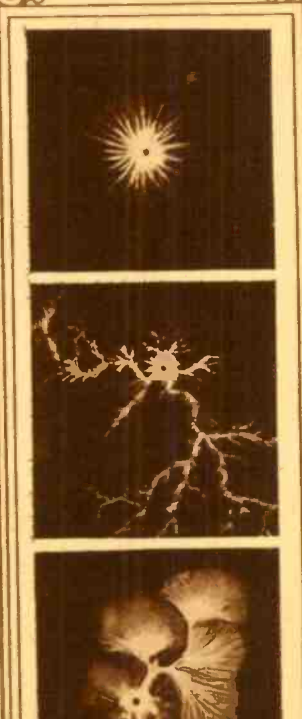


A NEW instrument, known as the klydonograph, has been developed by J. F. Peters, of the Westinghouse Electric & Manufacturing Company, for recording abnormal voltages on transmission lines. With this instrument, a graphic record of voltage surges of extremely short duration can be obtained, giving their polarity, magnitude, steepness of application, etc.

Heretofore, because of the many peculiarities in connection with abnormal voltages such as surges or high freqnency oscillations, it has been difficult to obtain detailed information concerning them. Their cause is quite often not known and their duration is generally so short that it has been practically impossible to measure with certainty their magnitude or duration. The result is that the knowledge of surges and abnormal voltages on transmission lines is rather limited, leading to questionable conclusions about their cause, effect and remedies.

The new instrument is based on an old principle first observed in 1777 by Dr. Lichtenburg and makes use of figures known as Lichtenburg figures. Dr. Lichtenburg found that, if he discharged a condenser, such as a Leyden jar, across a spark gap upon a terminal in contact with an insulating plate placed between this terminal and a ground plate, and then removed the terminal and sprinkled powder on the plate, the powder would arrange itself in a figure that had a very peculiar appearance. In 1888, J. Brown and E. Trouvelot found that with the insulating plate replaced by a sensitized photographic plate, the emulsion in contact with the terminal, figures very similar to those of Lichtenburg were created and appeared upon development.

(Continued on page 346)

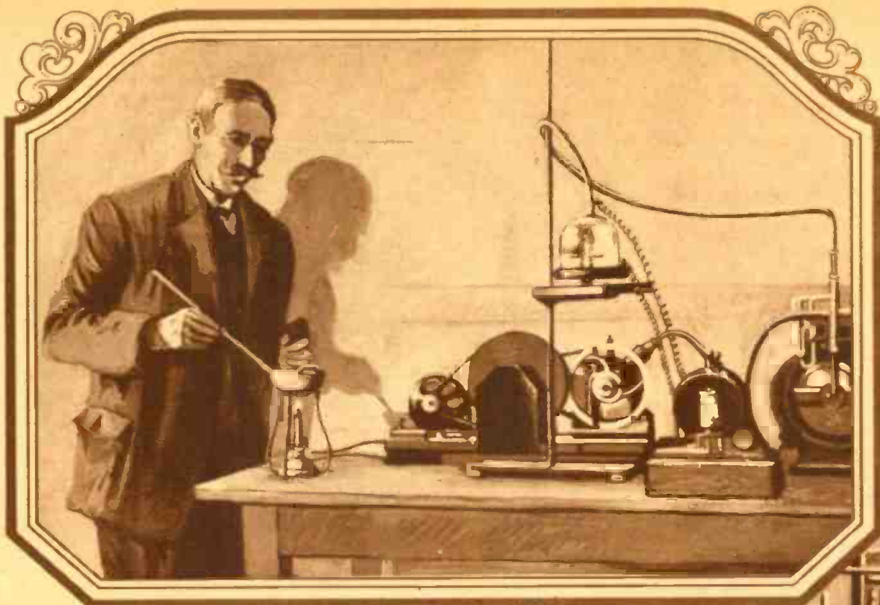


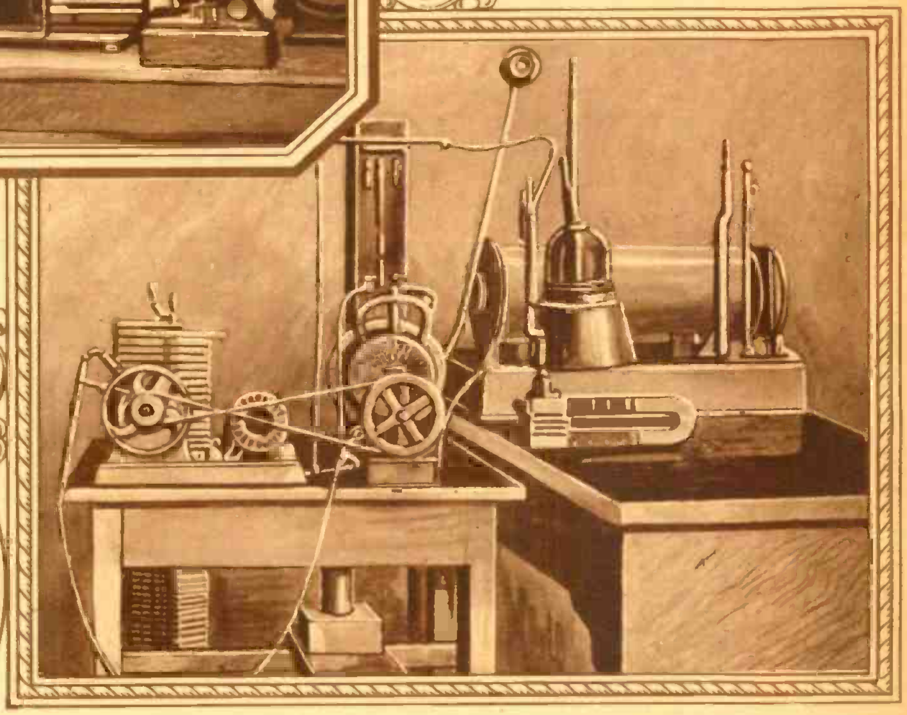
The photographs above show klydonographic records of an abrupt positive surge, a positive surge beyond the range of the instrument and a negative surge of a magnitude also beyond the range of the instrument.

Ionoplasty

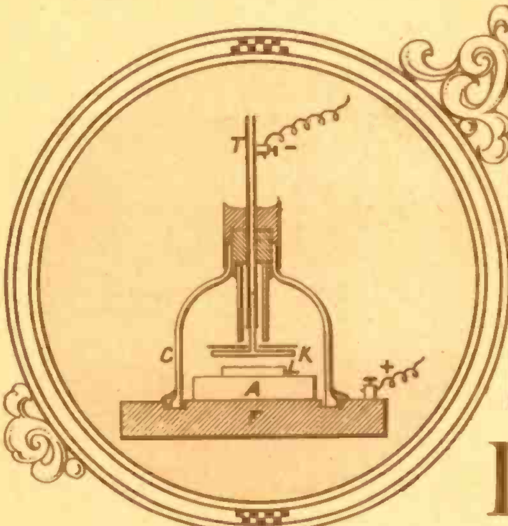
Electroplating Without Electrolyte

The illustration below shows the equipment used for the ionic deposition of metals. The apparatus on the left table is a pumping mechanism for high vacuum. The ionoplastic apparatus is under the evacuated bell-jar at the right.

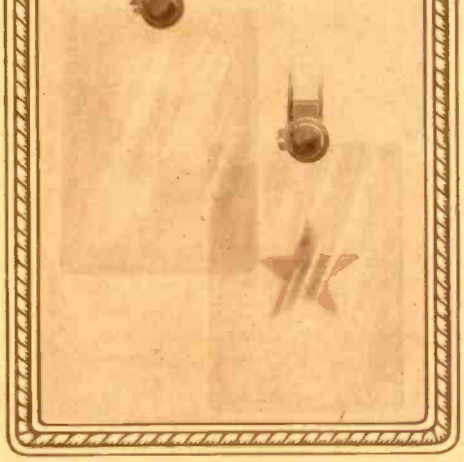




The plating after a brief exposure to ionic deposition is hardly perceptible, but will become readily noticeable if, as above, it is exposed to mercury vapor and becomes amalgamated by the latter.



This diagramatic view of the ionoplastic apparatus shows the plate K which emits the metallic ions which are deposited on the glass plate L as they move towards the anode F.



The glass plate at the left has been exposed for five seconds, the central area being screened by a star-shaped plate, to an ionoplasty of silver. The faint deposit was invisible until it was amalgamated by exposure of mercury vapor, producing the effect shown at the right.

IONOPLASTY is the name given to a method of depositing metals on any surface by ionic action. The diagram shows the general principle involved. (K) is the disc of the metal which is to be deposited on a non-conducting surface; the surface (L) is the one on which the metal is to be plated, which may be a plate of glass, the mirror of a reflecting telescope, or other object, and it rests upon a platinum plate carried on a base (A).

The whole is surrounded by a bell jar (C), closed at the top and bottom with India rubber so as to be completely airtight, and a vacuum is produced therein. A discharge from an induction coil which can give about a 3-inch spark does the plating. This has to be rectified by one of the regular appliances. A rectifier connected to an alternating current which rectifier may be of the Kenotron type, can be used instead of the coil. Even a storage battery will do the work if there are enough cells to give the requisite potential. The object is to pass from anode to cathode a current of a few milliamperes and a pressure of about 1,000 volts may be used. Under these conditions the metal of the anode will be deposited in a bright, adhesive coat upon the plate resting on the anode. Any substance will receive the deposit.

A pump such as used for evacuating lamps, X-ray tubes and other apparatus is used for producing the vacuum. It will exhaust a bell jar such as illustrated in our diagram in a very short time. A smaller apparatus can be constructed with a heavy test tube or specimen tube as the container. This is also shown in a diagram, in which (A) is the anode carrying the plate (L) to be plated; (K) is the cathode of the metal which is to be deposited; (C) is the test tube closed by an Indian rubber stopper; (M) is a metal ferrule, and (T) is the tube through which the air is exhausted.

By this process all sorts of non-conducting substances have been metallized. Glass, porcelain, India rubber and wood have all been coated. But while the operation succeeds excellently with what are called the noble metals, such as gold, silver, palladium or bismuth, with other metals such as copper, iron, chronium or nickel, it requires special care, and with the light metals such as aluminum, magnesium and sodium, failure really seems to be the rule.

Sir Williams Crookes, the celebrated physicist, has determined the relative weight of different metals deposited under the same conditions of time and current and finds that they range from palladium, 108; gold, 100; silver, 82; down to iron, 3.5; while aluminum and magnesium refuse to be deposited at all.

In experiments on ionoplasty we observe an unexpected phenomenon. A plate of glass subjected to ionoplasty was partly screened; the operation was maintained for only five seconds, and when removed, no deposit was visible, it was so thin. But if the plate was breathed upon, the part covered by the screen became sharply defined. This was due to the deposition of the breath upon the image. But if for the vapor of water, mercury vapor is substituted, which can be done very easily by holding the plate above a vessel of mercury heated to 60° C. (140° F.),

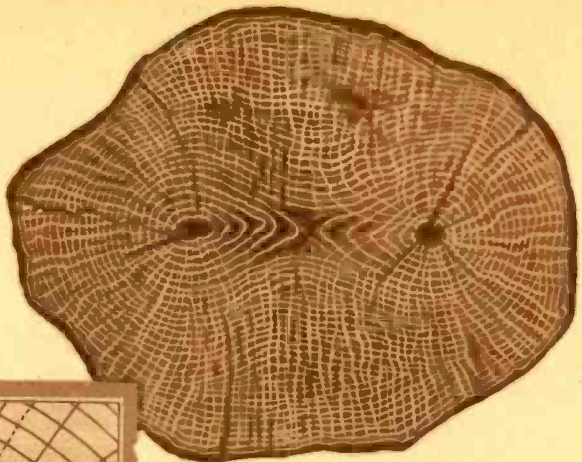
(*Continued on page* 343)

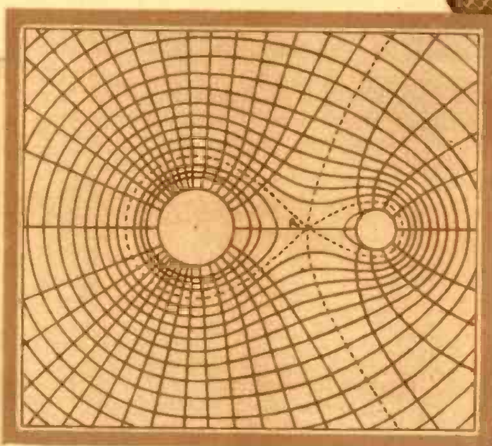
Is Life a Form of Electricity?

by

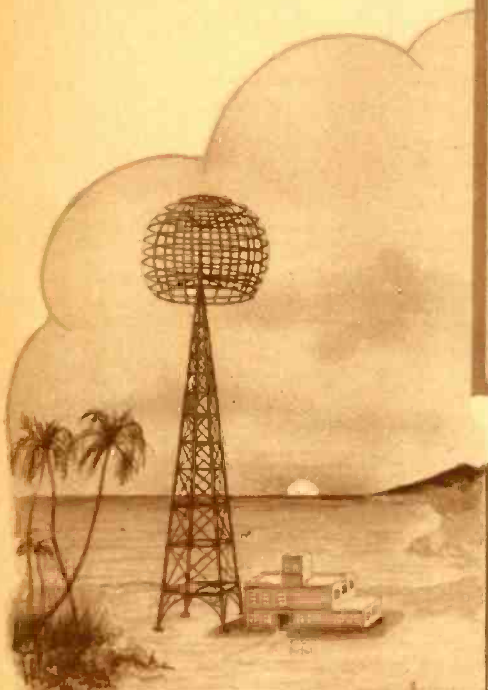
Prof. Alphonse Berget

(Mr. H. Gernsback, in the November, 1924, issue of THE EXPERIMENTER, *suggested the possibility of electromagnetic waves, such as those used in radio, affecting animal and vegetable life. Independently of Mr. Gernsback's investigations, Professor Stanoievitch of the University of Belgrade has conducted a careful research on the relation between plant life and electromagnetic lines of force. The article below is a brief review of these researches.)*





The remarkable analogy between the cross-section of a fir tree and the theoretical diagram of an electrostatic field between two charges, suggests the possibility that these two remote phenomena have characteristics in common. The tree section shown above was taken where a bifurcation of the trunk occured.



Are plants, radio waves, and the solar system regulated by a single law which holds over the universe as a whole as well as over all its parts?

CONCERNING the lines formed in wood, we knew only that these designs, however varied, indicate the age of the tree by their number, observed on a transverse cut, where they appear in the form of concentric rings more or less regular.

But as regards their lines along the trunk of the tree, the various forms which they present in longitudinal cuts we have for too long a time considered them a subject entirely foreign to scientific study and have not otherwise concerned ourselves with them.

Nevertheless, eminent scientists, among whom we could mention one of the first rank, Professor Stanoievitch, dean of the University of Belgrade, have studied this question and have shown its attractiveness in demonstrating that the law, according to which are formed the successive layers, whose accumulated deposits constitute the growth of vegetables, is none other than the law which rules the action of electric and magnetic forces in that part of nature which, for want of better knowledge, we call "inanimate."

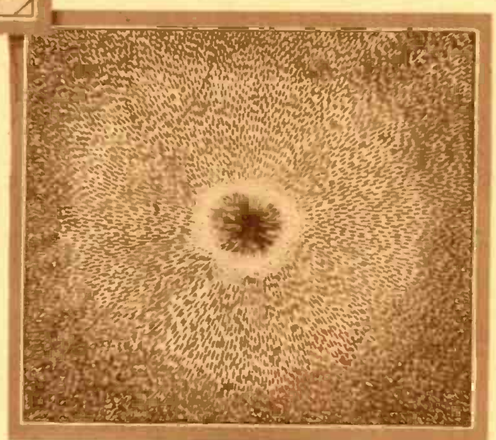
Magnetic "Phantoms"

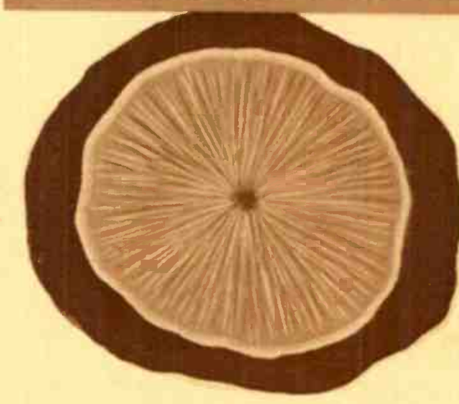
Let us recall first the elementary phenomena which are displayed by magnets in the manifestation of the "force" which seems to be radiated from them.

Everybody has seen, at least in pictures, the curious formations which appear around the pole of a magnet.

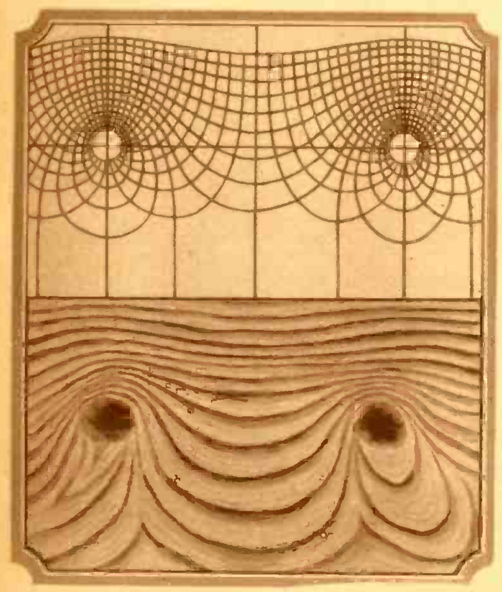
If we place a bar magnet vertically under a sheet of white paper, covered with fine iron filings (Fig. 1), we see the particles of filings disposed along continuous lines, all of which converge to the point under which the pole in question is placed. Above the pole itself, the action being stronger than elsewhere, we see an accumulation of particles instead of a single point, and all around it the converging lines

(Continued on page 344)





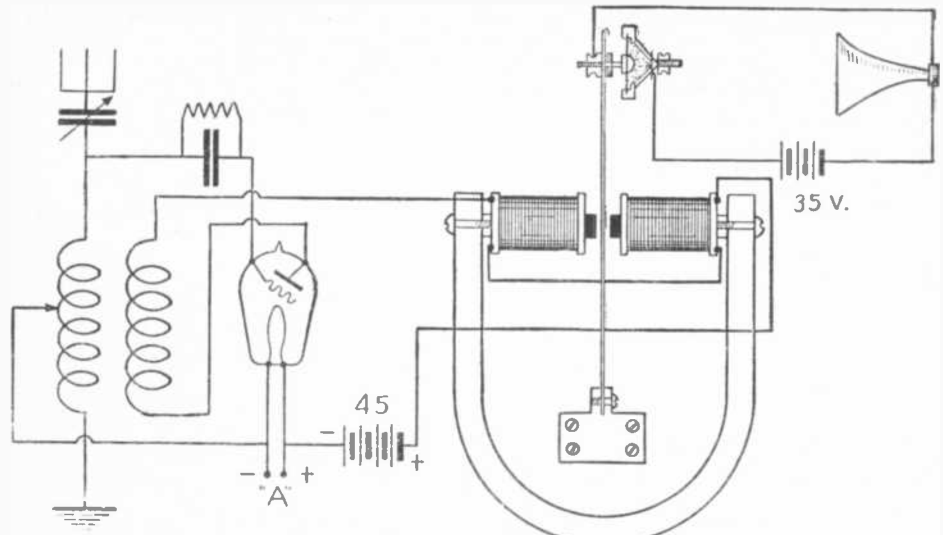
Above is a magnetograph (of iron filings), over a single magnetic pole which is curiously like the cross-section of a radish shown below it.

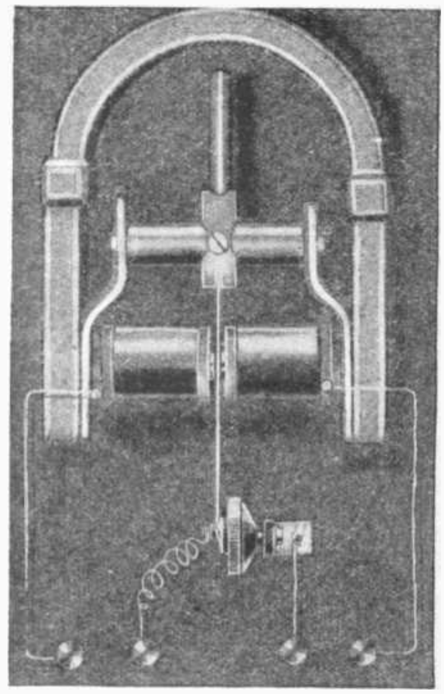


The disturbing effect of two magnets in an electric field is illustrated in the upper half of this picture. Note the strange resemblance which the grain of wood around two knots bears to this diagram.

A Microphone Audio Frequency Amplifier

By R. W. Reetherman





Photograph and diagram of the microphone amplifier showing how it is connected to a vacuum tube receiving set. This simple device amplifies local concerts loud enough to operate a loud speaker.

AN apparatus involving a novel departure from the regular run of audio frequency amplifiers has recently been constructed by the author. While the principle is an old one, the designer of the apparatus and the utilization of various parts from magnetos, Ford coils, telephone parts, are decidedly novel.

The efficiency compares very favorably with a vacuum tube amplifier with many of the squeals and howls of the latter absent.

No dimensions will be given as the average experimenter would vary them to suit the materials that he happens to have at hand.

The author used one of the magnets of an old Bosch magneto to energize the pole pieces which were taken from some telephone ringer coils.

The Bosch magnet has holes drilled and tapped in both ends and it is, therefore, much easier to attach the pole pieces than if a magnet were used that had no such holes. Of course, the temper may be taken out of a magnet and holes drilled, but it will then have to be retempered and charged again.

> The following parts will be needed:
> 1 Large permanent magnet from an old magneto.
> 2 Soft iron cores for pole pieces.
> 1 Section of secondary from a Ford coil.
> 1 Piece of hacksaw blade. 5½" long.
> 1 Piece of brass. ¾" x¾" x 1½".
> 1 Carbon microphone transmitter button.
> 1 Hardwood base. 6" x 9" x 1".

The wire was then taken off the ringer magnets and the wire from the Ford coil secondary wound on them. One section of such a secondary, evenly divided, will give the pole coils an approximate resistance of 1,500 ohms each or 3,000 ohms for the two. The wire does not have to be wound as evenly as it comes off the secondary coil, but must be even enough to prevent the wire from piling up in any one spot. When finished they are mounted between the prongs of the magnet facing each other. Enough iron washers are inserted between the magnet ends of the pole pieces to leave a space of ⅛" between them in the center. The vibrating reed is now made from the piece of hacksaw blade. Its width equals the diameter of pole pieces. It is then ground down on an emery wheel to one-half its former thickness. The length is 5½". One-half inch of this is clamped in the brass bar, which is then screwed down on the wood base so as to place the reed evenly between the pole pieces. Two-thirds of the reed should extend beyond the pole pieces where the microphone is mounted. A drop of sealing wax is sufficient to link the reed to the microphone. The location of the microphone on the end of the reed will have to be determined by experiment as there is only one point on it where the highest efficiency will be gained.

The circuit is very simple, the two coils in series are connected to the output of a detector circuit, a 35-volt battery in series with the microphone and a loud speaker complete it.

Using one tube in a regenerative circuit and the above described amplifier, a number of stations from Calgary, Canada, to San Diego, Calif., were received on the loud speaker.

A Simple CW Transmitter

ALMOST every radio experimenter desires at some time to have a transmitting set so he can do a little sending, but usually the price is too high for his purse.

A good many parts for the set described will be found in the scrap box. It is hard to state the range, but under average conditions the range is anywhere from 200 to 1,000 miles. The writer has used this set for some time and found it highly satisfactory from the standpoint of efficiency and economy.

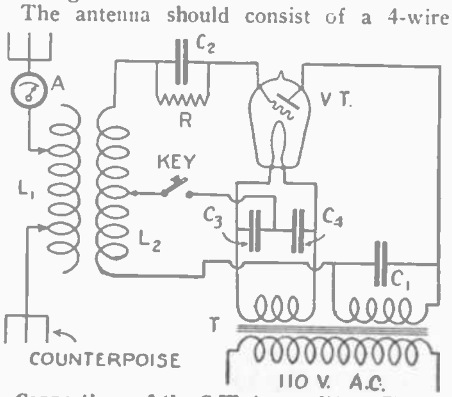
L_1 is a stationary spider-web coil wound with 23 turns of No. 16 D.C.C. wire, tapped every 5 turns.

L_2 is a movable spider-web coil wound with 26 turns of No. 16 D.C.C. wire tapped every other turn. C_1 is a fixed condenser capable of withstanding 1,000 volts and of .002 mfd. C_2 is a grid condenser .002 mfd. and C_3 and C_4 are Dubilier fixed condensers of .002 mfd.

R is an R.C.A. grid leak having 5,000 ohms resistance. V.T. is a UV-202 transmitting tube and K is the key. The transmitting tube should have a porcelain socket. T is the transformer having a plate output of 550 volts and filament output of 8 volts. A is the ammeter; although it is not absolutely essential, is useful for checking up the operation of the set.

The counterpoise consists of seven wires of No. 15 bare wire in a fan shape, 8 feet above ground.

The antenna should consist of a 4-wire cage 50 feet long and anywhere from 20 to 50 feet high. No. 14 bare wire is to be used.



Connections of the C.W. transmitter. It may be necessary to connect a resistance across the condensers C3 and C4.

Wire the set with No. 14 wire and solder all connections except the clips on the coils L_1 and L_2.

To tune it you must have a calibrated wavemeter and adjust the taps and vary the coupling of L_1 and L_2 until you get it adjusted to the wave-length you desire which must be below 200 meters.

Do not attempt to transmit until you have received your two government licenses. One is the operator's license that states that you have been examined and qualified to operate your radio sending set. The other is a station license certifying that your station is adjusted in accordance with the law as to wave-length, power, etc. To get information on this write to the radio inspector of your district.

This set creates very little interference to the B.C.L.'s because of its inductive coupling.

The writer would be interested to know the results obtained by anyone who tries this out. *Contributed by* ALBERT HARVEY.

Radio Explained by Mechanical Example

By Hans Gunter

THERE has recently been founded in Vienna a radio group of the Technical Museum which counts among its members numerous celebrated Austrian technicians, and at the first meeting of this society Professor Dr. L. Richtera, one of the most eager advocates in the Austrian radio group, gave a very interesting lecture on the basic foundations of wireless telephony, whose principles were shown by numerous mechanical analogies. In this way many things can be made clear which are otherwise very difficult for the unschooled reader. For this reason we give some part of the lecture here.

The simplest way for carrying waves of sound from speaker to listeners is, as the lecturer stated, the direct road through the air, which is the normal case when we listen. But this way of transmission does not apply to great distances, because the wave intensity diminishes with the square of the distance and the intensity of the sound even at a proportionately small distance falls below the limits of our auditory organs. That these waves are fabulously small to start with does not change this fact.

In the year 1902, Max Wien investigated the receptive capacity of the human ear. He used a membrane brought into oscillation by electricity, the amplitude of whose oscillations he diminished little by little until no sound could be received. When this point was attained, the amplitude was far below the limits of the very best microscope; by calculation it appeared to be only 0.000,000,000,6 cm., which is an inconceivably small quantity. Fletcher and Wegl have completed the investigation of the smallest variations in pressure of the air, which are necessary to give the sensation of hearing; these limits lie in the neighborhood of a change of pressure of 1/1000 milligram per square centimeter.

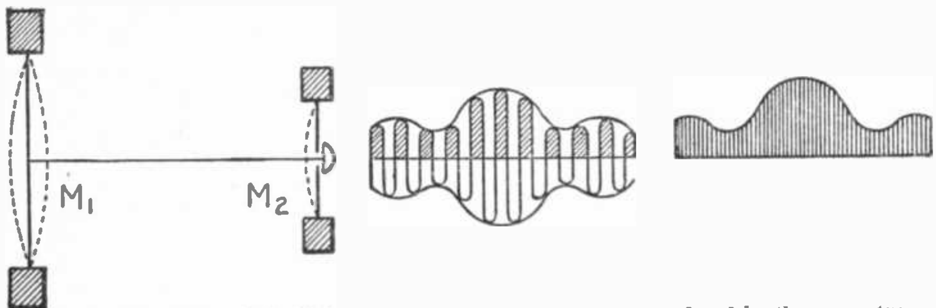


Fig. 2, the receiver of the high frequency modulated air waves produced by the apparatus shown in Fig. 1. Note that diaphragm M2 is actuated upon by only one-half of the incoming wave, giving the effect analogous to rectification or detection.

In spite of this extraordinary sensitiveness of the human ear, the limit in the transmission of waves through the ear is soon reached, beyond which nothing can be heard from us. If one wants to receive the sound at a greater distance, the sound waves in some way or other have to be "transferred" to a means of transport. Richtera names the problem here before us a simple problem of transportation. In daily life we have similar problems of many kinds; for example, one can take the case of America wanting to send gold quickly to Europe, in analogous comparison with the transmission of sound. Money as such is not transferred; money in America is changed into a telegraphic message that goes through the cable to Europe, and here again is changed back into real money.

In everyday wire telephony an analogy with this holds perfectly; we speak against the microphone of the telephone case; this changes the electrical resistance of the circuit of the microphone in tempo with the waves of the voice and changes in strength of the electric current flowing through the circuit is the result. In other words, the voice waves are changed into current changes. These current changes can be "transported" to great distances through wires, and then at the place of the receiving apparatus, by means of a telephone they are converted back into sound waves. In whatever way the speech between the transmitter and receiver is carried from transmitter to receiver is basically immaterial; thus speech may be converted into light waves which in a proper reception apparatus are brought bac kto sound waves. In naming this method we come to light-telephony.

This light-telephony is naturally only a special kind of wireless transmission, but as true radio telephony we characterize that which is done by electric waves for the comprehension of which we would refer to Fig. 1, which gives a mechanical analogy therefor. We see in the illustration on the top a funnel-shaped apparatus closed on one side with a membrane; still further to the top a machine is indicated, assumed o move aa high speed, and which vibrates the membrane a hundred thousand times in a second, back and forth. It follows that air waves come out of the funnel. These air waves we cannot hear because our ears cannot perceive air waves of higher frequency than 20,000 per second.

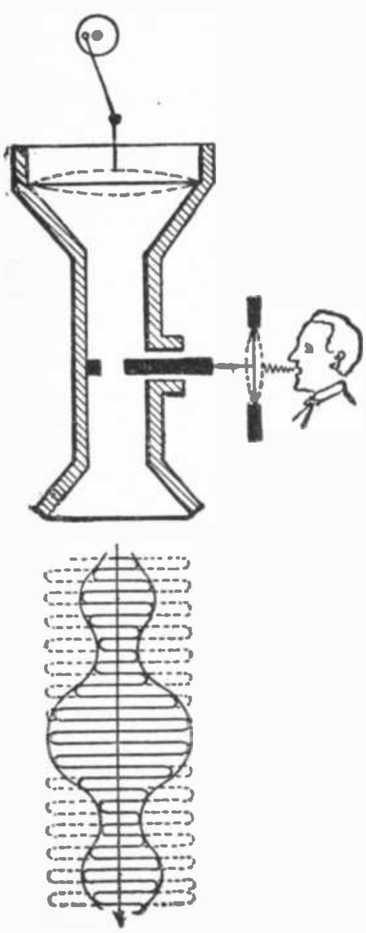


Fig. 1. Showing how high frequency air waves produced by the machine at the top are modulated by low frequency voice waves. The resultant wave shape is indicated at the bottom of the illustration.

These inaudible high-frequency air waves must issue from the funnel with very high energy if they are to be of tangible strength at a great distance. Then we can use the air waves for carrying on speech, so that they will give out the second waves of our speech in perceptible form for our ears. They are carrier waves.

For this purpose in the tube of our funnel a sliding valve is provided which also hangs from a membrane; now if we speak against this membrance, as this in accordance with the voice waves, bends up and down, it raises and lowers the valve gate. By the movement of this gate the aperture through which the high frequency waves from the other membrane pass through the funnel are successively made larger and smaller—the consequence of which is that these waves, with their original frequency unchanged, become weaker and stronger in tempo with the voice waves. In other words, their amplitude becomes greater and less in accordance with the voice. This makes the high frequency air waves originally produced the carrier for the voice, which has affected the motions of the gate of the valve; and in the changes in the intensity or amplitude of the high-frequency carrier waves the voice goes through space as the graph of the wave on the lower

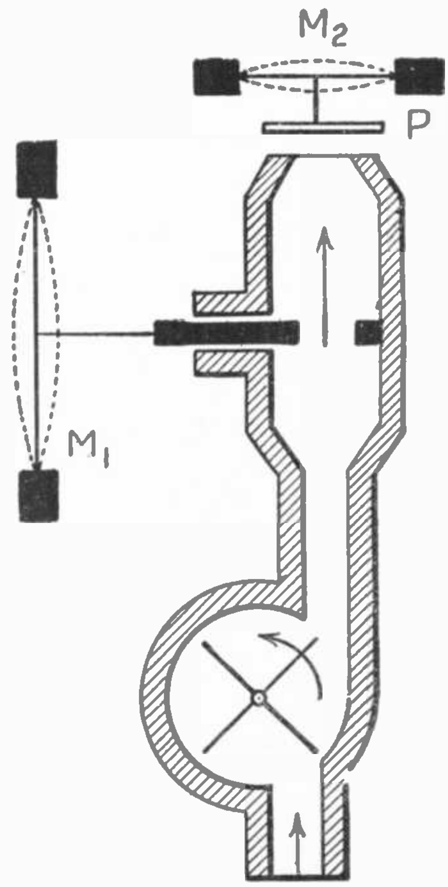


Fig. 3. The amplifier used for strengthening the high frequency air waves. The weak vibrations of M1 are used to control a senarate air current produced by the blower.

side of Fig. 1 shows.

This gives us at once an available means of transmission, and it constitutes a transmitter with whose help we can effect the transfer of the voice. But the receiver at the other end has to get back the speech, so we will take up a second analogy.

As the distance increases, the carrier wave gets weaker and weaker. To receive it with certainty at a great distance we use the principle of resonance; that is, we provide a reception membrane that is tuned to the exact rhythm of the carrier wave, therefore to a frequency of 100,000 per second. Through the first analogy we can see how we shall receive the approaching waves, for the reception membrane vibrates exactly in tempo and in accordance with the strength of the incoming waves. But this does not help us because we hear nothing whatever since this membrane, with a frequency of 100,000 per second, exceeds the power of our ears. So that we can hear anything, the sound waves which are brought along with the carrier wave must be set free. This can be done on the following lines:

In Fig. 2 (M_1) indicates the membrane vibrating in tempo with the carrier wave. A second membrane (M_2) is connected to it by a stiff wire, so arranged that the wire passes through a hole in the membrane and ends in a screw to receive a nut. When the membrane (M_1) swells out toward the right, the wire goes with it, without affecting the membrane (M_2), but it is quite different when the membrane (M_1) expands toward the left. Then the nut on the end of the wire presses on the membrane (M_2) and bends it also toward the left. What does this mean? Nothing else than that the membrane (M_2) is set into vibration only by one-half of the incoming wave, by the cross-hatched part of the wave shown next to it in Fig. 2.

If we take care that (M_2) shall not return at once to its original plane, but only in the tempo of the changes in intensity of the carrier wave, as if by damping with a thick fluid, the voice waves will be clearly sent out therefrom, as shown in the curve on the extreme left of Fig. 2. In other words, the speech is given back to the receiver. The apparatus doing this is called a rectifier. By increased distance between transmitter and receiver the voice received will become very low. It now is desirable to have some way of strengthening it at the receiving end.

Fig. 3 shows our analogy for this. We have a blower which sends a stream of air against a plate hanging from a membrane (M_2). (M_1) is the receiving membrane, which is familiar to us, and here also there is a valve gate, just as in the transmitter of Fig. 1. If now the membrane (M_1) moves in unison with the incoming high-frequency waves, opening and shutting the valve, the opening for the stream of air will thereby be changed in size in exact accordance and synchronism. With exactly the same periodicity the blast of air blowing on the plate (P) will be changed and varied in strength so that the membrane (M_2) will be moved back and forth more or less, always in synchronism. But this movement of the membrane (M_2) is much stronger than that of the membrane (M_1), as it is carried out by a strong current of air which the weak movement of (M_2) simply modifies. In exactly the same relationship and same proportion the waves of sound coming from (M_2) are strengthened. This gives the whole principle of the strengthening of wave telephony, whereby it is perfectly clear that all we have to do is to modify and control a separate source of energy situated at the receiving end. It is this source of energy which brings the strengthened operation. The weak waves only govern it.

We now have all the bases of wave telephony before us. Translated into electricity, the high-frequency air waves produced by the transmitter are represented by the electric waves. The gate of the transmitter's valve represents the microphone; the enforced unidirectional, or rectified, progress of the waves at the receiving end is effected by the detector; the amplifying of the rectified waves is done by the electron tubes or vacuum tubes, and the tuning of the receiving membrane to the frequency of the incoming carrier waves represents the tuning of the antenna by condensers and inductances connected thereto.

Uses for Burned Out Tubes

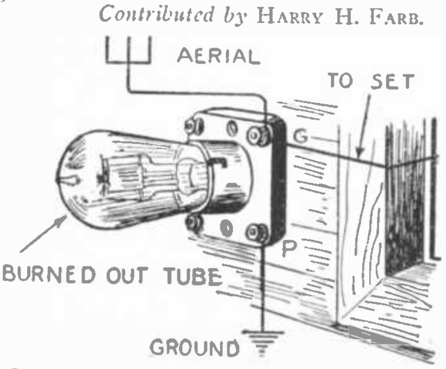
NO DOUBT many experimenters have some burned out tubes lying around waiting to be used. I have found some interesting uses for them.

First—Lightning Arrester. To make a lightning arrester from an old burned out tube connect the aerial to the grid and the ground to the plate.

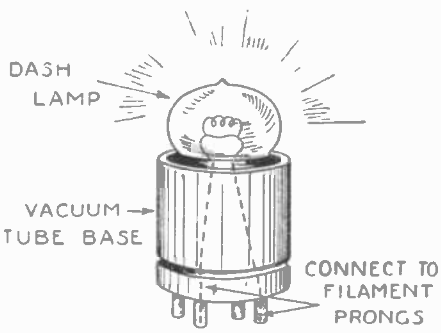
Second—Test lamp for radio sets. First remove the solder from the prongs on the base of the tube. Then break the glass and remove all the elements and wires from the shell. This is easily done by heating the shell over a gas flame. Then take a dash lamp and solder it to the brass shell of the base after having connected the dash lamp with bell wire to the two filament prongs. Then solder the wires at the filament prongs.

This test lamp will now fit in a standard tube socket and may be used after having wired a new set to prevent a blowout of a good tube.

Contributed by HARRY H. FARB.



Showing how a burned out vacuum tube may be used as a radio lightning arrester.



A dash lamp fitted into the base of a vacuum tube for testing the wiring of radio sets.

Static Eliminating Aerial

HERE is an aerial which will bring in music when other aerials are picking up nothing but noise, which feature alone is enough to make the labor and expense involved in its construction well worth while.

But in addition, when being used in connection with a rejector circuit, or even a variable condenser in series with the ground connection, it makes any broad-tuning receiver as fine as can be desired. Not only that, but when being used as an ordinary aerial, without a grounded lead, it will reach out and bring in more distant stations, owing to greater "skin-surface" and its capacitive effect.

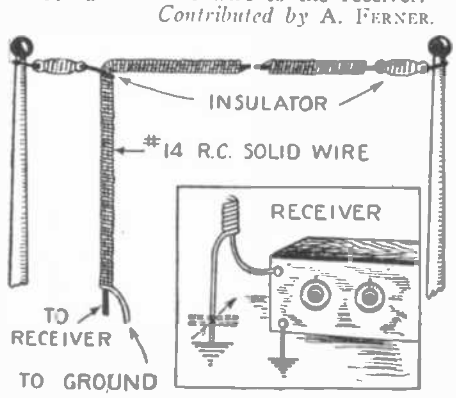
This aerial consists of an ordinary aerial wire, preferably stranded copper, wound for its entire length with No. 14 rubber covered solid wire. One hundred feet over all, aerial and lead in, is plenty; it is important that the grounded wrapping wire be brought as close as possible to the receiver, because static is active to a certain extent in a closed room, and to entirely eliminate static with this aerial it would be necessary to shield the receiver, phone-cords, and every part of the instrument.

However, it will be found that the aerial alone will effectively cut out 90 per cent. of static. I have used such an aerial for six months, having also an ordinary aerial with which to make comparisons, and the "bass-string aerial", as I call it, brings in stations in Denver, Mexico City, Toronto, and other such distant points, whenever the strong stations in Chicago are too noisy to understand, using the other aerial.

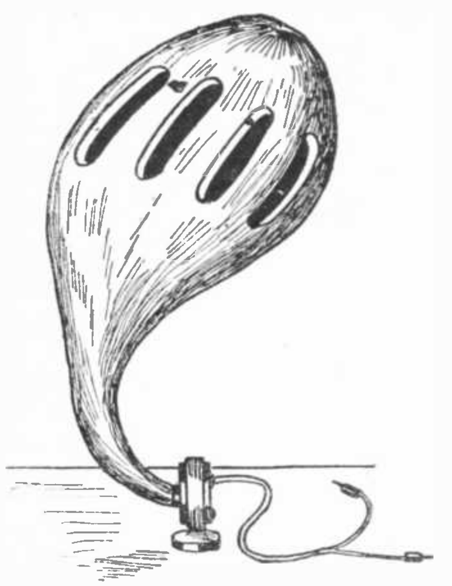
If used with a receiver which is selective, such as a tuned radio frequency receiver, no condenser or rejector circuit is necessary. For a simple circuit receiver use a .0005 mf. variable condenser in series with the ground and the wrapping wire.

For use as an ordinary aerial, connect both wrapping and core wire to the receiver.

Contributed by A. FERNER.



Static may be reduced by winding an insulated wire on the entire length of the aerial and grounding it.



Showing how a common gourd, after it has become hard and the seeds are withdrawn, is used as a loud speaker horn. Note the slots in the sides through which the sound waves pass.

"Natures Own" Loud Speaker Horn

THE common gourd furnishes the material for making a horn that combines two qualities rarely found together—artistic beauty and acoustic efficiency.

Take the longest gourd you can find—6 to 8 inches in diameter and 18 to 24 inches long—be sure it is perfectly dry. Saw the small end off at a place where it will fit your reproducing unit, or base.

Using a small fine saw, saw windows 3 to 4 inches long and 1 to 1½ inches wide about 1½ inches apart around the circumference of the largest part. Lift these windows out, taking care not to tear or disturb the inner spongy lining. This plays a great big part in the quality of the tone, by damping excessive vibrations. However, you must remove, by digging out and scraping, every bit of this lining from the neck of the gourd, from the small end up to where the swell of the large part begins. Be sure this part is as smooth as can be, so as not to interfere with the sound waves.

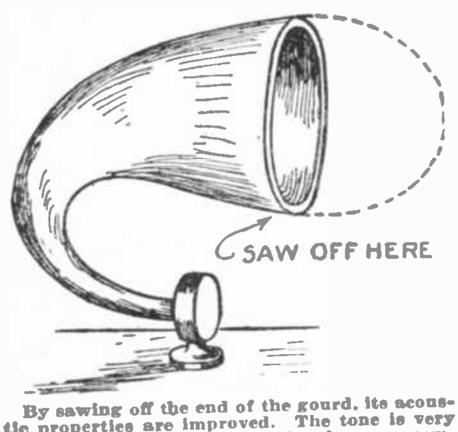
Bevel and smooth off all rough places, being especially careful to bevel the spongy lining down in the throat where it meets the smooth wall of the neck.

Your artistic taste will tell you how to treat the outside—polychrome, old bronze, ivory, or even a frieze of dancing figures or a stenciled design.

I believe this idea has real possibilities in a commercial way, and would like to see somebody take it up.

You'll really be surprised at the quality of tone that a well-made horn like this will deliver. I had been using a Western Electric unit on my phonograph horn, but since I have made the one illustrated, the phonograph has gone back to its old place and my "gourd" has the place of honor in the center of the room, whence it fills the whole house with tones, fuller, sweeter, more resonant than any other speaker we have ever tried.

Contributed by DR. W. H. McKIE.



By sawing off the end of the gourd, its acoustic properties are improved. The tone is very mellow and does not have the harshness so common to metal horns.

Crystal Tube Hook-Up

THIS scheme, which is of the greatest simplicity and efficiency, is suggested for amateurs who desire to set up a circuit quickly, and immediately obtain some practical results. It is also economical, as it only comprises two condensers, one galena crystal, three coils and the antenna.

The plate circuit is composed of an inductance from which one or two taps be taken, or it could be composed of a single coil with a slider, or else a honeycomb coil with different taps and proper contacts.

The grid circuit is composed of the inductance of the antenna and of the tickler coil, which is coupled inductively to the plate coil. The tickler coil should be of the proper size to suit the wave-lengths it is desired to receive. The most simple type which lends itself best to this hook-up is in the form of a coil of No. 20 wire, silk covered, and wound upon a pasteboard cylinder of the diameter of 2¼ inches between two flanges of pasteboard 2 inches apart.

The number of turns which should be used to cover the wave-length which it is proposed to be received is the following: Waves between 200 and 300 meters, 20 turns; waves between 300 and 500 meters, 60 turns; waves between 1,000 and 2,000 meters, 150 turns; waves exceeding 2,000 meters, 300 turns. For the large size coils the tickler may be bank wound.

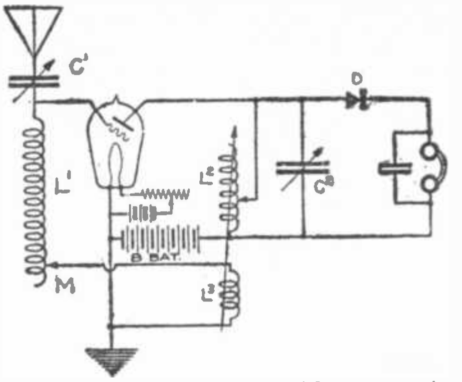
The portion of the inductance of the plate circuit which is coupled with the tickler coil may be of cylindrical shape and composed of 50 turns for waves of 200 to 300 meters; 80 turns for waves 300 to 500 meters; 300 turns for 1,000 and 2,000 meters; 400 turns for waves exceeding 2,000 meters.

The condenser (C^1) of the antenna serves to regulate the capacity of the oscillating circuit; with this, and using the tap switch (M), a greater or less number of turns of (L^1) may be put in the circuit and the entire wave-length range can be covered.

The condenser (C^2) puts the plate circuit in resonance with the grid circuit and gives very powerful regenerative amplification. In this hook-up the vacuum tube acts as a radio frequency amplifier and the galena crystal does the detecting. But sometimes it is desirable to use the tube for detecting when the galena crystal is thrown out of use and the hook-up is to be followed with the addition of the grid condenser and grid leak, which we have already noted. The phones, of course, are then connected in the plate circuit.

This circuit is particularly well adapted to the receiving of short waves, and works well on the entire broadcasting wave-length range.

Contributed by MATTIA LEPRI (Sarno).



A single circuit receiver with regenerative feed-back and a crystal detector. Extreme distances have been covered with this experimental hook-up.

Experimental Heterodyne

THE accompanying diagram shows clearly how to connect up a very simple independent heterodyne. The advantages of a separate generator are many and one of the most important is that the receiving tuner can be adjusted to the exact wave to be received, while the heterodyne is set at a wave slightly below or above this.

In the ordinary or autodyne circuit the receiver must be detuned from the wave in order to obtain a beat.

Another point which will appeal to the thoughtful reader is that by using a separate heterodyne the annoyance to other listeners from radiation is reduced.

This heterodyne is simple to construct and requires no "B" battery, yet it is a vigorous generator of oscillations.

Two spider-web coils are used, one with 20 turns and the other with 40 turns of wire. The wire used by the writer was No. 30, single cotton covered, and despite theoretical expectations the results have been excellent.

If the oscillations are not heard on hooking up, the tickler coil connections have in all probability been wrongly connected. Try reversing them.

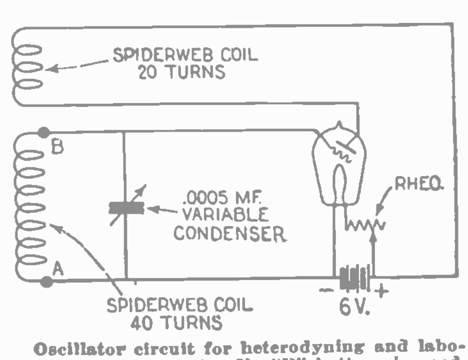
A variable condenser must be connected to the binding posts (A) and (B) for the purpose of tuning the circuit.

With this apparatus the writer receives CW on a crystal quite easily and when using tubes the same filament battery is used to light up the heterodyne bulb and the receiver tubes.

The data for this heterodyne shows it to be suitable, with a .001 mfd. condenser, for receiving waves from about 250 to 800 meters, and owing to the simplicity of construction it will be easy for the experimenter to construct other coils having lower or higher ranges. The same ratio should be observed, and it may be helpful to know that a coil of 200 turns for the primary and one of 100 turns for the tickler makes a combination which, with a .001 mfd. condenser across the primary, develops a range of waves from 1,800 to 3,800 meters.

The heterodyne should be kept on top of the tuner if possible or at least as close to it as possible. If this is not practicable, then a large loop should be included in the lead from the plate to the primary. If the oscillations are too feeble to be heard at the distance, a "B" battery must be used, but it is worthy of note that two or three dry cells will be found sufficient to start oscillations. If calibrated, this oscillator will be found very handy in the laboratory for generating waves of known wave-lengths.

Contributed by D. DEAN.



Oscillator circuit for heterodyning and laboratory measurements. No "B" battery is used.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE GREEK ALPHABET

In all science and engineering where a great deal of computation is necessary and the number of ideas to be expressed by means of formulas and symbols is very great, the 26 letters of the English alphabet are not sufficient. The Greek alphabet has come into general use as a result of this, and a radio education would hardly be complete without a knowledge of it. The symbols are very widely used in radio calculations, and it will be worth the student's while to learn them.

alpha	α	Α	nu	ν	Ν
beta	β	Β	xi	ξ	Ξ
gamma	γ	Γ	omicron	ο	Ο
delta	δ	Δ	pi	π	Π
epsilon	ε	Ε	rho	ρ	Ρ
zeta	ζ	Ζ	sigma	σ	Σ
eta	η	Η	tau	τ	Τ
theta	θ	Θ	upsilon	υ	Υ
iota	ι	Ι	phi	φ	Φ
kappa	κ	Κ	chi	χ	Χ
lambda	λ	Λ	psi	ψ	Ψ
mu	μ	Μ	omega	ω	Ω

RADIO DATA SHEET 15-11 shows the use of some of these Greek letters. The two that occur most frequently in radio writings are λ (lambda), for wave length, and μ (mu), or μμ (double mu) for the prefixes micro and micromicro, respectively. Others are used frequently in writings on electrical subjects, such as φ (phi) for either magnetic flux or phase angle, ψ for electrostatic flux or phase difference. θ is also used to denote an angle. The letter π (pi) is used to denote the quantity 3.1416, which is the ratio of the circumference of a circle to its diameter. Capital omega (Ω) is used as an abbreviation for "ohms." Rho (ρ) is used for the resistance of a conductor, and gamma (γ) for the conductance, which is the reciprocal of the resistance.

All these various things will be explained from time to time in the data sheets, so it will be well for the student to become familiar with their symbols.

The EXPERIMENTER Radio Data Sheets

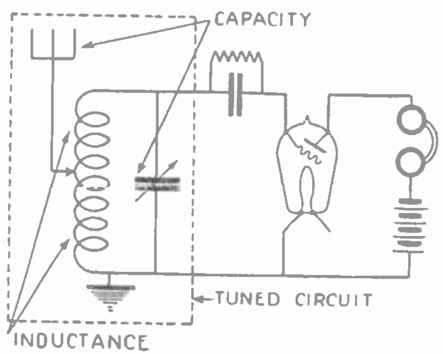
By Sylvan Harris

FUNDAMENTAL TUBE CIRCUIT

(*Continued from* 10-3)

The general arrangement of the circuit of the electron tube as used in radio receivers was shown in RADIO DATA SHEET 10-3. It is generally understood that the function of the grid in the tube is to act as a kind of trigger or release for the large amount of electrical energy stored in the "B" battery. The details of the functioning of the tube will be explained in section 3. For the present it must be understood that when voltages of any kind are placed upon the grid they cause changes in the value of the current flowing from the "B" battery through the tube from the plate to the filament.

As long as the grid voltage remains the same, no changes in the plate current will occur. The greater the change of grid voltage the greater will be the changes in the plate current. Hence, it is necessary to obtain as high voltages as possible to place on the grid.



The electromagnetic energy received by the antenna from the distant broadcasting station is extremely feeble, so for the purpose of making use of the greatest amount of this energy it is received in a tuned circuit, which comprises a capacity and an inductance. This circuit is tuned to the wave-length (or frequency) of the incoming waves. It picks up the greatest amount of energy when tuned exactly to the waves, although it will pick up some energy when it is tuned slightly off.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE FLOW OF CURRENT IN CIRCUITS

In RADIO DATA SHEET 1-3 something of the idea of current flow in a circuit was given and without going any further into the theory of the matter, we will take up the study in a way that will help the student to apply his knowledge.

The idea of potential was explained in that data sheet, and for a current to flow it is necessary to have a *difference of potenial* existing between any two points in a closed circuit of wire or other conductor. This difference of potential is called the *voltage* and may arise from many sources, as for instance, from a dry-cell or generator. When this voltage exists, as between the terminals of a cell, a current will flow when the circuit is closed, the value of the current depending upon the ability of the wire or conductor in the circuit to carry electricity (see 1-3). This is its conductance.

Generally, instead of considering the *ability* of the wire to carry current, we consider the *opposition* of the wire to the current. When the current has a constant value and always flows in the same direction through the wire, the current is related to the voltage by the formula $I = \frac{E}{R}$

in which, if E will be the potential difference in volts, I is the current in amperes, and R will be a constant of proportionality, known as the resistance. The practical unit of resistance is the *ohm*, and is the resistance of a conductor that will carry a steady current of one ampere under a difference of potential of one volt.

This simple relation, known as Ohm's law, after its discoverer, exists only when the current is constant and, furthermore, exists only when the distribution of the current in the conductor is uniform. This will be studied in detail later under "skin-effect."

If we consider a circuit composed of a wire and a battery, the voltage is greatest across the terminals of the battery, and the potential decreases from one terminal around through the wire to the other terminal. A difference of potential exists between any two points of the circuit which can be determined from the above formula, viz., E = RI.

CUT ALONG PERFORATED LINES

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The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

GENERATION OF HEAT IN ELECTRIC CIRCUITS

In data sheet 1-3.4 the simple relation existing between the current and voltage in a direct current circuit was explained, and the idea of resistance was given as a mere factor of proportionality between the current and voltage. The complete idea of resistance, however, is far more extensive than this.

When a current flows in a circuit, there must be an expenditure of energy. Where this energy comes from does not matter so much. It may come from the chemical energy being expended in the dry-cell or storage battery supplying the current. It may come from the steam engine which is driving the electric generator. This energy is expended in the form of heat in the wire carrying the current. If we do not for the while consider the mechanical forces which electric currents can supply, as, for instance, in motors.

The amount of heat generated depends upon the current flowing and upon a factor of proportionality, which is again the resistance of the circuit. The heat also depends upon the length of time the current is flowing, as more heat can be generated in a long period of time than in a short one.

Heat is energy, but in radio work we are not so much concerned with the energy as we are with the powr in the circuit. Since power is energy divided by time, we can apply this to the simple idea in the preceding paragraph and obtain the relation for the power expended in the circuit, viz.,

$$P = RI^2$$

As I (amperes) represents a rate-unit, the division by time or by T is implied.

It will be noted that the power depends upon the square of the current in the circuit. That is, if the current is doubled, the power expended in the form of heat will be quadrupled, etc.

This is a matter that should be of considerable interest to those who are building or using low-loss radio apparatus. The losses in the apparatus are expressed by this formula, which states, in ordinary words, that the power loss in a circuit tuned to resonance is equal to the resistance of the circuit in ohms multiplied by the square of the current in the circuit. The power loss will be given in watts. Evidently the smaller the resistance is made, the smaller will be the power loss.

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The EXPERIMENTER Radio Data Sheets

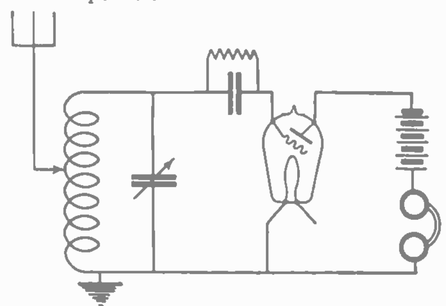
By Sylvan Harris

FUNDAMENTAL TUBE CIRCUIT

(Continued from 10-4)

IN RADIO DATA SHEET 10-4 we have considered the input side of the electron tube, which is the path from the grid to the plate, and have shown how the tuned circuit is connected to it for the purpose of picking up the greatest amount of energy that comes into the antenna. The output side of the tube, including the path from the plate to the filament, may be connected to any kind of a receiver of energy, as for instance, a pair of telephone receivers.

Many things can be done with the current output of an electron tube. This may be passed into an amplifier so as to strengthen the signals. The strengthened currents may be made to operate many kinds of electrical devices, as for instance, relays for closing circuits to operate motors, or to actuate a loud speaker.



The idea which this data sheet is intended to emphasize is the fact that the electron tube always operates the same, no matter in what kind of electrical circuit it is used. It always has its input and its output circuits, the weak incoming signals being fed into the input or grid-filament side, and the strengthened signals coming out of the output or plate-filament side.

There are a few special cases wherein electron tubes are made to operate differently, but these are not of immediate interest to the experimenter. Following through data sheets 10-2 to this one we have gradually evolved a simple radio receiver, as shown in the figure, with the tuned circuit picking up weak signals from the antenna, sending them into the input side of the tube which delivers them strengthened into the receiver of energy, or the headphones.

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The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

RADIO ABBREVIATIONS

There are many abbreviations in use in radio. These abbreviations have been standardized recently by the United States Bureau of Standards. A partial list of them follows:

amperes	a
ampere-hours	ah
centimeters	cm
circular mils	cir. mil.
cubic centimeters	cm^3. or c.c.
cycles per second	~
degrees Centigrade	°C
degrees Fahrenheit	°F
feet	ft.
grams	g
henries	h
inches	in.
kilograms	kg
kilometers	km
kilowatts	kw
kilowatt-hours	kwh
kilovolt-amperes	kva
meters	m
microfarads	μf
micromicrofarads	$\mu\mu$f
microhenries	μh
millihenries	mh
milliamperes	ma
millimeters	mm
ohms	Ω
pounds	lb.
seconds	sec.
square centimeters	cm^2.
square inches	sq. in.
volts	v
watts	w

The following prefixes are used to indicate smaller or larger units:

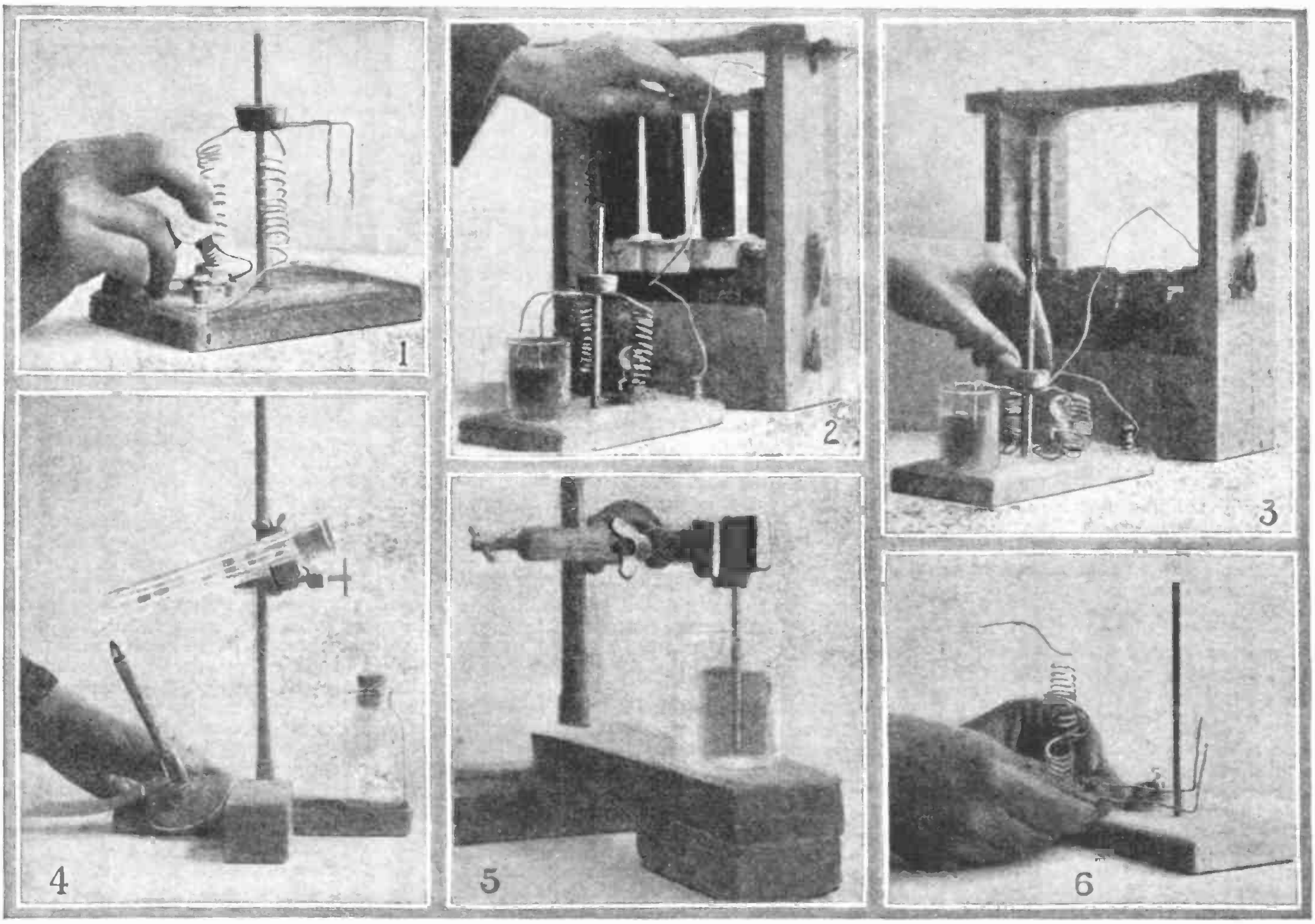
micromicro	$\mu\mu$	1/1,000,000,000,000
micro	μ	1/1,000,000
milli	m	1/1,000
centi	c	1/100
deci	d	1/10
deka	dk	10
hekto	h	100
kilo	k	1,000
mega	M	1,000,000

CUT ALONG PERFORATED LINES

EXPERIMENTAL CHEMISTRY

Traveling Ions

By Dr. E. Bade



1. Apparatus to show the conductivity of solution. Two spirals attached to a cork sliding on a rod carry the immersion electrodes for the tests. 2. All ready for the tests. The elements have now to be plunged into the battery. 3. The solution is now under test and a galvanometer or small electric lamp indicates the passage of current. 4. Dissociation of ammonium chloride by simple heat; litmus paper at different positions in the tube reacts for acid and alkali respectively, as described in the article. 5. Mercury in dilute sulphuric acid, with a trace of potassium bichromate, is caused to vibrate by contact with an iron rod as shown above. 6. Adjusting the apparatus for testing electrolytic solution for conductivity.

IONS may be described as modified atoms, which differ from the atom mainly in having a charge of electricity. This tiny difference gives the ion a distinct characteristic resulting in properties not inherent in the atom. Then, too, a universal property of substances capable of forming ions is that they are able to conduct the electric current electrolytically. But all acids, bases or salts dissolved in water do not produce the same number of ions; their molecules dissociate to a varying degree into ions or independent particles charged with electricity. The number of ions charged with positive electricity is equal to the negative electricity carried by other ions since the sum of the two kinds of electric charge must be the same. Under these conditions it frequently happens that one ion may carry two, three or more charges of one kind of electricity to balance the number of ions provided with the opposite charge.

Although the ions have never been seen, the results they produce can readily be observed in various ways. Some of the more striking effects induced by the ions are color changes, and the production of different potentials, causing the generation of an electric current. Chemical reactions are largely dependent upon ion formation for their successful completion. These latter chemical behaviors do not now come into view; but rather the activity of the ion itself interests us. First of all the presence of ions must be proved and this can be accomplished in various ways.

It is a comparatively simple matter to determine experimentally the composition of the ions into which acids, bases and salts dissociate. All of these substances are molecules; they are not groups of chemical elements. If each is dissociated and its parts provided with a charge of electricity, such parts may be groups of two or more elements so joined together that they have the property of an element possessing one or more free bonds. Then this group is a radical, as it is called, has one kind of an electrical charge, while the opposite charge is found on the remainder of the compound molecule which has been dissociated.

The fundamental difference between an ionized substance and one that is not, is that the former conducts the electric current; the latter does not. This can be easily proved. Pure water does not conduct the electric current to any appreciable extent. If, however, common table salt, an acid, or a base is added to the water, the resulting solutions are found to be good conductors. When the current passes through a liquid, some chemical change is always taking place, and this change is called electrolysis. If sugar is now added to another vessel containing pure water, no current will flow; this substance is not dissociated into ions. Its solution cannot form an electrolytic conductor.

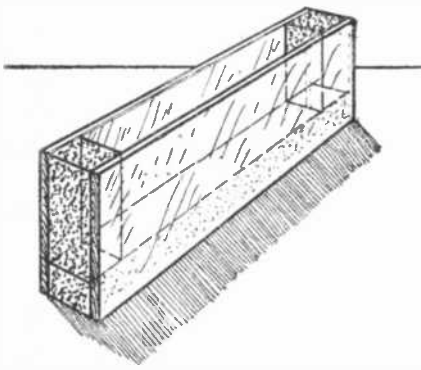
In order to prove this, it is only necessary to use a fairly strong battery such as a plunge battery and connect the two terminals in such a way that one wire is led directly into a small beaker containing the solution to be tested; the other wire leads into a socket of a small lamp; the other terminal of the socket is connected to the beaker. The socket is fitted with a small

(*Continued on page* 348)

Lessons in Elementary Glass Working

By Earle R. Caley, B.Sc.

GLASS is perhaps the commonest and most useful substance employed in the construction of chemical apparatus. Its characteristics, such as its insolubility in acids, etc., render it indispensable for the chemist. Yet the nature and character of glass necessitate the use of special methods for its shaping and cutting.



A lantern demonstration cell such as that illustrated above can be readily constructed by the experimenter who acquaints himself with the simple methods of glass grinding and cementing.

There is nothing especially difficult in constructing apparatus in glass when once the fundamental principles of its working are known. But without a knowledge of these methods glass appears to be a very difficult substance to handle. The reader should remember that in glass working as in almost no other laboratory art does the maxim "Practice makes perfect" apply so well.

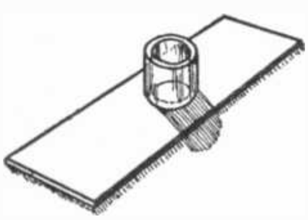
The Kinds of Glass

For all practical purposes glass may be classified as:—

(a) *Common sheet or window glass.* This type of glass is handy for making glass cabinets and balance cases. It should never be used under bell jars, where an air-tight joint is required, as its surface is never perfectly flat.

(b) *Plate Glass.* This is glass having its surface polished into a perfect plane. It is useful for placing under bell jars for suction filtering, for covering dessicators and jars and for other uses where an air-tight joint is required.

(c) *Glass Rod and Tubing.* This kind of glass is known as soft or soda glass and softens easily in the Bunsen flame. "Soft." The mouth of the jar has to be ground with sand and water on the plate to be used as cover. This is the origin of the incorrect but very common application of the term "soft." It may be recognized by the green tint presented when looking at it end-ways and by the yellow color imparted to the flame when working it. Sometimes a type of soft glass known as lead glass is obtained. This is objectionable due to the blackening caused by metallic lead when heated in the reducing flame. Glass tubing and rod of all sizes and shapes as used for glass blowing is sold by the pound and may be obtained from any one of the various scientific supply houses. Tubing that is old frequently has a series of fine hair cracks running through it. Such tubing is devitrified and should never be used for glass blowing.



A short section of glass tube is ground off on the ends and is cemented to a microscope slide. This gives a cell for microscopic work.

(d) *Hard Glass Tubing.* This type of tubing is used for combustion tubes and is recognized by the blue or white appearance at the ends. The experimenter should never attempt to blow this type of tubing as it softens only in a good blowpipe flame and can only be successfully worked in an oxygen-fed flame of some sort.

(e) *Special glasses* such as optical glass, flint glass, common bottle glass and enamel and colored glasses are rarely needed by the experimenter in ordinary glass working.

Apparatus Needed for Glass Working

The apparatus needed is simple and easily obtained and is usually a part of the equipment of the average laboratory.

For Cutting Flat Glass. For straight cuts a glass diamond or in place of this an ordinary wheel cutter should be provided. For cutting out glass circles a circular glass cutter is necessary. This is a device for tracing a circle on the glass with an ordinary wheel cutter. For cutting large glass tubing supply houses sell a device known as a tube cutter.

For Bending Glass Tubing. A Bunsen burner equipped with a fish-tail attachment is needed. This is a device whereby the ordinary round flame is converted into a flat one which heats about an inch length of glass tubing.

For Glass Blowing. The most important instrument used by the glass blower is the blast lamp. This may be obtained from the supply houses in a variety of forms, but one should be obtained that is capable of giving every conceivable variety of flame from a large brush flame to a very finely tipped one. Air may be supplied for the blast from a foot bellows or from a compressed air line. The blowpipe and all glass working apparatus may be placed upon a special table in the laboratory. This table should have its surface covered with sheet asbestos and should be high enough so that the worker can rest his elbows upon it while working.

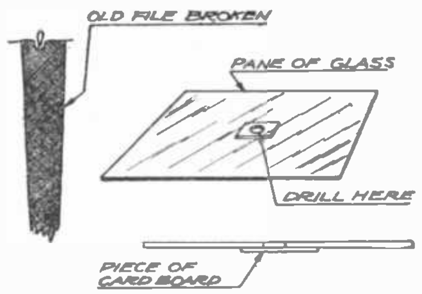
Cutting Glass

Small sizes of glass rod and tubing under ⅜" in diameter may be easily cut by the following procedure. The desired place is nicked by a single stroke of a sharp triagular file. The tube or rod is then grasped by the hands with the thumbs placed on the opposite side from the cut. The tube is bent slightly and at the same time pulled away from the cut. This treatment invariably gives a clean straight fracture across the tube or rod. Large sizes of heavy tubing cannot be cut in this way. For cutting sizes above ½" in diameter the following procedure may be used:

A file cut of about ½" in length is made on the tube and the cut touched with a hot glass rod. The tube will crack and the crack should be led around with the glass rod, if it does not extend around as formed. The regular tube cutters furnished by supply houses are also useful for cutting large sizes.

If the tube is to be used with rubber connections the sharp edges must be removed by heating the ends a few seconds to a minute in a Bunsen flame. This treatment rounds the sharp edges.

For cutting flat and plate glass the cutting diamond is the classic appliance, but the ordinary wheel cutter is almost as good when new and sharp. Dull wheel cutters are useless. The glass plate is placed upon a smooth piece of felt upon a smooth table. The cutter is then run over the glass with considerable pressure, using a straight edge as a guide. The "cut" will appear clearly. After cutting, the glass is tapped sharply along the cut, but on the opposite side with the wooden handle of the cutter until the cut comes through. This action is followed by grasping the plate on either side of the cut with the thumbs on the cut side and the fingers beneath and then bending steadily and firmly until the glass parts. In using a circular glass cutter the glass is tapped through in a similar manner.

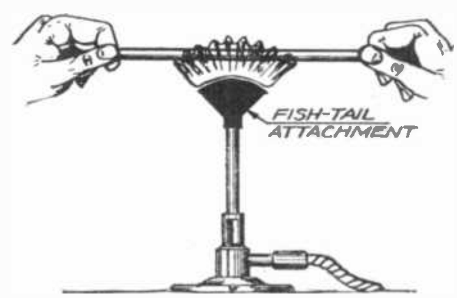


No special apparatus or very great skill is required to drill holes in plate glass. An old flat triangular or round file sharpened to a point, some turpentine as lubricant, and a little care, are the essential requirements. Note the little piece of cardboard.

One should never attempt to round off sharp edges of glass plate by means of a flame. This only results in cracking the glass. Edges of glass plate are usually smoothed by grinding and so producing the so-called ground edges. A coarse whetstone or a carborundum slip are excellent. An emery wheel is still better.

Drilling Glass

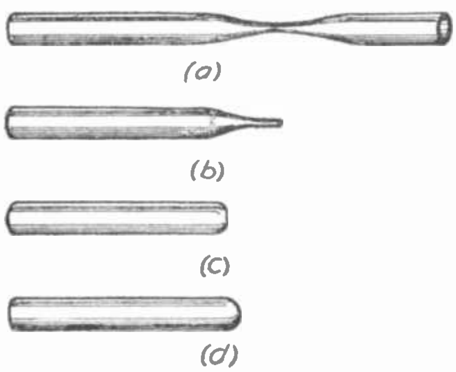
It is very often found necessary to drill holes in glass plates as in the construction of static machines. This operation is one dreaded by the amateur, but anyone using only ordinary care and skill may successfully drill holes in all kinds of glass. The drill used is a piece of an ordinary rat-tail file. The file is (old one will do) broken at the desired diameter and the break ground into the shape of a very flat triangular-based pyramid by means of an emery wheel or a grindstone. A drilling fluid consisting of a 10% solution of camphor in turpentine is used. This prevents the glass from chipping. The hole is best started by hand, the drill being held firmly



Glass bending is one of the easiest operations met by the glass worker. Good glass tubing becomes very pliable and easily worked when heated to the proper temperature.

against the desired point and slowly twisted one way and then the other. With a few turns the drill "bites" the glass and the hole is started. The hole may be entirely drilled by hand but this is a tedious process. The best means to propel the drill and yet secure the necessary light pressure is by means of a string and bow arrangement, the string being twisted around the drill.

In drilling holes completely through glass one half may be drilled first and the other half drilled through from the opposite side. Great care and very light pressure should be used when nearing the completion of a



The method of making sealed glass tubing is shown above. The glass tube first tapered is then exposed to the flame long enough to cause a complete closing and rounding of the end.

hole as this is the critical point. The drill point should at all times be flooded with the turpentine solution.

Grinding Glass

In making ground glass on a large scale abrasive wheels of various kinds are used, but on a small scale the amateur can do satisfactory work by means of emery cloth and files. The edges of all plate and other heavy glass should always be ground, as this eliminates the danger of cut fingers and hands, besides making a neater and more satisfactory piece of apparatus.

For grinding glass three things are necessary: First, some medium grade emery cloth second, a 10% solution of camphor in turpentine; and third, a good stock of patience. The piece of glass to be ground is held edge down on the emery cloth which should be tacked upon the work bench. Then while moistening the cloth with the turpentine mixture an even, firm, back and forth motion is imparted to the glass *in the direction of the length* until a smooth ground edge is obtained. By using coarser or finer emery cloth a coarse or fine ground effect can be obtained as desired.

Good practice in this grinding may be obtained by making a glass microscope cell or a lantern demonstration slide. The first is a section of half inch glass tube about ¼ of an inch in length having both ends ground as described above. This is cemented to an ordinary microscope slide with a good grade of waterproof or marine glue. An excellent preparation for this purpose can be made as follows:

> 3 oz. of gum shellac are dissolved in the minimum amount of ether over a water bath. 1 oz. of pure gum rubber is dissolved in a similar amount of ether. The two solutions are mixed and placed in a tightly stoppered bottle. (Caution: Ether is explosive.)

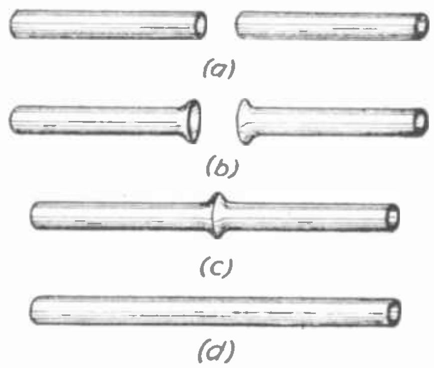
This glue successfully resists the action of both hot and cold water as well as of most chemical solutions.

The lantern slide cell shown is made by cementing three glass strips between two sized plates. All edges should be ground. With this apparatus chemical reactions occurring in the cell can be flashed upon the screen. Crystallization and electrolytic experiments are especially beautiful when performed in this manner. Plates for covering jars and spectroscope prisms and cells can easily be made by this means.

A rather more complicated case of glass grinding is in fitting glass stopcocks and similar operations. This is usually beyond amateur resources and skill, although badly fitting stopcocks and stoppers can be made to fit perfectly by simply grinding them while in place with a cutting medium composed of fine emery and the 10% camphor in turpentine solution.

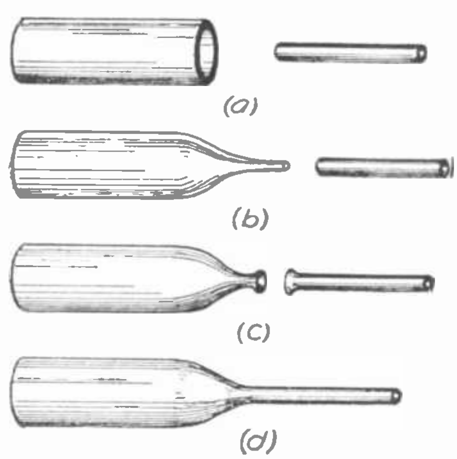
Glass Bending

Glass is worked by softening it by heat and then forming and blowing it into various shapes. Nearly all glass scientific apparatus is made by the so-called operation of "blowing." This term is made to refer to any means whereby glass is shaped while still in the hot and plastic condition. The simplest operation in glass blowing is that of bending glass tubing. This is easily done by the amateur in a flattened Bunsen burner flame. This flame is obtained by



Mastering the art of glass welding will prove a very useful accomplishment of the amateur experimenter, especially in chemistry. The successive stages in the welding of two tubes of the same size are illustrated above.

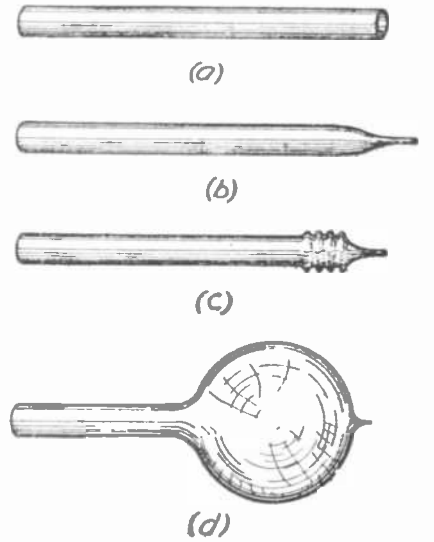
using the "fish tail" attachment shown in the illustration. The operation of bending is best performed by means of the luminous flame, which is the kind produced by closing the air holes of the base of the ordinary Bunsen burner.



In welding two tubes of unequal sizes, the end of the larger must first be drawn and tapered down to the diameter of the smaller. The operation is shown in three steps.

The piece of tubing to be bent is grasped lightly between the fingers of each hand and slowly rotated back and forth so as to assure an even heating on all sides. The tubing gradually softens at the place where heated. When the tubing just begins to sag it should be removed from the flame and bent carefully to the desired angle. This process is sufficient for successfully bending glass tube and rod of small diameter. Large tubes cannot be bent in this manner without producing the objectionable flattened bends which are a mark of poor workmanship.

Large diameter tubing is bent in the following manner. One end is tightly closed with a cork, and the tube is gently heated at the desired point and at the same time gently pressed in from both ends until thickened at that point. The tube is then



One of the more difficult problems in glass blowing is the making of bulbs out of glass tubing. First the heated glass is massed together as shown in (c), then keeping this end in the flame the operator blows into the tube, under the pressure of which air the soft glass expands.

removed from the flame, bent gently, while at the same time being drawn out at the bend, and blown into in order to keep the bend in shape. This operation requires much practice and some skill and is the method by which chemical U-tubes may be produced. Spiral tubes such as are used in condensers are made by bending glass tubing around a copper cylinder.

Sealing and Bordering Glass Tubes

Glass tubing and rod as cut off by a file leaves sharp edges which must be removed. This is done by placing the tips in the blowpipe flame for a few seconds until the glass begins to melt and the edges automatically round off. Glass stirring rods for chemical operations are prepared by cutting off a length of rod and then holding the ends in the flame until they become perfectly rounded. Glass tubes intended to be closed with a cork should have their ends expanded slightly. This operation is known as bordering.

The rims of all ordinary test tubes are treated in this manner. This is done by rotating the end of the tube in the flame until it softens and then gently pressing out the sides with a cone made of charcoal. Another operation that is very common in glass working is the production of closed or sealed ends in glass tubes. The simplest case coming under this head is the closing of glass tubes of small bore. The method is to heat a short portion of the tubing with a blowpipe and then to draw the tube apart a short distance. This tube is then reheated at the narrowest portion until it drops apart. (III.) One of these sections are then selected and the end heated until the glass collapses and produces the flat appearance shown. The tube is then removed from the flame and gently blown until a rounded end is obtained.

Blowing Bulbs in Glass

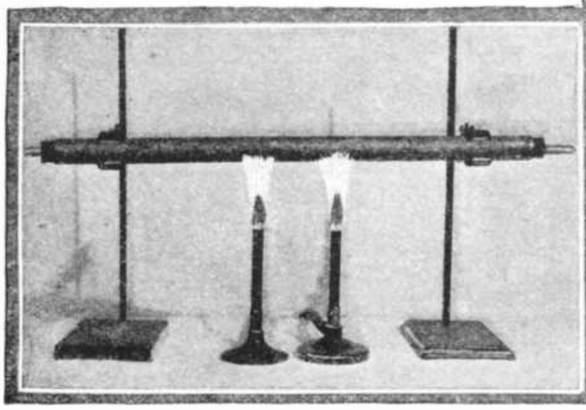
The most elementary operation under this head is the blowing of a bulb on the end of a tube. The formation of a bulb of uniform thickness on the end of a tube is not as simple an operation as it may appear. It is a simple matter to seal the

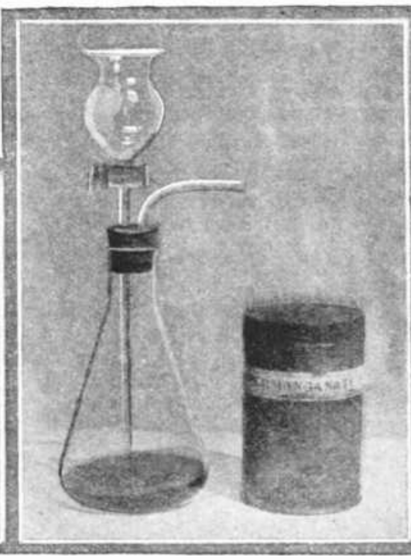
(Continued on page 346)

Fun With Gases

By Raymond B. Wailes

Below is shown the simplest possible version of the combustion tube. Its ends may be kept cool by small water tanks as shown in Figs. 4 and 5. The center photo shows the preparation of oxygen by the wet method. Great care is requisite. On the right is a desiccating apparatus for solid liquids or gases.





GENERATING, controlling, capturing and experimenting with something which one cannot see is quite enjoyable. This relates to the different gases which can be prepared and studied in the experimenter's chemical laboratory.

There are two ways in which many gases can be prepared—in the wet and dry way. A dry method for producing oxygen is to heat a mixture of manganese dioxide and potassium chlorate. This can be done in a test tube. A glowing splinter inserted in the tube after heating a few seconds, will burst afire with a "plop". A wet method for producing oxygen can be performed in the generator shown in Fig. 2. Crystals of potassium permanganate and dilute sulphuric acid (1:9) are placed in the flask and ordinary 3% or household hydrogen peroxide allowed to drop in through the separatory funnel, a drop at a time. Oxygen issues from the outlet tube.

Many gases can be made in the simple iron combustion tube illustrated in Fig. 1. An 18 inch length of iron gas pipe ¾ inch in diameter is fitted at each end with corks carrying glass tubes for attaching rubber tubing to the whole. The pipe is supported by two ringstands and heated by two or more Bunsen burners. It is well to solder little water receptacles on the ends to keep down the temperature.

Carbon dioxide gas can be produced in this tube by filling it with lumps of marble, heating to redness and sucking air through the tube with the simple suction apparatus described in the first installment of this series. If the combustion tube is fitted with a flask as shown in Fig. 5, containing lime water (shake lime with water and filter) the lime water will become milky, due to the precipitation of calcium carbonate by the carbon dioxide in the gas coming from the tube. This is a "test" for carbon dioxide. Further addition or passage of the same gas will redissolve the precipitate.

There will be lime left behind in the tube after the experiment.

Sodium bicarbonate (baking soda) will give off the same gas at a far lower temperature.

Water gas—a mixture of hydrogen and carbon monoxide gas, can be made by filling the iron tube with coke chips and passing steam through the coke which should be heated to full redness by Bunsesn burners as shown in Fig. 4. The empty bottle at the end will serve to condense and collect any steam which passes through the tube and does not react with the coke. The steam can be made by boiling water in a round bottomed flask. Flat bottomed flasks are liable to crack, due to bumping of the steam bubbles. The water gas can be ignited as it issues from the condensing bottle. A flame should not be applied here until the furnace has operated for at least five minutes. The gas is very poisonous—do not let any escape unburned.

Hydrogen can be made by passing steam

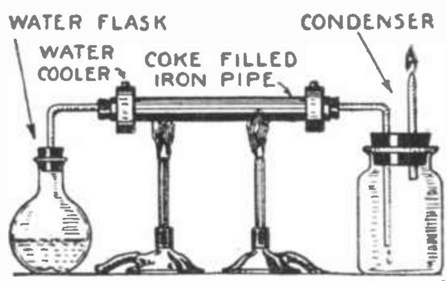


Fig. 4. Making water gas, the product of the decomposition of steam by incandescent carbon. It is a mixture of carbon monoxide and hydrogen.

over iron contained in the tube. Nails, tacks, etc., can be used. Steel wool wadded in is very porous and presents a large surface to the steam. The chemical reaction here is simple. The iron abstracts the oxygen from the water, forming iron oxide or iron rust which is left in the tube after the experiment. The hydrogen from the water passes through the apparatus and can be collected.

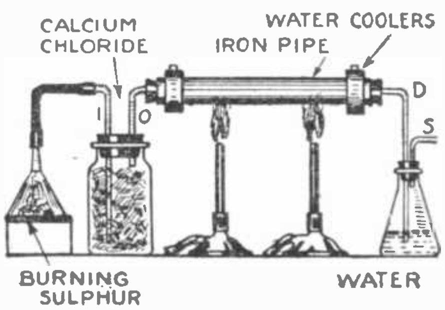


Fig. 5. The same apparatus slightly modified for manufacturing sulphuric acid. The iron pipe contains catalytic ferric oxide, which effects the oxydation of the sulphurous oxide.

Carbon monoxide gas can be produced by the decomposition of carbon dioxide gas by means of red hot coke. Using a gas generator described in the first installment of this series, and weak sulphuric acid and sodium bicarbonate, carbon dioxide gas can be produced. This, when dried by passage through calcium chloride, contained in a part of the apparatus shown in Fig. 5, is passed over coke heated to redness in the iron gas pipe combustion tube. The carbon dioxide is reduced, forming carbon monoxide. This gas burns with a pale but characteristically colored flame.

Dilute sulphuric acid can be made in a miniature acid plant which is illustrated. Suction is applied to tube S. This causes air to pass over burning sulphur placed under a funnel. The sulphur, in burning, forms sulphur dioxide which passes through the calcium chloride in the bottle which dries the gas. Tube I here extends into the bottle, tube *O* terminating just under the stopper. The sulphur dioxide and air then pass through the combustion tube, which is filled with asbestos coated with ferric oxide. This combination catalzes or affects a chemical reaction between the sulphur dioxide and the oxygen of the air, producing sulphur trioxide, which passes through the tube, and through glass tube (D) into the water in (*S*), making sulphuric acid at this point. A few drops of barium chloride solution added to several drops of this solution after the experiment will produce a white precipitate, showing that sulphuric acid has really been made.

The asbestos-iron oxide catalyzer is made by soaking shredded asbestos in ferrous sulphate (iron sulphate) solution and adding ammonia water to the whole mixture. Filter the whole and wash while on the filter paper with water. This leaves the asbestos coated with almost pure ferric hydroxide. Now scrape the mass from the filter paper and heat to redness in an evaporating dish. This changes the ferric hydroxide to ferric oxide. The resulting product is then placed in the combustion tube.

Nitrogen gas can be made from air by passing air through copper scraps heated to redness in the tube. Copper oxide is left in the tube at the end of the experiment, and nitrogen issues from the exit tube.

The copper oxide is left in the tube and ammonia gas is passed through it, while it is still red hot. This will cause another chemical reaction to take place, the copper oxide being reduced, or changed into ordinary metallic copper, while the ammonia will form water and nitrogen. The water will pass out with the nitrogen and can be separated from it by passing the issuing gas through a calcium chloride drying bottle or tube, thus allowing the nitrogen to be collected.

Fig. 6 shows a simple absorption tube for gases. Ammonium hydroxide, used as a reagent in the laboratory can be made with this device. Ammonium chloride (sal ammoniac) and lime, heated in a flask will produce ammonia gas, this passed through the small tube as shown will pass down and bubble through water contained in the larger tube, saturating it and forming ammonium hydroxide. The large tube contains bits of broken glass. This produces a large absorption surface. It might be necessary to apply suction at the outlet tube. Be careful not to inhale the gas

In experiments with gases, simple valves to control the flow are easily made. In Fig. 7, C, is shown a simple flap valve made from a soft rubber stopper partially slit at T. The flap (F) will open one way but will close in the opposite direction on passage of gases through it. D in the same figure is a simple valve, shown open and closed. The cork is usually inserted in the neck of a bottle. A and B show methods of connecting two different sizes of glass tubes together, using a large cork.

Fig. 8. A, shows how a gasometer or gas holder can be made from two different sizes of bottles which have their bottoms cut off. Gas is passed into bottle (B) through tubes (I), bubbles up through water contained in BOTH bottles and fills (A), which rises out of (B) as the gas volume in it increases. The simple valve in 7 (D) can be inserted in the neck of the (A) bottle in Fig. 8.

In the same figure (B) and (C) are two methods of making stop cocks from ordinary laboratory apparatus. The holes in the glass tee are made with a blowpipe and Bunsen burner, and afterward smoothed out. Both valves operate very well. To close the valve at (C) push the pointed glass rod or closed tube into the short length of rubber tube (C).

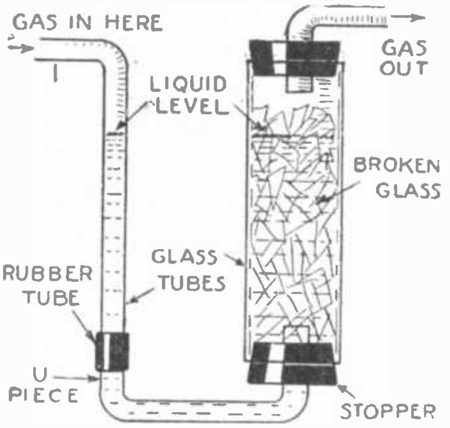


Fig. 6. Washing or absorption apparatus for gases. The large tube is filled with broken glass and the gas to be purified or absorbed is forced through it. This requires considerable pressure, but the action will be very good. Beads or glass marbles may be used instead of broken glass.

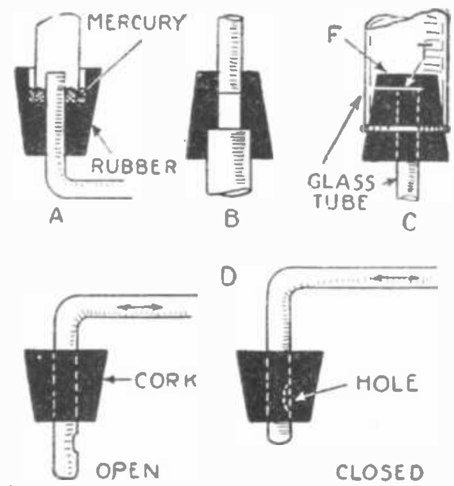


Fig. 7. Extemporized valves and stop-cocks employing rubber stoppers and glass tubing only.

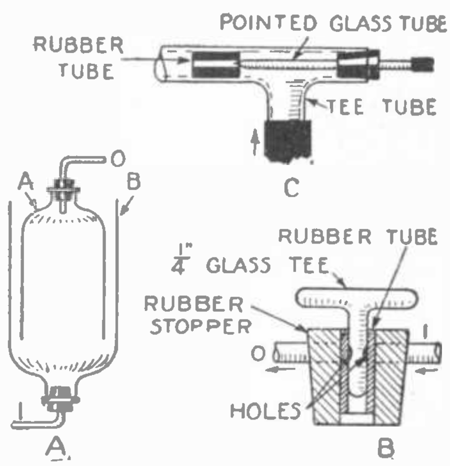
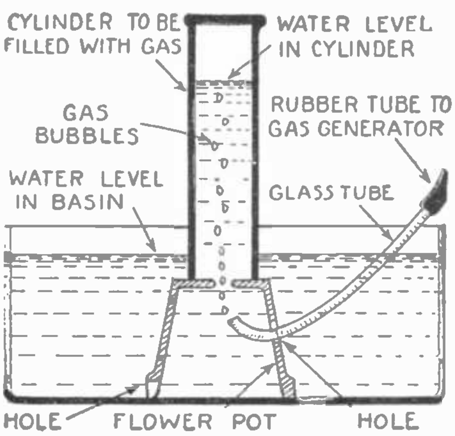


Fig. 8. Outline of a gasometer and two more versions of stop-cocks for use in gas experiments.

Flower Pot in Hydraulic Trough

By C. A. Oldroyd



A flower pot is used to carry a vessel to be filled with gas in a hydraulic trough. The interesting feature of the flower pot is that it is so soft that it can be readily drilled to admit a tube.

When a large cylinder is to be filled with gas in a hydraulic trough, as shown in the illustration, the cylinder in question is rather difficult to handle owing to its weight and size.

The illustration shows a flower pot placed inverted in the basin, and the latter is filled with water to a level well above the bottom of the flower pot. Through one side of the pot a hole is bored with a three-cornered file; the glass tube from the gas generator enters through this hole and its end is bent upwards as shown.

The gas bubbles enter the cylinder through the drain hole in the base of the flower pot, and are guided to this opening by the conical shape of the pot. To allow a corresponding amount of water to escape while the filling of the cylinder progresses, a triangular notch is filed away at the rim of the flower pot.

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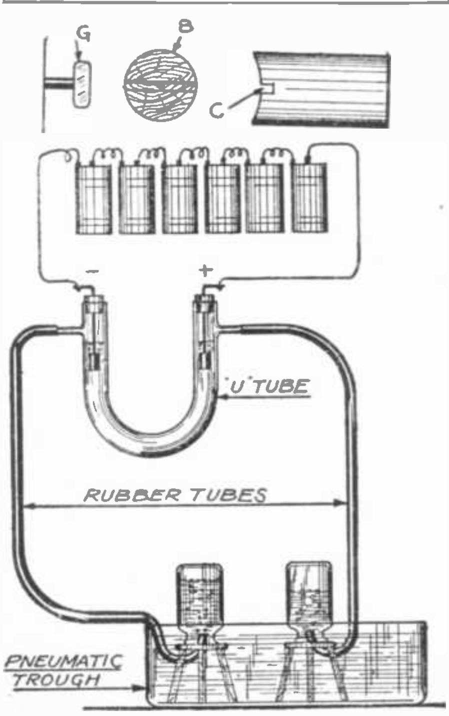
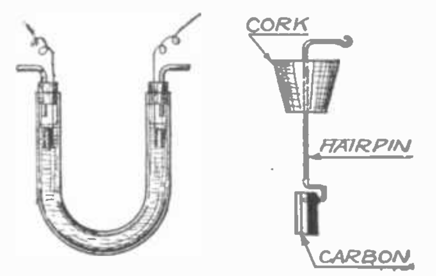


Electrolysis Apparatus

By Samuel McCord

Procure a glass U tube with side arms and two corks and a flashlight battery. With a couple of hairpins scrape the paint off the ends. Bend them into hooks at the top and then stick them through the corks as shown in Fig. A.



On the left is shown a simple U-tube with double perforated corks which will take the place of the expensive one shown in the other illustration. The way the carbon electrode is immersed in the solution and supported is shown on the right hand.

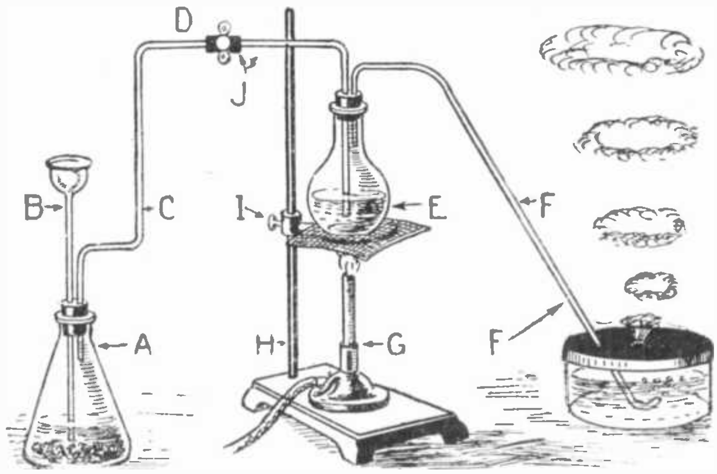
Take the carbon rod out of the flashlight battery and break it in two. Then drill a hole nearly through it and cement the wire in with sealing wax. Wrap the lower ends of the hairpins around the carbons as shown in Fig. A.

Now fill the U tube up to the level of the side arms with concentrated salt solution. Put the corks with their carbons in the upper mouths of the U tube and then connect the hairpin terminals of the electrolysis apparatus to six or seven dry cells. Chlorine bubbles will rise at the positive pole and hydrogen at the negative.

Decomposition of a solution by electrolysis, the gases being collected in bottles, as evolved from the two sides of a U-tube. This is a particularly nice way of conducting the classic experiment of the electrolysis of water.

Phosphine

By Leslie R. Raymond



Generation of phosphoretted hydrogen or phosphine; this gas when thus generated is not absolutely pure and there is enough of another hydride in it to make the mixture spontaneously inflammable, as the pure gas, PH_3, does not possess this property. Beautiful smoke rings are produced as bubble after bubble ignites.

ONE of the most interesting and spectacular experiments for the amateur chemist is the preparation of phosphine.

Phosphine is a very poisonous gas which is composed of 91.13 per cent. of phosphorus and 8.87 per cent. of hydrogen and has the chemical formula, PH_3. When prepared as described, it contains small percentages of liquid phosphine, P_2H_4, which gives it the property of igniting spontaneously when coming in contact with the oxygen of the air.

Before describing the preparation of this interesting gas, I wish to impress upon my readers that, unless the directions are followed carefully, this experiment is quite dangerous and may result in a serious explosion. Be sure that all connections are absolutely tight and that all air is driven out of the apparatus before heat is applied to flask E.

Set up your apparatus as shown in the figure. (A) is a flask arranged for the generation of hydrogen by the action of zinc on sulphuric acid and contains several pieces of metallic zinc. It is fitted with a two-hole stopper through which are slipped the funnel (or thistle) tube (B), and the delivery tube (C). The hydrogen is delivered through (C) to flask (E), but may be cut off by compressing the short rubber tube (J), with pinchcock (D). Flask (E) should of about 100 to 125 cubic centimeters capacity and is supported on ringstand (H) by the ringclamp (I), and rests on a small square of wire gauze. (G) may be either a Bunsen burner, alcohol lamp or other small source of heat. The gas, when generated, is delivered through a glass tube (F) which is curved upward at the end and this curved portion dips in, and is covered by warm water which is contained in a small pin or dish.

Put about five grams of sodium hydroxide (or potassium hydroxide) in the flask (E) and add to it about fifteen cubic centimeters (one-half ounce) of water. Now place a few pieces of metallic zinc in flask (A) and insert the stopper, being certain that it is tight. When the solution in flask (F) has become cool, drop into it a few pieces of stick (yellow) phosphorus about the size of a pea. Connect the flask and also make certain that the connections throughout the apparatus are tight. Now open the pinchcock (D) and pour a few cubic centimeters of dilute sulphuric acid into the funnel tube (B). The zinc in (A) will immediately decompose some of the sulphuric acid, producing hydrogen which will be driven through flask (E), forcing out the air which it contained. The air will escape through (F) and rise as bubbles in the water covering its mouth. This should continue until you are certain that all air has been driven from the apparatus, adding a little more dilute sulphuric acid to (B), if necessary. When all the air has been driven out, which will take several minutes, close pinchcock (D) and disconnect (C) from rubber tube (I). *Be sure that (D) is closed tightly.* Flask (A) may be placed in the sink so that cold water will run into (B), stopping the action between the sulphuric acid and the zinc. Now heat flask (E) gradually and soon the gas, phosphine, will begin to escape in bubbles from the submerged end of (F). As each bubble comes in contact with the air, it bursts into flame, forming a smoke ring, and if the air is quiet, these smoke rings will slowly ascend, growing larger as they rise and making a very pretty sight.

When the experiment is concluded, remove the heat and allow the apparatus to stand for some time before loosening any of the connections, for if any undecomposed liquid phosphine remains in it, it may explode when air is admitted.

For those who do not wish to assemble this apparatus, phosphine may be prepared by dropping a small piece of calcium phosphide into a pan or dish of water to which has been added a few cubic centimeters of hydrochloric acid. However, the results are not so satisfactory as by the method given above.

The experiment above is both interesting and instructive, and, if properly performed, is not dangerous, but it should never be attempted by a careless worker.

Glass Stopcocks

By Raymond B. Wailes

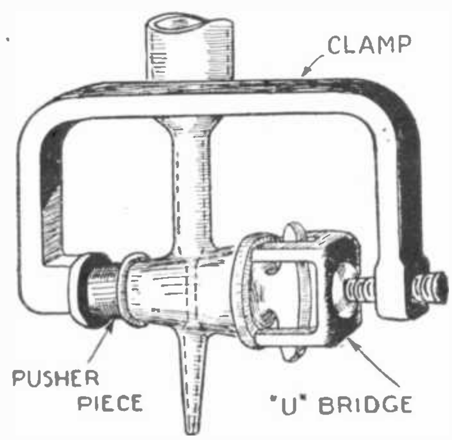
MANY pieces of chemical apparatus such as burettes, gas generators, etc., have glass stopcocks. Very frequently these pieces of apparatus become inoperative and absolutely worthless because the glass stopcock has become "frozen," or stuck very tightly. Of course, the preventative should be administered before the stopcock has become stuck, this being an application of a good lubricant, which will prevent the stopcock plug from sticking, and will lubricate the bore, as well as seal the stopcock tightly.

A good lubricant for all around use is a very thin film of vaseline. Some experimenters might find this too thin, especially in hot weather. In this case, lanolin, or wool fat, can be used. As a happy medium, a mixture of equal parts of lanolin and vaseline melted together can be used in all weathers. Some have found that a rubber lubricant made by dissolving springy, fresh black rubber tubing, cut up into chips, in vaseline and paraffin, is good. A widely used formula is:

Fresh springy black rubber	18 grams
Vaseline	16 grams
Paraffin	1 gram

This can be mixed in an evaporating dish. Melt the vaseline, add the paraffin and then the rubber chips. Keep hot until the rubber is melted. More vaseline makes it thin, less vaseline makes it thick and viscous.

But how can a stuck and stubborn stopcock be loosened, once it has become "frozen" in its barrel? Sometimes pouring hot water upon the barrel with light tapping of the plug will loosen it. Warming the barrel with a match will also expand some stuck stopcocks so that the plug will move freely.



Apparatus for extracting the glass plug from stop-cocks. It is well to tap the barrel lightly with a piece of wood while applying the pressure.

But many times the plug will not budge and often the heat will crack the glass.

A handy stopcock remover is shown here. It consists of a C-clamp applied to the stuck parts by means of two little pieces of these hard fibre. In tightening the screw of the C-clamp one of these hard pieces presses against the small butt end of the stopcock plug, the other or bridge piece presses against the shank of the barrel of the stopcock. Speedy removal is possible with these three items.

In putting away apparatus having glass stopcocks, it is best to insert a small piece of paper between the plug and the bore or barrel. This will effectively prevent sticking.

Perhaps the chief reason for a stopcock sticking is the film of chemical drying out between the plug and the bore. This is especially true with sodium hydroxide and other caustic solutions. The caustic soon reverts to the carbonate, on exposure to the air. Then, too, alkalies readily attack glass, forming insoluble compounds much like a cement. Caustic solutions such as standard sodium hydroxide solutions should not be titrated with or run through glass stopcocked burettes. Rubber tubing, pinch clamps and glass tips should be used with the Mohr or stopcockless burette instead for such solutions.

Circulation Power Battery

By W. Ph. Hauck

An adequate galvanic element should have as high a potential difference between its terminals as possible, and the number of binding posts to be used should be as small as possible when a higher potential is desired. The internal resistance should be small, so that the elements will take up little room. When standing on open circuit, they should not deteriorate, and the constants should be about the same as those of the Daniell cell.

These requirements are met by the coupling together of 10 elements to be next described, all into one block, with only two terminal binding posts. The use of renewable parchment diaphragms and the closeness of the electrodes, within ⅜ inch of each other, along with the arrangements for circulation of the electrolyte, insure a saturated solution of copper sulphate whose formation would be prevented by saturated poorly conducting zinc sulphate solution, bringing down the resistance extraordinarily and give the battery a very constant character.

We will find on inspection that this battery has considerable resemblance to the Volta pile, and its setting up is carried out in the same manner. First, a plate of zinc is laid upon a perfectly level board, which plate is provided with a terminal wire. Next comes a leaf of parchment with a gauze layer secured to its upper face. Next comes a U-shaped frame of paraffined pasteboard, which serves at once as an insulator and to retain the fluid. Next comes another zinc plate, but this is coated on the side next to the parchment with a layer of lead turned over where the U-formed frame is open. Now comes on the zinc side another parchment piece, another frame, another lead plate, zinc electrode, etc., until we have reached the tenth frame and the eleventh zinc plate (coated with lead), which constitutes the tenth lead plate.

Next comes the cover board. Through the projecting margins of the boards, bolts are passed and the nuts are drawn down on them so hard that the pasteboard frames make watertight contact with the metal plates. The whole is set up with the open portions of the U-shaped frame face-upward, so that now we have a vessel with ten divisions, with zinc and parchment on one side and lead on the other.

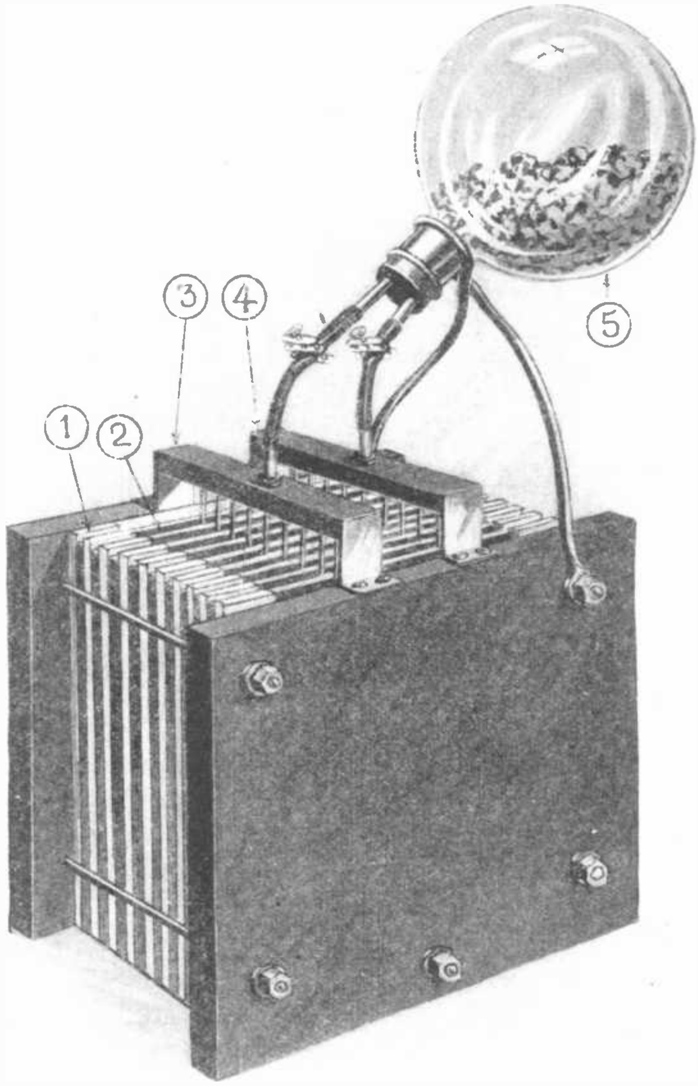
The last plate of zinc with its lead coating has soldered to it a copper wire that comes under the binding post screwed into the board next to it. A corresponding one is fastened to the other board, making contact with the terminal wire of the zinc.

There is a little opening made through the pasteboard about a half inch below the upper edge of each frame. In mounting the apparatus, this must be kept open and serves to maintain the liquid at the same level in all the divisions. An important feature of the battery is the comb-like series of feeder tubes which take care of the supply of copper sulphate and of the removal of zinc sulphate. These sets are kept in communication by rubber tubes provided with pinch-cocks with the supply vessel, which stands at a higher level than the battery. To set them into action the cells are first filled with water, so that it begins to run over at the margins, and then the rubber tube coming down from the container of the electrolyte is closed by means of the pinch-cock and the same vessel is filled with crystals of copper sulphate in quantity according to the size of battery and with water, and then is closed airtight by an India rubber cork. The two sets of feeder tubes are then set into the battery so that one end of each is immersed in the fluid of one of the cells. If the container of the electrolyte should empty itself, something which could only happen by incorrect handling, the first thing is to see if all the cells are filled with water, if the container and feeder tubes are all in watertight connection, and if the ends of all the tubes dip into the cells.

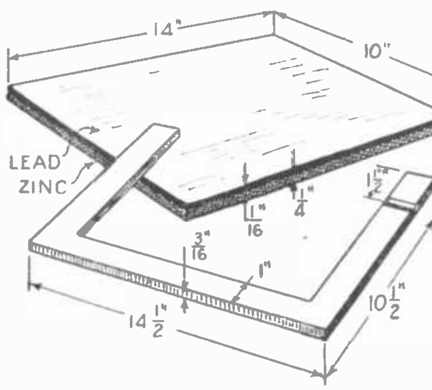
We have to be certain that the feed tubes are open at their ends, which is easy to ascertain by letting water run through them. After this has been done long enough to be sure they are clear, the pinch-cocks controlling the supply are opened, whereupon the fluid will begin to circulate, and the battery in about twenty minutes will reach its full power, which will reach its full long as there is an excess of copper sulphate in its container. To bring the battery into full action, in a shorter space of time, water about 80 degrees Fahrenheit in temperature can be used. Rain or distilled water is the best for it. To put the battery out of action the pinch-cock is closed. The lamps which it is supplying are allowed to burn until the copper sulphate solution in the battery is completely exhausted, which is brought about by precipitation of metallic copper from the solution still in the battery.

The rack of tubes supplying one of the solutions withdrawing the other is a sort of comb or rake in contour. The idea is to avoid disturbing currents, such as would be called by a concentrated downflow of heavy solution through the vessels so the copper sulphate is led down near to bottom of cells.

As the battery will still work for an hour, after the closing of the pinchcock, it is well to shut the cocks about an hour before the lights are to go out. The battery then is to be emptied of solution, washed out well with water and filled with pure water until

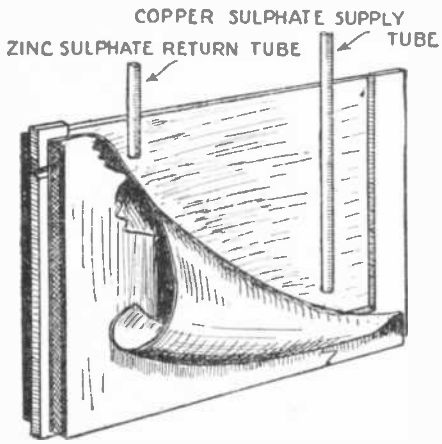


The battery above consists of a set of electrodes (2) separated by cardboard separators (1) forming small cells between the plates. From the flask (5) copper sulphate is supplied to the battery through the feeders (3) and zinc sulphate solution formed in the battery is returned to the flask through the return tube (4).



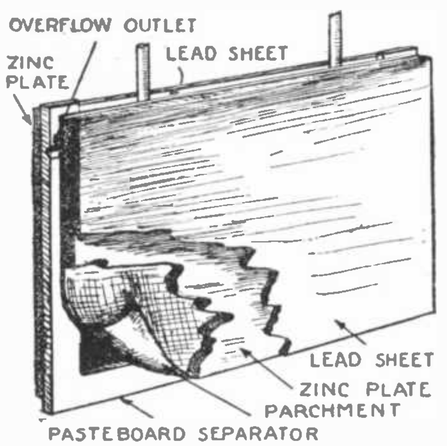
The drawing shows detail of electrodes and separators. The electrodes are double; a zinc plate about a quarter inch thick is covered on one side with the lead sheet one-sixteenth of an inch thick. One is the positive and the other is the negative plate.

the time comes to use it again. When first put in use it must stand for five or six hours full of water and in doing this we must take care that some water finds its way between the parchment and the zinc. The renewal of plates and parchment, if the battery is properly handled, should take place after 80 or 100 hours' service. The changing of the plate can be done very readily. A battery 14 x 10 x 5½ inches will give 20 watts. A battery 8 x 6 x 6 inches will give 7 watts.



The illustration shows the disposition of supply and return tubes in each cell. The copper sulphate tube conducting the heavier solution reaches to the bottom of the cell.

If the battery stands longer than eight days on open circuit, it is to be recommended to keep it on closed circuit for an hour the day before it is to be used, and to keep it on closed circuit with a lamp or other re-



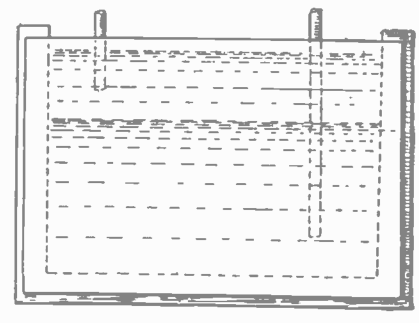
The structure of one cell of the circulation battery is shown above. As seen, each cell has a lead and a zinc electrode, the latter being covered by a strip of parchment.

sistance in the line. The battery will then be ready for use.

Fig. 1 shows the smaller battery which is able to deliver 7 to 10 watts, so that it will take care of a lamp of that wattage.

The larger size has found a more extensive use for small lighting plants and has even been used for arc lamps. The arrangement of the battery for these purposes is shown in Fig. 2. They have been used extensively for electroplating, as they are free from production of nitrogen oxides and the zincs require no amalgamation. The handling of them is perfectly simple. An hour before the current is to cease, the pinchcocks are closed, so that the residual copper sulphate will not be precipitated on the zinc and injure the batteries. It is highly advisable in the final discharge of the batteries to connect them to a storage battery; then when the pinchcocks are left open and the current still flows, and the lamps are extinguished, what we call the residual current goes into the storage battery. Two of the larger sizes act perfectly for driving a sewing machine. As already stated, the handling of them is simple. The exhausted fluid is taken out and the battery flushed out with clean water to remove any slime which collects on the bottom, and in case of need a wooden spatula must be used to get rid of it. Then, filled with pure water, the battery is ready for its next run. A disadvantage is, however, that when the batteries are kept out of use for a long time, they do not develop their full power when put into action. This trouble is got rid of by the use of warm water and a short circuit. It is recommended to preserve the precipitated copper for sale.

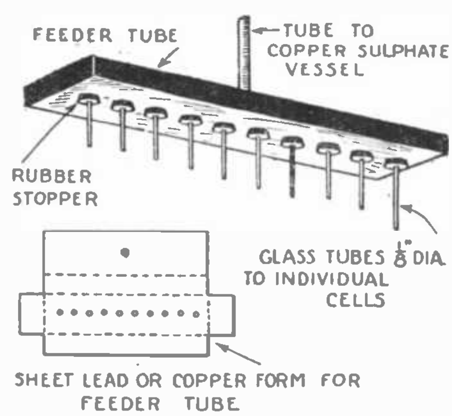
Those who have had charge of large gravity batteries will remember how obstinate the copper was in depositing itself in long streamers or otherwise upon the zincs, so that they had to be scraped from time to time, unless, of course, the battery was kept in active service. In the Daniell battery there was another trouble. The metallic copper was sometimes most mysteriously deposited in quite thick coating and very hard upon the porcelain. This last action, it seems to the writer, has not been sufficiently



In operation, the zinc sulphate, formed by the reaction of zinc with the copper sulphate solution, rises to the top of the cell because its density is lower than that of the copper sulphate solution.

investigated; how the non-conducting porcelain could catch the conducting copper seems quite a mystery. The way to keep a Daniell battery or a gravity battery in order is to constantly take a current, greater or less as the case might be, from it, and thus prevent the copper sulphate getting at the zinc.

An incidental trouble in the gravity battery came into the action of the two solu-



The feeder tubes can be very readily constructed of sheet lead or copper. The drawing above illustrates the method of construction.

tions, zinc sulphate and copper sulphate. As long as the copper sulphate solution was of higher specific gravity than the zinc sulphate solution, all went well. But as the zinc dissolved, the solution of zinc sulphate continually increased in specific gravity, and as soon as it got heavy enough it would descend, displace the copper sulphate solution, and all would be confusion. It will be observed that in the interesting battery which has been just described there is a very perfect displacement or circulation system for the two solutions, based on their differing specific gravity.

One thing is certain, anyone who has had the job of scraping zincs will run a copper sulphate battery so as to avoid the necessity arising.

A Remarkable Battery

By Hugo Gernsback

THE battery which we present to our readers today is a really remarkable one, one with which the writer experimented extensively in his college days. It is remarkable for the reason that it occupies little room and gives not only a high voltage, but a good amperage as well. The battery pictured here gives a steady current of 2 amperes at about 10 volts. The following are a few hints which the writer thinks necessary to give before the reader attempts to build the battery.

One of the most important points is the parchment. The parchment in this battery acts as a porous wall and not all grades are satisfactory. There are many papers masquerading as parchment, which are not parchment at all. Use only real animal parchment and make sure that it is not ordinary paper. There are two rough tests which you can make to convince yourself of the parchment. First, by placing a small piece in your mouth, it should have a sweetish taste. Also the parchment must be quite heavy; that is, thick. It must have the distinct parchment crinkle and stiffness to it. There is no such thing as perfectly smooth parchment, for it always has a rough texture. This is the best to use. The thicker the parchment used, the less the resulting amperage; the thinner the parchment, the more amperage you will get from the battery, *but the quicker the zinc will be consumed.*

Note in connection with this battery that this is a closed current type and cannot be used like dry cells or storage batteries. When it is not being used, it consumes its zinc by local action on open circuit. Failure to keep it on closed circuit will consume the zincs in short time. This is the case with all copper sulphate batteries, which cannot be used for open circuit work. Where it is not desired to flush out the battery with water, as recommended by Mr. Hauck, the best way to keep it in order is to have a small incandescent lamp supplied by it, burn continuously, or otherwise to use a resistance that is equivalent to that of this lamp when the battery is not in use. Very little current will be taken and in this case the battery will be ready at any time you require it. This is particularly the case if you wish to use the battery for laboratory work, to light up your workroom, or a small dwelling, or for other similar work.

Making Celluloid Battery Jars

By Hugo Gernsback

Member American Physical Society

VERY often the experimenter requires certain types of jars or vessels in carrying out important experiments, an not infrequently these experiments are abandoned for lack of the container.

Storage batteries particularly require square or oblong jars, and such jars are not easily procurable in the open market. Very few supply houses carry them in stock, and the glass manufacturers as a rule do not sell small quantities. The same holds true of hard rubber jars to a large extent. And when it comes to particularly odd sizes or shapes, the experimenter as a rule is up "against a stone wall."

Somehow, the fact that celluloid battery jars are more than desirable in one way does not seem to be known to the experimenter at large. Nevertheless, celluloid jars are distinctly superior to glass or hard rubber. They are light and are not affected by even severe jars, as are glass and hard rubber. Celluloid jars are not affected by storage battery electrolytes or ordinary salt solutions. Such jars are transparent, take up little room, and best of all they can be manufactured by almost anyone. The cost is not prohibitive and almost any size can be made.

The editor of this journal, who has had considerable experience in manufacturing automobile and motorcycle, as well as small pocket storage batteries, herewith desires to give his experience to the readers of THE EXPERIMENTER.

The first step to take is the securing of the necessary celluloid sheeting. Only three companies in this country make it, and there are only a few concerns jobbing the celluloid.* The right material to use is what is known as either "Amber" or "Colorless" transparent celluloid sheeting. As to the thickness, no exact advice can be given, as this depends upon the size of the vessel to be made. Naturally, a large jar containing a quantity of heavy plates must have thicker walls than a small jar. As a rule, small jars not larger than 3 inches by 3 inches by 5 inches require celluloid about 1/32 inch thick. Larger jars require walls of about 3/64 inch and heavier. Figure out how many square feet you require and then order about 10 to 15 per cent. above your requirements.

While you are waiting for the sheeting it is necessary to build the *Hot Plate*. This consists of a gas or electric stove topped with a heavy steel or iron plate at least ¼ inch, or better, ½ inch to 1 inch thick. See Fig. 1. The most important part is that the heat must be regulated. With a gas stove this is simple, as the cock can be opened more or less. With an electric stove we will need a good rheostat. Now heat up the hot plate in such a manner that a small test piece, cut from the celluloid sheeting, will remain on the hot plate for at least ten seconds without bursting into a flame. Then, when taken off the plate, it must be as soft and pliable as a thin piece of fresh dough. Should the test piece of celluloid blister badly, the plate is too hot. In that case reduce the heat.

Caution: Always remember that celluloid is extremely inflammable. *Keep away from an open flame.* For this reason the square hot plate, at the end where you work, should overlap the stove for at least two inches.

With a small piece of sheeting, say, 3 inches by 3 inches, begin practicing to gain experience in bending and shaping the material. Fig. 1 shows how a square bend is made. As soon as the sheeting is soft, quickly bend to the required shape and pull it off at once from the hot plate. If a right angle is desired, place the hot sheeting over a square block of wood. In thirty seconds the shaped piece has cooled and is stiff. Bends can, of course, be made downward or upward as indicated by dotted lines in Fig. 1. The important part is that the corners, after cooling, must not show cracks or fissures. If they do, you attempted to bend before the celluloid was sufficiently heated. Fig. 2 shows the main body of a battery jar, bent four times. Fig. 3 shows the bottom (or top) before bending, while Fig. 4 shows the same part after bending.

Before attempting to bend the sheeting

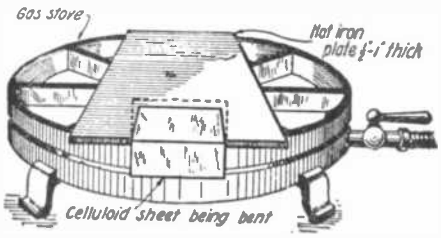
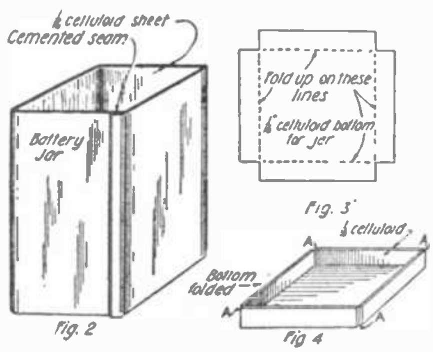


Fig. 1

When warm celluloid can be shaped very readily. An iron plate placed over the heater as illustrated above makes this operation possible without exposing the inflamable celluloid to the open flame.

take a sharp-pointed tool and scratch lines on the sheeting at the points where the bend is to come. These lines can be easily watched while bending and the resulting jar will be more perfect than when no guiding lines are used.

There is still another method of bending celluloid. This is the *hot water* method. Thus, a piece of sheeting when plunged in *almost* boiling water for a few seconds will come out soft and pliable. It can then be formed over wooden blocks to the required shape. This method is not considered a



Celluloid battery jars can be constructed by the amateur experimenter with little difficulty. The one illustrated above is made of two separate sheets of celluloid, cemented with a solution of celluloid in amyl acetate.

good one by the writer, as it tends to warp the entire jar.

Cementing

Alcohol, amyl acetate and acetone are good solvents for celluloid. From these the necessary cements are made.

The writer prefers the use of acetone, which is fairly cheap and can be had at most drug stores. Procure half a pint in a wide-mouthed bottle and remember that acetone is inflammable, and when strongly inhaled causes coughing and dizziness. Otherwise it is not dangerous. When commercially pure, it should be colorless as water.

Cut up *very thin* strips of celluloid and drop them into the bottle containing the acetone. Into the one-half pint bottle throw about two ounces of the celluloid strips. Before putting the bottle away, shake it for some minutes. You will observe that the celluloid begins to dissolve slowly. In from 24 to 48 hours all the celluloid has been *digested* and the cement is ready. During this time it is necessary to frequently shake the bottle, otherwise the imperfectly digested celluloid will stick to the bottom of the bottle in a thick, sticky mass.

When ready, the cement should have the consistency of mucilage. If too thin, add more celluloid; if too thick, add acetone.

Now take the part shown in Fig. 2 and apply the cement with a small brush to both surfaces which are to be in contact permanently. Do not spare the cement, use plenty and put it on thick. After applying, put the seam face down and apply weights on the inside of the jar, so that the seam part is under pressure over its entire length. Leave in this position for *at least six hours,* and better, twenty-four hours. After that you have a water- and acid-proof seam. Remember celluloid cement does not stick in the manner of paste or mucilage. It actually *dissolves* the celluloid surfaces to a certain depth, and after drying the seam is as solid and homogeneous as the entire jar.

The bottomless jar now receives its bottom, Fig. 4, but before doing so, all the contacting surfaces of both jar and bottom must be heavily coated with cement. Be sure that there is plenty of cement in the four corners, otherwise there will be leaks. Place weights on top of the jar and leave in this position for *at least six hours.* Heavy rubber bands should be put around the bottom part, to insure good contact with the jar. The latter is quite important. After the cement has set, apply a new lot in the inside corners as well as where the jar edges touch the bottom. The outside corners should also be cemented again, and for a good job small celluloid pieces should be cemented in the open corners, shown at (A), Fig. 4. The jar is now completed and is then put in a *dry* room for at least twelve hours.

After that, test by filling it with water to the top. Compress at two opposite corners, which forces the jar slightly out of shape. If no leak develops, the jar is water- and acid-proof.

Should a leak develop, do not attempt to cement *until the jar is absolutely dry.* Even a slightly moist surface prevents the cement from taking hold.

Oscillatory Properties of Neon Lamps

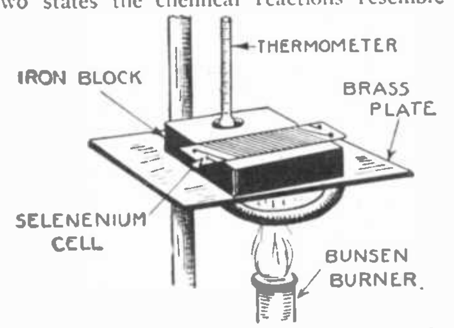
A discussion of the oscillatory properties of these lamps was recently given in the Proceedings of the London Physical Society. A particular type of neon lamp containing 80 per cent. neon and 20 per cent. helium passes an intermittent current when shunted by a condenser and connected in series with a high resistance to a D.C. supply.

When cold, the lamp fails to pass any current until subjected to an E.M.F. of about 171 volts. If, however, the voltage be reduced whilst the lamp is glowing, the current continues to pass until about 140 volts is reached, when the current suddenly falls to zero. When an E.M.F. of 200 volts is applied, some time elapses while the condenser is charging up to the necessary 175 volts. At the end of this time the lamp begins to take current, the current increases, and the voltage across the lamp falls to the limit of 140 volts, when the lamp goes out. The cycle of operations is then repeated.

Selenium Cells and Their Uses

By Kenneth M. Swezey

SINCE its discovery in 1817, by Berzelius, the element selenium has been a substance of mystery and wonder. Some hold that is is a metal, and others say that it is not. At any rate, selenium, in the periodic system, lies between sulphur and tellurium, and is found in amorphous, vitreous and crystalline states. In the first two states the chemical reactions resemble those of sulphur, but in the third it has many of the characteristics of a metal—and the crystalline form is generally called metallic selenium.



Powdered metallic selenium is melted on the sheet of mica or slate on which copper or iron wire has been wound as shown above. The melted selenium fills the space between the wires and when allowed to cool, crystallizes.

It is this latter form which is of interest to the student of photometry and the electrical experimenter; for it has the property of changing its electrical resistance in proportion to the amount of light which is thrown upon it or to which it is exposed. The value of a substance with such a property can be readily surmised, for it means that the substance can be used to measure the intensity of light, or can affect by means of light any piece of apparatus that can be operated by a relay.

Selenium makes it possible to control with a ray of light anything from a small bell to the largest power plant in the world; in fact, a bell could be rung or a huge motor started and stopped by simply waving a hand over a selenium cell.

Cells of selenium are already in use for switching on and off the lights on life-buoys, lighting them at the approach of darkness, and extinguishing them when the light is sufficient for safety. They are used to start and stop machinery; to measure the light for the exposure time of ordinary photographic and movie camera films; for measuring the light of heavenly bodies; for registering railroad signal lights; for reproduction of sound waves, such as in various systems of talking moving pictures; for assorting cigars, coffee beans, or any article where a difference of shade from white to black is to be distinguished; for protection against burglary, and so on.

The number of uses the experimenter can find for selenium is limited only by his imagination.

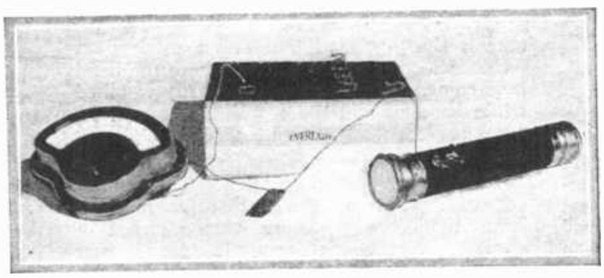
In darkness, crystalline selenium has an exceedingly high resistance. In light, the resistance is considerably lower; but the penetrability of the metal to light is so small that every means possible has to be taken to utilize every bit of available surface. With this end in view, selenium is arranged in what are known as cells, the different types of cells bearing the names of the investigators whose names were associated with them.

The simplest form of selenium cells, and the one most generally used, is the Bidwell. This consists of a strip of mica or slate about 2½ inches long and 1 inch wide, around which is closely wound, with just a slight separation, two strands of fine bare copper wire. This is heated, and the selenium applied between the wires, after which the whole is annealed.

For electrical work, purchase only the purest selenium obtainable. This comes in grayish sticks, having a semi-gloss, and costs about $2 an ounce. Specify that you want metallic selenium for electrical work, and you are quite sure to get the kind that is required. An inferior grade of metallic selenium can be obtained on the market for less than half the price mentioned, but this is practically useless for the making of cells. It really is not expensive material, for an ounce will make many cells; which on the market may cost from five to forty dollars each.

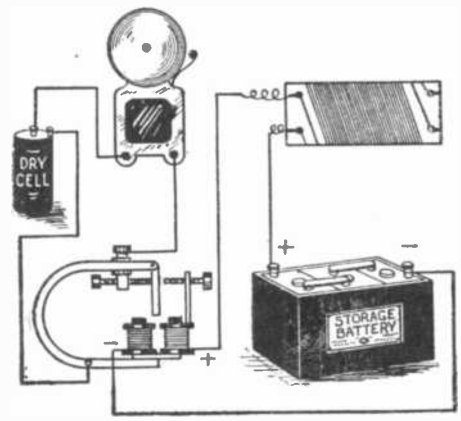
Mica is satisfactory for the form on which to wind the wire, but unless it is unusually thick it cuts quite easily when the wires are drawn tight—and these must be tight, for the wire expands upon heating, and if they are the least bit loose in the beginning they will surely touch and short-circuit when they are heated.

Slate is better, because it has more body and is easily worked into any desired shape. Any piece will do that has no metallic veins in it. A piece broken from a roofing slate is excellent.



By connecting the selenium cell in series with an ammeter to a radio B-battery or other source of current and then playing a flashlight beam upon the cell, the sensitivity of the latter is readily determined.

The thickness should be about an eighth of an inch, and the length and width as before mentioned. It may be broken or sawed into the rough shape, and then smoothed down with a file, tapering it toward the long edges. With a very small triangular file these two long edges may be slightly notched at points about 1/32 inch apart. This helps in keeping the wires in place. Two small holes may be drilled in each end to secure the ends of the wires.



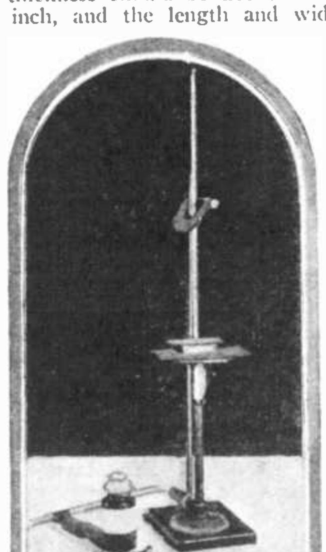
A common application of the selenium is shown above. The cell under the influence of light will have a reduced resistance and allow the passage of sufficient current to actuate the relay, which in turn closes the bell circuit.

The size of the wire makes little difference, but No. 28 or 30 is generally used. Some advocate smaller wire, though the beginner may find the practice disastrous, as the wires break very easily after they have been heated for a while. Better choose No. 28, or even No. 26.

Secure the end of one of the wires in one of the small holes you have drilled for the purpose, then proceed to wind it around the form, skipping every alternate notch. When you reach the other end, secure the wire in the opposite hole, and allow about three or four inches to project for connections. Then wind the second wire, starting from one of the unused holes, and winding in the notches which were before skipped. Finish it up in the hole that is left and leave also a short length for connections.

The wires should be as close together as possible, but they should not touch at any point, for a single short-circuit will spoil the cell, and may possibly be the cause of the burning out of a relay or of a current measuring instrument.

Next comes the applying of the selenium and the annealing process. And to do this properly one should supply himself with the few necessary pieces of apparatus. A Bunsen burner is excellent for supplying the heat, and an adjustable chemical ring stand will serve admirably to support the cell. Upon the ring of the stand should be placed a thin copper or brass plate, and upon this a small block of iron about 2 inches square and ½ inch thick, with a ¼-inch hole drilled almost through it near one edge. This hole is a well for the end of a thermometer. A Centigrade thermometer, reading up to about 250 degrees, is indispensable. Put mercury in the cavity.



The apparatus for applying the selenium is shown above. A mica or slate sheet is wound with wire, forming a lattice on which the selenium is retained. The mica is placed on an iron plate in an aperture wherein the bulb of a thermometer is set, and the plate is heated until the selenium spread on it melts, careful regard being given to the temperature.

Mount the apparatus as shown in the photograph, and lay the embryo cell upon the iron block. If the thermometer fits its well too loosely it may be wrapped with a little steel wool.

Bring the temperature up to about 117 or 120 degrees C. Powder a small piece of selenium, by carefully hammering it on a metal plate, or by grinding it with a pestle in a mortar, and spread this over and between the wires. It will melt almost immediately and take on a lustrous appearance. The temperature must be regulated carefully, for if too low the selenium will turn gray, and if too high it will roll up in globules like mercury. At the right temperature it will appear lustrous, yet it can be spread and will stay where it is put. Scrape off the surface with a piece of mica or the blade of a knife, and press the selenium well between the turns.

When the surface of the cell has been covered satisfactorily the cell should be taken from the block and laid upon a metal plate to cool. In the meantime the Bunsen burner is adjusted to give a temperature of about 130 degrees C.

When the cell is cool it is again placed in the iron block and allowed to heat again. In a few minutes—maybe five or ten—the surface will begin to turn gray, due to the crystallization. If this does not take place within a reasonable time the temperature should be raised a little.

After the surface has entirely crystallized the temperature should again be raised, until signs of melting begin to appear. This state becomes evident by the edges becoming glossy. When this occurs, immediately remove the Bunsen burner and allow the edges to recrystallize. If this is not done quickly enough the whole surface may run together and require the crystallization process again.

Turn down the burner a little and replace it under the block. The temperature should remain somewhere between 190 and 210 degrees C. Watch it carefully for a few minutes, and if it rises higher than the latter mentioned number the burner should be turned down still further; for if the selenium actually melts again all the previous work would be spoiled.

After the proper heat has been fixed the cell should be left for about four hours. Watch it occasionally to see that the temperature does not exceed the limit.

When that time is up the heat may be gradually lowered in steps distributed over periods of an hour, finally removing the heat entirely.

The cell, when cool, is ready for use. Or at least it is generally so. Cells vary greatly in resistance and sensitiveness to light, and some have to be further treated, after being annealed, by passing an alternating current through them. But usually they are satisfactory immediately after cooling.

To determine the variation in its resistance, a cell may be connected in series with a radio "B" battery of from 22 to 45 volts, and a milliammeter. It is probably best first to connect the cell directly across the battery, to make sure that it is not short-circuited. If it is, a portion of the wires may melt and the cell will have to be discarded; which, at its worst, is better than burning out the meter.

Where it is desired to use the cell to operate a relay, one of the polarized type may be used, and should have a winding resistance of at least a thousand ohms. The connections are shown in the diagram.

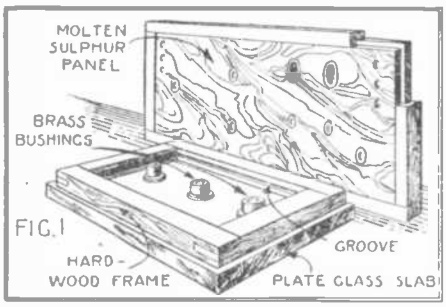
The experimenter may build model boats or automobiles, using light rays to control them. The "radio dog" works on that principle, its relays and circuits being so arranged that it will follow a light. John Hays Hammond, Jr., has used selenium cells to control all the operations of his famous experimental boat, directing its action from the shore, entirely by light beams.

Some may want to use the cells as a sunrise alarm clock, waking them early on a bright day and allowing them to sleep when it rains. The intensity of the light necessary to operate the relay can be accurately predetermined by proper adjustment.

Sulphur Panels

By Philippe A. Judd

HAVE you ever stopped to think what insulation is costing you—particularly panels? As a friend of mine says, "Ain't it awful?"—Yes, it certainly is "awful." In fact, the amateur's purse begins to look rather anaemic, not to say thin, by the time he has purchased a suitable panel for his set. Of course, bakelite is an excellent insulator, but it's also devilish expensive.



An attractive panel for your radio set can be made from cast sulphur, requiring very little machining after the cast has cooled and is withdrawn. Screws and bushings can be imbedded in the hot sulphur, enabling the experimenter to construct his panels in a very short time.

Casting about for a substitute, I decided to try shellac and sulphur. I chose sulphur for my first experiment, because of its relative cheapness and the ease with which it can be handled.

It melts at a comparatively low temperature, 109 degrees Centigrade or 228 degrees Fahrenheit), has high dielectric properties, and may be readily cast into various shapes.

Upon solidifying it assumes the texture of the surfaces with which it is in contact. Thus various surface finishes may be reproduced by varying the material of the mold.

A cross sectional fracture of the finished panel shows a semi-crystalline structure. The panel is a greyish or greenish, yellow color, mottled and veined like marble, due to the impurities in the commercial product. The back of the panel presents a crystalline surface covered with very small pits. When less than three-eighths inch thick, peep holes and bezels are unnecessary, as the panel is then translucent to the light of the vacuum tubes.

It may be worked, after casting, in much the same manner that hard woods are treated, and should be drilled from both sides to prevent chipping.

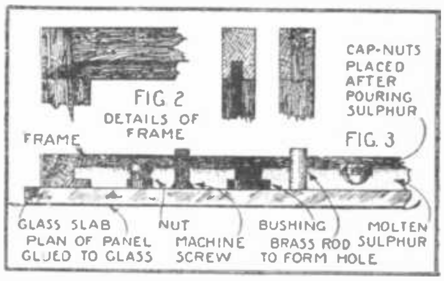
I have found the following process the best for the construction of panels.

A frame is first made to fit the front of the cabinet, as shown in Fig. 2. This not only adds to the appearance of the set but also reinforces the panel. The frame is laid upon a sheet of plate glass, being held in place by several dabs of sealing wax or other cement. The glass, in turn, is laid over a plan of the panel on a perfectly level surface.

All lugs, threads, bushings and holes are cast in the panel at the beginning, so that subsequent drilling is unnecessary. To do this, the nuts, screws and bushings are cemented to the glass in their proper positions, as located on the plan through the glass. This is clearly shown in Fig. 3.

Before pouring the sulphur the glass should be slightly warmed to prevent cracking.

The sulphur may be melted in an enamel or earthenware vessel and should be just hot enough to pour well. This should be done in a well ventilated place, as the fumes are inflammable and are very unpleasant if drawn into the lungs. The



The method of casting a sulphur panel is illustrated above. The nuts, screws, bushings and other metal parts are first arranged in the mould according to a predetermined lay-out. The sulphur when hardened firmly retains these parts.

melted sulphur is self-leveling and will fill all the crevices in the mold. A tongue of sulphur forms in the groove of the frame to hold the panel in place.

As soon as the sulphur has solidified, run a thin blade between the frame and the glass to loosen the panel. Then remove any of the rods and screws where holes are wanted and your panel is complete.

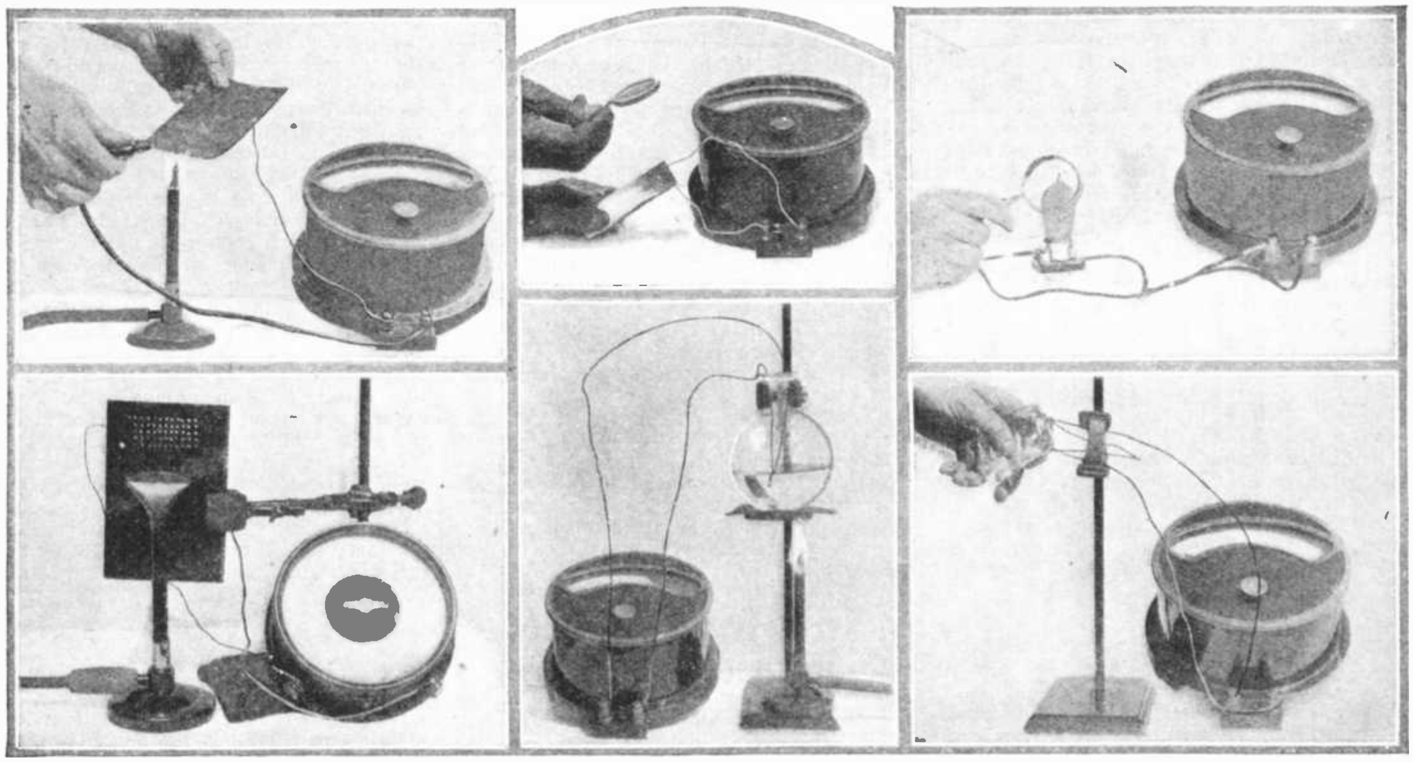
Should a mat, or a grained finish be desired, an unglazed tile slab, or a piece of hardwood may be substituted for the glass. In this case, however, it will be necessary to lay out the plan of the panel on the upper surface of the pile of wood.

To vary the color, a small quantity of asphaltum or resin may be added to the sulphur. This will produce varying shades of brown according to the amount added. Don't add too much otherwise the two ingredients will separate upon cooling, thus leaving spongy spots in the panel.

Dia's and knobs may be reproduced in molten sulphur, using plaster casts of the commercial forms, as well as special parts, which, of course, require various special patterns.

Experiments with Thermo-Electricity

By Raymond B. Wailes



The thermo couple is an endless source of experiment. Some can be made sensitive enough to detect the heat due to solar rays focused on them by a weak lens. They can be used to give the temperature of heated solutions and a number of them connected in series will form a battery of considerable potential. Such a battery is shown at the lower left. The couple is as sensitive to cold as to heat, as illustrated in the picture on the right.

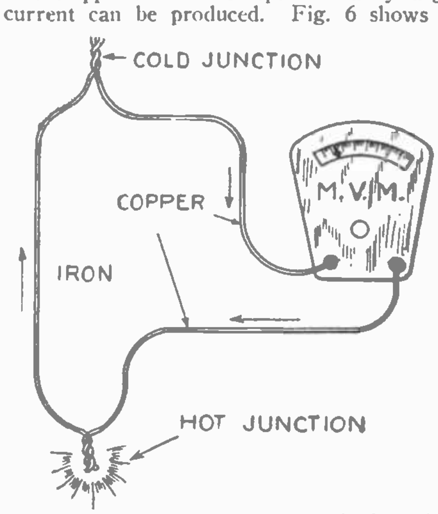
HEAT applied to two dissimilar metals joined together in a closed circuit, applied to their junction, will produce a current of electricity. This is the principle of thermo-electricity. Fig. 1 illustrates Seebeck's discovery which is the basis of thermo-electrical disturbances.

Here, an iron and a copper wire are joined together at their ends as indicated, and a sensitive current-indicating instrument such as a millivoltmeter is inserted in the copper lead. If one junction is heated and the other junction kept cold, a current will flow from the iron wire to the copper wire at the cold junction and also from the copper wire to the iron wire at the hot junction. Cooling one junction or heating the other junction increases the current.

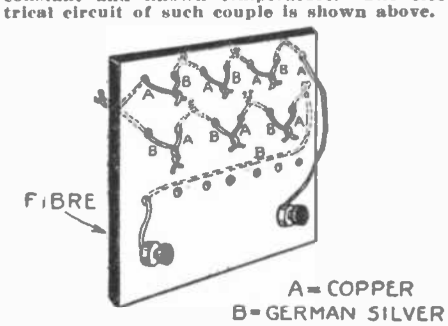
Perhaps the simplest of all methods of producing an electric current is shown in Fig. 2. Here, a copper foil is connected with a millivoltmeter. An ordinary spring jaw battery clip is connected to the other terminal. On heating the copper foil and clipping the spring clamp upon it a decided movement of the instrument hand can be observed. Here, nickel and copper, the metals used, produce the electric current.

Another easy method of producing a current is shown in Fig. 3. A UV-199 vacuum tube is used. The spot where the end of the filament wire is welded to the lead-out wire should be heated with a small magnifying glass. The sun's rays should be concentrated upon this welded junction which consists of two different metals. A current can be seen to be produced when this junction or weld is heated, if an indicating instrument is connected with the filament terminals of the tube. You might have to search for a thin or weak spot in the silvering of the tube but practically every tube can be used for this little experiment as the silver coating is not very uniformly distributed.

A battery of small thermo-couples can be mounted on a sheet of asbestos board or even hard rubber as shown in Fig. 4. Here the wires AAA are copper and the wires BBB are German silver, constantin or iron. The end wires are led to binding posts. If one set or "battery" of junctions such as those on one side of the drilled support are heated and the other junctions or thermo-couples on the opposite side are kept cool fairly large current can be produced. Fig. 6 shows a



A sensitive thermo couple should have besides a hot junction a cold junction kept at a constant and known temperature. The electrical circuit of such couple is shown above.



The illustration shows the manner in which the thermo couples of a thermo-battery are connected. The couples are connected in series as the potential difference in a single couple is slight.

method of performing this experiment. A current can be produced as indicated by a millivoltmeter by focusing the sun's rays upon one thermo-couple of the whole battery as shown in Fig. 5.

In making a battery illustrated in Fig. 4 the wires should be twisted together, or better, welded in a small electric arc after twisting.

The effects of cold or the principle of the cold junction is illustrated in Fig. 7. Here, three thermo-junctions are formed, two on one side of a cork and one on the opposite side. In the sun, with the two couples shaded, a current can be obtained, which will be increased by cooling the two shaded or cool junctions with ice.

Up to certain temperatures with different metal-combinations, the electric current produced increases directly with the applied temperature. Heating two metals, say, copper and iron wires, to a temperature of 100 degrees Centigrade, will always produce the same number of millivolts, provided the resistance of the wires does not change due to corrosion or other agencies. Conversely, if the same wires were used and the junction heated and the millivolts produced were indicated by a millivoltmeter, a close comparison of the temperature at the heated junction could be made.

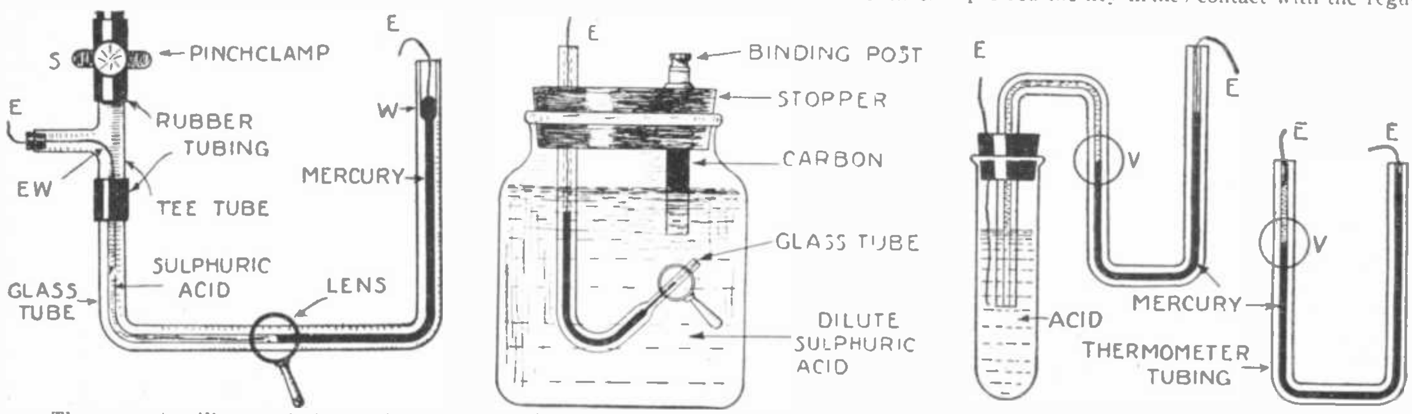
As in Fig. 8, using a copper and a German silver wire tightly twisted together and welded in a small electric arc, a certain millivoltage will be produced when the junction is placed in boiling water (100 degrees Cent.). Whenever, at another time, the millivoltage is the same, it could be said that the heated junction is at a temperature of 100 degrees Cent.

The experimenter can plot a curve of millivolts against temperatures and have a fairly accurate electrical thermometer or pyrometer system. Thus by immersing the junction, or twist, in tin, the reading in millivolts when the tin just melts and flows can be called 232 degrees Cent. Pure lead can also be used, its melting point being 327 degrees Cent.

Making and Using a Capillary Electrometer

By Raymond B. Wailes

A CAPILLARY electrometer is an instrument with which small electric currents can be detected. It consists of a glass capillary tube, or a tube of small internal diameter, in which lies a thread of mercury connected with suitable electrodes. Voltages applied to the electrodes will cause the mercury thread to move, the movement being visualized by the naked eye or with a microscope or other magnifying means.



The apparatus illustrated above, Figs. 1-4, are various forms of the capillary voltmeter. The essential feature is a thin capillary tube containing sulphuric acid and mercury, each in contact with one terminal of the source whose potential is to be measured. The passage of a minute electric current alters the surface tension at the boundary between the mercury and sulphuric acid and causes the thin mercury stream to move. This motion is observed with a lens or microscope.

Figs. 1 to 4 show several types of easily made capillary electrometers. Fig. 1 is a very serviceable instrument and is made from a piece of glass capillary tubing of ¼" outside diameter and 1/25 to 1/50 inch (1 mm. to ½ mm.) inside diameter. It is bent in the shape of a U and has a tube of a larger inside diameter sealed on at W. The other arm of the U has an ordinary tee-tube fitted to it by rubber tubing.

A platinum or even nickel or copper electrode is thrust through a cork fitted into the arm of this tee-tube. The upper leg of the tee carries a two inch length of rubber tubing, closed at the top by a cork or glass plug and provided with a screw clamp. A solution of 1 part of sulphuric acid in five or ten parts of water is placed in the tube and mercury is poured into the larger arm, (W). By adjusting the screw clamp the mercury thread can be made to occupy one half of the U, from (V) to (W). A magnifying glass or better, a small or even a toy, microscope is placed at (V) to view the movement of the little mercury thread when the current is applied to it. Graduations can be made on the tube by a sharp carborundum crystal, or better are etched with hydrofluoric acid, or a small paper scale may be fastened behind the tube so that a means of comparison of current strength can be had.

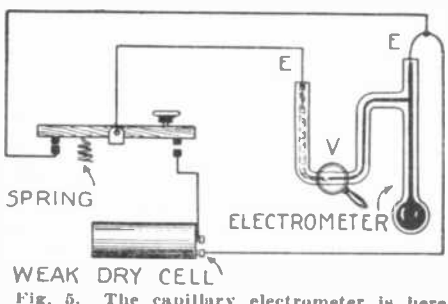


Fig. 5. The capillary electrometer is here hooked-up for demonstration purposes. The electrometer is normally short-circuited and when the key is depressed the motion of the mercury will be noticed.

Any small source of potential such as that of a very weak and old dry cell connected with the electrodes (E) (E) will cause the movement of the mercury thread in the small bore tube. The right hand electrode (E) makes connection with the mercury, the left hand one with the dilute sulphuric acid, which of course is contained in the tube and meets the mercury at V.

Fig. 2 requires less glass working to construct, than Fig. 1. To make the capillary tube (Fig. 2) a glass tube is heated in a flame and drawn out to a small bore tube. Fig. 3 consists of a glass capillary tube with a double U bend. Dilute sulphuric acid is contained in a small vial as shown. Fig. 4 is the simplest of the four types, consisting of a single U tube of small bore tubing. Some thermometer tubes can be used in this and other types. In all types, the microscope or strong magnifying lens is placed at the termination of the mercury thread, at V, the small circles at these points representing the lens. In all instances, one electrode (E) makes connection with one side or end of the mercury thread and the other electrode (E) makes contact with the dilute (1:5) sulphuric acid solution, this acid thread in the tube meeting the other end of the mercury thread. A nickel or even copper wire can be used as electrode for the acid for a few hours' operation of the instrument, but a small platinum wire is best as it will not dissolve in the acid.

Experimenters should not be alarmed at the mention of a platinum wire. A small wire is not expensive. Even the cut-throat old jewelry man asks only a small sum for a short piece, which is all that is needed.

Fig. 5 shows how the capillary electrometer should be connected for demonstration purposes such as that of illustrating the action and use of such a handy indicating instrument. The key is a made over telegraph key, with a third contact added. The added spring holds the rear or added contact point down so that the capillary electrometer is kept short circuited at all times. This is important! When the knob is depressed the key makes contact with the regular contact point and closes the battery circuit. The operator, viewing the end of the mercury thread in the small bore tube, will then see the thread move a distance which varies with the current strength. An ordinary telegraph key can be mounted on a wooden base and fitted with three binding posts, this combination affording a suitable working instrument for use with the electrometer.

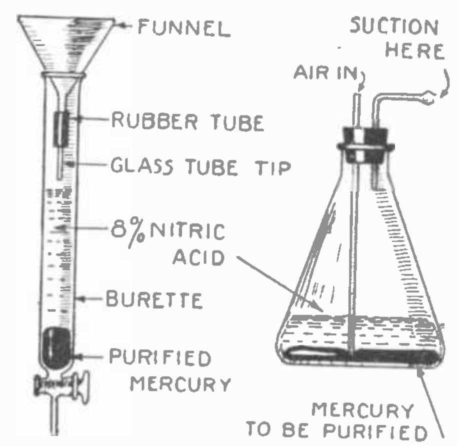


Fig. 7. The mercury used in the capillary electrometer must be chemically pure. To clean mercury either of the two methods shown above can be used. At the left drops of mercury are allowed to fall through dilute nitric acid, while at the right air bubbled through the mercury mixes the latter with the acid.

One of the many uses to which the capillary electrometer can be put is that of an indicating device in a Wheatstone bridge which is shown in Fig. 6. Here a resistance wire (AB) is traversed by a sliding contact (S), the unknown resistance being at XR and the standard or known instrument being at SR. The electrometer in Fig. 6 simply replaces the galvanometer shown in the ordinary Wheatstone bridge circuit.

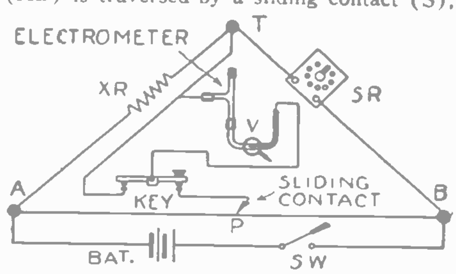


Fig. 6. The capillary mercury electrometer will serve as a useful current indicating device in connection with a Wheatstone bridge. Note that the electrometer must normally be short-circuited.

The mercury thread should be connected with the negative side of the source of current to be indicated. Currents at more than one volt should not be applied to the electrometer.

Only pure mercury should be used in the instrument.

A fine stream of mercury allowed to fall through an 8% solution of nitric acid will lose some of the base metals which have become associated with it.

Another method is to cover the mercury with an 8 per cent. nitric acid solution and to blow or draw air through the mercury for several hours, thus exposing all parts to an oxidizing action.

Mercury Vapor Lamp

By Dr. Russell G. Harris

ONE of the most interesting, and next to the incandescent lamp, most useful, sources of light is the mercury vapor lamp. The peculiar bluish color of the light emitted by this arc has prevented its wide adoption as an aid to vision, but it is very valuable for photography and has found many commercial uses.

At the outset we must distinguish between the glass type of the lamp and that constructed of quartz, which is the more valuable type of the two. This is because quartz transmits ultra-violet light, while glass does not, and as the so-called mercury flame inside the arc is rich in ultra-violet rays, a quartz container is desirable. The ultra-violet rays are used in photography and in killing bacteria, fading dyes and treating certain diseases. A number of interesting experiments with ultra-violet light will be described in a future article, and the quartz arcs to be described are valuable sources of these short rays.

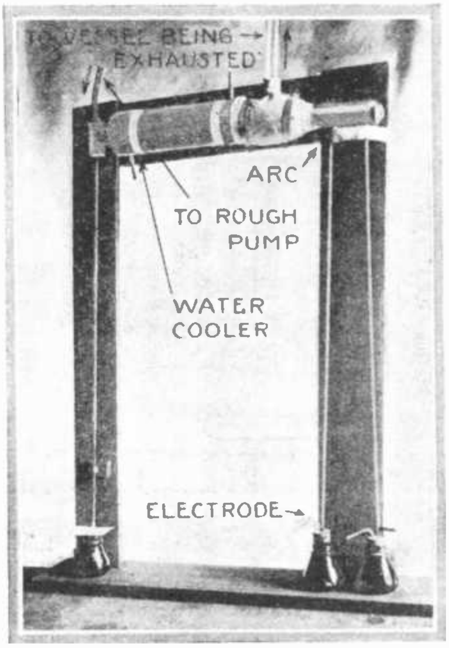
We will describe several simple types of mercury lamp, and since any one works practically as well as another, the choice of which to build will depend largely on the apparatus available. It should be remembered, however, that while the glass type of lamp will give an intense bluish light valuable for indoor photography and useful for a large number of experiments, most of the ultra-violet rays do not escape from it. Quartz is difficult to obtain and to work, however, and herein lies the great advantage of the arc shown in Fig. 5 and illustrated in the photograph, as the materials can easily be obtained. This is a type of arc which the author has never seen described before, but it works very nicely and has the great advantage of being practically indestructible and wasting little power.

In Fig. 1 is shown the simplest type of glass arc, which has the advantage of not requiring a pump to exhaust it. It is especially suitable for photographic work.

The long U-tube is made of glass tubing about an eighth of an inch internal diameter and with fairly thick walls. Each arm of the U is about 30 inches long. Two small bottles such as ink bottle are provided with corks, each having two holes. The end of the U fits into one of these holes and into the other goes an electrode of iron wire, which, if galvanized, should have all the zinc scraped off, or dissolved with acid, as this amalgamates with the mercury and coats the walls of the arc with "gunk." If a pump is available, it should be connected to tubes passing through third holes in the corks, in which case the arms of the U may be shortened. If no pump is used, the extra holes in the corks are left open. If a pump is used, the arms of the U should not be less than six inches long to allow for proper dissipation of the heat evolved in the arc. The bend in the U should be from one to two inches in diameter, to prevent undue heating of the glass.

The U-tube is first inverted and completely filled with mercury. Now, with a little mercury in the bottom of each bottle, the tubes are carefully put in place, no air being allowed to go up into the U. The mercury should fall to a little below where the arms join the bend of the U. The arc may then be started when the current has been put on by blowing into the bottles, forcing the mercury up into the bend momentarily, and allowing it to fall back, when the light should strike.

This arc will run on from 12 to 110 volts direct current (D.C.). It should be connected to the D.C. line through a resistance which will carry at least five amperes. The eyes of the experimenter should be protected by colored glasses if the arc is viewed intently, as although the glass jacket of the arc absorbs most of the ultra-violet, some of the longest waves get through.



By connecting the mercury vapor lamp consisting of the two tubes at the right to a condensation chamber at the left an efficient low pressure pump is formed. The mercury vapor passing out of the arc draws gas molecules with it and thus evacuates the chamber to which the apparatus is connected.

Fig. 2 shows a type of glass arc which is slightly more complicated but is better in that no glass blowing is required, and only a small quantity of mercury is necessary to run it. The central part of the arc is a straight glass tube about an inch in diameter, and to its ends electrodes made of iron pipe are fastened with sealing wax. These electrodes are provided with water coolers to prevent the sealing wax from melting. This makes a very nice portable type of vertical arc, and is probably the best of the easily constructed glass arcs. The lower electrode is a pool of mercury in the iron pipe, while the upper electrode is made of the supporting wires from a burned-out high power incandescent lamp. Be sure that these wires are of molybdenum or tungsten, and not of copper as they sometimes are. If such wires cannot be obtained, a piece of iron wire or a nail will do, but it will not be so permanent and will have to be renewed occasionally. The arc is completely exhausted with some type of fairly good vacuum pump, preferably a mercury pump such as one of those described in a recent article of this series, and the arc is started by tipping it until a thread of mercury runs down between the two electrodes, and then tilting it back. A couple of teaspoonfuls of mercury is sufficient for this arc. Needless to say, it should not be measured out in ordinary teaspoons, as it would ruin them and impair the mercury. Tungsten and iron or steel are safe in contact with mercury, however.

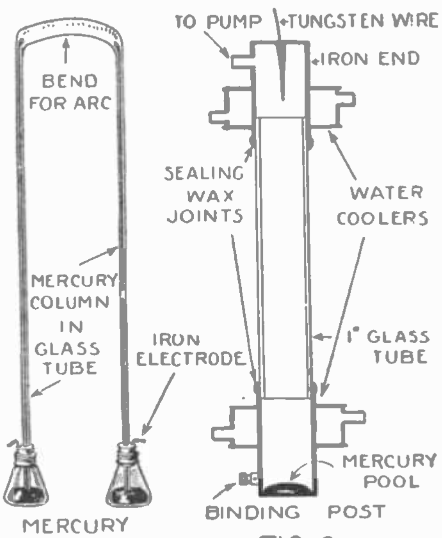


FIG. 1 FIG. 2

The mercury vapor lamp of Fig. 1 needs no pump to evacuate it. The tubes made slightly more than thirty inches long are filled with mercury. When the tubes are inverted and placed in operating position the mercury level drops, leaving a perfect vacuum at the top. Fig. 2 shows a form of lamp which requires no glass blowing. Iron caps are sealed to the ends of a glass tube. The joints are water cooled.

If a horizontal type of arc is desired, it can be made similar to the vertical one, but the tube should be slowly heated in a large Bunsen or blast flame until soft, and then given a slight bend. The tube is then laid horizontally and can be started like the vertical arc, but the incline keeps the condensed mercury running back into the electrodes. It will be found that there will be a gradual carrying of mercury by the current from the positive electrode to the negative one, but this will be slow and can be remedied by running some back occasionally.

The hotter the lamp gets the more light it will emit for a given power input, and the higher its resistance will get. The writer has constructed arcs of quartz glass similar to the ordinary glass ones here described, which were run until red hot, and which required over two hundred and fifty volts to drive three amperes through a hot column only seven inches long. No glass arc will stand this temperature, however, and one should not attempt to run these with a greater voltage drop than two or three volts per inch. Some resistance should always be used in series with the arc, but it is evident that a glass arc up to about three feet long could be run where a D.C. line with 110 volts potential is available. Any current of from one ampere to four or five will do.

Leaving the glass mercury lamps, we will turn now to two types built of quartz, which are designed so as to be easily constructible. In Fig. 4 is illustrated the simplest and most efficient lamp of the outfit, but it requires the services of a glass blower equipped with oxy-acetylene flame for its construction, which is easy to accomplish, however. It is included because of its striking ease of manipulation, and its efficiency.

It consist of a small U-tube made of capillary quartz tubing with a hole about one-sixteenth of an inch in diameter. The ends are widened out so as to hold more mercury, and into these dip the iron electrodes. The tube is filled with mercury and 110 volts from a D.C. circuit with about 30 ohms resistance in series is connected to the electrodes. The tip of a Bunsen flame is then played on the center of the U. This causes the mercury to boil there, the thread breaks, and an arc forms across the break and generates enough heat to keep the column broken. If the mercury around the electrodes gets too warm, it should be air-cooled or water-cooled, both to prevent it from evaporating and because mercury vapor is very poisonous. This arc is remarkably intense and efficient because the pressure inside it is greater than one atmosphere. The resistance will be found very high; probably a drop of about 90 volts on an arc three inches long will occur. On no account should one look at this arc, either directly or indirectly, on account of the great amount of ultra-violet light emitted by it. This produces serious injury to the eyes, and the experimenter does not begin to notice the effects for several

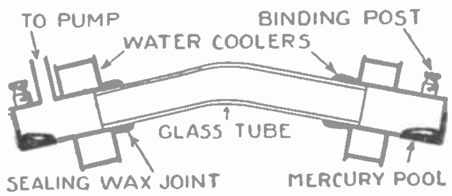


FIG. 3

This mercury vapor lamp is designed to be mounted horizontally. The glass tube is bent so that the condensed mercury will flow to the metallic caps at the ends of the tube.

hours. Several ⅛-inch thicknesses of window glass should be used to cut off the ultra-violet, and then the arc should only be viewed through colored glass to decrease the intense visible light. An arc of this type, of the same length and the same current-carrying capacity as one of the glass arcs described, will be found to have over a hundred times as much light emitted from it as the latter. The writer wore heavy welding goggles while working over such an arc for about five minutes, and received such a burn on his face as could only be acquired in three weeks at the seashore. Incidentally, doctors are now using this method for curing boils in adults, and rickets in children. It has been tried for X-ray burns.

The final type of arc to be described, Fig. 5, needs no quartz blowing, and is probably the easiest to construct for the average experimenter as far as obtaining the materials is concerned. The arc is made of iron pipe or seamless steel tubing, and requires that one or two welded joints be made. This can be done at almost any large garage or machine shop. The light leaves the tube through a quartz lens. This can be obtained very cheaply from an optician by asking for a pebble-glass or rock-crystal spectacle lens, as these names are commercially used for crystalline quartz lenses. If possible one should be obtained having a focal length of about six inches, or in other words, a strength of about seven diopters. The exact value is not essential, but the side tube through which the light leaves should be made about one and one-third times the focal strength of the lens used, provided one is interested most in the ultra-violet rays. If in the visible rays the tube should be twice the focal length of the lens in length.

The barrel of the arc is made of pipe or tubing of about one and three-fourths inches internal diameter, and the other dimensions are to scale as in the diagram and photograph. The water coolers may be made of brass or of tin cans and are of the same type that have been used on various pieces of apparatus described in this series of articles. The water should be kept flowing continuously while the arc is burning, and should flow in at the bottom and out at the top, all the coolers being connected in series.

The upper insulating bushings may be made of glass and mica. The water cooler which fits inside is quite essential, as the tungsten terminal gets red hot and most of this heat is conducted up the electrode rod. The glass bushing is cut out of a plate of fairly thick glass by means of a brass tube of the proper diameter charged with emery and turpentine (or water), run in a drill press or lathe. The water cooler is then wound with several layers of mica, and the whole is thoroughly heated when in place and coated with sealing wax. If heated to just about the melting point of the wax, a good air-tight joint will result, with sufficient insulation so that the current will not short at this point.

The arc takes place between a tungsten wire, taken from the anchor wire of an old 200-400-watt incandescent lamp, placed in the end of a quarter-inch steel rod and pinched there, and a shallow pool of mercury in the bottom of the arc. If any difficulty is had because of the arc tending to form between the tungsten electrode and the wall of the tube, this can be overcome by heating the bottom of the mercury well with a flame. After the tube has been thoroughly pumped out, the arc is started by shaking the tube for a moment. The tungsten terminal should be about an inch above the surface of the mercury, and with care this can be

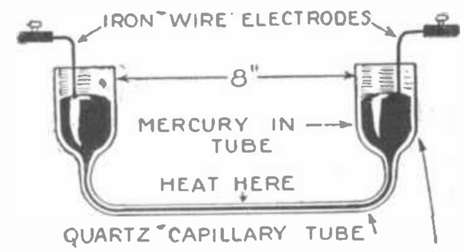


FIG. 4

This simplest of all mercury vapor lamps consists merely of a capillary tube terminating in two reservoirs. These latter are connected to the electric circuit, and when a Bunsen burner is applied to the center of the capillary tube, the arc is started.

increased to two inches, because the arc would rather go to the mercury surface than to the walls because the former furnishes plenty of ions once the arc has been started. If it once starts to the wall, however, it must be shut off and started again. If much trouble is had, a shield of mica may be shoved down so as to partially surround that part of the tube where the arc takes place, internally.

If small droplets of mercury form on the lens and tend to obscure it, it may be cleaned without taking the arc apart by allowing the mercury to run down along the side tube and flow over it. This should be done only when the mercury is cold, however, as crystalline quartz will crack when heated suddenly, although fused quartz will not.

This arc is very short, and hence does not use much power. Since only a small part of the luminous column is used in most arcs, this is an advantage. When the central part of the tube gets warm enough, the vapor pressure goes up considerably, and we get a fairly efficient source of light of great brilliancy. The light is more concentrated too, being allowed to escape only in one direction, so fewer shields are needed to make it safe. Again, the experimenter must be cautioned not to look at the arc when burning except through several thicknesses of glass.

Although the mercury arc looks blue, it is in reality a peculiar mixture of colors. White light contains certain amounts of every color from violet to red, but the mercury arc confines its radiation in the visible principally to five colors. There is some red, more orange, lots of yellow, a great deal of green, more blue than anything else, and a little violet. These have such relative intensities that the resultant has a greenish-blue tinge.

The great advantage of the type of arc last described, and the one purpose for which it was built by the author, is that other metals besides mercury can be used in it, giving lights of different colors. Sodium gives a brilliant yellow light, while cadmium, lead and other metals, which can be melted by a Bunsen burner applied to the outside of the arc, give others, some being almost white.

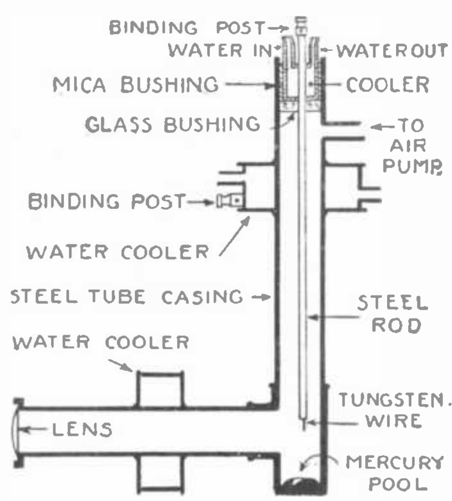


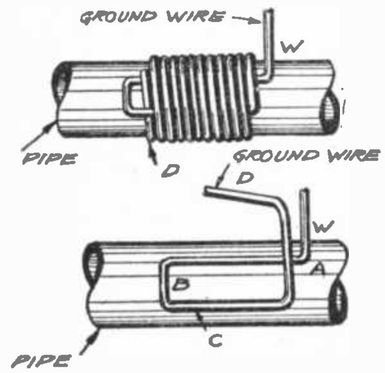
FIG 5

This elaborate mercury vapor lamp is made of seamless steel tubing, the arc taking place between a tungsten wire and the mercury pool at the base of the lamp. A quartz lens is provided to allow the passage of ultra-violet rays.

Connecting a Ground Wire

A NEAT and efficient method of connecting a radio ground wire to a water pipe is illustrated here.

The pipe is thoroughly cleaned with emery or sandpaper at point of connection and the bare wire is placed on the pipe as shown, A, B, C, D, then the free end (D). Fig. 2



The method of making a ground connection shown above ensures a firm and extended contact surface. No sort of contact, however, can be a satisfactory substitute for a soldered one.

is wound around the pipe as shown in Fig. 1. When sufficient wire has been wound on the pipe, the free end of the wire (D) is passed through the loop (B) after which the wire (W) is pulled, drawing the loop (B) tightly under the turns around the pipe.

—Contributed by William J. Edmonds, Jr.

Step-Down Transformer

By Arthur Siniscal

THE transformer described in this article is simple to make, and when completed will be a valuable asset to the experimenter's laboratory. With this instrument enough current can be drawn without overheating to light two 21 C.P. automobile lamps. It will also run

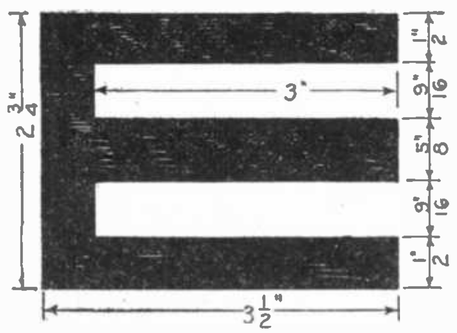


FIG. 1-A

Details of the lamination of a shell type transformer; both the primary and secondary windings are mounted on the central branch of the laminations.

motors at a high speed, and work all sorts of annunciators and small electrical apparatus.

The first step in the construction is to cut out the laminations for the core. Sheets of common tin, aggregating about four square feet, will suffice. These are cut into enough pieces of the size and shape shown in Figs. 1A and 1B, to make a pile from 5/8 to 3/4 inches high when clamped tightly in a vise. About 60 pieces will do if ordinary sheet tin is used. The experimenter need have no fear of this large amount as the work was done by hand in the writer's case. First cut one piece of the exact size and then from this cut out all the rest.

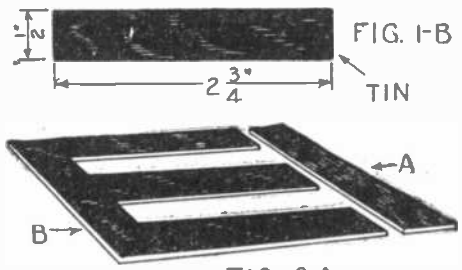


FIG. 2-A

The upper figure shows the details of one member of the lamination; the lower one shows the relative positions of the two parts of the lamination, just before assembling. To avoid lamination vibrations, it is imperative that the laminations be by some means clamped tight.

The next step is to make the two coils. For the primary, you will need some 360 feet of No. 28 S.C.C. wire, or about one-quarter pound. This is wound in 14 layers on a cardboard tube, 1 1/8 inches in diameter by 1 3/4 inches long. For the secondary you

will need about 90 feet of No. 18 S.C.C. wire or about one-third of a pound. This is wound in 6 layers on a tube 1 1/8 inches in both diameter and length. Take a tap-lead out at the end of the third and fourth layers in the secondary coil. Shellac over each layer as you go along to keep the wire in place, and tape over each coil when finished.

In assembling the transformer, place the two coils alongside each other with the free ends together, *i.e.*, leaving the ends with the connecting wires opposite. Then insert the core parts through the coils and lay them out in the manner shown by figures 2A and 2B. When you have made a compact mass of about the required amount (50 to 60 pieces), connect the primary coil across the 110 volt line to determine the exact number of pieces needed. This is done by watching the disc of the meter in the cellar. Be sure no current is in use elsewhere in the house at the time of experimenting, so the meter will not be registering. When connected, the disc will either rotate very slowly or very fast, depending on the size of the core. Now increase or decrease the number of laminations in the core until the movement of the disc is hardly perceptible. This will determine when it is of just the right size.

The last step is to mount the apparatus on its base. The simplest way is to cut a baseboard of wood, 3/4 x 4 1/4 x 7 1/2 inches. Place the transformer on this so that the long sides of the core rest on two wooden supports (WW), as shown in Fig. 3. These are 1/2 inch square by 4 inches long. Two wooden clamp pieces press down over the core sides and are held in place by four

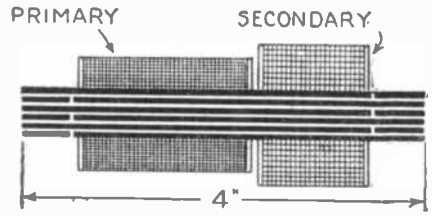
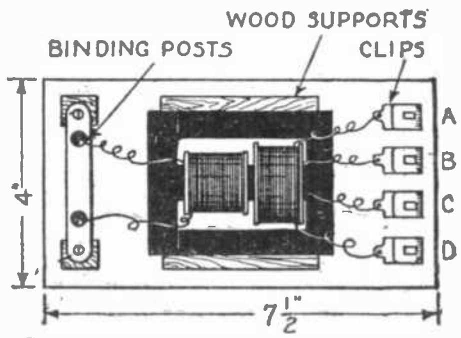


FIG. 2-B

The position of the two windings when mounted on the core. This so-called shell type transformer offers a low reluctance path for the magnetic flux and is for that reason much used in transformer design.

2-inch screws. These two upper clamp pieces are 1/2 inch square by 5 1/2 inches long.

For making connections, near one end of the base (on the primary side), a strip of hard rubber (R, Fig. 3) is fastened, having two binding posts attached. The primary ends are connected to the latter. At the other end, four Faehnstock clips are screwed into the base and these form the secondary terminals. In this set the ends of the coil are connected to the first and fourth clips, while the two taps are joined to the two inner ones. Furthermore, the lead taken off at the third layer must be connected to the terminal "C" (Fig. 4).



Top view of the assembled shell type transformer. While the figure shows no clamps, it is important that some means for clamping the laminations be used.

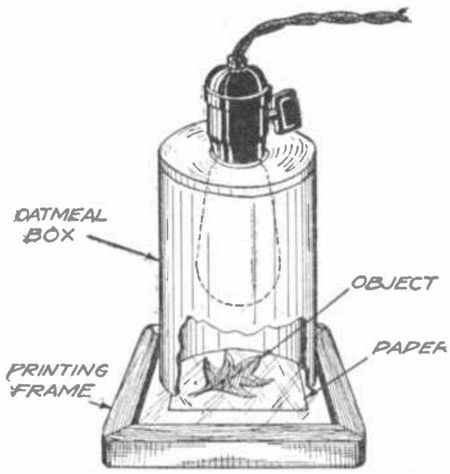
The approximate stepped down voltages are as follows:

A and B	4 volts
B and C	2 volts
C and D	6 volts
A and D	12 volts

A top view of the complete instrument, with top clamp pieces removed for clearness, is shown in Fig. 4. All the wooden pieces should be shellacked or varnished before being joined. Some details have been omitted which the amateur can fill in to suit his convenience.

Photographer's Printing Lamps

THE illustration shows a method of taking blueprints on cloudy days or at night. The bottom of a good size oatmeal box is removed. The inside of the box is coated with lamp black. An electric lamp is placed



An oatmeal box with one end removed is here furnished with an incandescent bulb and used for blueprinting on cloudy days or at night.

at the top of the box. Be sure that the lamp is placed at the center of the top.

The object is placed in the printing frame and the box is placed over it. The lamp is turned on for about forty seconds. The printing paper is then taken out and treated in the usual manner.

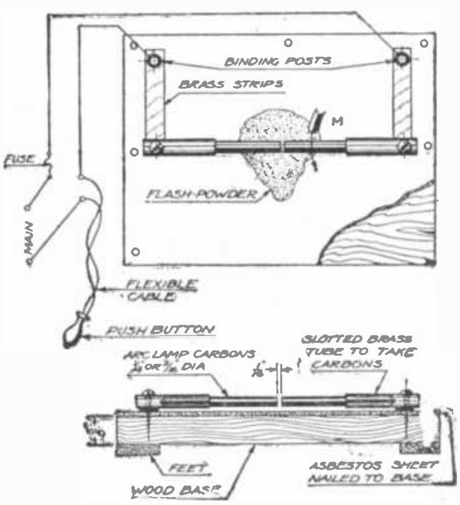
—*Contributed by Irvin E. Pippin.*

Novel Electric Flash Lamp

By C. A. Oldroyd.

THE electric flashlamp shown in the illustrations requires *neither a fuse wire or a spark* for the ignition of the flash powder, as a small electric arc burning between two carbons is used to set it off.

Fig. 1 shows the lamp in sectional elevation, the base is of wood and about 5/8" thick. To prevent the wood surface being scorched, and to obtain better insulation for



A very simple flashlamp can be constructed of two carbon pencils such as used in small arc lamps. With a gap of about 1/16" between the carbon ends a small arc between the carbons ignites the flash powder the instant the carbons are connected to a source of potential of more than 60 volts.

the carbons, a sheet of asbestos is tacked or glued over the wooden base.

A short distance above the asbestos sheet are two carbons, measuring about 1/4 or 3/16 inch in diameter. Small electric arc lamp carbon pencils can be used for these. The carbons are held in two short brass tubes; to facilitate insertion and adjustment, the free or rear ends of the tubes are slotted by making a saw cut.

The tubes are fixed to the base by a woodscrew driven through a hole in the end; between tubes and the asbestos sheet are two narrow brass strips (A) and (B).

These strips should not be too thick, 1/32" is sufficient. At the free ends of the brass strips, binding posts are fixed into the base board, holes being drilled through the strips to allow the wood-screw end of the post to pass through.

In operation, this flash lamp is very simple; the carbons are connected into the circuit, as shown in Fig. 2; the voltage must be at least sixty volts, but much higher voltages can be used.

The carbons are separated so that the ends are about 1/16" apart, and the flash powder is placed on the asbestos sheet near the carbons, as shown in Fig. 2. Care must be taken not to place the powder in a heap over the carbon ends, and it should be well distributed, a very small quantity being sprinkled in the gap between the carbons.

As soon as the push button is pressed, a small arc will burn between the carbons, and set off the powder. The metallic magnesium which forms the greater part of all flashpowders, acts as a bridge and starts the arc. If some kinds of powder should not ignite readily, a small amount of pure magnesium powder may be sprinkled in the gap.

The action of this lamp is sure and certain, owing to the hot arc; and only after each flash new powder need be placed on the asbestos sheet to take the next photo, as the carbons are always ready for use after being adjusted at the beginning.

The carbons can be easily inserted and cleaned as the tube can be swung outwards, as shown by the arrow (M). To adjust the gap in the least possible time, a piece of wood or cardboard of the right thickness, (1/16") should be kept as a gauge, and the carbons pushed up against it on each side. When the gauge is removed, by drawing it out sideways, the gap will be correct.

The push button need only be pressed for a fraction of a second, to start the arc; the ignition of the powder in instantaneous. It is advisable to insert a fuse into the circuit, near the main terminals.

Indicator for Door Bell

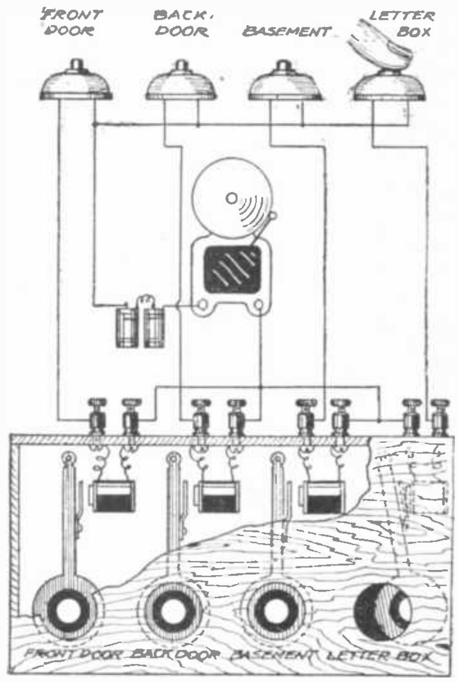
IN some private houses there are a large number of push buttons operating one call bell, the trouble being that one never knows where it was rung from. Again, to have different bells for each push button would not be advisable. Therefore, to overcome this I constructed an annunciator which is very simple and does not cost very much.

If the house is already wired, all that is necessary are electro-magnets, the number corresponding to the number of push buttons, and a hard rubber panel if you wish to have the apparatus neat looking. The panel should be approximately 4" by 8".

The principle the annunciator is worked on is this. Each push button excites its own electro-magnet when it rings the bell. In front of each magnet there hangs a pendulum which carries an armature. The armature is attracted by the electro-magnet when the current flows and releases it when the push button is released, which sets it in motion and it continues to swing for a while. This is noticed through the large holes and under each is labeled the place from which the bell was rung. The diagram explains the construction and the wiring clearly.

The pendulum is constructed by gluing a colored disk on a rod which is suspended in such a position that the electro-magnet can attract it and allow it to swing freely when released. If one pendulum strikes another, then pivots must be arranged to stop it at that point or all of the pendulums will begin to move, and there would be a confusion. The diagram is one-third of the exact size.

—*Contributed by Otto Lustig.*

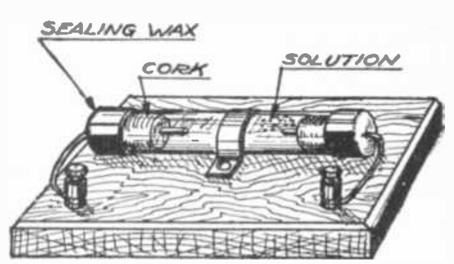


With a number of doors to a house and as many push buttons operating a single bell, what housekeeper has not been irritated by the problem of determining at which door the button was pushed? To these housekeepers the simple annunciator illustrated above will be a godsend.

Pocket Polarity Indicator

OCCASIONALLY in the laboratory the experimenter loses much time in testing the ends of connections of distant batteries, magnetos or radio outputs in order to determine their polarity. The suggestion for the construction of a cheap polarity indicator will be appreciated and the instrument will be found indispensable for many a chemical, electrical or radio enthusiast.

To make an indicator for these purposes procure a medium sized test tube and neatly file away the bottom. In one end of the tube insert a cork through which a piece of wire is tightly forced. After sealing this end with sealing wax, fill the tube with a saturated solution of salammoniac (ammonium chloride) and close the other end in



A small glass tube containing salammoniac solution and provided with terminals at its ends constitutes an effective polarity tester. When connected to a line the side at which bubbles are formed in the negative.

the same manner as described above. The ends of the glass must be rounded in an alcohol or gas flame. Now clamp the tube to a neat baseboard and lead the wires to two binding posts.

In order to use the indicator connect the wires of the apparatus to be tested to the terminals of the indicator, and that end of the wire in the solution from which bubbles are given off is the negative side.

—*Contributed by Hugo Alessandroni.*

Awards in the $50 Special Prize Contest

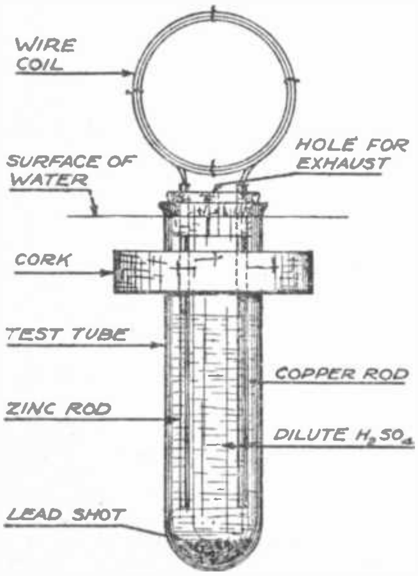
For Junior Electricians and Electrical Experimenters

First Prize, $25.00	Second Prize, $15.00	Third Prize, $10.00	Honorable Mention
Robert Rollins, 1886-A Harmon St., Berkeley, Calif.	Robert Rollins, 1886-A Harmon St., Berkeley, Calif.	Marion W. Gieskieng 4135 East 16th Ave., Denver, Colo.	A. B. Grover, Montgomery, Ala.

First Prize

A Novel Experiment

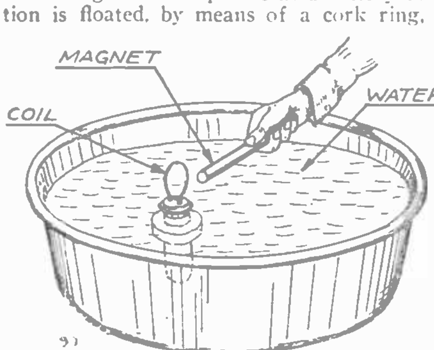
THIS is an odd variation of the floating magnet described on page 714 of the October PRACTICAL ELECTRICS. It is just as easy to make as the other one, and per-



A very small battery is arranged in a test tube ballasted with lead shot and buoyed up by a cork. The cork is completely submerged and the current through the coil gives a number of interesting experiments.

forms a very amusing and perplexing trick. As you see, it is nothing but a floating wet cell energizing a wire coil. But, differing from the type previously shown, the liquid on which it floats is not the liquid of the cell. This difference is due to the fact that I worked with an acid cell and disliked the waste and the danger of working with a large pail of acid solution. And, too, this type reduces friction at the surface that acts against the turning of the coil—a necessary precaution.

The construction is simple. A test tube containing dilute sulphuric acid battery solution is floated, by means of a cork ring, in



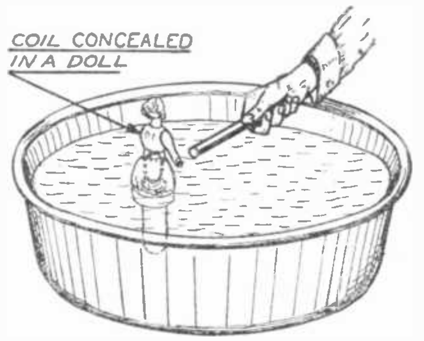
This shows the coil floating with the cork below the surface of the water and being acted upon by a bar magnet. Under this influence it performs various queer antics.

a pail of water. The tube contains two metal strips, copper and amalgamated zinc. These form the terminals of the wire coil, which, by chemical action, they energize with a fairly large current.

The acid solution should not be too strong. The zinc strip may be cut from the top of a fruit jar, and the copper electrode is a short piece of heavy gauge copper wire (or small gauge wire folded back and forth upon itself to give a sufficient surface area). The coil is of copper wire of sufficient gauge not to stop the current. I used No. 20 double cotton covered wire. The loop is about three inches in diameter and consists of at least three or four turns. It is held in place by bits of tape. The cork disk is a section of a large cork perforated to fit the tube. The tube is weighted with lead shot and is partly filled with the dilute sulphuric acid solution, until the upper surface of the cork is submerged below the surface. This reduces the friction against turning to a minimum. The coil will stand up if the two electrodes in the tube are heavy and press against the sides. However, it can be firmly supported by a cork in the mouth of the tube. This cork must have an outlet for the gas that is evolved in the reaction in the cell. So much for the construction.

As every student of electro-magnetism knows, when two fields interact, the resultant force acts upon the conductor of the current as well as the current itself. Because of this fact, we have a queer phenomenon. Place a small bar magnet near the freely floating coil parallel to the surface of the water and level with the center of the coil. The coil will swing about, squarely face and approach the end of the magnet, slide over it and come to rest diagonally across its center. Now suddenly pull the bar from the coil and thrust it in through the other side. The coil will slide off, turn about, and repeat its performance.

The inquisitive experimenter will go further, of course, and try floating two of these coils next to each other, or using a floating bar magnet (like the one previously described in this magazine) in place of the permanent one. Or, if he is lazy, and doesn't like the pulling of the magnet, he can make an electro-magnet of a soft iron rod wound at one end with some insulated wire. Now energize this magnet with direct current, and when the coil is at rest around it, change the poles by means of one of the numerous current reversers shown in previous numbers of PRACTICAL ELECTRICS. With each change in the direction of the current, the magnet will slide off and "do its stuff."

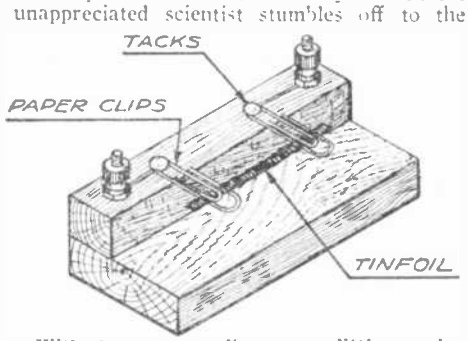


A little doll is made to conceal the coil so that the little figure acts strangely under the influence of a magnet.

Second Prize

Experimenter's Fuse

ONE of the many troubles that torment the electrical experimenter is the blowing of fuses. Often he works for hours on his do-funny and connects it up. Then, with a quiver of expectancy, he throws the switch—and is plunged into darkness! Shouts of none too gentle nature come from all parts of the house. Sister's late now for the show and she can't powder her nose in the dark, can she? Mother simply refuses to wash dishes without a light. And dad was shaving and cut himself when the blow-out occurred, and he'll bleed to death if that blankety-blank kid doesn't hurry. Then the unappreciated scientist stumbles off to the



With two paper clips some little wooden blocks and a bit of tin foil or thin wire, the young experimenter constructs a fuse to take care of his work without disturbing the fuses (and the family) on the house circuit.

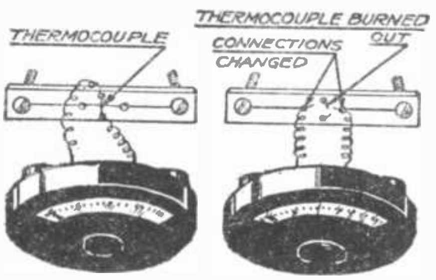
switch-box to stick a penny behind a fuse and returns to face the music.

Well, even that's not a disaster if you are a millionaire, but experimenters are not wealthy; and, with fuses at a dime an issue, the matter's no joke. Many budding geniuses have given up the ghost and sunk into obscurity just because parental authority forbade further endangering of the fuse-box. "You might set the house afire." (This from dad.) "And kill yourself." (From mother.) Oh, experimenting is no bed of roses. I know that well, and nothing pleases me more than to be able to smooth off a few bumps in the stormy paths of my fellow-bugs. Now, dry your eyes, and we'll get down to business.

Here's a little fuse block that you can make in a jiffy and refill and blow to your heart's content while maintaining peaceful relations with the family; and all this with no further outlay than an occasional bar of chocolate (the kind that's done up in tin foil).

Tack two paper clips on a little block of wood, stick a strip of this tin foil in them, and the job is done. If you are looking for permanence, two little binding posts for connections and a bit of asbestos or bakelite to shield the flash can be added. Lead foil or fine wire (about No. 30) can be used for refilling. The strip should be less than a quarter-inch wide, but this will vary, of course, with various currents and thicknesses and kinds of foil used. If you're very particular, you can determine the exact size of foil necessary for your work, and any reference book will give you a table of the blowing-points of various size wires. In any case, this intermediate fuse should blow before the regular 10 or 20 ampere ones in the house circuit.

Third Prize
D. C. Milliammeter



ALMOST every radio transmitting station has a burnt out meter. Little use is found for these meters. "Only 220 volts passed through this one," explained my friend, as he showed me a "burnt out" thermo-couple ammeter of a popular make that would have remained useless had I not discovered what I will now relate.

I asked for a screwdriver, ten minutes, and permission. These granted, I proceeded to find out "What made the blooming thing percolate." After five minutes I was struck by an idea (those who know me would say that was queer). The remaining five minutes were spent in making two connections and assembling, and as the tenth minute elapsed I handed to my friend a D.C. milliammeter.

Here is the solution: I remember that reading the manufacturer's booklet on the thermo-couple ammeter I learned that "an ammeter of the thermo-couple type employs an especially sensitive miniature direct current movement (the registering part) actuated by a thermo-couple. I proceeded to find the miniature direct current movement (the D.C. milliammeter). The milliammeter is the main part of the works and two wires lead from it to the thermo-couple located on an insulated strip. I changed the connections leading from the milliammeter to the binding post that protrude from the case. The result—a sensitive D.C. milliammeter.

Later I placed different values of shunts across the milliammeter, giving it capacities from 15 to 500 milliampers. The dial was removed and one made and calibrated in its place. I find this D.C. milliammeter is as accurate and sensitive as the one I have from a recognized manufacturer of radio instruments.

Left. A thermo-couple ammeter when burned out is converted in ten minutes into an effectual milliammeter. The diagrams clearly show how this is done.

Right. A really effectual alarm for the overflowing refrigerator pan or other similar use about the house or kitchen. A tobacco can forms the all-important float.

Honorable Mention
Refrigerator Alarm

THE pan under the refrigerator kept running over, and there was no way of running this water through the floor and into the sewer without considerable expense. So I constructed the apparatus shown here, and it is a sure-fire thing in preventing overflowing.

To build this outfit it is only necessary to have a dry cell, a bell or buzzer, a Prince Albert tobacco can, a few wood screws (round head), some hardwood sticks and wire.

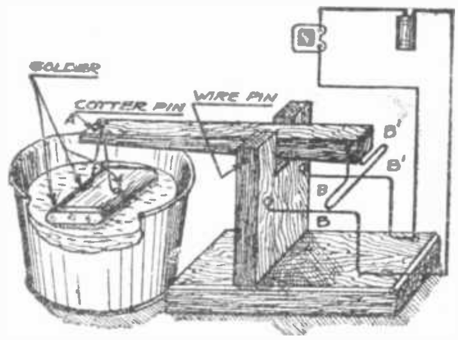
No explanation is needed, except that the tobacco can, used as a float, must have the lid soldered up tight, so that the can will not fill with water.

Dimensions are given of all the principal parts; however, the builder must find his own dimensions by the height of the refrigerator floor from floor of house.

In this case this distance is seven inches. The base sits on the floor, while the float hangs in the pan. When the water in the pan rises to within an inch of the top, contacts (BB) and (B'B") touch and the bell rings until the pan is emptied.

Fig. 6 shows the elevation and all connections. While this outfit would not be needed in real up-to-the-minute homes, there are quite a number where it would be found convenient.

It is applicable in many other places than under the refrigerator, and it is one of the most effectual that we have yet shown. Several such have appeared in our columns.



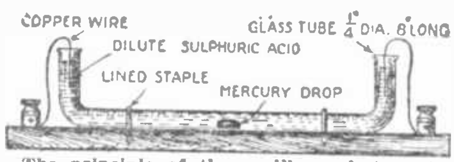
Capillary Electrometer

By Robert Rollins

THIS is an easily made, very interesting and instructive device. As its name implies, its primary use is as a measurer of electromotive forces, and it is particularly suited for the measurement of currents produced by potential of less than a volt. But beside this, it is an excellent illustrator of one of the factors of surface tension.

A glass tube of about a quarter-inch diameter and from six inches to a foot long is bent as shown at both ends. These bends need be no longer than an inch. In fact, if you have not the facilities for the bending it can be eliminated entirely by plugging both ends with paraffined corks, through each of which a wire has been thrust. But, if this is done, the tube should not be completely filled, and the pressure caused by the evolution of gas from the electrodes should be frequently released by tipping the tube up and loosening one of the corks. This is an annoyance and disturbs the mercury drop, so if you make this with an intention of using it often, the bending of the tube will be found well worth while. It is fastened with padded staples to a base, and should be as nearly horizontal as possible. It is filled with dilute sulphuric acid of a concentration great enough to carry a fairly weak current, and contains a drop of mercury. This drop should not be more than a quarter-inch across. One of larger dimensions will be sluggish in its movements.

Now, with a dry cell or other source of direct current, send a current through the instrument, and watch the mercury. It will move in the direction of the current; that is, from the positive to the negative terminals, with a speed dependent upon the voltage of the circuit, the concentration of the acid, the size of the mercury drop, the level of the tube, etc.



The principle of the capillary electrometer illustrated by a home-made appliance; a most interesting piece of apparatus, depending for its action probably on surface tension of liquid mercury.

The odd phenomenon is explained by the fact that the surface tension is increased where the current travels from the acid to the mercury and is decreased where it travels from the mercury to the acid. This difference in tension is sufficient to move the drop along the tube in a manner comparable to that in which a bit of camphor propels a little boat, and for the same reason (a difference fore and aft of the surface tension).

The electrometer must be calibrated by means of another instrument, because the speed, as has been said, varies with varying conditions and must be determined for your particular instrument. It is calibrated by sending currents with known potentials through it and measuring the speeds of the drop by means of a scaled strip of paper under or beside the tube. In this reading, be sure to avoid the error of parallax, always looking straight down on the scale. The various speeds and potentials that caused them can be plotted against each other in the ordinary manner to obtain a curve. With this curve, the potential of any circuit can be determined at once when the speed of the drop has been noted under its influence. Of course, care should be taken to have the tube always at the same level when in use as when calibrated. This can be accomplished by means of a small level fastened to the same base.

With means of changing the direction of the current as the drop reached one end of the tube, it could be kept in constant motion. This would make an interest-catching and mystifying window exhibit.

What Our Readers Think

Nickel and Silver Plating

Editor, EXPERIMENTER:

Will you give me a few suggestions on experimental nickel and silver plating? I tried the experiment this week, but had only fair success and thought possibly it was through some fault of mine. I was attempting to silver plate a phonograph tone arm, half brass, half iron or steel. I used a glass jar filled with a solution of HCl and water, a quantity of "quicksilver" in the bottom of jar and three No. 6 dry cells. The tone arm was connected to positive of battery, and the quicksilver was connected to negative of battery.

The insulation on the wire was scraped until I made a circle and immersed in the mercury, insulation being immersed also, and while the mercury plated on nicely for the brass part, I could get no silver plating on the steel part, but it kept up showing "copper" deposit. The wire from the negative of battery to mercury was copper, but all copper was covered with mercury and insulation. I tried various kinds of wire such as lead, aluminum, copper, brass, etc., but got the same copper deposit. If you will be so kind, I would like to know what per cent. solution is correct to use, also what kind of silver is best for plating, how much current should be used, and should the article to be plated be connected to the positive of battery and plating material connected to negative. I am very much interested in various kinds of plating and would like to know more about it.

Any information you would care to give me will be appreciated. I am an enthusiastic reader of RADIO NEWS and your other publications, and have bought many dollars' worth of stuff from the old E. I. Co. . . . remember it? Hi. Also am a real HAM when it comes to radio, and was making a loud speaker when I tried to do above silver plating, and made a mess of it.

Yours very truly,
C. D. BLAIR.

Buena Vista, Va.

(Quicksilver is not silver at all, and is a very poor and often very injurious substitute for silver in plating operations. Its effects on metal are sometimes quite disastrous; it will ruin gold jewelry by making it as brittle as glass and it has the same effect on brass. If you want to plate with silver, use the real metal, and the same applies to nickel. If you got a real copper deposit on your steel or iron, it might have been derived from the brass portion of the phonograph arm going into solution and precipitating upon the iron surface. It hardly seems likely that your copper wire was responsible. We give you formulas and general information about plating with nickel and silver. Keep mercury away from everything of brass or gold.

For nickel plating use 12 to 14 ounces of nickel-ammonium sulphate per gallon of water in a clean stone jar. The solution should be slightly acid. Care must be taken that this acidity is not excessive. The current to be sent through the plating solution depends on the surface of the object to be plated. The current density should be about .05 to .1 amperes per square inch of the surface of the object to be plated. The anode in regular nickel plating is a special nickel made up for the purpose.

For silver plating, the double cyanide of silver and potassium is the standard solution. Good silver plating solution can be obtained by dissolving 25 grams of pure silver cyanide in a solution of 25 grams of potassium cyanide in 300 to 500 cubic cm. of water. The solution must then be diluted with water until it forms one liter. Of course, if larger quantities of the plating solution are required the same proportions of ingredients must be maintained. The best current density in silver plating is from .006 to .03 per square inch of the surface of the object to be plated.

A silver anode is used in regular work. A carbon from a battery will probably answer your purpose. The cyanides are virulent poisons.— EDITOR.)

Wants Articles on Motor Starters

Editor, EXPERIMENTER:

Have received my copy of EXPERIMENTER and am pleased with it, especially the articles by Harold Jackson and Sylvan Harris. I would suggest articles on motor starters.

Frequently an article appears regarding transmission of power (electrical) by wireless. My opinion is: if wireless power transmission ever becomes a reality, which I doubt, radio must be done away with, for several reasons.

First, it is necessary to have aerials, for radio transmitting and receiving power. The same applies to radio, telephony and telegraphy, except, of course, loop receivers. This being the case, the power waves would interfere with radio waves, causing radio aerials to pick up power, blowing out tubes, coils, etc., also affecting the transmitting stations. I thought this information, or opinion, would be welcome to some who are experimenting along this line.

Yours sincerely,
J. GOTCH.

Plymouth, Mich.

The Experimenter Is Looking Good; More Power To You

Editor, EXPERIMENTER:

Give us more articles by Hugo Gernsback. Give us more articles on Chemistry by T. O'Conor Sloane. Insist on authors giving full data on subjects as weights, dimensions, if possible formulae, solubilities, solutions, (how to make) etc.

THE EXPERIMENTER is looking good; more power to you.

Sincerely yours,
Cleveland, Ohio. L. A. LICASTRE.

The New "Experimenter" Compares Very Favorably With The Old

Editor, EXPERIMENTER:

I have just finished looking through four or five years of the old "Electrical Experimenter" and on taking up the new "EXPERIMENTTER" I find that it compares very favorably with the old.

Your first edition is excellent and if you keep up to that standard you need have no fear of failure.

Give more of that wizard, Dr. Bade's articles, Elec-Tricks and Short-Circuits. If you want humor: what price the '*Phony Patent Offiz*' of bygone days?

But give us more of *your* editorials and heaps of fiction. And now I'm going to ask a question. Where, Oh Where, is Tom Reed and Thomas Benson and George Holmes and Sydney Gernsback? And Samuel Cohen and Winfield Secor? We want 'em back, old timer; no "EXPERIMENTER" can be the same without 'em, can it? 'Member Reed's articles on "Bats" and Clocks?

A series of "home built" laboratory instruments would be very much appreciated by the younger "Sperrys" I think.

Long Life to THE EXPERIMENTER and best of luck to yourself, Hugo Gernsback.

Sincerely,
Guelph, Canada. ROSE BENNETT WALKER.

Articles Wanted

WE want good electrical, chemical and radio articles, and here is your chance to make some easy money. We will pay from one to two cents a word upon publication for all accepted articles. If you have performed any novel experiments, if you see anything new electrical, if you know of some new chemical or radio stunt, be sure to let us hear from you. Articles with good photographs are particularly desirable. Write legibly, in ink, and on one side of the paper only.—EDITOR.

A Friend of PRACTICAL ELECTRICS

Editor, EXPERIMENTER:

Please accept my congratulations on turning out such a splendid magazine as "THE EXPERIMENTER."

The first copy I read of "Practical Electrics" was the October number which was given to me by a friend. One of my first thoughts about it was that if it only included radio in its make-up it would come nearer to my ideal than had any other magazine so far. Then I noticed the announcement of "THE EXPERIMENTER." To me, it is the best magazine on the newsstands to-day, because it is devoted wholly to experimentation. "Radio News," of which I have been a reader for over a year, I will admit is "Radio's Greatest Magazine." But no matter how good a thing may be, it can always be made better, and I think the best improvement you could make in it would be to insert a few pages on experimental radio each month. I know you have an article of this kind now and then, but what is really needed is a permanent department. I'm sure the "gang" would keep you plentifully supplied with material as they do now in "With the Amateurs" and others.

Very truly yours,
Toronto, Ont., Canada. WILLIAM FENWICK.

Wants More Departments

Editor, EXPERIMENTER:

In the editorial of your November number of THE EXPERIMENTER you ask the readers to send in the voting coupon filled out or to write you a letter telling how they like THE EXPERIMENTER or offering you suggestions. That is why I am sending you this letter. I will be as brief as possible.

The make-up of the magazine seems good. In fact I am delighted with it, and I hope the magazine will be prosperous. I am hoping that you will treat all scientific subjects. A subject that I am very interested in seeing in THE EXPERIMENTER is Astronomy. I am also hoping that you will have some subjects on physics. I believe that with the addition of these two sciences you will be covering all of the interesting parts of science. As an example of physics experiments take light. There are many things in the sky that an amateur astronomer will see with the proper guidance. I am favorably impressed with the department, "Junior Experimenter," but I notice that all of the articles deal with electricity. Experiments in other sciences might be desirable. There is one thing in "Experimental Radio" that I would like to call to your attention; and that is the symbol for the vacuum tube in the diagrams. This is a very small detail but I think that it has a strong psychological effect. The symbol looks too much like a light globe. I showed the diagrams to a friend and he was of the same opinion. I am sure that the symbol used in *Radio News* would be much better. I want now, to congratulate you on the production of THE EXPERIMENTER. Articles on construction and experimenting are good for this magazine I believe.

Yours truly,
Tacoma, Wash. MELVILLE T. PRESS.

From a Faithful Reader

Editor, EXPERIMENTER:

I have just completed reading the first issues of the EXPERIMENTER. As an old and faithful reader of the ELECTRICAL EXPERIMENTER, wish to say that the return of it is like the return of a friend that has been away for several years.

I am interested in all the departments, particularly in the chemistry section.

Wishing you and the EXPERIMENTER a happy and prosperous New Year, I am

B. H. CASEBOLT,
Operator, Kern Canyon Power Plant.
Edison, Calif.

A Wise Change

Editor EXPERIMENTER:

Seeing that you would like to have the opinion of your readers regarding your new magazine, the EXPERIMENTER, I thought I would give you mine.

I have been a reader of PRACTICAL ELECTRICS for the past six months and thought it was the best magazine ever, but I think you have made a wise change. The radio department is an excellent addition and the chemistry section is fine if you don't go too "deep" for us "lowly" experimenters.

If you give us some chemical articles that involve electricity I think it will be a great success, but don't cut down too much on your electrical articles and experiments. The various electrical departments are good and should be kept up.

Meanwhile wishing the EXPERIMENTER a great success, and hoping that nothing will stop me from getting the next copy, I am

Sincerely yours,
MALCOLM PIHL.
St. Paul, Minn.

Hafnium and Celtium

Editor, THE EXPERIMENTER:

Taking three of your magazines, I have enjoyed the change from "PRACTICAL ELECTRICS" to "THE EXPERIMENTER," especially wherein you treat of chemical matters.

I am wondering if a list I have of the chemical elements is complete. The list that I have I give you.

Do you consider the new element hafnium well enough established to include in a list of the regular chemical elements? About all the information that I have found on this new element is that given in the 1923 Year Book of the International Encyclopedia. I understand its atomic weight is 72, but I do not know what its specific gravity or valence is.

What is the status of the element celtium?

Information in reference books seems to be so sparse on these new elements that I thought of addressing you on the subject. Any elements that are established since the list that I have mentioned above I am interested in, and especially in knowing in just a few words something of their occurrence and preparation as well as their place in the Periodic Table and their specific gravity and valence.

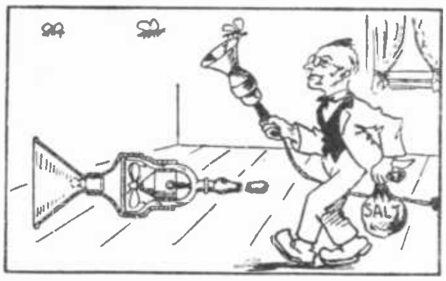
Very truly yours,
D. E. FARQUHAR,
Chicago, Ill.

(Your list of chemical elements is fairly complete. You might add to it the following: Holmium, At. Wt. 163.5; Luteciam, 175; Niton, 222.4. And, of course, Hafnium, At. Wt. about 179. Dr. G. Hevesey of the University of Copenhagen, in The Chemical News of June, 1923, puts it between 178.4 and 180.2. It falls in a periodic table between Zirconium and Thorium. The element Celtium is rather doubtful, for Hafnium and Celtium we would refer you to the London Chemical News, February 1, 1923, April 20, 1923, June —, 1923, December 7, 1923. The periodic number of Hafnium is 72. This is the number you have taken as its atomic weight.

Hafnium is associated with Zirconium in its minerals, and is extracted therefrom by a crystalization process operating on the mother liquid of the potassium zirconium fluoride or similar salts. —EDITOR.)

Latest Electrical Patents

Fly-Catcher



The inventor of the fly-catcher shown above displayed much good intention, if not equal ingenuity, in devising the suction apparatus for drawing flies and other insects into the small chamber inside the apparatus. Once the fly is drawn in, the only outlet is closed with a stopper and presto! the fly is captured. Should the device fail the operator carries a bag of salt ready to apply to the tail of his unfortunate victims.

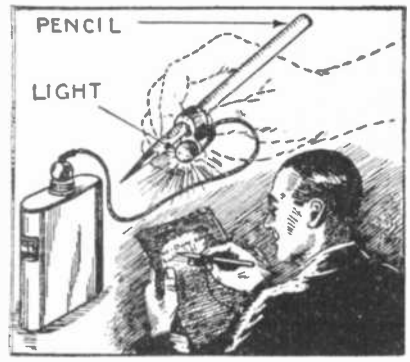
Patent No. 1,517,131 issued to W. H. Thompson, Carthage, N. Y.

Daylight Effect Lamp

An electric lamp of blue tinted glass is mounted within a set of reflecting mirrors, the lamp being operated at a specially high voltage. This may cause it to emit an increased proportion of light in the short wave band of the spectrum, and the blue tinting of the bulb cuts off the orange and yellow rays. The mirrors can be given different colors as desired, and a lead glass plate may be used with a plate of tinted glass to intercept ultra-violet and other rays as desired.

Patent 1,519,148 issued to Charles H. A. Gamain of Paris, France.

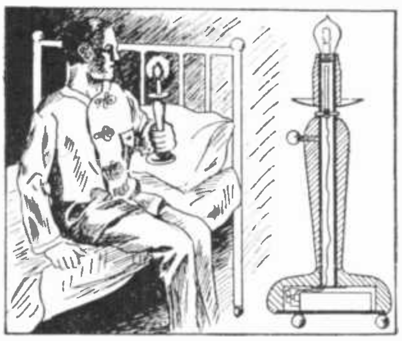
Pencil Flashlight



A small flashlight which can be attached to a pencil should prove a very useful device for reporters and other people who have occasion to write in poorly illuminated or dark places. The small battery in the shape of a cigarette case is carried in the vest pocket.

Patent No. 1,516,647 issued to J. W. Saunders, Pocatella, Idaho.

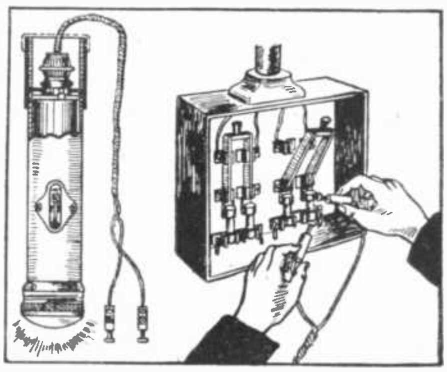
Electric Lamp



The lamp is supported on the end of a metallic tube. Near the top of the tube there is a vertical rod which is free to move up and down and a transverse bar at the foot of the rod projects through slots at the side of the tube. When the lamp is taken up in the hand, an outside wooden tube which surrounds the tube slides upwards, strikes the transverse piece, pushes up the brass rod so as to touch the base of the lamp, and this completes the circuit from the supply battery contained in the base.

Patent 1,518,530 issued to Clarence Lipper of Philadelphia, Pa.

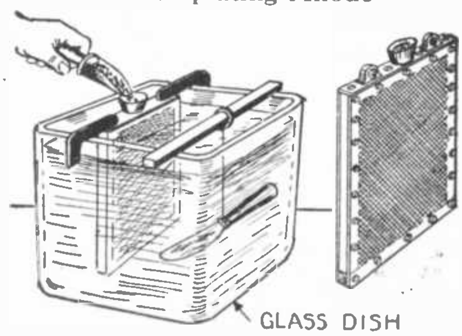
Circuit Tester



A very ingenious attachment to the ordinary flashlight is illustrated above. It consists of a metallic case which can be screwed on the base of the ordinary flashlight case and which contains a pair of insulated wires connected to the terminals of the battery. The other ends of these wires are brought into contact with the terminals of the circuit to be tested. If the circuit is not "open" the flashlight will light up.

Patent 1,508,990 issued to F. J. Schmitt, Steelton, Pa.

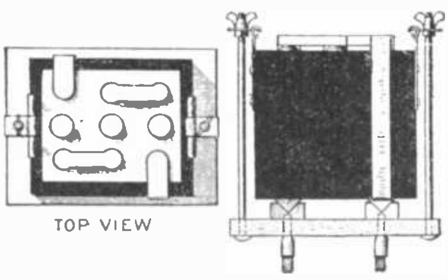
Electroplating Anode



This is a cell with sides of perforated insulating material such as celluloid; there is a hopper which leads into the interior and in use it is to be filled with pellets or lumps of the metal to be deposited. As long as there are pellets of metal in the funnel, a circuit is completed through the metal of the hopper and the two suspending lugs, one on each side of it, and the top plate of the cell to which all three are secured.

Patent 1,517,630 issued to Giraldus Jones of Birmingham, England.

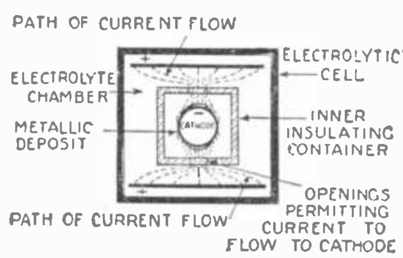
Storage Battery



A part of this invention is the case into which the battery is lowered when in use. Multiple knife switches or other form of contact are provided on the bottom of the case within it and on the bottom of the battery on its outside. The battery circuit is permanently connected to the contacts in the bottom of the box. When the battery is lowered into position, the contacts meet each other and give a closed circuit as far as the battery and its case are concerned. Clamps are provided to hold the battery in place. It can be instantly removed from the box for charging or repairs without breaking any electric contacts.

Patent 1,519,701 issued to Benjamin F. Poth of New York City.

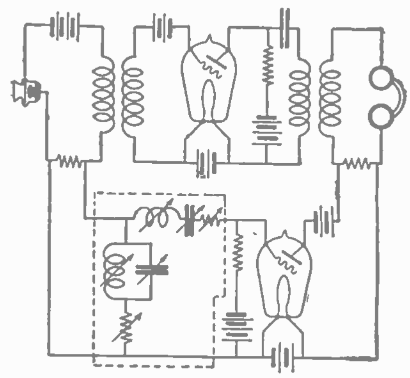
Electroplating



Within the bath used for electroplating there is a chamber of insulating material, within which the cathode is suspended. The insulating chamber is pierced with holes, each one opposite to any place on the cathode it is desired to thicken by depositing metal thereon. By this apparatus local plating can be done, weak spots can be thickened, or especially thick spots can be formed on the cathode, all according to the arrangement of insulating case with its perforations.

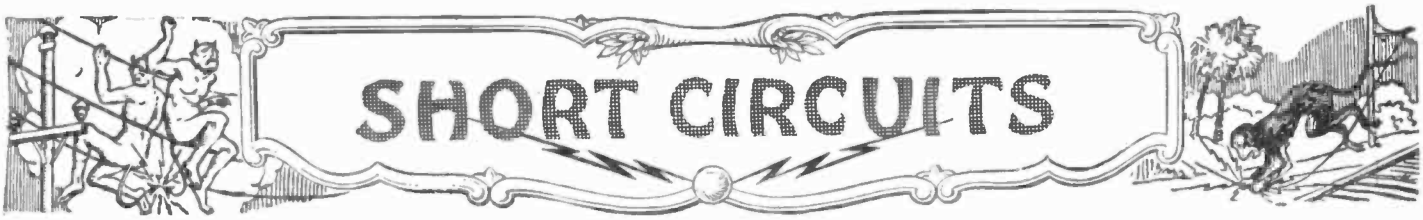
Patent 1,519,572 issued to Albert Wolf, Geislingen-Steige, Germany.

Loud Speaker Circuit



A telephone transmitter sends its undulatory current through the ordinary type of circuit including transformers and amplifier with "A" and "B" batteries to a loud speaker. The sound from the loud speaker is liable to react on the telephone and cause singing; therefore, a second amplifying circuit is connected electrically to the local loud speaker circuit and to the local receiver circuit, thus being in parallel with the original amplifying circuit. The acoustic transmission of energy is thus neutralized by the electric transmission from the parallel circuit.

Patent 1,519,211 issued to William H. Martin of New York City.



SHORT CIRCUITS

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

Beneath this stone
Rests Ann McNair.
She was getting a drink
While curling her hair.
—?

Deep in this dust
Lies Josephus McFain.
His trombone touched
The lighting main.
—DICK D. WOODWARD.

This spot is the grave
Of Patrick O'Dorm.
He listened in during
A thunder-storm.
—B. KOWANDA.

Here lies Johnny Hun
A prospective voter.
His support was a pipe
While repairing a motor.
P. W. PALADIN.

FARMER ELECTROCUTED BY "LIVE" WIRE FENCE

GOSHEN Sept 22.—Monroe Essig, 67 prominent Elkhart county farmer, was electrocuted near his home shortly before noon today when he came in touch with a charged wire fence on which a 33,000-volt electric line of the Interstate Public Service company had fallen.

Essig was unaware the fence was charged. He went to the location to extinguish a fire which was started in grass when the electric wire fell. Surviving is his wife and one son.

Filomena Bonfield, wife of Peter Bonfield, fruit merchant, was found lying on the bathroom floor at her home unconscious. She barely escaped electrocution when a short circuit was formed as she grasped an electric heater wire. Her hands and feet were burned.

LIVE WIRE KILLS BOY AS HE RESCUES PIGEON

Special to The New York Times.

CHICAGO, Dec. 6.—Edward Clark, 13 years old, gave up his life to rescue a mother pigeon, whose feet had become entangled in a piece of string she was trying to weave into her nest. The bird had built a nest in a mass of electric wires under the elevated railway structure. Knowing the danger the bird incurred in establishing a home among the live wires, boys in the neighborhood tried to frighten her away, but she remained.

Today the boys discovered her hanging exhausted, one foot tangled in a piece of string. Edward volunteered to climb up and release her. He reached the pigeon, cut her loose and set her back in the nest. As his companions were cheering him the boy touched a high tension cable, his body stiffened and plunged out and to the ground. Death was instantaneous.

This is the tomb
Of Silas O'Dell,
His umbrella tapped
The street-light shell.
—D. BERNARD HEDRIK.

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

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

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

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

Positive Plate Trouble

(501) Aaron Shapiro, New York City, writes:

Q. 1. My storage battery gases excessively and the positive plates are losing the active material on them. Could you explain the cause of this?

A. 1. Over-charging often causes the effects you describe. It will loosen the active material which then collects between the separators and plates in the form of a fine brown sediment. Overcharging sometimes causes destruction of the plates and the separators by increasing the temperature. Great care must therefore be taken that the battery be not overcharged, for excessive charging will considerably decrease the period of its useful service.

Q. 2. What are the effects of undercharging a storage battery?

A. 2. Repeated undercharging of a storage battery causes a gradual running down of the cells, manifested as a progressive lowering of the specific gravity and a tendency of the plates to become somewhat lighter in color. Such persistent undercharging generally results in the exhaustion of some of the cells before the others are quite used up. Charging the battery until the cells are again in normal condition might remedy the undesirable effects of undercharging. It should be noted also that some authorities claim that a most frequent cause of buckling of the plates is insufficient charging. Too high a discharge rate is also assigned as a cause of this trouble.

Water Vapor Detector

(502) D. T. Koshland, Buffalo, N. Y., asks:

Q. 1. Is there any electrical instrument that will detect the presence of water vapor?

A. 1. We give here a view of a water vapor detector developed recently. In the closed glass tube are two platinum wires sealed through the glass. These are connected to copper wire leads inside. The outside of the glass tube is coated with platinum, after which a thin line is etched around to break the continuity of the platinum surface as shown. This is done by coating the tube with paraffin and scratching a line through the wax and etching the platinum with chlorine water. The tube is filled with paraffin. Sulphuric and phosphoric acids or various hygroscopic salts are used to form a conducting film across the scratch. The resistance to alternating current of the scratch is a measure of the concentration of water vapor present.

Short Circuiting in Storage Batteries

(503) Carl Wehde, Springfield, Mass., inquires:

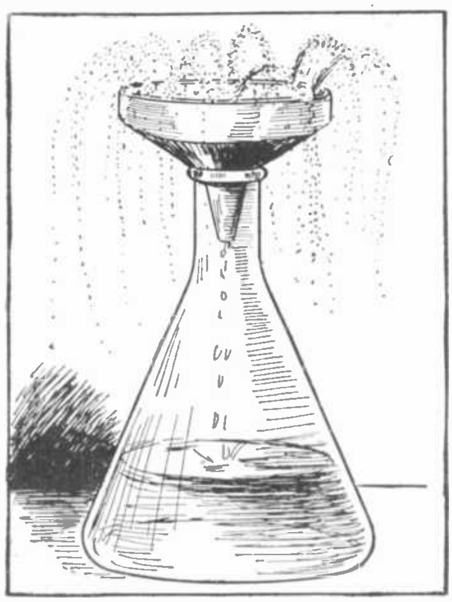
Q. Some of the cells in my storage battery give an extremely low reading of specific gravity even when the battery is receiving its normal charge, and an extremely low open-circuit voltage. They become rapidly discharged. What is the cause of this trouble, and how can I remedy it?

A. The effects you describe are characteristic of cells which are short-circuited internally. Short-circuits may be caused by the breakdown of the separators between the positive and negative plates, or by the accumulation of sediment upon the bottom of the jars. Sometimes it is due to the formation of a tree-like structure of lead over the tops of the separators from the negative to the positive plates. We cannot tell which of these causes are active in your battery. However, in all such cases of internal short-circuit we would recommend a complete dissembling of the cells, a thorough washing of the jars; and an examination of the separators which if found defective should be replaced by new ones.

Strange Static

(504) L. M. Norman, Pasadena, Calif., writes:

Q. 1. I was recently pouring kerosene from a tin can into an earthenware container and was much surprised when, without the presence of any flames, a small explosion occurred at the mouth of the receiving vessel Could you explain the cause of this explosion?



A very curious phenomenon due to static excition of a non-electrolytic liquid.

A. 1. The friction of the kerosene while it was poured generated static electricity and so the liquid poured into the vessel became charged. The earthenware vessel being an insulator allowed the kerosene to retain and accumulate this charge. While pouring you brought the mouth of the tin can near the receiving vessel and the spark discharge so caused ignited the explosive mixture of hydrocarbon vapor and air above the container. In pouring kerosene or other explosive liquids, both vessels should be carefully grounded.

While filtering kerosene in our laboratory we noticed a beautiful manifestation of this static electricity. The friction of kerosene against the filter paper generated enough static to cause thin streams of kerosene to spout from the edge of the funnel (see Fig. 1), giving the appearance of a miniature fountain.

Sulphation of Storage Battery Plates

(505) F. Hartmann, Budapest, Hungary, asks:

Q. What is meant by the sulphation of storage battery plates?

A. According to one theory of operation of lead-plate storage batteries, lead sulphate is formed and deposited on the plate when the battery is discharging. This lead sulphate is reduced by the chemical action occurring during the subsequent charge. If, however, the battery is allowed to stand in a discharged condition for a long time, this sulphate deposit will harden and the battery will become difficult to charge. When the battery is in this condition it is said to be, "sulphated."

Excessive sulphation may also be caused by an increase in the quantity of acid above the normal amount used in the cell. It is not an infrequent practice among amateur experimenters to add acid to the cell when the latter is in a run-down condition, in order to obtain a little more energy from it. This practice generally results in the formation of excessive sulphate. If the battery in this condition is charged fully the specific gravity will become abnormally high and the acid may injure the separators.

Telephone Repeaters

(506) L. C. Schneider, White Plains, N. Y., writes:

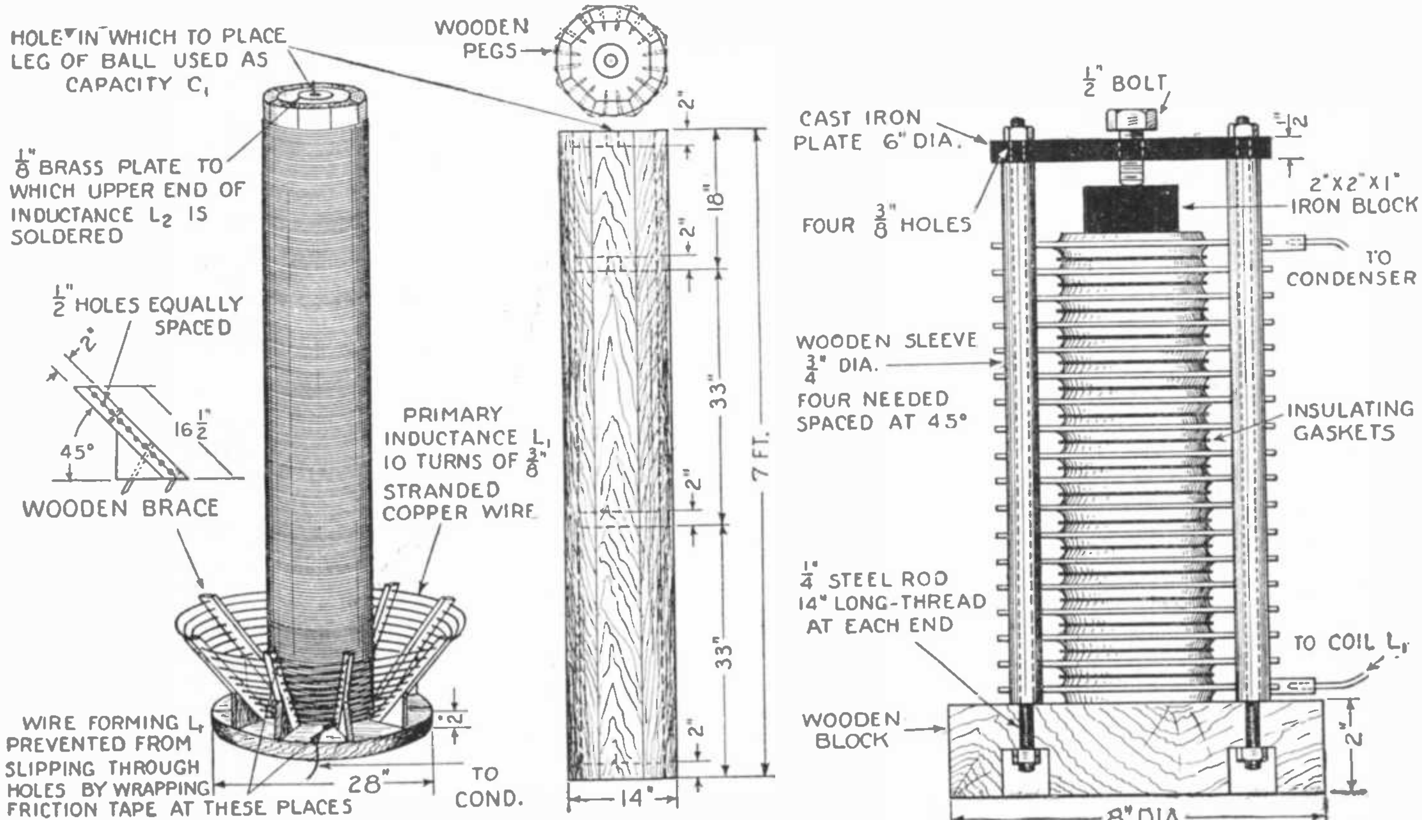
Q. 1. I have heard that radio vacuum tubes are used in wire telephony. Will you please explain the function of these tubes in a telephone system?

A. 1. The length of wire over which audible and distinct messages can be sent is limited, and when it is desired to communicate over distances exceeding this limit it is necessary to employ some device that will repeat or relay the message with added energy at points on the line where messages would otherwise become too weak. Fig. 1 illustrates one form of this repeater. Messages are impressed on the grid circuit of the tube and are amplified in the plate circuit and transmitted on the output side of the system. This type evidently is a "one-way" repeater, for messages can be sent in only one direction through it. In Fig. 2 a "two-way" repeater is represented. Modulations of the current from either side of the line may be impressed on the grid circuit of the vacuum tube and fed back to the line from the plate circuit. The coils (L) are inserted to balance the line which would otherwise become unbalanced by the transformers (T). Sometimes a condenser is placed in the plate circuit to prevent continuous currents from circulating. In this case only the high frequency modulations of this current will traverse the plate circuit.

High Voltage Experiments

By Lester Reukema

(*Continued from page* 308)



The illustrations at the left show details of a seven-foot high-frequency coil used at the University of California. The coil is extremely simple and can be constructed at very little cost by any amateur experimenter. At right is shown a very simple adjustable quenched spark gap. The details of its construction are shown on another page.

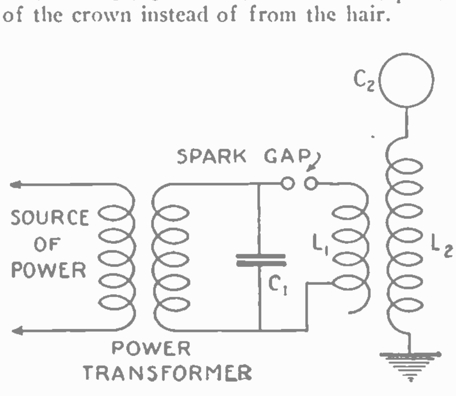
of close to a million volts into their bodies through a saber. The sensation produced by this high voltage is powerful, tensing all of the muscles of the body, but is not painful. At our show this year a large number of persons in the audience, including a six-year-old boy and about thirty young women, took the discharge into their bodies in this way.

The really spectacular part of the performance comes when the ball is removed from the top of the coil and a man substituted in its place. Since at least eight feet clearance must be allowed between the man's head and the ceiling, we place the man on a table alongside the coil, instead of on top of the coil in the position of the ball. Any method of contact would be satisfactory. We formerly fastened the man to the coil by means of a band around the arm, the band being connected to the coil. However, when large amounts of energy were being used, the current density on the arm became so great as to be painful, so that now we have substituted therefor a tub full of salt water, the tub being connected to the coil by braided wire. The salt water conducts the current from the tub to the feet, and since it comes into contact with the feet and legs over a considerable greater area than that of the arm band, it allows very much larger amounts of energy to enter the body without discomfort. The tub is insulated from the floor so as to prevent flashes to ground. We use two tables for this, one on top of the other. The large flames pouring out of the twisted wires held in the hands (Fig. 5) are a measure of the amount of energy traveling up through the body. The only reason for causing the electricity to leave this bunch of wires, instead of leaving the hands directly, is to prevent the hands being burned.

It is not necessary to hold anything in the hand to get a discharge. However, when the flames come directly from the fingers, it is necessary to wet the hand and then shake it rapidly, so as to prevent the flames from coming for more than an instant from one spot. Unless this is done, burns are sure to result.

If both hands are held close to the body the flames come from the head instead of the hands. The smile on the face of the man in Fig. 8 shows that the sensation of being charged to almost a million volts, while powerful, is not painful. Sometimes a more concentrated discharge, as, for instance, that shown in Fig. 9, sets fire to the subject's hair. Of course, a fire would always result if the hair were not kept thoroughly wet.

One way to prevent setting fire to the hair is to wear a metal crown as in Fig. 10. In this case the flames come from the points of the crown instead of from the hair.



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

Fig. 12 shows the reason for the swimming suit seen in some of the other pictures. Here the student, sitting up to his waist in water, seems to be getting quite a kick out of his weekly bath. It is fairly certain that no man in the history of the human race ever got more of a thrill out of his tub. This picture also shows how hard it is to prevent energy from leaking out on all sides when using these high voltages. Streamers of flame are seen pouring from every corner of the table.

Some of the stunts illustrated required a strong control of the nerves, as, for instance, maintaining an intense power arc between a rod held by the man in contact with the coil and another one in the hand of a man on a nearby chair. This represents a current of several amperes on the surface and even in part through the body, and is a real test of a man's ability to stand an extraordinary powerful sensation. The sensation is not one of pain, but the inexperienced brain will usually diagnose it as such. The brain does not know how to classify it, so considers it pain, and sends a message to the arm to pull the hand away from danger. How strong a power arc a man can stand depends entirely on his mental attitude. If he is able to tell his brain that it is mistaken in its diagnosis, he can take all of the power that the apparatus is capable of giving with a smile. One stunt that always provokes applause is the pulling of sheets of flame from any place on the body of the man who is connected to the high voltage. Of course, the body must be wet to prevent burns. A favorite stunt is to wave sheets of paper within a few feet of the body, the flames which shoot out setting the paper afire.

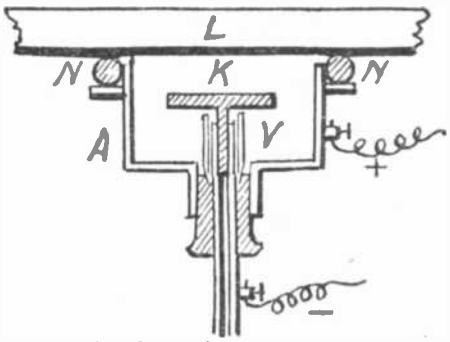
The experiments can easily be performed by anyone at a very small cost for apparatus and without any danger whatever.

Ionoplasty

(*Continued from page* 311)

a slow development of the image will be seen, resembling the development of the photographic plate in its bath.

If we examine it with a microscope, a multitude of little droplets will be seen, which constitute the image. They have been counted and the number was found to be 218,000 to



A modified form of ionoplasty apparatus is shown above. The glass bell jar of the previous type is here replaced by a metal case. This form was specially designed for coating large telescope mirrors with silver film.

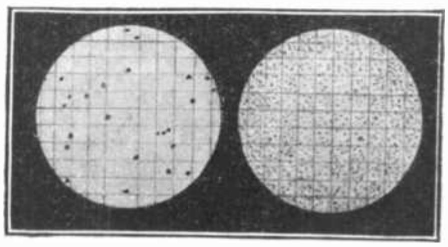
the square millimeter, which is 1/647 of a sq. in. The part protected by the screen showed only a few drops widely dispersed.

The explanation of this phenomenon is very simple; each of the particles of silver projected upon the unscreened portion of the plate became the place on which the mercury condensed, and the resulting droplets each attached to a little particle of silver, led to the interesting result, that in counting the droplets of mercury the particles of silver were also counted. The result of applying the balance was that each grain of silver as projected weighed six-millionths of a milligram, and a milligram is .015432 of a grain. Fifty millions of particles are distributed over less than one-quarter of a square inch of the surface, and they are comparable to grains of cement thrown against the wall by the mason's broom in stuccoing operations. So fine is the division and so close are the particles that the deposit appears as a bright mirror.

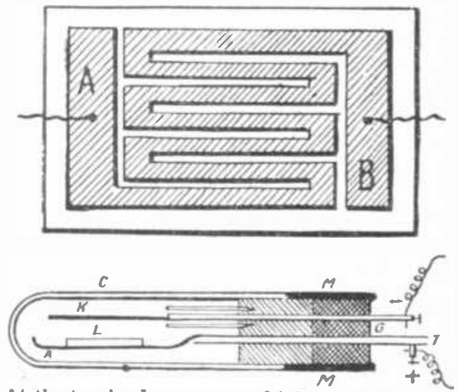
Ionoplasty is the most practical means at our disposal for coating insulating material such as glass and porcelain with gold, platinum or other heavy metal. In the deposition of silver, it can in certain cases be advantageously substituted for chemical plating; this applies to pieces of moderate dimension, and it is interesting to note that the reflecting power is superior to that of the chemically deposited film.

Sometimes silver articles of glass such as the mirrors of reflecting telescope show spots on which the silver has disappeared or lost its reflecting power. To resilver the whole surface might be quite an expensive operation, but by applying this process to a limited area of the object the defective place can be covered perfectly.

The apparatus shown in one of the diagrams is for this purpose; here the bell (A) is of metal and forms in itself the anode. It is pressed against the glass and packed with an India rubber ring (N) against the glass (L) which is to be repaired. A brass tube (V) carries the cathode and through this



The deposit resulting from a short exposure to ionoplasty when examined under a microscope will have the appearance of the picture at the right. The untreated plate is shown at the left.



At the top is shown a very high metallic resistance consisting of a very thin film of ionoplastic silver. Such resistances are high enough to be used as grid leaks in radio, where at present metals are rarely used for this purpose. Below is another form of ionoplastic apparatus.

the air is exhausted. A quarter of an hour suffices to give a perfect coating of silver, which can be protected afterward by varnish. It is an admirable way of making high metallic resistances for use in radio, or for the volometer and one of our illustrations shows such a resistance.

These are especially the scientific aspects of the case, but the same process will lend itself to very beautiful decorative effects, in gold plating china and glass ware.

Abstract from Article by L. Houllevigue in *"La Science et La Vie."*

The Ark of the Covenant

(*Continued from page* 307)

to New York you need any help in giving evidence to the police, you'll find me at the National Metallurgical Bank—Mr. Lamont and my mechanic, too."

"Thanks, young man," said the sailor. "Now about these hands you want. Here you—Clark!" he said to a seaman who was standing by. "Nip along to the officer on duty. My compliments, and will he kindly muster as many hands aft as he can spare?"

"Aye, aye, sir!"

I will say for the British seaman that he is a handy fellow. The *Merlin* was no small weight, but Milliken and a quartermaster, with the aid of a score of men and a few rollers, soon had the seaplane round with her engine pointing to sea on the port quarter. It was now a question whether we should risk taking off with our passengers aboard or get safely afloat—which was not at all a certainty—and pick them up from one of the ship's boats.

Lord Almeric appeared with his secretary, and she—well——

Miss Torrance Appears

If I had thought of the secretary at all, I had thought of her as one of those efficient women, hard, competent—the sort of woman one can admire for qualities one would rather see in men. But Miss Torrance was just sheer girl. The littlest thing, until you got a good look at her, and then you saw that it was her ways rather than her size that gave the impression. She had the same clean look as my *Merlin*—silver and blue—only her hair was gold—and there was nothing the least bit cold about her. I was willing to bet that she was as competent as any he-woman alive, for when I took hold of her neat little hand on Lord Almeric's introduction, I was reminded somehow of Milliken's clever fist.

I spoke to Lord Almeric about taking off.

"I take it that you don't think you'll come a purler?" he asked.

"There's a good chance that we may," said I. "I shouldn't like to have a lady aboard ——"

"You will make me feel extremely uncomfortable, Mr. Boon," Miss Torrance interposed, "if you don't treat me exactly as you would a man. We won't sink, if we do capsize?"

"Oh, no."

"Then it seems to me that we ought to risk it. Sir Peter has been delayed enough without having to put off a boat for me. Please don't consider me."

I looked into her eyes. She was as genuine as the Koh-i-noor.

"Thank you," I said. "Will you please step aboard, then?"

We said our good-byes, and we all climbed aboard save Milliken, who stood on a float to swing the propeller and to give the signal for release. The score of men took hold of her wherever they could. Milliken swung the propeller. Contact! Full throttle. The *Merlin* gathered strength and began to slide. I waited until the ship began to rise on our side, then dropped my hand to Milliken—and we shot out over the water. Next moment we were circling the *Parnassic* to a cheer that was led by Sir Peter Weatherly himself, who stood sturdily on his damaged awning, and waved his braided cap in hearty farewell. The great ship began to gather way as we sped ahead of her.

Milliken climbed through the hatch with his usual air of complete calm, and began to be busy with hampers of food. Presently, eating a sandwich the while, he silently ousted me from the pilot's seat so that I might break my fast.

Naturally, the main topic of conversation as we ate sandwiches and drank coffee was the piratical raid on the liner, but we soon exhausted the subject for lack of explanation of the mysterious sleep, and Miss Torrance then wanted to know what everything on the *Merlin* was for. Old Milliken, with a grin all over his ferocious mug, nodded at the wireless set. It was a bright idea and, having lowered the aerial, I fixed the receivers over her ears, switching into the phone attachment.

"I can hear someone talking," she laughed delightedly, "and he's got the loveliest gruff voice! Oh, take this quick, somebody—something has happened to another ship!"

I stopped her from taking off the cap, and switched into the open receiver.

Gasoline Taken from a Navy Ship Mysteriously

"Yes, sir!" came the harsh voice, with an unmistakable New England twang. "U. S. oil-carrying steamer *Westbury*. We were slowed down by a red riding-light floating ahead of us, and a message came from the battleship *Argonne*, telling us to heave to because of danger ahead. At eight bells of the middle watch, sir. Since then we don't know a dern thing of anything, except that our forrard tank is short of 3,000 litres of the highest grade aviation spirit by the gauge. Yes, sir. And there ain't a man on the ship, sir, that can say what was doin' in the last two hours. An' what I wanna know, sir, is—what the roustin' hell's bells of Jeeroosalum the U-nited States navy's playin' at with one of the United States oil freighters? I wanna know what prinked-up, bullion-ornamented, lime-juice-weaned sonofagun in a skin-tight u-nifo'm has had the sass——!"

The rest was verbiage. I dissed the radio and looked at Dan and Lord Almeric, who were sitting side by side, open-mouthed. His lordship was the first to speak.

"Farragut, by Jove!" he said. "Piracy plus the knowledge of the twentieth century!"

CHAPTER VI.
KIRSTEEN

I.

Lord Almeric's Niece

We had left the *Parnassic* at about 6 o'clock, New York time, with a flight of nearly 1,200 kilometers before us. Keeping the *Merlin* at a steady four-sixty per hour, we expected to make the Battery soon after half-past eight.

From the bearing which the radio indicator had given us of the *Westbury's* position, Dan and I plotted out her relation to the *Parnassic* at the time of the raid, and found that she had been just over 60 kilometers from the liner. She was probably one of the freighters we had sighted in approaching the *Parnassic*.

Now, the hour given by the *Westbury's* skipper as the time when she was brought to—eight bells in the middle watch, or four o'clock in the morning—revealed the astonishing fact that the raid on the *Parnassic* had been pulled off, sixty kilometers covered, and the oil-tanker stopped, all within an hour. Even at record airship speed, the flight between the two vessels would occupy nearly 25 minutes, which left 35 in which to board the liner, break open the strong room and specie boxes, and remove 3,000 kilos of gold before casting off. It seemed incredible that one group of pirates could have effected the two operations.

We tried to work out the raids with every conceivable type of craft, taking into consideration

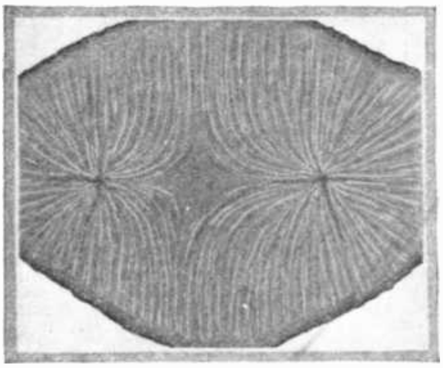
Is Life a Form of Electricity

(*Continued from page 312*)

which are pictured by the iron filings and the material manifestations of those lines of force, along which the magnetic action is exerted.

Around the pole of a square magnet we see lines of force extending from each of its four sides. But if we put beneath the paper covered with filings, not one pole, but two magnetic poles, the appearance of these magnetic phantoms become entirely different.

Fig. 2 shows us the distribution of filings on a sheet of paper under which we have placed two magnetic poles of opposite sign—



The cross-section of a tree shown above bears a striking resemblance to the magnetograph of two like poles.

a north pole and a south pole. We know, by the laws of magnetism, that two poles of opposite sign attract each other. The "lines of force" manifest, therefore, a special curvature, passing from one pole to the other, and by the direction along which the filings are aligned, they materialize the direction of magnetic attraction between the two poles.

On the other hand, if these poles are of the same sign, they repel each other and the lines of force then present the appearance of Fig. 3.

If we place a straight magnet flat underneath a sheet of paper the particles of filings distribute themselves as shown in Fig. 4, and if we place there a horseshoe magnet, the arrangement of filings presents the appearance of Fig 5. All these "magnetic spectres" were obtained by Professor Stanoievitch with the aid of a camera.

The intensities of the magnetic forces around a single pole (the case of Fig. 1) are the same at equal distances from the pole. If, therefore, we consider concentric circles whose center is a pole, all the filings situated on one of these circles will be attracted by equal forces. These circles are called equipotential lines, to use a technical word, and physicists make important use of them in their calculations. Equipotential lines always cut the line of force at right angles.

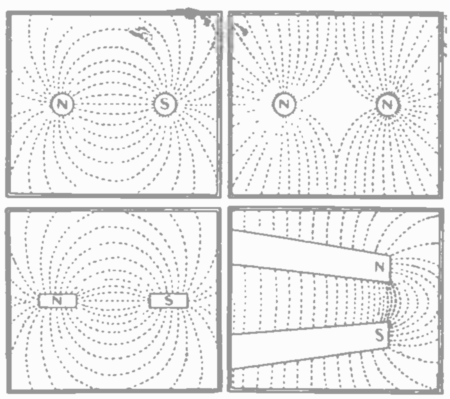
Now, in living nature, we find remarkable examples of lines of force and equipotential lines, at least in the vegetable kingdom. Let us take a radish and cut it along a section as square (Fig. 6); we see with its axis the lines of force extending from the center toward the circumference and the equipotential lines cutting the former perpendicularly, and describing concentric circles. Fig. 7 represents a transverse cut of the trunk of a fir tree; here the equipotential lines appear alone, but with an impressive clarity; as to lines of force they are only manifested here by the radial cracks which are produced in the trunks of the tree. The analogy with the figures obtained around the magnetic poles is truly striking, and can escape no one.

But if we take, not a simple plant section, but a complex section, for example, the section made in a branch, above a bifurcation of a main trunk, we find in this case the representation of lines of force which are produced through two magnetic poles. Here, for example, is a section in the trunk of a chestnut tree at the place where it separates into two branches (Fig. 8). We see the lines of force, described with great clearness, assume the appearance of the magnetic lines of force of Fig. 4, where the repulsive actions of two like poles is represented.

Lines of Force of Plants

We can go still further in taking points of comparison in the domain of electromagnetism and in determining what is the disposition of lines of force in the electric field formed by two poles of somewhat different intensities but of the same sign.

We cannot explain within the limits of this article the theoretical considerations by which the forms of these lines of force and



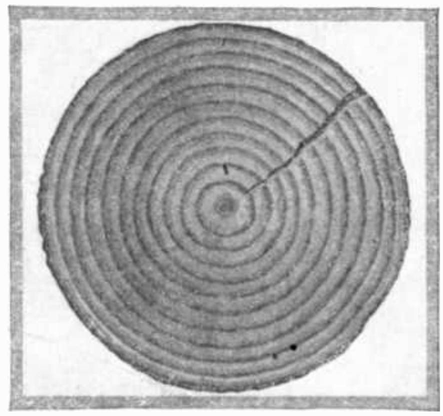
Lines of force to be compared with the lines on cross sections of vegetation.

these equipotential lines are determined. We shall simply give the geometric figure which represents graphically the results of the calculation. We see around each pole lines of force bent back upon meeting those which repel them and deviate them from their first direction and we see the equipotential lines which, enveloping the two poles in their immediate vicinity, are deformed in such a manner as to envelop together the two poles, assuming vaguely the form of a guitar.

Such is the result of calculations.

Now, what does reality show us? An identity truly complete.

Fig. 10 shows a section made an inch or so above a branching of a chestnut tree. All the details of the theoretical figure appear here with the clarity of a diagram—devia-



The cross-section of a fir tree illustrated above shows concentric rings analogous to the equipotential lines of the electrostatic field around a single charge.

tions of lines of force which repel each other, curvature of equipotential lines which end by completely enveloping the two poles; nothing is lacking for the similarity, or rather, for the identity to be as complete as we can hope.

We can calculate the form which the equipotential lines must assume in the case of an "electric field" disturbed by the infusion of two magnets; the diagram which represents these calculations is given in Fig. 11.

Now, in the "cellular field," which determine the alignment of cells, there may be a disturbing element anologous to a magnetic pole which penetrates into an electric field; this is the knot in wood. Well! here is a real disturbance, caused, in a fir tree, by the presence of two knots (Fig. 12); the identity between the two forms, that of the theoretical diagram and that of the alignments in a wooden board, is complete.

Professor Stanoievitch has not attributed to animal tissues the manifestations of laws which appear in so striking a fashion in the case of plants. However, he has remarked that on the teeth of elephants and that on ivory in general one can notice striations, which fact seems to prove that there, also, the cells align themselves according to precise and perfectly definite laws.

And so, we find in entire nature, life under the form of movement; and this life here is manifested by the same laws in the skies as in the atoms, in inert bodies as in living ones. . . . .

The Ark of the Covenant

(*Continued from page 343*)

the time factors and the 6,000 kilos weight in gold and oil that had been carried away. We even tried Dick Schuyler's idea of a motorship, giving her the highest known speed for sea-borne craft, but we found the thing impossible, despite the fact that we provided her with hydroplane type of power boats as auxiliaries. We were inevitably brought back to our airship.

When we came to consider what kind of machine would have made possible the whole series of operations—from the gasoline station at Newark, Wall Street the *Parnassic*, to the descent on the *Westbury*—the weight of the evidence was strongly in favor of a dirigible of the very latest type; and the abstraction of the gasoline from the Newark station and from the *Westbury* was an additional support to the idea, since an airship carrying out these operations would certainly need to replenish her fuel.

We imagined the pirates operating from a base within a day's flight of New York and, judging from the raid on the *Parnassic*, probably situated over the Canadian border. The weakness of the raider's position in using a dirigible or dirigibles for their operations lay in the conspicuousness of their craft, and of the sheds necessary for docking them. We did not lose sight of the possibility that the pirates might be masquerading as a corporation engaged in civilian transport. A few such companies were in existence, despite the popular prejudice against the so-called "lighter-than-air" machines on account of the structural weaknesses which in the latter seemed to be past curing. But every dirigible that took the air, whether experimental or otherwise, could only do so under permit or license from the government. It would present no great difficulty, therefore, for the police to run to earth any unregistered airship on American territory.

With the help of Lord Almeric and Miss Torrance and an occasional word from Milliken, Dan and I decided on a present plan of action. If the raiders had used an airship, they would now be making for their base and could not be far away from us in the air. To escape detection they would probably get to as high an altitude as possible. We determined that, while keeping our

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The Klydonograph

(*Continued from page 310*)

The klydonograph in its simplest form is indicated in Fig. 1. The photographic plate, of course, must be in a dark box. If a voltage is impressed between the terminal and the ground plate, as at (E), on developing the photographic plate, figures will appear which will give pertinent information concerning the nature of the voltage impressed. If, for instance, the voltage is in the form of a surge that is unidirectional, with a sheer front or a tapered front, the figure of the photographic plate will differentiate between the tapered front and the abrupt front and it will also indicate whether the surge was of positive or negative polarity. The diameters of the figures also give a measure of the magnitude of the surges, although the positive and negative figures have quite different calibrations, the figure for the positive surge being considerably larger than that for the negative surge of the same magnitude.

For practical application, the instrument is made continuously operative and is capable of recording the exact time of the occurrence of the disturbance. Fig. 2 shows a klydonograph suitable for such application. This instrument makes use of a 10- and 12-inch plate in a special plate holder. The moving parts are driven by a clock that makes one complete revolution in 24 hours. Fig. 3 shows a method of connecting the klydonograph to the line. Since this instrument is practically a zero current device, it is possible to connect it to the line electrostatically. This makes it possible to connect to a high voltage line without introducing an insulation hazard. With the klydonograph connected as shown in this figure, the figures produced give the magnitude and polarity of the surges.

Fig. 4 shows a method of connection that will give the steepness of the surge front. A counterpoise is run underneath or alongside the transmission line for 1,000 or 2,000 feet, with the far end grounded directly and the near end grounded through a high impedance. The klydonograph is then connected across this high impedance to ground. The voltage induced in the counterpoise is a measure of the steepness of the current wave, and since the current wave and the voltage wave have exactly the same shape, it gives a measure of the steepness of the surge front. By comparing simultaneous readings of the klydonographs, one connected to the line through the electrostatic potentiometer and the other to the counterpoise, the following information concerning the surge can be obtained: magnitude, polarity, steepness of front, and the direction in which the surge is traveling on the toransmission line.

Magnitude and polarity are obtained directly from the first klydonograph, steepness of front directly from the second, and from the relative polarity of the two figures the direction in which the surge is traveling is obtained; that is, if the polarity of the two figures is the same, the surge is of the same polarity and is traveling in a direction fixed by the manner in which the recorders are connected to the system. If the figures are of different polarity, the surge is of the polarity indicated by the recorder connected to the potentiometer and is going in the opposite direction to that of the one previously mentioned.

The klydonograph is one of those interesting scientific appliances in which one distinct branch of science is called upon to help out the other. Here we find the sensitized electric film used to register the passage of an electric surge of extremely short duration.

Lessons in Elementary Glass Working

(*Continued from page 321*)

end of a tube and then blow a bulb in the end, but such bulbs are thin and are unsuitable for apparatus work. To form a useable bulb on the end of a tube proceed as shown in the figure.

One end of the tube used is first drawn out to a point as shown. This narrow part should be from two to three inches in length depending upon the diameter of the tubing. The tube is then heated immediately back of this reduction until soft and then pressed in slightly. This is done in several places as shown in (b) until sufficient glass is collected to form the bulb. This compressed and ribbed area is then heated as a whole with a large brush flame—until it smooths out and assumes a symmetrical appearance. Often, the tube must be blown into during this step to prevent it from collapsing. When ready the bulb is then blown into the desired diameter, using great care in blowing and employing a succession of small puffs rather than one continuous effort.

Welding Glass Tubes and Rods

Complicated pieces of physical and chemical apparatus are often made by welding together several parts separately made. In welding glass it should be borne in mind that only glass of identical composition can be successfully welded. It is even better if the pieces joined come from the same lot. It is frequently required to join two tubes together. These tubes may be of the same or different diameters. In case the tubes are of the same size proceed as follows. Border slightly the ends of the tubes after the manner previously described. Then close the opposite end of one of the tubes with a small stopper. Now heat the two bordered ends at the same time in the blowpipe flame, using a fine flame so that only the very ends are heated to an almost molten condition. When they are nearly melted bring the two tubes together carefully with enough pressure to make them adhere together. Then with a fine pointed flame heat successively each point in this rough joint to redness, blowing carefully at the same time into the tubes in case the junction shows any tendency to collapse. If the finished joint is too large in diameter it must be carefully drawn out and reduced.

In the second case where the tubes have different diameters the large one is always drawn out and severed at a point where the diameter equals that of the smaller tube. The procedure is then the same as when the tubes are of the same diameter. Another elementary welding operation consists in joining a tube to the side of another one. This is done as follows.

The second tube to which the attachment is to be made must first be pierced. The method is to heat the tube at the desired point with the "needle" flame, the smallest flame the blast lamp will give, and then to blow out this spot. The ends of this tube are now closed with corks and the second tube whose end has previously been bordered is then joined as described above. The joint should be properly finished by blowing and reducing until an evenly appearing juncture is obtained.

Annealing Glass

All glass that has been heated must be annealed. This is done by allowing the glass to cool slowly to moderate temperatures. The process of slow cooling removes all internal strains in the glass. Unannealed joints will break at the slightest blow. It is very essential to anneal all glass work if any degree of permanency in the finished

work is desired. For small bulbs and ends of stirring rods, etc., it is enough to cover the hot glass with a layer of soot from a candle flame. Large pieces are best annealed by wrapping them in cotton batting or soft asbestos fabric.

Etching and Marking Glass

There are three methods of successfully inscribing marks on glass. There are:—

(a) The use of a writing diamond. This method is permissible only when a single figure or mark is to be made. When making graduations or numerous figures on glass apparatus the methods below give more uniform and safer results. The use of a marking diamond on glass apparatus is very liable to ultimately cause a fracture at that point if the mark is made of any depth.

(b) This method depends upon the etching properties of a solution of hydrofluoric acid. This acid may be obtained from supply houses in wax bottles. The glass surface to be etched is covered with a thin layer of wax and the desired markings written on the glass through the wax by means of a sharp steel point. The liquid acid is then brushed over the wax by means of a swab of cotton fastened to the end of a handle. Care must be taken not to get any of this acid on the skin as it forms sores difficult to heal. Etchings made in this manner are clear and translucent.

(c) This method although the most bothersome is the best one of all for it gives white marks easily seen especially on graduated apparatus. It consists in exposing the waxed surface prepared as in the last method to the fumes of gaseous hydrogen fluouride. This gas is generated by the action of sulfuric acid on fluorsphar. It is essential to use a leaden trough to generate the gas and to hang the glass pieces over the top.

Travelling Ions

(*Continued from page 319*)

not destroy the filament if the bulb becomes shorted with the battery. The solution to be tested is poured into the beaker, the battery is connected, and, if it is a good conductor, that is, if the solution is ionized, a current will flow through the lamp which will then glow. This gives a visual indication of the character of the solution.

When the ions touch the electrode, they are discharged which induces a physical as well as chemical change. But this is done instantaneously and the atom reappears as an ion by again being dissociated in the fluid in which it is dissolved.

Salts in solution are ionized, and different salts of the same metal will show many of the same properties, as for instance the same color, because of its common ion. If ionization does not take place, widely different results might be expected. If a crystal of cupric chloride is added to a few drops of absolute alcohol (not 95%) which is a nonconductor of electricity, the color of the solution is an olive green, adding a few drops of water changes the color slightly due to decreased concentration, but the color still is green and any change is due to the slight ionization of the salt. Cupric nitrate is blue in solution and the color is due to a fuller ionization of the metallic part of the salt.

Dissociation can also be illustrated by heating. Here partial decomposition takes place, and, on cooling, returns to its former case. Ammonium chloride illustrates this type of ionization very readily, because of the difference in diffusibility of the dissociation product, whereby a partial separation is brought about. A few grains of ammonium chloride are placed in a test tube and through a two hole rubber stopper, a long glass rod is passed. On this rod, moist litmus paper is tied or even stuck by ad-

hesion in such positions that a red and a blue are near the bottom of the tube, and a red and blue are at about the mid-way point. When the bottom of the tube, where the ammonium chloride grains are lying, is heated with a small flame, the chemical is volatilized and partially decomposed into hydrogen chloride and ammonia; the lighter and more volatile gas, which is ammonia diffuses more rapidly and changes the red litmus to blue. This for the two lower papers; then the hydrogen chloride rises slightly and changes the blue to red; the upper paper by this time has changed, due to the ammonia, from red to blue.

The results that ions produce are, at times, freakish in the extreme. An iron nail placed in dilute sulphuric acid liberates hydrogen; add a drop of a concentrated solution of sodium bichromate and no difference in the action can be noticed. But if a globule of mercury is added and the iron is brought in light contact with the mercury, a ceaseless vibration of the globule takes place. This rapid to and fro movement can be easily observed and will last for hours. Here, in all probability, the mercury receives a charge of electricity in the acid, the charge being removed by the nail and again replaced by the acid, and so on.

Tuned Radio Frequency Circuits

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amplifiers. The Super-Heterodyne also may employ single control circuits. Another use is for multiple tuned circuits illustrated in the diagrams, Figs. 4 and 5. It is well known that the ordinary three-circuit tuner with tickler feed-back is not very selective in localities in the vicinity of broadcast stations. In the early days of wireless telegraphy, when crystal detectors were used, selectivity was increased by using several tuned circuits between the antenna and the detector with very slight coupling between each circuit. This required several tuning condensers and the selectivity was considerably improved. There is no reason why this system cannot be used today with vacuum tube detectors. It will enable the experimenter to build a three-tube set equal in selectivity to the present day five-tube sets. With regeneration added, it will receive over as great distances as the larger set.

The diagram of Fig. 4 shows three tuned circuits connected to one tube, of which the variable condensers, C1, C2 and C3, are controlled by one dial. The taps, T1 and T2, are approximately at the center of the coils, L2 and L3 If these taps were exactly at the electrical center, or nodal point, the coupling between the circuits would be zero and the set would be non-radiating. By connecting the taps, T and T1, slightly off center, we get a slight amount of coupling between the circuits, and tuning is extremely sharp. Low loss coils and condensers are essential.

Fig. 5 shows a similar circuit, except that the coils, L1, L2 and L3, are placed in inducted relation with each other so that the energy from the antenna circuit passes from coil L to L3 via coil L2. The three tuning condensers, C1, C2 and C3, are controlled by one dial. Regeneration is obtained by means of the feed-back coil, L4.

The Ark of the Covenant

(Continued from page 344)

course for New York, we woud go up in search.

First, we got in touch by radio with Dick Schuyler's headquarters, but while we were asking for him, he himself broke in from another direction.

"I'm just taking a flip out to meet you, Jimmy," he explained cheerfully. "Look out for me soon."

"Have you heard from the *Parnassic?*" I asked him.

"Just got the radio from her captain. The airship notion seems to be all right. Anyway, we cops are acting on the idea, and are going through our particular sphere with a fine comb. It's a silly question, Jimmy—but you haven't seen any signs of a dirigible, have you?"

"No, I'd have told you——"

"Help us in this. Climb as high as you can without discomfort to your passengers and keep a sharp lookout. If you see anything, tip me the direction, and we'll be after the jokers like a knife. For the nonce, so-long, Jimmy! Cheerio, Dan!"

Dick's request came on the heels of our own decision. We had already turned on extra heaters and the compressed air, and were climbing good and high. We kept up a bright lookout, but until Dick and his scouts hove in sight below us to the west, the upper air was clean of aircraft.

As we dropped to meet him, Dick began another discussion. He agreed that the likeliest direction in which to look for the raiders was to the northward, and on his order his five scouts made a sweeping movement under our bows to starboard which was pretty to watch. He himself came near enough to us to let us see his cheery grin and to give us a wave of his hand, before turning to follow his scouts. Presently all six were the merest dots on our starboard quarter.

It was worth while carrying a passenger like Miss Torrance. She was keenly alive to everything that was happening, and, like her uncle, took a useful part in the lookout. In fact, she had her eyes so steadily fixed on the upper air that we were in good sight of New York before she realized the landfall.

Miss Torrance's First View of New York

I will say that her first view of the city was almost worthy of her. I have never seen the old hive look quite so splendid. It was one of those cool bright sunny mornings we sometimes get in March that make everything look so clean.

The pale golden light pricked out all the towers and pinnacles of the city in wonderful definition, until they became mere points of light against the smeary blue of the distance. This blue distance rose up and up till it lost itself in the tawny base of the sky, and from that, cloud was piled on cloud in an arch that curved toward us in gold and pale tan and grey, to end in dazzling white against the deep blue right over our heads. The waters of the bay looked in the sun like a filmy grey-green gauze carrying countless spangles, except where the tall buildings threw their long shadows, which were deep indigo with lighter patches of pure cobalt. I think even Lord Almeric was stirred out of his habitual quiet by the sight.

"My dear," he said to his niece, "you are to be envied. New York has summoned all her charm to greet you. In all the years I have known her, she has never seemed so winning."

"Lovely, lovely! See all the buildings like golden cliffs," the girl cried. "So tiny! It makes one think of man as only a very industrious insect—like the weeny things that build the coral islands."

"Then you have to thank Mr. Boon for giving you a god's-eye view of your kind, Kirsteen," said Lord Almeric with a smile.

She turned to me and looked up with those serene blue eyes of hers very grave.

"Do you ever develop a godlike indifference to the invisible little active creatures below you, Mr. Boon?"

"No," said I. "I'm afraid I'm always too conscious that I'm just one of them myself, and that my particular activity is only a part of the human scheme, Miss Torrance."

She turned to Milliken with a smile, and his wide grin about split his old face.

"What about you, Mr. Milliken? Do you ever feel superior?"

"Bless you, miss," said Milliken. "I know the old earth's pulling at me all the time, and that sometime I'll have to give in and get down. You can't be a god if your job has a string to it."

"The philosophy of flying in a nutshell, Kirsteen," Lord Almeric laughed.

"I see I must not become imaginative," said Miss Torrance. "Mr. Mililken is braver-minded than you are, Mr. Boon. I'm sure there are moments when he isn't earthbound."

When Milliken goes red, he gets black—if the Irishism can be excused. I have never seen him quite so dusky as he was when he pushed the *Merlin* into the long drive that would bring us into our hover to the landing stage at the Battery. It was a marvel to me how quickly he and Miss Torrance had understood each other, and I was not a little envious of my mechanic. I'd have given a good deal to have said something that pleased her.

Well, anyway, the god's-eye view soon became the ordinary human view, and we floated gently up to the seaplane jetty just after the quarter to nine. My father had already arrived. In fact, I had seen the *Seven* pass far below us as we came down over Long Island. He was waiting for us on the landing stage, and he and Lord Almeric shook hands like old friends. There was a trifle of formality to go through with the customs, but that was soon over.

Lord Almeric and Miss Torrance poured thanks on Milliken, who was to take the *Merlin* back to Gardiner Bay, until he was almost ebony color with embarrassment. Then Dan and I joined the party to go uptown for breakfast.

II.

The Story of the Sea Robbery Is Told

While we waited for Lord Almeric and Miss Torrance to discard their wraps and make themselves comfortable after the flight, Dan and I gave my father a full account of the morning's doings. He already had heard the bare particulars, as supplied to the press by the captain of the *Parnassic*, for the papers were selling in the streets with the news. The full force of the air police, both the sea and land divisions, had been mustered at once to sweep the air in a wide radius around New York. The navy and the river police were active among the shipping at sea and in dock. Through the night, the territorial police had been scouring town and country, examining garages and all places where the thieves might be concealed, and all known criminals in New York of the safe-breaking persuasion had been rounded up and their haunts thoroughly examined. But no clue to the whereabouts of the stolen gold was discovered.

"The chances are that it is in the air at the present moment, dad," I said to him. "We must have passed somewhere near the airship—if airship it was—on the way out. We must have sighted the *Westbury* less than half an hour after the pirates left her. If the airship is making for the American continent at all, it can hardly escape being seen, at least, with all those police machines out."

"Do you think they'll be able to send her down?"

"It depends greatly in what circumstances they come on her. She may be too high to be got at in an open plane, and the police machines are notoriously unsuited for high altitudes. But the fellow that sees her may be able to broadcast her position to all aerodromes, and so get properly equipped planes to help. I won't consider she's escaped until dark has come on."

"Let's hope you prove right," said the old man. "Things are too uneasy to be comfortable, and a solution of the mystery would stave off a lot of trouble for the business world."

Miss Torrance and Lord Almeric joined us then, and we went in to breakfast. The talk, perhaps naturally, was still of the robberies, until the two bankers fell to discussing some obscure financial situation. Lord Almeric, asking his niece for confirmation of some figures, effectually isolated Dan and Myself, and it was with something of awe that we heard Miss Torrance talk familiarly of millions, using such phrases as "ranking pari passu," "funded loan," "par of exchange." In spite of her obvious efficiency, the talk fell strangely from the lips of such a pretty girl. I think even my father was surprised.

"You have a wonderful grasp of figures, Miss Torrance," he smiled.

"Wonderful because of my sex, Mr. Boon?"

"Not at all," said my father; "wonderful in any case."

"My niece," Lord Almeric explained, "comes of a stock famous in mathematics. Robert Torrance, the mathematician, was her uncle."

"Then, Miss Torrance," Dan Lamont butted in, "you must be related to—— I beg your pardon!"

He broke off in confusion and flushed red. Miss Torrance regarded him with kindness.

"If you intended saying that I must be related to David Torrance, the physicist, who disappeared just over 22 years ago," she said, "I am proud to say that he was my father, Mr. Lamont."

"I'm sorry," Dan stammered. "I did not mean to cause you pain."

"You do not hurt me by recalling the fact of my father's disappearance. I never saw him—and he never saw me. I was born after he was lost. Uncle Almeric is the only father I have known—indeed the only parent—and his kindness has softened any regrets I may have for my real father. He was a great physicist, I believe, and I treasure any information about him, any praise that is given to his work."

David Torrance

"David Torrance was a great man," Dan said quietly, with recovered equanimity. "Every scientist owes him a debt of gratitude and must regret that he was not permitted to work longer. The best men of our time," he finished warmly, "are plodders and half-blind crawlers compared with David Torrance!"

"Thank you, Mr. Lamont," the girl murmured, and her eyes were misty.

"Well spoken, Dan!" said my father, and turned to Lord Almeric and his niece. "Dan Lamont," he explained, "has one of the greatest reputations among physicists in this country—so his opinion on such a subject is of some value."

Red-faced as usual at any reference to his eminence, Dan rose in some confusion.

"If you'll excuse me, Miss Torrance—Lord Almeric," he said hurriedly, "I—I must be going. Some important work—I—good-bye, Miss Torrance—sorry I was so clumsy. Good-bye, Lord Almeric——"

"Wait a moment, Dan," said I. "I'll come with you."

I, too, made my adieus, and we both went off. There was nothing new to hear in Dan's laboratory, except a lot that was speculation and clean over my head at that, so I left my friend to take off his jacket and plunge into work. I could see no useful purpose to be served by stopping in New York, and I went down to the Battery where Didcot was still standing by with the *Seven*.

We moored at the workshop jetty within half an hour.

III.

What Did the Radium Mean?

Then began a fortnight of close application to work. The flights we had made on the *Merlin* had given me ideas for slight variations in the design, and I wanted my shops to be set as soon as possible on the task of making a *Merlin II*, which would incorporate those ideas.

My hurry was actuated by the certainty that I had of the raids being carried out with a new type of dirigible. I had that inexplicable feeling, generally termed a hunch, that we had not seen the last of the raiders, and that before we were done with them there would be a few *Merlins* in the air.

I was puzzled by the radium, which the back of my mind refused to let me dissociate from the pirates. If, indeed, those priceless boxes had come from the mysterious organization that had carried out the amazing series of raids in two days, they were no ordinary crooks that we were opposing. The sale of the radium, Dan assured me, would have brought in nearly as much money as the robbers had stolen.

There was something underlying the raids that the mind could not fathom, an idea too big to be merely criminal, too vast in conception to find its limit in the affairs of the past two days.

To me, my side of the job was now plain. The menace was from the air, and the air was my element. I had, I could tell myself without immodesty, the finest weapon for air fighting that was known to exist, and my business was to perfect that weapon to the best of my ability.

To bring the position to its lowest estimate:

If the gifts of radium to the institutions were not the work of the raiders, it was extremely unlikely that a criminal gang, possessed of such powerful and effectively proved aids to plundering, would be content with their present gains. It would be humanly impossible to resist the temptation to work the feat again. They might wait until the outcry against them died down, till the forces that might be opposed to them were lulled into a false sense of security, but it seemed to me psychologically impossible that a criminal gang could withstand the itch of their fingers for such easily acquired wealth.

In any case, hurrying up my work would do me no harm. My ideas for the improvement of the *Merlin* were concrete enough to warrant pushing ahead. I did not want, for some indefinable reason of sentiment maybe, to part with my original model to the government. The *Merlin* was almost alive to me, and I knew that Milliken shared the feeling. Besides, in herself she was the most flexible of machines—responsive, grateful to one's hands—just that uncanny accident of assembled material that happens once in a hundred times. Her design might be repeated over and over again to the fraction of a millimeter, and yet no machine be produced that had her personal quality.

The variations in the design which I contemplated were merely to make the machines that might be built from it safer in unskillful hands. The original *Merlin* in the hands of Milliken or myself would be capable of everything that her sister planes could do.

Before dark that Tuesday night it became plain that no trace of the air pirates would be discovered. The air police abandoned the chase, having combed out a great radius from New York without the slightest result. During the day I had been in radio communication with Dick Schuyler, who kept me well informed, and his last message before he went off from a long spell of duty was that the authorities were taking the tardy step of doubling the patrols for the night.

My father arrived at the workshops soon after seven, and for a while he sat beside me on a high stool as I worked at the drafting table. Thus perched, he told me very calmly of an exhausting day. The run on the banks of the Monday had been repeated on the Tuesday, and there had been the greatest difficulty in meeting the situation. Nothing but selling had gone on in the Stock Exchange and the fall that had ensued in all classes of shares, in some cases reducing quotations by as much as half, had produced a position in the matter of loan accounts unheard of in the history of banking.

"If the government investigators were to examine our books at this moment, Jimmy," said the old man, "they'd find a position of affairs that theoretically could land me in jail. Think of that!"

"I'd rather not think of it, dad," said I. "The thing's quite abnormal, isn't it? It's out of all relation to the actual loss?"

"Of course it is. It's the result of cold feet—don't you call it?—among speculators in the stock markets. Not a few men have been ruined today who, two or three days ago, were worth considerable fortunes. There's nothing more unreasoning than a scared investor or speculator. It's all

madness—stark madness! Coming home to dinner?"

"Give me a minute to hand this over to the pattern maker, and I'll be with you."

We had a quiet dinner together at Hazeldene, and my father approved of my plans.

"I don't see what else you can do, son," said he. "The thing is too big for ordinary detective work. I'm convinced you're on the right lines. What about finances?"

"I'm well in funds, dad. That mooring tackle brings in enough in royalties to keep the sheds going full swing, even if they did not pay—which they do. Thank you all the same, dad."

"That's all right, then. I depend on you to play fair and let me stand my share of the expenses. Mind that."

"You shall have the gasoline account, dad." I grinned at him. "I can see old Milliken joy-riding furiously at your expense!"

"Ah!" my father said suddenly "That's a good man of yours, Jimmy—that Milliken. Lord Almeric and his niece are greatly attracted to him.

"By the bye," he went on. "I have asked them both out here for the week-end. I hope you'll be able to show them round your shops?"

"Very glad."

"And perhaps you'll be able to spare a little time from your work to look after Miss Torrance. She is very much a business girl, but I'm sure she'd like to do a theatre or two—something like that."

"When I have the drafting done for the new *Merlin*, I'll be delighted."

"Good. I knew you would. Well, I must do some work, son. Are you going back to the shops?"

"Must, dad," said I. "I want the men to have a clear start in the morning. Good-night, dad. See you at breakfast, I hope. I'm bunking down at the shops, but I'll come over in the morning."

"Half-past eight, then. Good-night, Jimmy."

Next morning, by the time I had breakfast with the old man, I had done enough work to let my fellows get a clean start on laying down the keels of three new *Merlins*. The drafting had taken me and my assistant all night, so when I had driven my father down to the jetty, and had seen him off with Didcot on the *Seven*, I turned in, leaving Milliken in charge of the construction.

IV.

The "Parnassic"

I slept until two o'clock in the afternoon, when I was awakened by an SOS through the bank from Sir Peter Weatherly, who had berthed the *Parnassic* in the morning and wanted the evidence of Dan and myself for the police. It was a nuisance, but there was nothing for it but to take the *Seven* and get to the Battery as soon as I could.

The Government Investigators

I found Dan and the old sailor being badgered into a state of irritation by one of the government investigators, who could not accept the evidence they had given him, but wanted the very things explained that everybody was puzzled about. The pair of them greeted my arrival like a couple of lost pups—they both had that extraordinary likable doggy quality you sometimes see in men—and listened to my evidence with obvious relief. I imagine the investigator had badgered them into thinking my version might possibly contradict their own.

"But it's preposterous!" the investigator cried. "Three sane men can produce only a bare yarn like that!"

"What sort of yarn do you expect us to produce?" I asked. "Of course, it's preposterous from start to finish. It's up to you to explain the preposterousness."

The man was rattled. A relic of the bad old days of the police, he found himself, like the rest of us, against a blank wall, and the fact annoyed him. He banged his fist on the table.

"This is a case of collusion!" he yelled.

"I'll give you one minute to get back your sanity," I told him. "If you can't do it in that time, my friends and I will quit."

"Quit, will you?" he snarled. "If you say another word, I'll have the three of you detained."

"If you say another word like that," said I, "I'll have you pushed out of the service for the damned fool you are! You get an account of this affair from a man so distinguished at his job that his country gives him one of its highest honors. You get another account from another man, equally distinguished, except for his age, and a man trained in the most exact observation as well. I'll say nothing of myself, finally, except that until now my honesty has never been questioned. And you have the gall to use such a word as 'collusion'! As an investigator you're not only crudely impertinent—you're a pitiful vulgar joke!"

"Why — why — you pup! You — you — skinny, mangy pup!" he gasped, livid with rage.

"You're a judge of pups. Maybe the kennel you came out of taught you that," said I, "but it failed to teach you how to investigate! Come on, Sir Peter. Come on, Danny."

There was no attempt to stop us, and we got into the street. Old Sir Peter took hold of my hand and shook it nearly enough to take my arm from its socket.

"I congratulate you, young man!" he cried.

"Fifty years at sea, and I never heard a man ticked off like it before! And only one casual cuss-word in the whole recital. That's the wonder of it!"

It was curious how the traditional dread of the shipmaster for the police had got the better of the dignified commander of the great liner, and had reverted Sir Peter back to the innocent sea-dog, putting him at the mercy of a common bully. But by the time we had adjourned to the smoke-room of a neighboring hotel the sailor was himself again.

"I won't forget that, Mr. Boon," he said. "That fellow had got me so flummoxed that I thought I had been in league with the pirates."

"You ought not have gone to the Police Bureau at all, Sir Peter," I told him. "You should have received all inquiries on your own deck."

"I wish I had," he breathed. "I'm at home there—and even my King, bless him, couldn't order me about!"

I was mad at the treatment of my friends, and we went to the hotel stenographer, who took down a letter to the Chief of the Police, in which I explained that Sir Peter and Dan had been treated with extreme discourtesy, and that apologies were due to them. They got letters of apology next morning.

The incident, however, was symptomatic of the exasperation and bewilderment the authorities were experiencing. The newspapers came out with the most wonderful theories, interesting enough to read, but not the least helpful to those whose job it was to solve the problem of the raids. The country was gone over, as it were, with a fine sieve, without the slightest result. The land and air police were bitterly attacked by the press, and even the naval and military authorities came in for condemnation. As time went on the old ground had been turned over and the old facts redressed so often that the public got sick of the affair, and skipped any items in the papers that referred to the raids. But business confidence remained badly shaken.

Dan Lamont's investigations of the gold tarnishing resulted in his finding compounds of copper, and a hint of some radio activity. This seemed to me absurd, but it fired Danny's enthusiasm, since he thought it indicated that the raiders had discovered some enlargement of the science of radio activity as applied to the atomic theory. He had the terrier's tenacity, and he went after the thing from every possible angle, worrying the facts and himself until he developed between the eyes a permanent furrow of concentration. He bored after an explanation of the mysterious sleep, too, and discovered at least one gas which, if not lethal in its effect, was tremendously anæsthetizing in so far as it stunned the olfactory senses. Properly, it might have been called a lachrymatory gas, for its effect on the nose made the eyes stream!

The work on the three *Merlins* meantime progressed rapidly at the workshops near Gardiner Bay, and I had time to devote to social obligations. Dan and I dined two or three times with Lord Almeric and Miss Torrance, and we all had a golfing-flying party at Hazeldene during a week end. The workshops were inspected thoroughly, and Milliken and Miss Torrance formed a curious compact of friendship that had the effect of making my mechanic go about with a ready grin on his normally formidable countenance. She petted him shamefully, and even flattered him into letting her take the joy-stick of his beloved *Merlin*. Nobody could blame Milliken for being enslaved—Miss Torrance had a way of deserving any little service one might do for her. Hazeldene and the workshops were dull places for quite a while after she went back to New York on the Monday.

The establishment at Gardiner Bay was not a large one, but it was fairly well equipped. It had a small foundry where we did all the castings for the wings and body work of our planes and, of course, we had a moulding shed. There was a smithy with a good welding plant, drawing office, pattern-maker's shop, fitting shop and in addition to our mooring shed and landing stage, we had a large field for landing with a one-bay hangar.

The only part of the work we did not do ourselves was the building of our engines. These came from a little-known factory in which I had an interest near Pittsburgh. Its products were reliable to a degree, and beautifully finished, developing a great horse-power in ratio to their weight. We seated these engines ourselves on the machines we constructed, and we had our own notions of fuel supply and cooling system.

With this small establishment working at top speed, we were able to have three *Merlins* lying in the fitting shop awaiting their engines by the Wednesday of the second week after the Wall Street affair. This last piece of assembling had to wait. It was all to our advantage that our power-units should undergo the very strict tests that the factory at Pittsburgh considered necessary before passing out any engine.

V.

More About Miss Torrance and Her Uncle

There was one thing that made the enforced wait easier to bear. I had more time to spend with Lord Almeric and his niece. Their visit to New York was nearing its end, for Lord Almeric had almost finished the work that had brought him to America. Only a matter of business with the Treasury in Washington remained to be seen to before he returned to England. Miss Torrance, it appeared, was taking advantage of the trip to spend some months in Washington with relatives there, a piece of news that seemed pretty good to me. It sounded such a waste of time for a girl like her to come to America for a fortnight. Washington was less than an hour away for a machine like my *Merlin*.

We were having dinner together on the Saturday evening before going to a theatre. My father was there, Lord Almeric of course, Dan Lamont and Miss Torrance. I was telling her how easy it would be for me or Milliken to run down to Washington and take her back again if she wanted even a day in New York. She laughed at me.

"There doesn't seem any end to your American hospitality," she said. "Does there, uncle?"

"American hospitality," said Lord Almeric, "is the only thing known to work more than 24 hours a day."

"No, but seriously, Miss Torrance," I insisted. "I think it would be a real good plan just to wire me if you wanted to come to New York. 'Boon, Gardiner, L. I.: Plane wanted. Torrance.'—just that, and within an hour Milliken, or me, or Didcot would be fluttering down on the Potomac."

"As easy as that?"

"As easy as that," said I. "And to show you how easy it is, I'm going to ask Lord Almeric to let me carry you both to Washington tomorrow. May I, Lord Almeric?"

"My dear Mr. Boon—you must not make us impose on your good nature."

But I had my way. At seven o'clock on the Sunday evening, Milliken and myself took off from the Battery in the *Merlin* with Lord Almeric and Miss Torrance, and some of their luggage. Soon after half-past seven, in the first creep of dusk, we sighted the pale lights of the aerodrome and seaplane basin on the Potomac, and by twenty to eight we had landed our passengers.

"Don't forget, Miss Torrance, that there will always be a bus at your disposal whenever you want to come to New York," I said.

"I won't forget, Mr. Boon. Good-bye, and my grateful thanks for many kindnesses," she said. "Good bye, Mr. Milliken! Remember that you're to coach me for my pilot's certificate."

Milliken grinned that big grin of his.

"I'll remember, Miss Torrance," he said. "It won't take you long."

"Good-bye, Mr. Boon," said Lord Almeric. "I shall see you on my return to New York. Good-bye, Milliken. Best wishes for the success of your new machines."

They stepped into a government automobile that was waiting for them, and drove off.

"Dad fetch it, Milliken!" I grumbled. "What's the good of making friends only to lose them? I don't even know her address. It seemed inquisitive to ask."

"That's all right, Mr. Boon," said Milliken cheerfully. "She's a niece of the President. Everybody knows his telephone number."

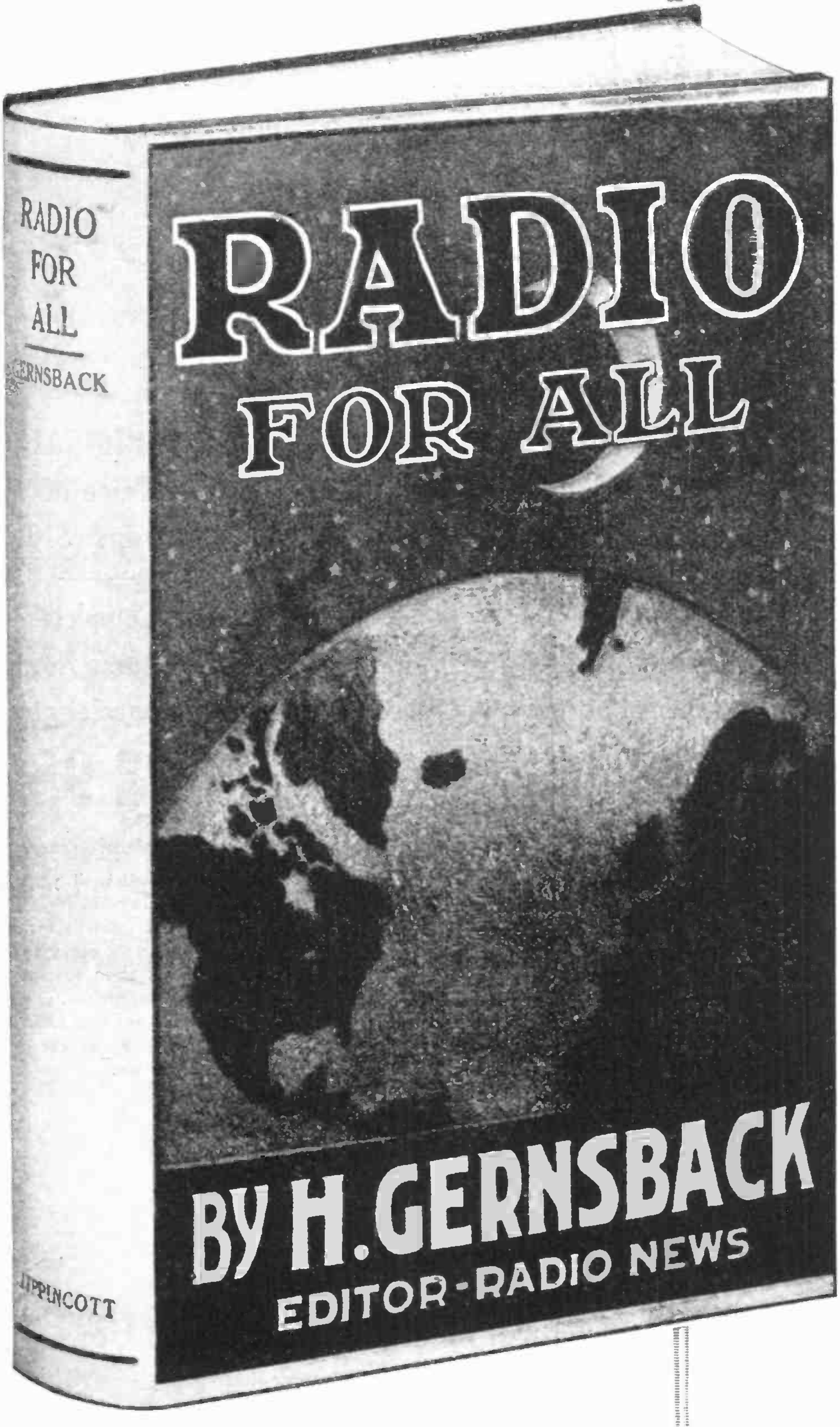
"The White House! How did you know?"

"She told me comnig along. I have to send her a copy of your book on flying."

"Why didn't she ask me for one? I'd have had one specially bound for her——"

Milliken looked at me queerly.

(To be continued)



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