November 1925 25 Cents

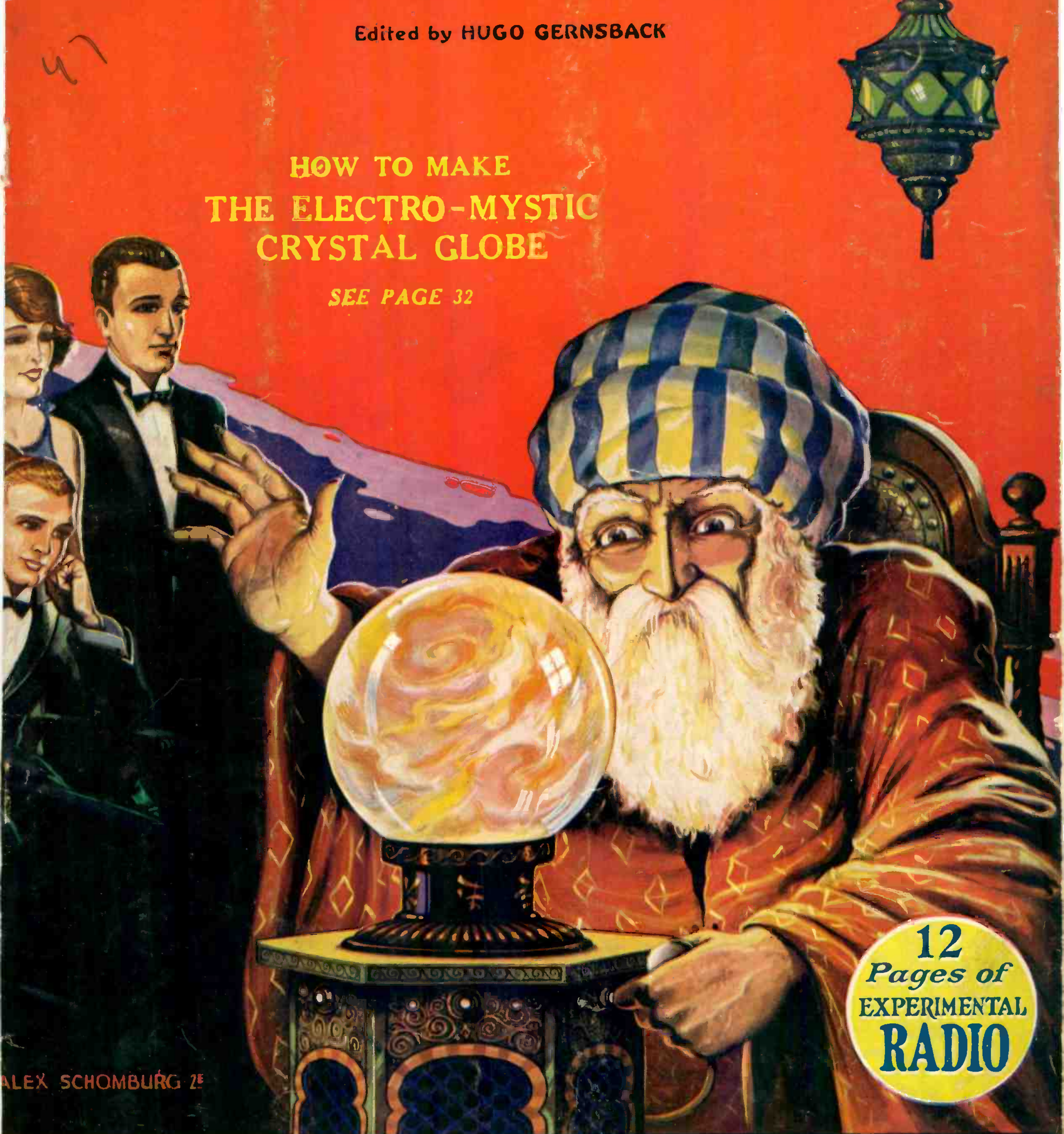
The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

HOW TO MAKE
THE ELECTRO-MYSTIC
CRYSTAL GLOBE

SEE PAGE 32



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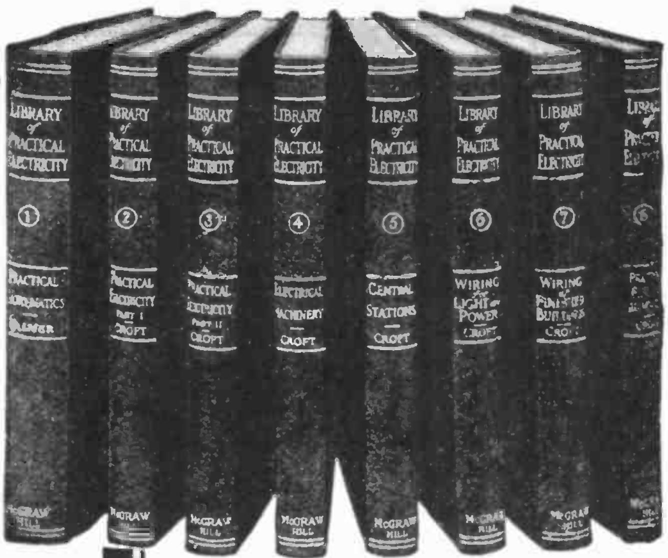

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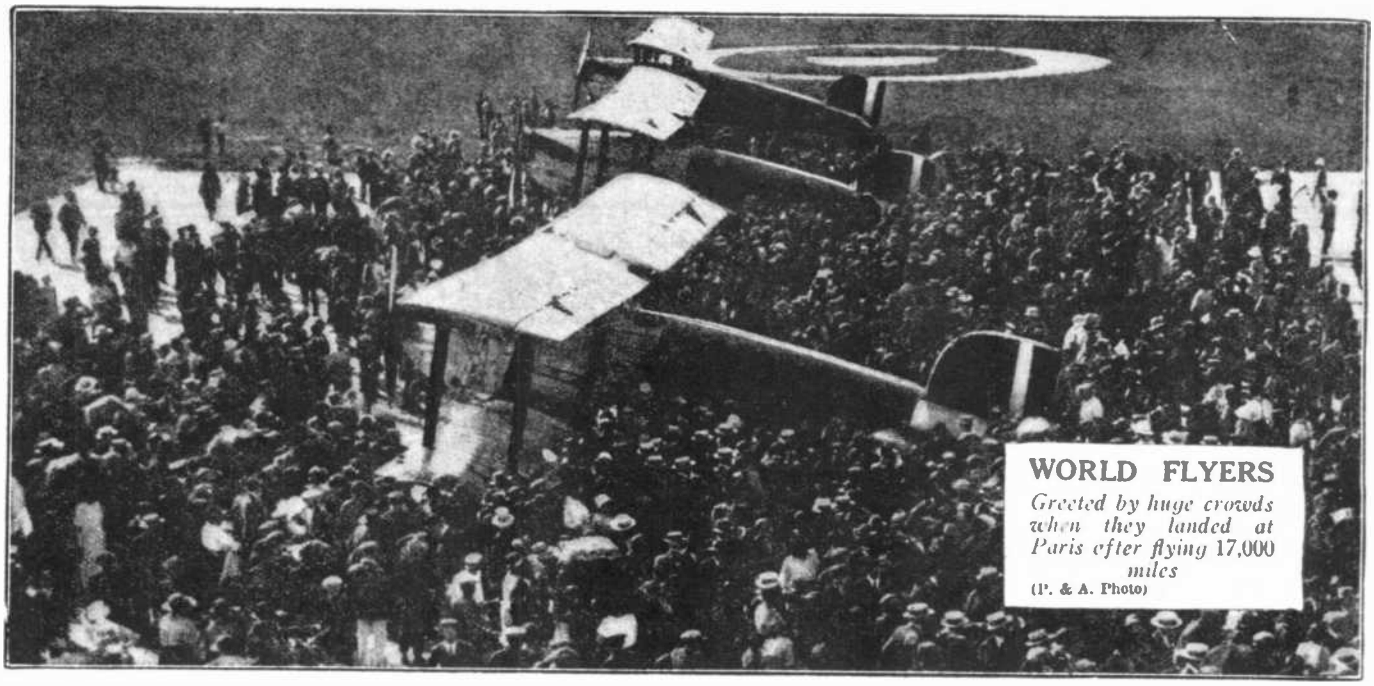

WORLD FLYERS

Greeted by huge crowds when they landed at Paris after flying 17,000 miles

(P. & A. Photo)

Daring Young Men Needed in Aviation

Aviation in America is on the threshold of an amazing new development. The prediction of pioneers is now an actuality—for in the past few months the newspapers have announced the establishment of gigantic commercial air lines. The biggest capital and business forces in the world are behind this enterprise. And now, even in the beginning, thousands of young men are needed. For those who can qualify there will be thousands of highly paid jobs which will lead quickly and surely to advancement and success.

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Volume 5
No. 1

The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

November
1925

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

Materials Used In Experimenting

By Hugo Gernsback

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

AN important thing the experimenter should keep in mind when starting out on no matter what experiment is to attain thorough knowledge of the materials he intends to use. It seems commonplace and trite enough to say this, but the average experimenter would be astonished at the time, labor and money being wasted annually by those experimenters who as yet have not learned what certain materials may and may not do. Just to give a few examples: An experimenter makes a knife switch, using soft brass for the blade and blade clips. If any amount of current is used, the brass soon turns black and becomes covered with an oxide which will put a high resistance into the circuit, and poor results will be had. Also, clips of soft brass will spread so that still poorer contact will be made. The material to use is, of course, hard copper, which, first of all, is springy, gripping the blade. Second, it does not oxidize, except at high heat, and third, it is a much better conductor than brass, which is a relatively poor conductor.

An experimenter recently wrote in that he had constructed a Tesla Coil according to specifications, but that it didn't work. We were puzzled, ourselves, until we found that instead of using the suggested glass insulators, he had used porcelain cleats, which were not even glazed. Now if there is a poor insulator for high frequency work it is unglazed porcelain. This material is very porous and literally leaks like a sieve as soon as the high tension current is turned on. Porcelain could have been used in such a coil, but the experimenter should have used at least glazed porcelain, which would have given fair results whereas the unglazed material did not.

Another experimenter recently attempted to construct a Wimshurst Static Machine. It was built according to specifications, but did not operate. The reasons were, as we soon discovered, that the glass used for the Leyden jars was ordinary lead glass, which, to the high tension currents, and particularly such as due to static charges, is about as good as a piece of metal! In other words, it is no insulator at all. Any one who builds a static machine must use the so-called "potash glass," which is not easily obtainable in this country. In Europe it is a commonplace substance and is used much more than the lead glass we have here. In this country, where the use of potash glass is not in vogue, it is best to use a substitute such as good hard rubber tubing, or bakelite tubing, or a tube cast in sulphur.

A test for a Leyden jar is that after the jar is finished, coated inside and out with tin foil, and the jar charged, it must retain the charge for at least a full half minute. In other words, when charging it you should be able to pull out a good strong spark half a minute after charging the jar. Otherwise the static machine will not work well. Mica can also be used for the same purpose, and retains its charge very well.

When making chemical experiments, only chemical glassware should be used, and we need not urge this too strongly, because most chemical experimenters are aware of this, but the beginner is not. He often uses vessels that crack as soon as the Bunsen burner is turned on, with disastrous results, many times.

Those who experiment with permanent magnets for radio or other purposes find that the only steels that retain their magnetism are in the order as given here: tool steel, chromium steel, and tungsten steel, the tool steel being the poorest—the tungsten the best. If you use soft steel or cast iron, it is true that such can be magnetized, but the magnetism will be retained only a short time, after which it has to be remagnetized. Naturally, if we need an instrument that should stay put for any length of time, we would wish to use only the best tungsten steel, as, while it is very hard, it can be heated and bent into shape and worked by means of an emery wheel. Afterwards it must be heated to a cherry red and dropped in oil for hardening. Then it is ready to be magnetized.

A few hints about magnetizing steel may not be amiss. When magnetizing, be sure you know which polarity you require, because once the steel has been magnetized you can not easily reverse the magnetism. If you find you have the wrong polarity, it is then necessary to first heat the magnet to cherry red again, reharden it, and then remagnetize it. It is a wrong impression, when magnetizing for permanent work, that the electric current should be left on for any length of time. The magnet is magnetized practically instantaneously, ten seconds being sufficient for all purposes. While it is being magnetized, it is a good plan to hit the magnet with a piece of hard wood or hard rubber a number of smart blows, which seems to assist in realigning the molecules of the magnet, and a much stronger magnet results.

In winding radio coils, a most important item is frequently overlooked. Most designers give specifications of double cotton covered wire, which is really excellent, but they forget to tell that such a coil is highly hygroscopic; that is, it will work very poorly on a wet day when the insulation will absorb a good deal of the moisture of the air, which spells defeat for long distance reception. The obvious thing to do when using double cotton covered wire is to put a *very* light coat of thin shellac over the entire coil. This gives the protection required without adding greatly to its capacity.

One of the most interesting materials to work with is celluloid. Here is a substance that has been overlooked a good deal by our experimenters. There are thousands of different uses to which celluloid can be put in making models, etc. The material can be worked easily, and by means of a simple liquid can be cemented together in such a manner that it is impossible to pull it apart, because, unlike most other materials, celluloid practically welds together under a cement, and as the liquid dissolves it, the cemented sections really become one and the same piece. The cement is made as follows:

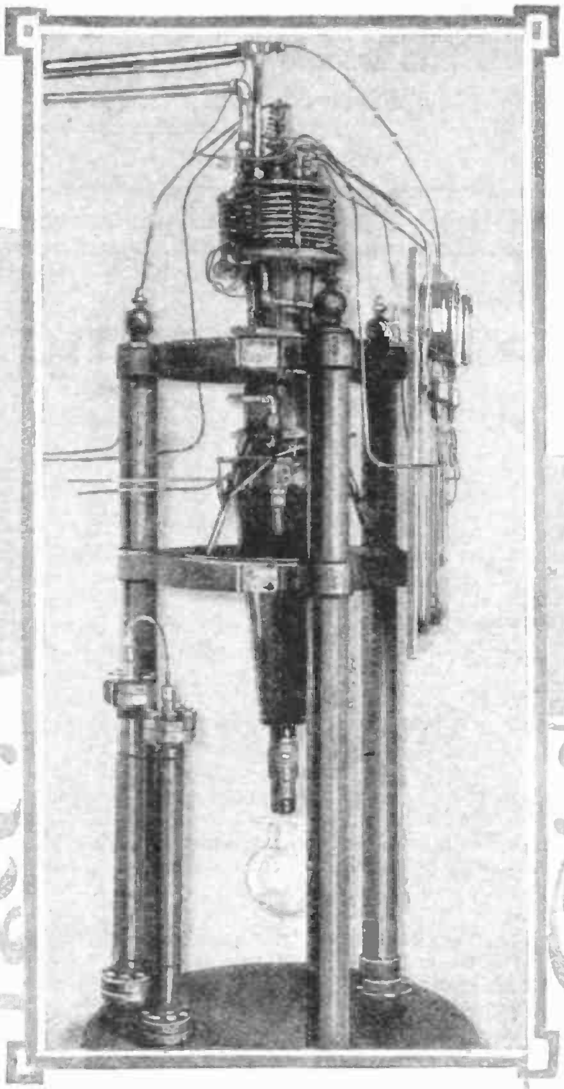
Procure a wide-mouthed bottle of acetone. Into this throw small pieces of celluloid—pieces such as you get from photographic films, which must be clean of its emulsion. The emulsion comes off easily in hot water. The pieces must be rather small, and no large ones should be thrown into the bottle. After the bottle has stood overnight, you will find, next morning, that the celluloid has all been dissolved, and that you now have a celluloid cement. If made correctly, its consistency should be that of *thin* syrup. It must not be heavy flowing, and if it is too thin, add celluloid. If too thick, add acetone. Use the cement with a brush, but be sure that the bottle is well stoppered, otherwise the acetone will evaporate, the cement becoming too thick. This cement can be used in a myriad of different ways. It is good for cementing together porcelain, pieces of wood, and can be used to much better advantage than shellac for many different purposes. Self-supporting radio coils can be made by coating a thin coat on the wound coil and then withdrawing the mandrel. This leaves a really beautiful coil.

Using a number of thin photographic flat films and very little cement, sheeting can be built up by this means to any desired thickness. Other celluloid pieces can be welded to it, by using the cement and putting the cemented pieces under pressure over night. Flowers and beetles can be covered with this cement in a most beautiful manner, that is astonishing in its effect.

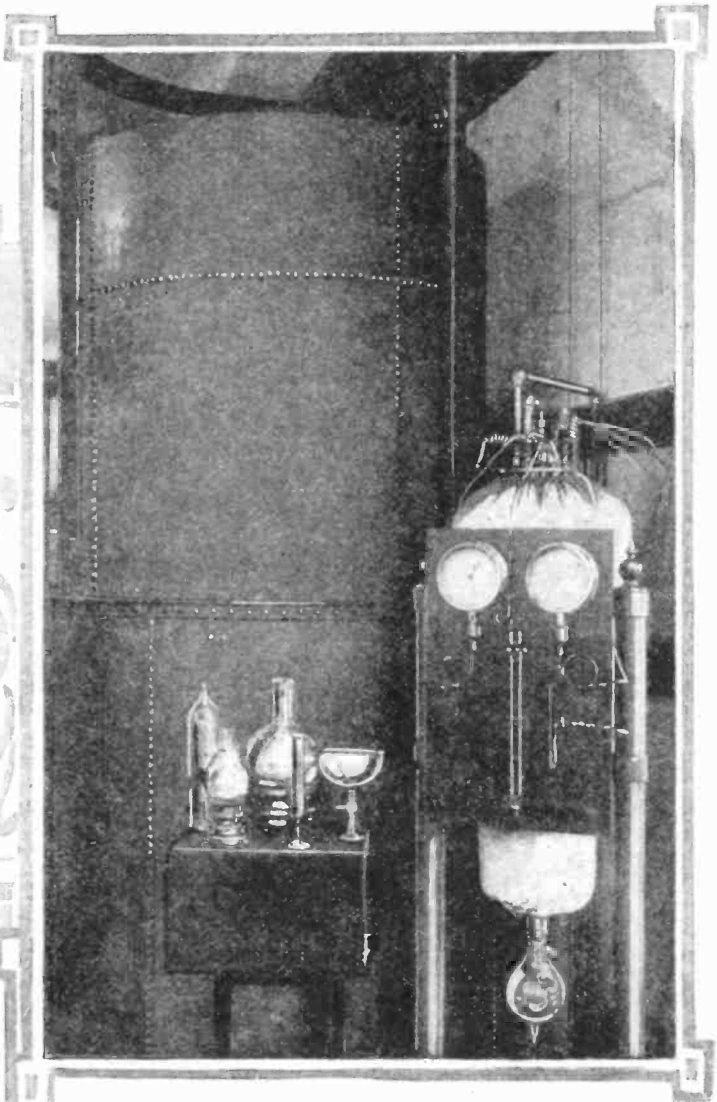
Mr. Hugo Gernsback speaks every Monday at 9 P. M. from Station WRNY on various radio and scientific subjects.

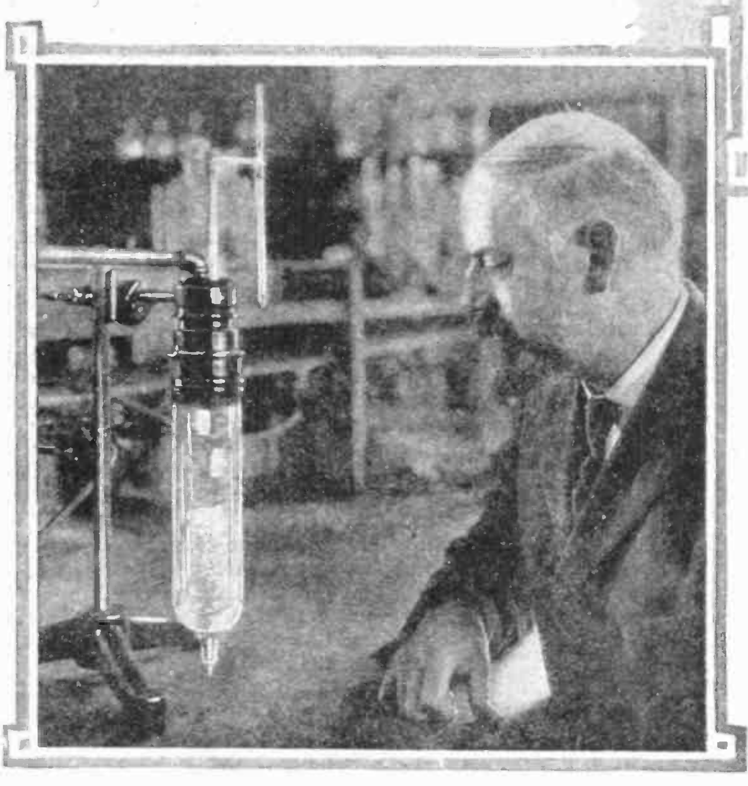
Liquefying Hydrogen

General view of the apparatus for liquefying hydrogen used by the Bureau of Standards at Washington, D. C., is shown below. The compact apparatus is impressive from its small size. In the background is seen the gasholder, containing the chemically pure hydrogen. On the little table are seen various containers of vacuum-jacketted or Dewar type.



A view of the apparatus for liquefying hydrogen, with its non-conducting lagging or casing removed. In both this and the photograph to the right the Dewar flask for receiving the gas as liquefied, is shown at the very bottom of the apparatus.





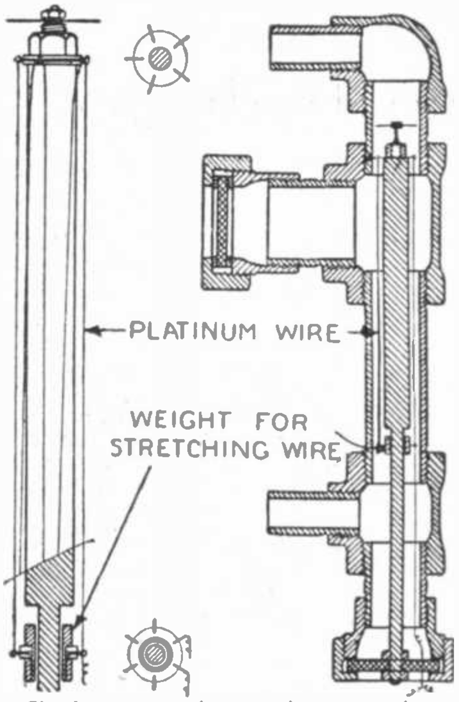
When liquid hydrogen is made to evaporate under reduced pressure by a quick acting vacuum pump, it freezes and forms hydrogen ice. The small apparatus required for this is shown on the left.

THE United States Bureau of Standards has been doing very interesting work on the liquefaction of hydrogen in its laboratory at Washington, D. C.

Sir James Dewar first liquefied hydrogen in England, about 25 years ago, and this, in spite of any earlier claims, it is fair to say, is the first certain liquefaction of hydrogen.

Two years after this liquefaction the English scientist succeeded in freezing the liquid to a solid. The famous cryogenic laboratory of Prof. Kamerlingh Onnes, in Leyden, Holland, has produced considerable quantities of the liquid.

The principle employed in liquefying hydrogen is quite simple: hydrogen gas is first compressed to a pressure of 75 to 100 atmospheres and then pre-cooled to a temperature of about —200° C. (—328° F.), which temperature is produced by the evaporation of liquid air under reduced pressure. The principle of heat exchange is then applied. The cool gas is passed through a coil and expanded as it issues from its end, and withdrawn in contact with the outside



Simple apparatus for removing traces of oxygen from hydrogen. A heated platinum wire brings about the combination of any traces of oxygen with the hydrogen so that water is formed and is condensed or frozen out.

of the tube through which it has just passed. The expansion lowered its temperature still more, so, in this way, the incoming gas is cooled to a lower degree. The temperature keeps falling until —253° C. (—423.4° F.) is reached and the hydrogen begins to liquefy. This temperature is only 20° C. (36° F.) above the absolute zero, — 273° C. (— 459.4° F.)

If the hydrogen contains oxygen and nitrogen, which inevitably find their way into it, they must be removed, because they liquefy and solidify long before the hydrogen yields to the apparatus and they thus plug up the expansion valve; that is, the valve at the end of the coil through which the pre-cooled and compressed hydrogen expands. The problem of liquefying hydrogen in quantity is comparatively simple if absolutely pure gas can be obtained, and the Bureau of Standards has taken up the work of purifying the gas and, incidentally, of analyzing it to determine the infinitesimal amount of nitrogen which it contains as oxygen is easily idsposed of.

To free it from oxygen, the gas is passed through a tube within which is supported a series of parallel leads of a long platinum wire, which are vertical in position and kept in place by a weight at the lower end. These are heated by an electric current and the gas passed through and over the wires; any trace of oxygen present combines with the hydrogen to form water, which is readily condensed. No matter what is done, however, nitrogen always finds its way in. This is removed by refrigeration.

The hydrogen is made by electrolysis, using an alkaline electrolyte, such as sodium hydroxide or potassium hydroxide solution. The gas is collected and stored before liquefaction in a gas-holder; this holder floats in glycerine; originally oil was used, but nitrogen penetrated into the gas-holder from the air, diffusing into the hydrogen. Glycerine resists this action better than oil. Very ingenius methods of analysis were devised to detect the amount of nitrogen, all based on liquefaction at low temperature.

By refrigeration of the hydrogen with liquid hydrogen outside the glass tube in which the hydrogen was being purified, the nitrogen was reduced to as little as 2 millionths of 1 per cent. of the original samples. The analysis is supposed to be accurate to 1/1500 of 1 per cent. The few hundredths of 1 per cent., however, clog up the apparatus.

One way of determining the nitrogen consists in passing about 200 cubic centimeters of hydrogen over heated cupric oxide; the hydrogen reduces this to metallic copper, forming water which is frozen out, and by repeated passage, along with reoxidation of the cupric oxide, all the hydrogen is burned up, forming water. Liquid air is used to get rid of the water; the amount of nitrogen which is the residuum left after this treatment is determined by measuring the pressure of the residual gas. The results of different determinations of hydrogen containing a few hundredths of 1 per cent. of nitrogen agreed within 1 thousandth of 1 per cent. Nothing is said about the removal of argon, but when we recollect that this is only about 1 per cent. of the total nitrogen, it will be seen that its amount is infinitesimal. The liquefier used by the bureau reduced about 2 liters of liquid hydrogen per hour; it was found that it could be preserved for a day or two in silvered glass Dewar flasks.

The value of liquid hydrogen is in its use for theoretical investigations on the properties of matter at low temperature and it is more than a simple triumph of chemistry or physics. After it has been liquefied it can be easily solidified into hydrogen ice by placing it in a vacuum container or Dewar flask and evaporating it under reduced pressure by a rapid action vacuum pump. The freezing point is —259° C. (—434.2° F.), which is only 14° C. (25.2° F.) above absolute zero.

The Bell Telephone Museum

MANY months have passed since we illustrated in our pages various examples of old telephones and of scenes in the early history of the science, the latter reproduced from contemporaneous publications.

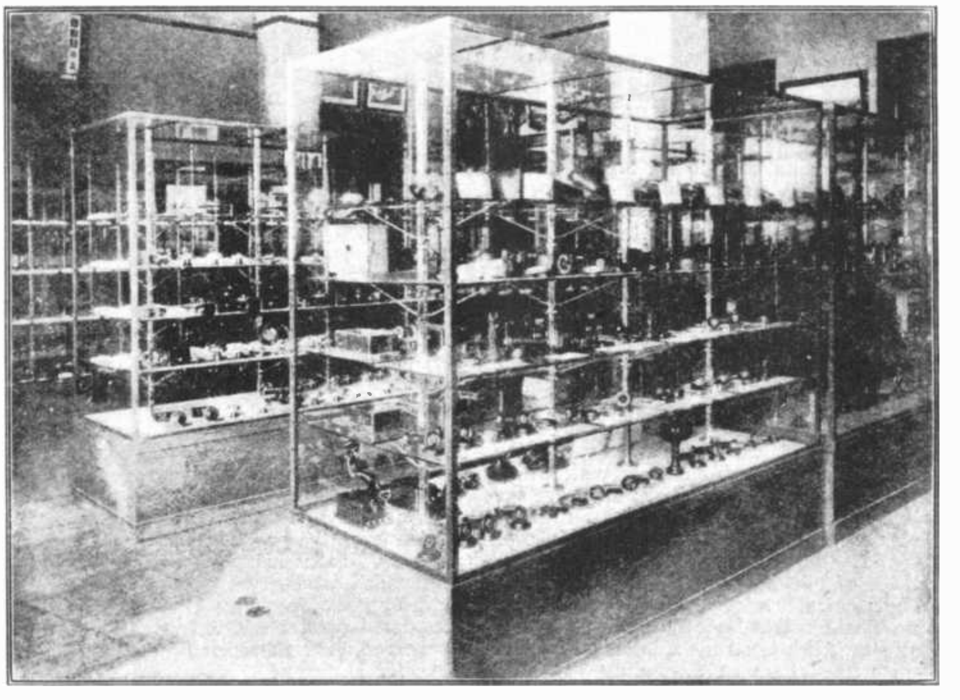
The Western Electric Company, of this city, has established a museum of historical relics of the Bell telephone, and the examples of early telephones which we showed were those exhibited in the cases thereof.

Quite an extensive museum has been installed in the West Street building of the Bell Telephone Company in this city. Numerous glass cases are filled with the interesting original telephones or reproductions of the old-time instruments. The exhibits precede the telephone in date, for an accurate copy of the famous harmonic telegraph transmitter and receiver of 1875 is there. This is less than a year older than the famous bell telephone that transmitted the first message in history: "Mr. Watson, come here, I want you." Even an original smoked glass tracing of speech sounds giving its graphs of speech is here. It was made by Alexander Graham Bell and Dr. Clarence John Blake before telephone days had come.

Wherever there was a gap in the series of relics it was filled by a reproduction, but, fortunately, a great number of the exhibits are the genuine original ones, veterans of the telephone, and which served in commercial practice. In the early days, once the microphone was adopted in commerce, changes were, perhaps, comparatively few; then came a period of development leading up to the present granular microphone, and now, except for wireless headsets and the like, it would seem as if more or less of a period of rest were once more obtained.

It is interesting to note that the subject of wireless telephony is well represented; such historical instruments as the transmitter which sent the first spoken word from Arlington, Va., to France and Honolulu is preserved. The original apparatus used at President Harding's inaugural is presented intact; vacuum tubes from the first crude devices to the modern high-powered tubes are shown. The apparatus developed by the Army and Navy for war use is to be seen with samples of submarine cables.

There are over two thousand exhibits in the collection and our illustration conveys an idea of how they are displayed.



A view of the Museum of the Western Electric Company. We are indebted to the company for the photograph of which the above is a reproduction. In its cases there are contained a wonderful collection illustrating the history of the Bell telephone and of the development incident to the microphone and the vacuum tube.

Transmitting Photographs by Cable

By Leon L. Adelman

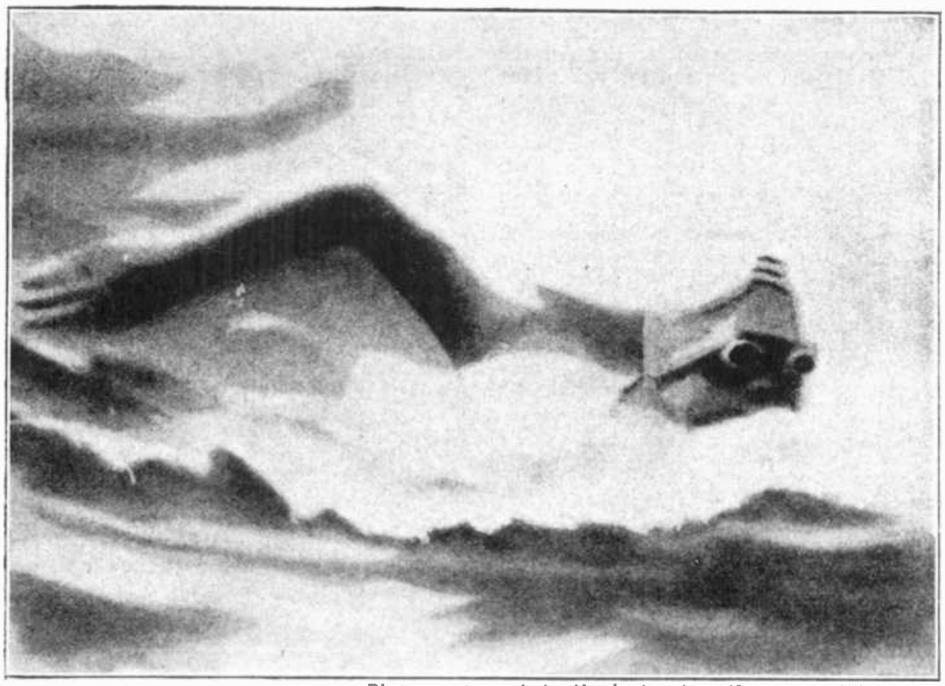


Photo courtesy of the North American Newspaper Alliance

The unretouched photograph of Miss Ederle in her attempt to swim from France to England as drawn by the artist at the receiving end, in New York City a few hours after it was taken in the British Channel. Note minute details, even some of the bubbles in the water have been successfully reproduced.

FOR the first time in history a picture of a European news event was transmitted by cable on the day the photograph was made and reproduced the following day in newspapers in New York City, Chicago and San Francisco.

The feat was accomplished by the use of the Leishman Telegraph Picture Process and the American Telephone and Telegraph Company's Tele-photo-graph process and stands as a record of achievement.

The Leishman process is the only one that will operate on a trans-oceanic cable and consists of the following steps: The picture to be sent is enlarged if it is a small one, usually to 18 inches square, and is placed upon the surface of a so-called coding device. This latter is a board having two scales, one horizontal and the other vertical, the letters of the alphabet representing the graduations of the scales. The coding board and photo being of the same size, the outlines of the various tones comprising the picture are traced by means of movable arms similar to those on the Telautograph, and as this is done the positions of the tracing stylus are indicated on the two scales. There are more than 100,000 different positions possible on any picture and the readings on these scales indicate the movement of the stylus from one position to another.

The readings on the scales are thus in the letters of the alphabet and are incorporated into a code message with letters that indicate the exact shade of the various parts of the picture. The system is therefore one which is entirely different from those with which we are more or less familiar; such are the modulated carrier wave system, as used by the R.C.A., and the bichromated gelatin process of Belin and the Jenkin revolving prism methods of telephotography.

The particular picture in this case was a photo of the world-famous American swimming star, Miss Gertrude Ederle, which was taken while she was struggling her way through the choppy sea of the English Channel.

The photograph was developed in the usual manner and an enlargement was made. The enlargement was placed on the coding machine and an operator decoded it. Each position of the stylus corresponded to a group of five letters, the first of which denoted the vertical position on the board; the second, the horizontal position; the third, fourth, and fifth, the intensity of the shading.

Regarding the intensity of the shading, there were five degrees of shades corresponding to plain white, light, medium, heavy, and black. It required 548 groups of letters with five letters to the group to code the picture of Miss Ederle. At the receiving station, an operator had a similar coding board and recorded the series of letter combinations as points. These points were then connected by lines which it is interesting to note were never more than 1/32 of an inch out of the way, and the areas were shaded according to the code letter prescribed.

Thus the picture is built up mechanically by the receiving operator and after final shading has been completed is reduced in proportion to about the size of the original photograph.

This was the process which was used at the receiving station in New York City. In order to send the picture further on to San Francisco, the American Telephone & Telegraph Company's photogram system was utilized, which is entirely different from the Leishman system.

The photogram method consists of the following steps:

A positive transparent print is made of the picture and it is wound on a rotating cylinder which has the light of a small lamp contained within it focused on its periphery. By means of a worm-gear arrangement, the beam of light cuts a tiny swathe 128th of an inch wide, passes through the transparent positive and falls upon the active element of a light sensitive or photoelectric cell. This produces what is known as a modulator current which is super-imposed upon a carrier wave or radio frequency current. It is this modulated current which is transmitted and at the receiving station is brought back into the original picture by means of photoelectric recording devices kept in perfect synchronism with the transmitting apparatus.

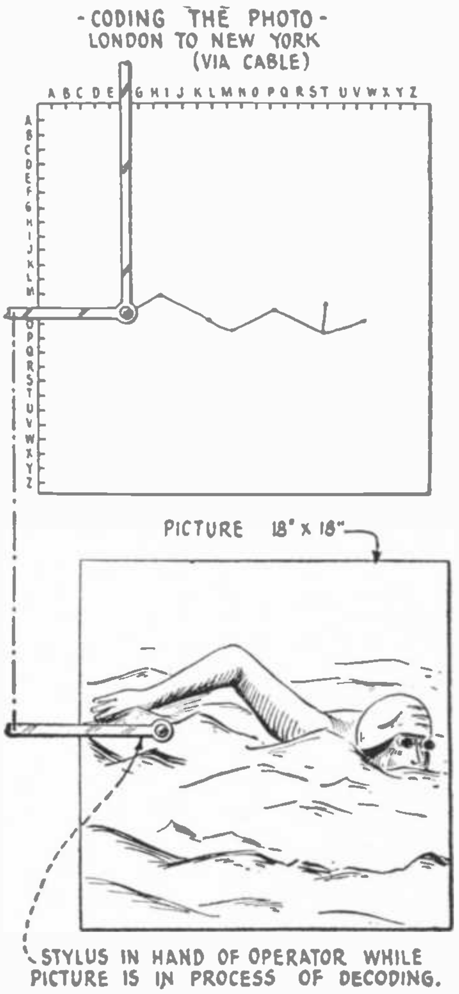
Thus, while the photogram system requires absolute synchronism, the Leishman system is independent of synchronism. In the Leishman system an automatic tape is used to record the letter combinations and the picture can be decoded later at will.

One may be led to believe that minute details could not possibly be reproduced by this system, but the success of the process lies in enlarging the picture before transmitting it. The operator is enabled to outline carefully even the smallest detail and in the picture of Miss Ederle, it will be seen that several bubbles arising from the tops of the waves were exactly detailed.

It has not as yet been possible to send a fluctuating direct current such as would result when modulating by means of a transmitting microphone button, over a trans-oceanic cable. The attenuation in a line prevents such a method being used; as yet it has been impossible to use the modulated carrier wave system. The pulsating modulations which would result from decoding a picture in the manner such as is used in the photogram system or Belin's process would be very similar to the voice currents set up if telephone communication were attempted. And of course as we all know, sub-sea telephony over such great distances has been found impractical.

An analysis of the Leishman process will show that it is a very simple practical method, which involves no special apparatus nor takes into account the time elapsing between transmission and reception as some of the other methods do. It is surprising to note with what exactness it is possible to build up a picture from mere combinations of letters. Even a poor artist can readily fill in with the

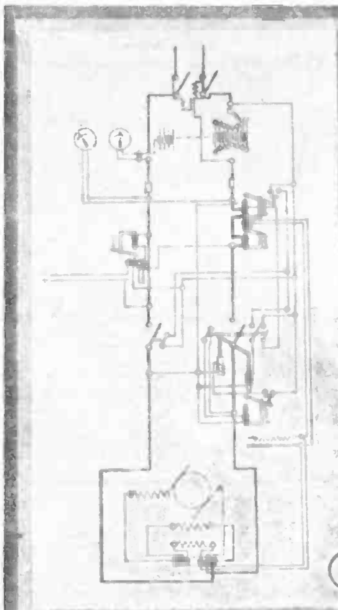
(*Continued on next page*)



Showing the method in which the picture was coded. A pantograph arrangement with a horizontal and vertical scale together with a code representing the intensity of tint of the various areas forms the basis of the Leishman telegraph picture process.

Electricity From Wind

By Dr. Albert Neuburger



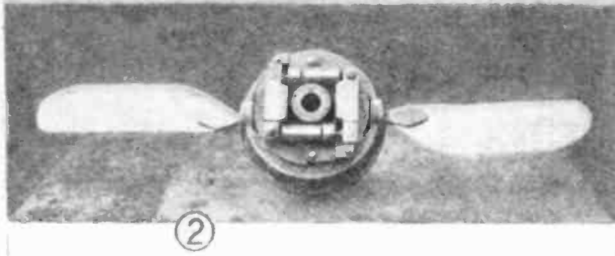
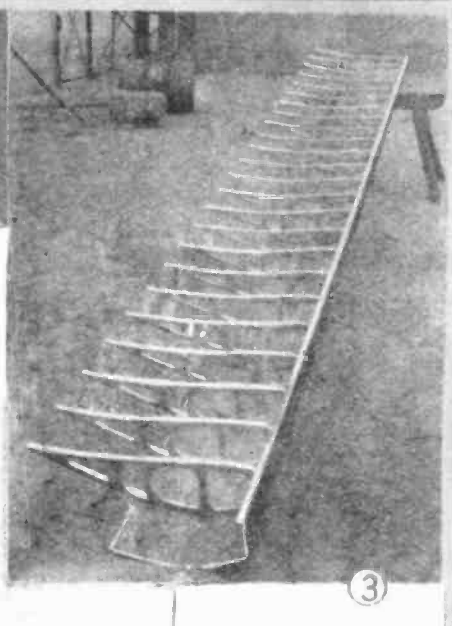
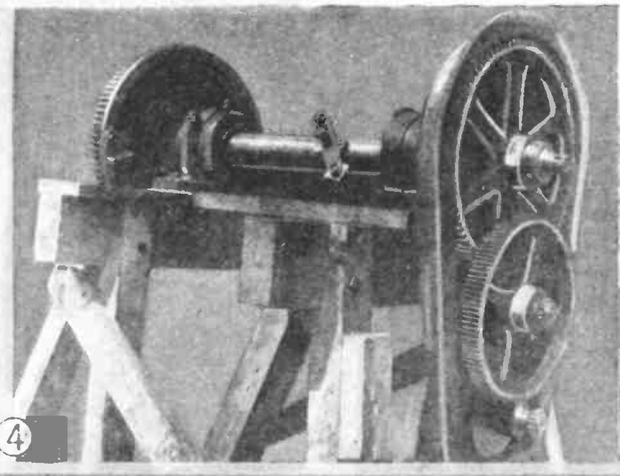


Fig. 1 shows the general layout of what may be called a farm electric generator, taking its power from a windmill, whose speed of rotation is controlled by a governor.

Fig. 2 shows the governor located on the hub of the windmill to prevent it from going too fast in a high wind.

Fig. 3 shows the framing up of one of the wings before it is completed. It recalls the construction of an airplane wing.





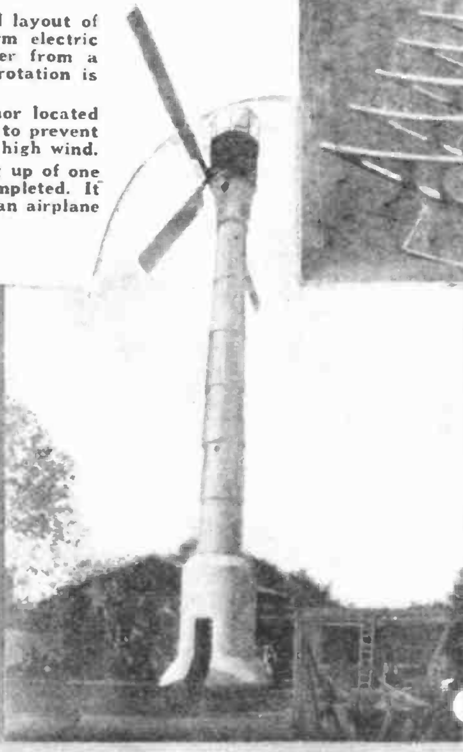


Fig. 4 shows the main shaft of the windmill with the transmission gear for giving proper speed of rotation to the generators.

Fig. 5 illustrates how the apparatus is mounted, presenting quite a contrast to the American system of farm windmill. This apparatus is a German production.

MODERN technical science contrives to make more use of the wind than has been done heretofore; it is specially used to produce electricity. As the wind is an unreliable sort of fellow, which may not blow when electrical current is desired, there are some difficulties to be overcome. Still, the question is settled to a certain degree.

Our photograph shows a wind-motor. Four big wings are to be placed in the direction most favorable with respect to the wind. Based on experience in aeroplanes they are constructed so as to revolve with high relative speed. If the wind has a speed of 18 to 25 feet per second, rather considerable amounts of electricity can be produced by it—of course, differing with the size of the plant. The revolving windmill operates a dynamo generator charging the battery.

The current produced can be used either at once for purposes of lighting, driving machines and so on, or it can be used to charge storage batteries or accumulators. When power is needed and no wind of a sufficient strength blows, the electricity can be taken directly from the batteries where it has accumulated on windy days.

Transmitting Photographs by Cable

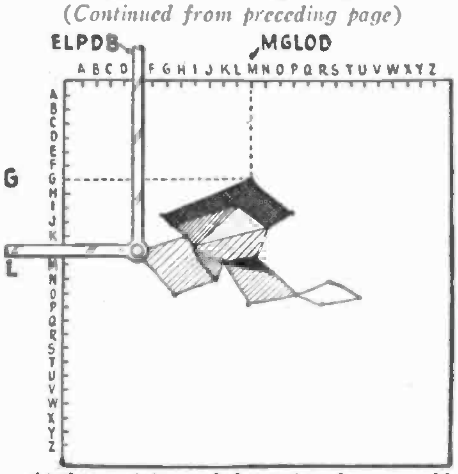
(*Continued from preceding page*)

necessary shades the areas which he outlines by connecting the various points, which he plots.

It would have been possible to send the letter combinations via radio as well as by cable.

In the transmission of the various letters by cable, it has been found that some of them do not register very well and perhaps become unreadable at the receiving station. These characters are omitted and not all of the 26 letters in the alphabet are used. Another interesting fact is the time required to transcribe the character groups into the picture. A relatively short space of time is required to do this but a careful artist will take a bit longer in putting on the final touches.

The following data illustrate the speed with which this particular photograph traveled. After it was taken when Miss Ederle was half way across the English Channel at about one o'clock Tuesday, August 18, a speed boat conveyed the photographer back to Dover



At the receiving end the various letter combinations are plotted by the operator and filled in by the artist.

where a train took him directly to London. There, in the London office of the North American Newspaper Alliance, it was coded by a Leishman operator and sent by cable to the New York office. It is interesting to know that the picture was sent in two parts so that the receiving operator was able to work on the first half of the picture while the second half was still being sent.

As soon as it was completed, it was filed with the American Telephone & Telegraph Company who relayed it by telephotographic process over telephone wires to Chicago and San Francisco, where it was delivered to the press.

While the various methods of transmitting photographs by wire, cable, and radio, have their particular advantages over one another, scientists are far from satisfied with the results and will not stop until the problem of television itself has been solved.

EXPERIMENTAL RADIO

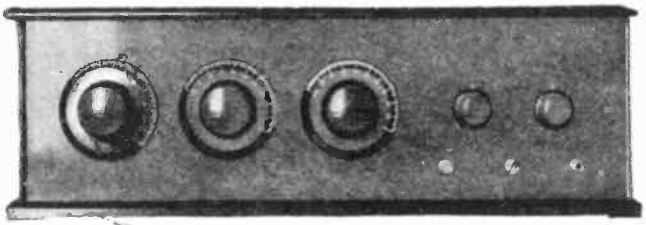
CONDUCTED BY LEON L. ADELMAN

"The Luludyne"

By Simon Kahn, 2CGX

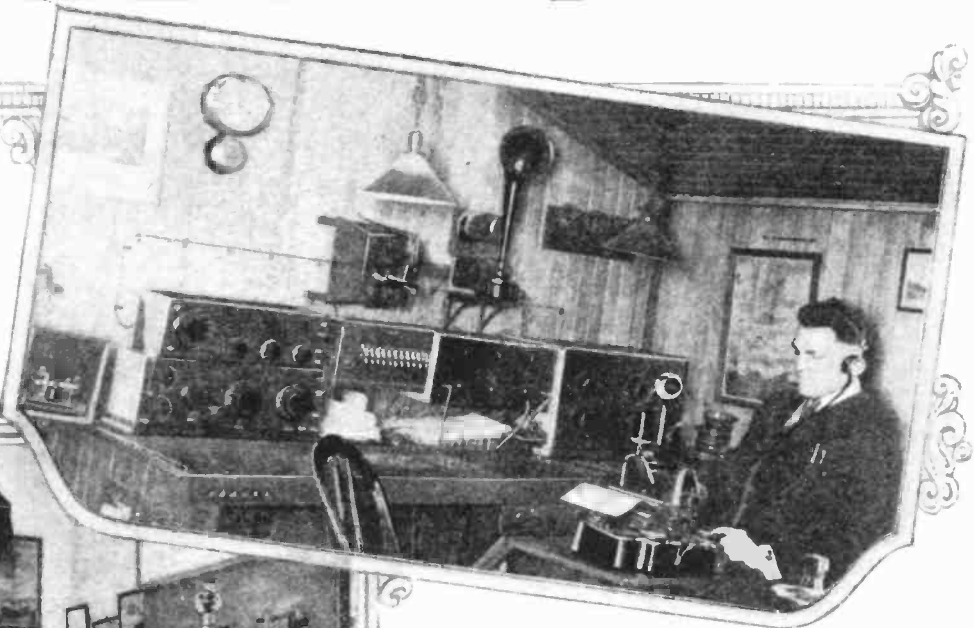
"Lulu always wants to do What we boys don't want her to ———." *

A true and interesting narrative, in which Lulu is the star of inspiration, and Fred creates the masterpiece of his career.



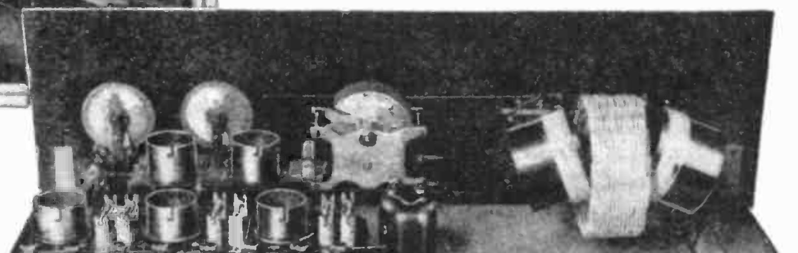
CAST OF CHARACTERS

Lulu—Miss Lucille Falcier.
Fred—Mr. Fred A. Parsons, 2ABM.
Frank—Mr. Frank Frimerman, 2FZ.



A corner of 2ABM's shack with Fred A. Parsons, the owner and chief operator, at the "mill." Mr. Parsons, a real old-timer in the wireless game, has one of the most up-to-date stations in existence. Note the key-switch, plug-jack control system which automatically controls the various relays, amplifiers, meters, motors and signal and pilot lights. A 100-foot triangular pyramidical tower of home-made construction supports the antenna, spark signals from which have been heard over record distances.

Radio 2FZ and Mr. Frank Frimerman at the helm. The station and its owner have gained wide publicity, having been named as first honorable mention in competition for the 1924 Hoover cup. As will be seen from the photo, the apparatus is practically all home-made and a control system similar to the one used at 2ABM is employed. The transmitter is used for phone, CW and ICW, the three 50-watt tubes acting as modulator, speech amplifier, and oscillator, respectively.



Rear view of the famous Luludyne. Note the exceptionally well balanced layout and arrangement of apparatus. Of especial interest are the relatively short leads connecting the various instruments and the separation of the tuning unit from the rest of the set so as to prevent losses by absorption and interaction. The grid leak and grid condenser are connected directly from the tuning condenser to the grid post of the detector tube. This is a vital consideration where efficiency of the highest order is to be maintained.

"OH, for something more exciting," mused Lulu, as she sighed, with restless ease. "This monotonous drone of rise early, dress quickly, swallow breakfast, and then race for the subway in a determined effort to get to work—on time or otherwise—is simply getting on my nerves!"

Versatile Lulu!

Besides the theatre, the art galleries, the chase, the various social functions with their innumerable dances, and a host of other things to take up her time, Lulu had nothing to do except spend an occasional hour in learning the intricacies of radio and practicing the code. In truth, what Lulu could do with two hands, few could do with four. Agile, alert, robust and strong, beaming with a radiance that fairly emanated the health of youth and vitality: her figure—divine even as that of Venus; her hair, a world of it,

*From the popular song hit, "Don't Bring Lulu."

more lustrous by far than Diana's; her eyes —softer and more brilliant than Helen's of Troy; her lips—rubies that shone resplendently, more beautiful than Cupid's bow at its best. Such was Lulu—and more, yes, much more. For Lulu can cook, she can sew, she can sing, and, if I may be allowed to use the familiar phraseology, she can "pound brass," as well as the regular he-man operator.

But with all these diversions, Lulu was restless. Life was becoming just one dull affair after another. Not that she lost interest, nor was bored, but because events seemed to follow in a fixed sequence. Her date book was usually filled for several weeks in advance, and if perchance something transpired to interfere with her plans, she still managed to fulfill all obligations.

Would she care to play tennis this afternoon? No, that would hardly do. Horseback riding came first. Would she like to go swimming some time next day? Sorry, but an engagement to entertain at tea would prevent that. And so on and so on.

To say that Lulu was pampered would not do. She simply wasn't.

True, she had found the study of radio both timely and interesting. For had she not been tutored, in her spare time, by her friends who had followed the progress of the so-called wireless since the early days? Fascinated by the art, she became enthused to such a degree that she finally mastered the code, and it really is wonderful to see her copying at "30 per" with a nonchalant air about her.

But Lulu was quite discontented. Enthralled though she was with the diversity of activities which fell to her lot, she was constantly yearning for something else, some new thrill.

It is rarely that one's wishes and desires are granted and fulfilled to such a large extent as were Lulu's. She usually got what she desired, although she had to work very hard for it. Her grit and determination, combined with an exceptional power of will, soon overcame seemingly impossible situations which might have caused consternation and bewilderment for a man. But in the face of all this she never lost her temper or became angry. To become provoked was not in her constitution. Yet, pity the one who wilfully violated her rights!

* * * * * *

Frank is one of the sort that can stretch the rather vivid imagination beyond the limit of elasticity and then go a step further. Many a time and oft he repeats the episode of the "flying bull"*—when he was able to receive such stations as Nauen, Moscow and Yokohama on a crystal set using a loop antenna during a severe thunderstorm. So he solemnly swears, but little does he dream that Fred, of whom we shall hear more shortly, "fixed" him that evening. (Please don't be too previous. It was nothing to drink.)

For Frank to sit down and work out a problem with pencil and paper was an impossibility, and he admitted it. Strange to relate, he could diagnose a cause and source of trouble in the most perplexing complications, but when confronted with the simplest rudiment, he failed completely to account for anything, except for the fact that he knew he didn't know! Ordinarily, Frank is a high-strung individual who, being temperamental in the extreme, is a fine specimen of a handy man around the house. He is carpenter, plumber, artist and painter, electrician and hod carrier, all in one. But above all, he is an accomplished radio man, adept to a great degree in building, wiring and installing sets. His handiwork is most pleasing and he takes no small pride in his products. In the vernacular, he gets great enjoyment in telling the "cock-eyed world" about his achievements. However, one cannot blame him, because his work is really exquisite and he is continually trying to improve it. And he did try very hard at a special occasion, with most gratifying results. But wait, we shall see later.

Some say that Frank was too busy with his work to think of anything but radio. Others say that he was constantly dreaming of new worlds to conquer. Of these, the latter are correct in their assertion. Frank was a born dreamer. Not that he wasted his time in deep somnambulistic trance, but he strove in utmost fashion to create things worth while. He would start with a spurt, all elated over the prospects on the outcome of some certain project, and then invariably fail to complete it until after too long a time had elapsed. His inspiration seemed to fade out soon, distressing him sorely. How to relieve the situation was beyond his power.

With serious intent, Fred began a lengthy lecture on the benefits of recreation, its effect on stimulating the mind, the body—and the reaction on the pocketbook.

It did not take Frank long to see the point, a very literal transition indeed, for the next week-end saw them both down at Rockaway Point, enjoying themselves and glad to leave the turmoil of the city.

* * * * * *

"I must introduce you to Lulu and the gang," was the opening remark made by Fred when they got there. For Fred and Lulu had been great chums for many years, and by putting two and two together, Fred figured that no small amount of fun was in prospect.

Did you ever meet a fellow who was good looking—a regular fellow in every way who was as "straight as a string"? Did you ever have need of a friend who could be depended upon, be thoroughly trusted and do more for you than justifiable expectation could demand? No less than such a friend was Fred. Muscular, powerful, well-built, with a mind that could think quickly and clearly under the most adverse conditions, Fred was truly a super-man.

Fred was an old-timer in the radio game. He first became interested when announcement was made of Marconi's successful trans-oceanic experiments. The next day, and for several months after, he could be found listening-in, in his spare time. He admits that about all he heard for two months was the 60-cycle A.C. hum from the nearby transmission line. Yet, his persistence, adroitness and general enthusiasm kept him at it, and so after many a moon had passed he was rewarded for his patience by the strains of melodious open-gap spark signals from a ship that happened to be in the immediate neighborhood. From that time on he and radio have been inseparable. What has gone before is forgotten history, as it would take several volumes in order to put down all the escapades, trials and tribulations which were Fred's. You will recall that I mentioned that Fred listened-in in his spare time. Verily, but his teacher must have thought all his time was spare, as Fred had the happy faculty of forgetting to go to school, and often remained at his wireless contraption all day long. But men change with time, and although the proverb states that men are but grown-up children, Fred was the exception that proves the rule.

* * * * * *

The meeting was pleasant, one which I shall not forget soon. I can remember Frank, with face beaming, Fred with flustered cheeks and Lulu with a twinkle in her eyes that fairly teemed with mischief.

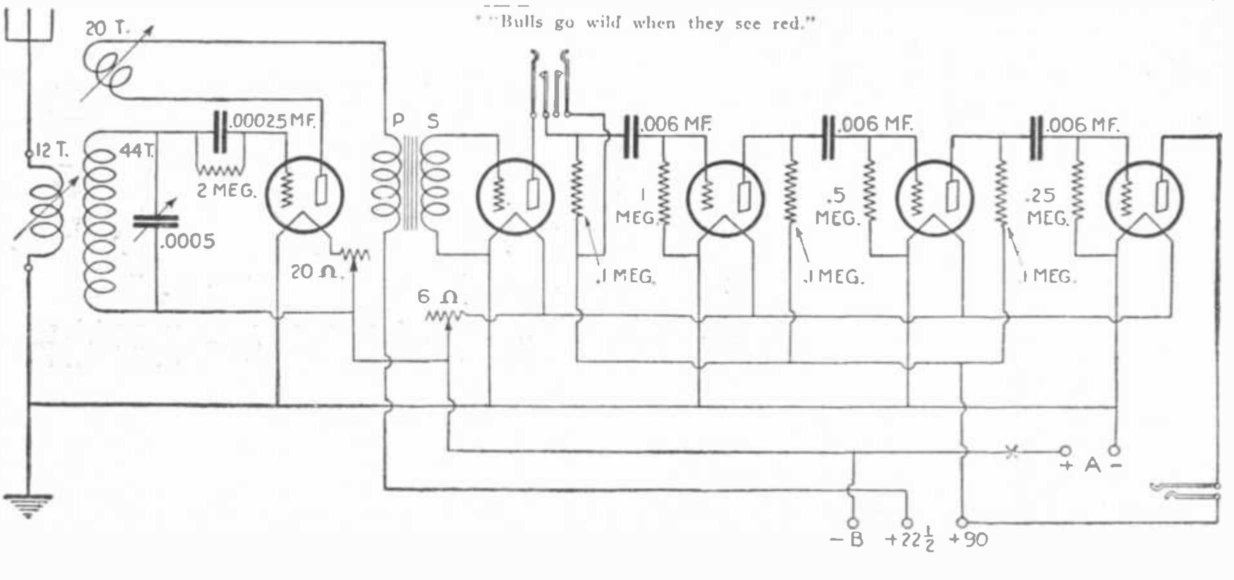
A short time later found Frank raving to Fred about how charming Lulu was. After Frank winded himself—he must have been speaking for several hours—Fred quietly told him that he knew all about it and more. You can imagine Frank's consternation!

Noticing the conspicuous absence of a radio set at the bungalow, Frank suggested that he should bring one up the next week-end. On second thought, he didn't have one which would serve the purpose. Frank usually gets bright ideas, but Fred has the knack of getting brighter ones, so the "four-letter crossword puzzle" suggested that they each build one in Lulu's honor which would do her justice.

It was an excellent idea, thought Frank, and he was in rapturous ecstacy. He knew that Fred was determined to beat his efforts and thus made up his mind to do his very best.

(*Continued on page 48*)

* "Bulls go wild when they see red."



The circuit employed by the Luludyne. It consists of a three-circuit regenerative detector, a single stage of transformer coupled and three stages of resistance coupled audio frequency amplification. It gives splendid results.

Sound and Audio Frequency Amplification

By Theodore H. Nakken*

PART III.

IN the preceding article the author dealt with transformer coupled amplifiers, and indicated a particular construction, which gives exceptionally good results combined with great volume, and exceptional quality for that type of amplifier. However, at the present time it can scarcely be said that the transformer-coupled type of amplifier gives the best possible results, above all at the very lowest sound frequencies.

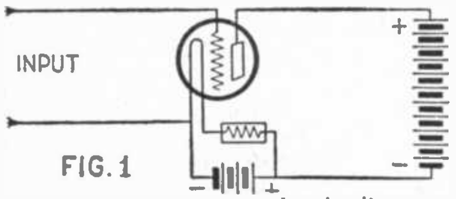


FIG. 1

A simple vacuum tube circuit.

It will now be the endeavour of the writer to give constructional data and a popular explanation of two types of amplifiers, which are almost perfect in their functioning: the so-called resistance and choke coil coupled amplifiers.

Right here it should be pointed out, that these names are more or less wrongly applied, because, as will appear later, the actual coupling between consecutive tubes is not accomplished by resistances or chokes in these amplifiers, but by a condenser. Both types of amplifiers then might rightfully be called capacity coupled amplifiers.

To fully understand the manner in which these amplifiers act is not a simple matter, and an explanation without the use of mathematics, as will be attempted here, is extremely difficult, but with the proper application on the reader's part can be understood.

First of all, then, we must realize, that the tube is the real amplifier. In other words, that when a certain alternating current is fed into the grid circuit of a vacuum tube, an alternating current of greater magnitude will be released in its plate circuit. As the action of the vacuum tube is practically without any lag, almost instantaneous therefore, it appears then as if in some manner the current used to actuate the grid has grown and appears largely magnified in the plate circuit. Needless to say, this increased energy is derived from the plate battery and released by the action of the tube.

Discounting now the true functioning of the vacuum tube and its action in the circuit, we might represent the matter in this way: that it appears as if in some magical way a greatly magnified current has been induced in the plate circuit. Roughly we may say that the amount of magnification or amplification is determined by the characteristics of the vacuum tube, or rather one of the characteristics, which is called the voltage amplification factor of the tube, or, with a convenient term, its Mu, (Greek letter μ.)

Let us first suppose that we have a vacuum tube and that no apparatus of any kind is inserted in its plate circuit. There will then be no other resistance, or, as we are dealing with alternating currents, impedance, in this plate circuit than the internal impedance of the tube itself, its resistance between filament and plate. Such a condition is represented in Fig. 1, where we see a vacuum tube, containing a grid circuit as input, and an extremely simple plate circuit. If in this circuit the "B" battery has a potential of say 45 Volts, these 45 Volts are fully effective across filament and plate, so that we may say that across these two points there is a voltage drop of normally 45 Volts. The current flowing in this plate circuit depends then only on the resistance between filament and plate at the particular moment. As was explained in the previous article, this resistance is determined largely by the grid potential, and therefore, the current flowing is a factor of this grid potential.

As is generally known, a battery connected in a circuit has generally a lower potential than it would show when it was not connected in a circuit; unconnected it shows the so-called open circuit voltage. As soon as it is connected in a circuit, a certain amount of current flows, depending on the resistance in that circuit—and the voltage drops according to the amount of current the battery is called upon to furnish. Thus, if the resistance of the circuit, including the battery, would be nil, the current flowing would be infinite, and the battery voltage would drop to zero.

In our figure we then have a variable resistance, the tube itself—the resistance of the tube being determined by the grid potential. This then causes the battery potential available to vary in accordance with the resistance of the tube, (with the grid potential therefore) but at all times this potential will appear across plate and filament of the tube, neglecting the slight resistance of the battery proper and the connecting wire.

If, however, we insert a resistance in the plate circuit, it is apparent that the voltage

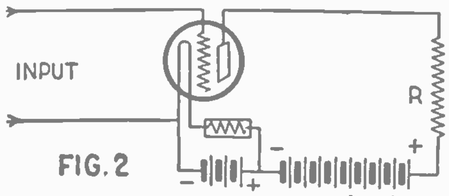


FIG. 2

Showing the relation of an external resistance in the plate circuit. The voltage of the "B" battery is now proportioned between the internal impedance of the tube and the external resistance.

drop in that plate circuit is no more confined solely to plate and filament terminals, but that now there are two distinctly different places where a voltage drop occurs. For this refer to Fig. 2. The total resistance in the plate circuit is now equal to the internal resistance of the tube plus the resistance of R, and if the "B" battery still is 45 Volts, and R is equal to the momentary tube resistance, the voltage drop would be 22½ Volts across the tube and 22½ Volts across resistance R.

But, as has been understood, the tube resistance is not constant, but depends on the grid potential. Imagine now that we were able to completely nullify the tube resistance by means of its grid potential, then the result would be that the total "B" battery voltage would appear across resistance R, which is constant, and in that case the voltage across its terminals would be almost 45 Volts. Or again, if we make the resistance of the tube infinitely large, there would be no voltage whatsoever across the resistance R, as in that case the full voltage would appear across filament and plate of the tube.

Of course these are the two extreme cases, which are never reached in actual operation, but the reader can realize that at least theoretically, it should be possible to vary the voltage drop across the resistance R from zero to almost 45 Volts.

It is then clear from the above, that if we discount the very small resistance of the "A" and "B" batteries, there will appear a changing voltage across filament and plate, when the grid potential varies and also across resistance R, and that these last variations depend upon the proportion between the tube resistance at any moment and resistance R. Also, it can be easily grasped that these variations will be largest when the two resistances are alike, or, better still, when R is greater in resistance than the tube resistance. To understand this, is only necessary to imagine resistance R smaller than the tube resistance, or completely absent, as in Fig. 1. In that case the full voltage fluctuations in the plate circuit are confined to the two terminals at plate and filament of the tube, the resistance of the rest of the plate circuit being negligible, and therefore not showing any potential differences whatsoever.

But—the tube resistance or impedance is constantly varying, and can assume quite high values, and for this reason then, the resistance R should be equal to the higher values of the tube impedance, to retain maximum effectiveness, as explained in the preceding paragraph. It is for this reason, that the best effects would be obtained when resistance R is extremely high, but in that case it would be almost impossible to use the apparatus in practice. To understand this clearly it should be remembered that the vacuum tube needs an effective plate voltage for proper functioning, *i.e.*, a certain voltage between plate and filament. With a given "B" battery voltage, the mean voltage across plate and filament depends on the plate-filament resistance and resistance R, so that if we enlarge the latter unduly, the effective plate voltage decreases to a point where the tube cannot function any more. To attain in those circumstances a suitable plate voltage it would be necessary to increase the total "B" battery voltage, and this of course can be done only to a certain extent, as otherwise the voltages employed would become quite dangerous and great leakage would occur in the B batteries. For this reason we give resistance R a compromise value, mostly of about 100,000 ohms. Due to this arbitrary value there is of course a certain limitation to the pure proportionality of the voltage variations across resistance R, as a consequence of this practice, but it may be stated that in the main, the voltage variations across R are perfect for all practical purposes.

We will now see how we can use these voltage variations across resistance R for the purpose of application to the grid circuit of another tube. For this purpose we

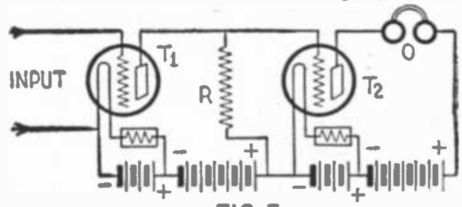


FIG. 3

A theoretical resistance coupled amplifier which would give a maximum transference of energy but which requires the use of separate batteries for each stage.

refer to Fig. 3. There we see two tubes, T1 with the same circuit as in Fig. 2, and T2. The resistance R lies in the grid circuit tube of tube T2. From the foregoing it follows then, that if, as demonstrated in Fig. 2, the voltages across resistance R vary as a consequence of impulses on the input or

* Research Engineer, Radiall Co.

grid circuit of tube T1, there occur the same voltage fluctations across grid and filament of tube T2, and thus tube T2 will be directly affected by the output circuit of tube T1, so that we will have amplification in both tubes T1 and T2, with the result that we will find a greatly amplified signal in the telephones O. But—and this is very serious—we cannot use the same "A" and "B" batteries, because if we did so, the grid of tube T2 would be extremely positive and this tube then would cease to function. As the circuit is arranged now, however, the circuit would function quite effectively, as all that would affect the grid of tube T2 would be the fluctations across resistance R.

Of course it would be quite impossible to use this circuit, on account of the large number of batteries required, and therefore, the circuit should be rearranged in such a way that the same batteries may be employed for all stages. To do this, it is imperative that the grids of the various tubes to be employed should be separated electrically from the steady high potentials of the preceding plates, but only as far as this steady potential is concerned, while the fluctuating voltages of these plates should be effective on the grids of the adjoining tubes. A logical way of doing this is by means of condensers, because it is well known that a condenser is an effective barrier against direct currents and constant voltages, while it affords an easy passage to alternating currents and potentials. The circuit of Fig. 3 changes then automatically to that of Fig. 4.

In Fig. 3 it will be seen, that the circuit of tube T1 has remained the same, but that its plate, instead of being connected directly to the grid of tube T2, is separated from the latter by means of condenser C. If now voltage fluctuations occur across resistance R, these voltage fluctuations will be effective also across the grid and filament of tube T2, because resistance R actually exerts its influence between plate and filament of tube T1, when we disregard, as we may, the batteries. As condenser C conducts voltage fluctuations quite easily, the voltage fluctuations across R are then effective also between the common filament and the grid of tube T2.

Without further additions, the grid of tube T2 would then have no grid return, which in some cases might be extremely detrimental to quality amplification. With most tubes, the grid would accumulate negative charges, due to the electronic emission from the filament, and irregular action of the tube would result, and thus it is necessary to provide a grid return, in the form of a grid leak R1. This grid leak at the same time serves the purpose of affording a by-pass to voltages due to leakiness of condenser C, which condenser rarely would be completely perfect, and which condition would tend to make the grid positive, thus allowing a grid current to flow, again imperiling its proper action as an amplifier.

Of course, several stages can be combined in this manner, but of this we will speak a little later. We will first determine some of the proper values for condensers and leaks.

The grid leak R1 is, as will be readily seen, a direct shunt across the grid and filament of tube T2. This then means, that, if we make its value small, the voltages developed in this grid circuit also will be small—the amplification of which the tube is capable cannot be attained under those conditions. Accordingly, we will make this value quite high—thus retaining the highest possible amplification. R1 should preferably have a value of from 500,000 to 2,000,000 ohms. By making it variable, we can control the resulting amplification completely.

Of course, we will want the fullest benefit of the voltage fluctuations across resistance R, and this means that we will want the influence of condenser C to be as small as possible, or in other words, its apparent resistance to alternating potentials, its reactance, as this resistance is called, should be as small as possible.

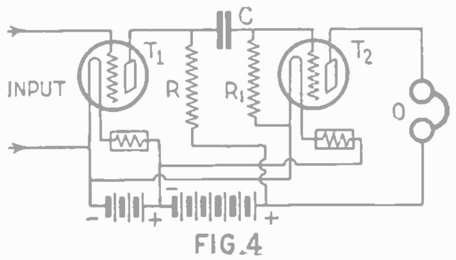


FIG.4

The practical resistance coupled amplifier. The value of the reactance of C at low frequencies should be as slight as possible.

Now the reactance of a condenser decreases with its size and the frequency of the alternating currents applied. Therefore, we must take a condenser which has a low reactance at the lowest frequency we ever will apply. As we are concerned solely with audio frequency amplification, the reactance of condenser C should be quite low at a frequency, if possible, of between 15 and 30 cycles per second. That this should be so will be understood from the following reasoning:

Condenser C and leak R1 are in series as far as the potential fluctuations across resistance R are concerned. Imagine now that R1 has a value of 500,000 ohms, and that the reactance of C at, say 20 cycles, also has a value of 500,000 ohms. In that case then, the voltage fluctuations would be equally devided between C and R1, but only the voltage fluctuations across R1 are effective on the grid of tube T2, so that this grid would only have fluctuations equal to half of the total voltage fluctuations available across resistance R. As we now increase the frequency, the reactance of C decreases, therefore the proportion of the voltage fluctuations across R1 to the total voltage fluctuations available increases—thus the amplification obtained increases, and the result is unequal amplification at various frequencies. We must therefore make condenser C of such a size, that its reactance at say 20 cycles, is insignificant against the resistance of leak R1. This condition can only be obtained when using a large condenser, of one microfarad, for instance. With such a condenser the reactance at 20 cycles is only 8000 ohms, so that if R1 is equal to 500,000 ohms, the voltage fluctuations across R1 will be about 500/508th of the total fluctuations available—practically the whole fluctuation will then be effective and amplification will be almost completely equal over all frequencies, as the increase of amplification with frequency can be only very slight indeed—less than 2 per cent., in fact.

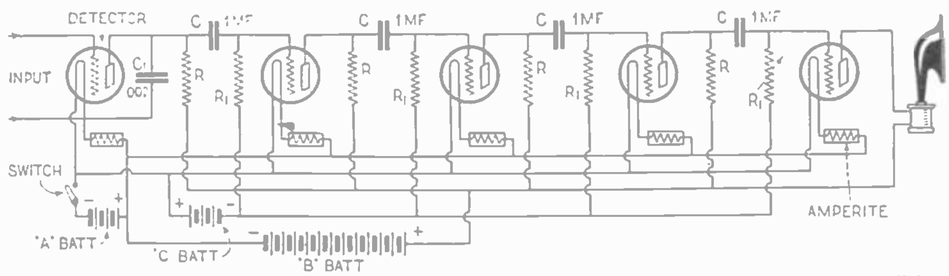
We now come to the actual construction of an amplifier of this kind, but first will consider another point of great importance.

In the preceding article we explained the action of vacuum tubes in detail, and took pains to point out that precautions should be taken that the grid of an amplifying tube never should become positive, as in that case distortion was sure to result. We prevented this occurring by means of a C battery, and stated that the grid should be given such a negative potential, that even with the very strongest signal the grid never would become positive.

It is evident that the same thing holds true in the case of the amplifier contemplated here. One may even say that distortion would be more pronounced in this case. We will see why.

If an extremely strong signal serves as the input and we thus give a considerable positive potential to the grid of tube T2, this grid will at once start to draw a certain amount of grid current, in other words electrons are attracted by the grid. These accumulate on condenser C, because leak R1 does not allow them to flow off rapidly enough. But—this action then means, that the tube is apt to become paralyzed and in any case to distort grievously, because first, by the influence of the attracted electrons, which represent negative charges, the grid cannot complete its full swing toward its highest positive potential, attainable in the absence of electronic charges accumulating upon it. Then, in the second place, when the grid fluctuates toward its highest negative potential, the grid becomes entirely too negative due to the presence of the electronic charge, as far as the latter did not yet leak off. The natural result is tremendous distortion and blasting of the loud talker.

Commercial makers of this type of amplifier seem to have been completely ignorant of the fundamental principles of their own product—and had to find some way out of the above difficulties. They did this by gradually decreasing the resistances of the leaks R1 in successive stages, until in the last stage they went to a ridiculously low value, simply to enable the accumulated charges on the grid and condenser to leak off quickly—which prevented blasting, but left the distortion as it was and decreased the possible amplification appreciably.



The circuit of the carefully designed resistance coupled amplifier using four tubes. It will be noticed that the coupling condensers C are of high capacity and that the grid leak on the last tube is variable. As high as 250 volts can be employed and good volume with exceptional clarity insured.

And yet it can be so easily understood, that the simple addition of a C battery would have prevented the grids from ever carrying current, and thus the trouble encountered would have been ended at once, while at the same time almost perfect amplification could have been obtained.

Another serious drawback in these commercial units is the too small coupling condenser. One manufacturer started out with condensers of only .006 microfarad, which at low frequencies had a very large reactance (at 20 cycles almost 1,300,000 ohms), with the result that amplification at low frequencies was not one-third of what it might have been. At present this manufacturer uses condensers of .1 microfarad, but, while this represents quite an improvement, the difference in amplification between low and high frequencies is still more than 10 per cent.

How strongly this amplifier distorts is proved by the fact that in the literature on

(*Continued on page 48*)

How to Make and Use a Wave-Meter

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

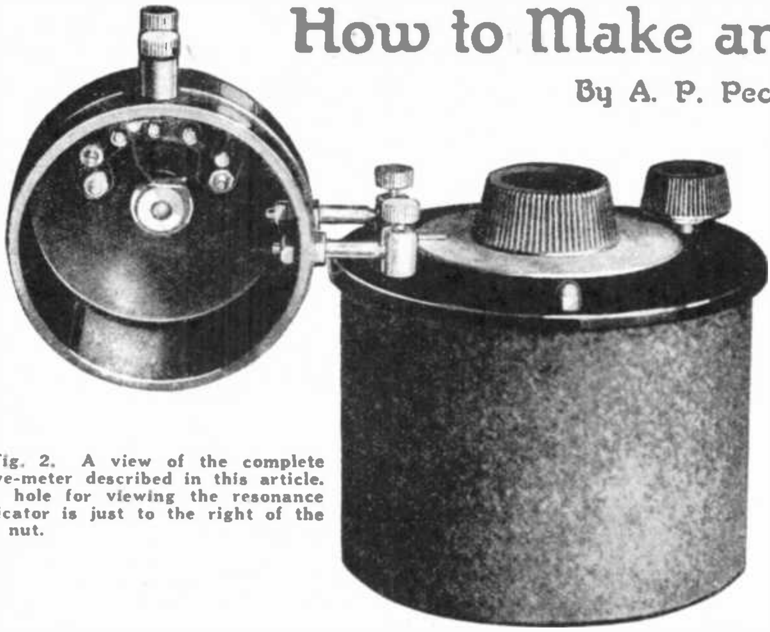


Fig. 2. A view of the complete wave-meter described in this article. The hole for viewing the resonance indicator is just to the right of the cap nut.

IT IS quite true that there have been numerous articles written dealing with the construction of wave-meters in general, but in most of them only the barest outline of the work is given and the uses of the instrument are left to the imagination or the ingenuity of the reader. In this article we will present enough constructional details on wave-meters for the average reader to design his own and at the same time, we will show how to calibrate wave-meters from standards and how to use the instrument to the best advantage after it has been carefully and accurately made.

In essentials, a wave-meter circuit stripped bare of its useful accessories consists of a coil and condenser connected in series and nothing more. Although it might seem that a combination of this kind would be limited in use, still when one knows how to manipulate it, it can be applied in many ways to both transmitters and receivers for measuring the frequency to which the circuits are tuned. In order to extend the scope of an instrument of this nature and make it easier for use in measuring the wave-lengths of transmitting stations, some sort of a resonance indicator may and should be added. For C.W. transmitters, nothing is simpler than a neon gas-filled tube. Probably the easiest way for the average person to obtain one of these tubes is to purchase one of those automobile ignition testers which show a flash of light through a slot in a hard rubber tube. This flash emanates from a gas-filled, electrically sensitive glass tube, contained within the outer protective casing. After you purchase one of these instruments, carefully remove the glass tube from within, being sure not to break any wires that may be connected to the ends of it. Some of these tubes have wires sealed into the ends, whereas others merely are provided with a silver-like coating on each end. In either event, the tube will suit our purpose if it is not broken in removal. This little indicating instrument or resonance indicator, as we may term it, is connected in parallel with the variable condenser in the wave-meter circuit and all of the connections are shown in Fig. 1.

There is an excellent little wave-meter on the market today made by the General Radio Co. that is particularly adapted to amateur work. It consists of a coil and condenser connected as mentioned above and with a little ingenuity the reader should have no trouble in attaching a resonance indicator. The photograph in Fig. 2 shows a view of this instrument and it will be noticed that a hole is drilled in the top of the casing of the variable condenser. This is done so that the resonance indicator, mounted directly below the hole, can be viewed to best advantage. Placing the glow tube within the casing in this manner puts it in the dark and renders even an almost imperceptible glow easily visible. The wave-meter illustrated is supplied with a standard coil that covers a range of from 200 to 600 meters and the wave-length readings are engraved directly on the dial. The accuracy of the unit is great. You can also purchase to go with this wave-meter two extra coils, known as half-wave and quarter-wave coils. With the former, one-half of the dial reading indicates the wave-length to which the circuit is tuned, and with the latter, one-quarter of the dial reading is used. The writer is at present employing one of these wave-meters at his own station and finds it to be very accurate in its work. The only difference between his wave-meter and the one illustrated is in the vernier attachment. The company manufacturing these instruments have now changed from the gear type of vernier shown to a geared vernier dial. Either type is quite satisfactory.

The resonance indicator shown in the photograph in Fig. 3 does not have any wire sealed into the ends, but the silver-like coating mentioned, is provided. All that is necessary to do is to wrap wires tightly around the tube at the ends, as illustrated, and connect the wires to the two terminals of the variable condenser. Before this is done, a hole is drilled and countersunk in the cover of the variable condenser so that the indicating tube can be seen.

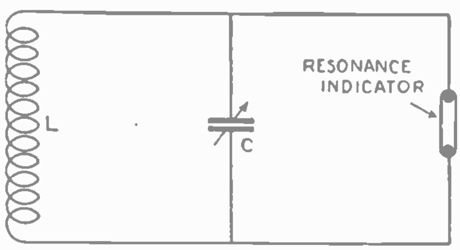


FIG. 1

The circuit of a simple wave-meter equipped with a gaseous tube indicator.

If you purchase one of these complete wave-meters and desire to reach even shorter wave-lengths than the quarter-wave coil will give you, make up a form for winding a basket-weave coil with a diameter of 3 inches. Make up a 2-turn coil using No. 12 D.C.C. wire. Form the ends of the winding so that they can be plugged into the two binding posts. Tie the coil securely so that it cannot change its shape and take it off the form. This coil might be termed a one-twentieth-wave coil and it gives an approximate range of from 10 to 30 meters. Read 1/20th of the wave-length inscribed on the dial when the meter is in resonance.

A 4-turn coil wound on the same size form and securely bound gives a range of from 20 to 60 meters and might be called a one-tenth-wave coil. Read 1/10th of the designated wave-length. Remember that these two coils are only designed for use in connection with the wave-meters illustrated in Figs. 2 and 3 and give only approximate readings. The addition of the resonance indicator or gas-filled tube does not change the characteristics of the circuit very much and, therefore, you need not worry about it.

For those who do not have a wave-meter of the type shown and wish to make their own, the following details will be of value: Use a variable condenser of good make in which the rotor and stator plates are rigid and accurately aligned. Choose one with a maximum capacity of .001 mf. The plates should preferably be soldered together as this results in greatly increased efficiency and precludes the possibility of change in calibration after the wave-meter is in use. The coils to be used with this condenser are to be wound on a cylindrical form 4 inches in outside diameter. This form should be very rigid and the coils must be wound upon it tightly so that they cannot possibly become disarranged. A layer of thread or cord wound over the coil will make the whole unit more rigid.

A range of approximately 40 to 110 meters can be covered with 5 turns of No. 12 D.C.C. wire wound on one of these forms. Thirteen turns covers approximately 65 to 260 meters and with these two coils it can be seen that the more important amateur bands can be covered.

We are not giving any details herewith on the actual mechanical construction of this wave-meter as we will leave that to the reader's ingenuity. The variable condenser might be mounted in a shielded box with binding posts on the top to which the coils can be connected by means of lugs. Ground the shield when using the instrument. You can get a good idea of standard practice in wave-meter construction from Figs. 2 and 3. With the above coils and this variable condenser, an indicating unit can be connected as shown in Fig. 1.

It is sometimes desirable when calibrating receivers to add a buzzer or driver to the wave-meter circuit. This can be done by making the connections shown in Fig. 4. The buzzer current passes through coil L, exciting it and causing its field to interact with the fields of any other coils that may be within its range. More will be spoken of later regarding the use of a wave-meter equipped with a buzzer.

There are other methods of determining resonance in wave-meter circuits than with the gas-filled tube mentioned above. A crystal detector is a common form and circuits for its use will be found in Figs. 5 and 6. We will pass over this phase of the subject quickly because crystal detectors are not suitable for use with pure C.W. stations, but can be used on phone stations. In general, however, the form shown in Fig. 5 is preferable as the exact resonance point can be more nearly determined.

Probably the best all-around resonance indicator, but on the other hand the most expensive, is a current-square thermo-galvanometer having a full scale reading of about zero to 100. This is to be connected in the circuit as shown in Fig. 7.

How to Use a Wave-Meter

Probably the most valuable instrument in the amateur's station when it is properly and intelligently handled is the wave-meter. The whole trouble is that a good many amateurs do not know how to get the best from these comparatively simple instruments. You should most certainly have one at your station if you wish to get the very best results. A wave-meter is very easy to make as can be seen from the above description and you certainly cannot afford to do without one. With it you can determine the wave-length of an oscillator, the wave-length upon which you are transmitting or you can calibrate your receiver and can measure the wave-length of incoming signals.

After a wave-meter has been constructed and before it can be used, it must be calibrated. Before you do this, make sure that the dial is fastened so securely to the shaft that it can never work loose, because if it does, the calibrated curve that you will make will be valueless. The best system to follow for calibrating a home-made wave-meter is to inquire around among your friends and borrow a standard wave-meter. Probably you can locate one of the type shown in Fig. 2. Then make up a standard oscillator using the center tap circuit with a variable condenser across the entire inductance. Place the coil of the calibrated wave-meter near the coil of the oscillator and set the dial of the wave-meter at its lowest reading. Start the oscillator working, varying the wave-length by means of the variable condenser until the resonance indicator shows that the two circuits are tuned to the same wave-length. Move the wave-meter coil further away from the oscillator coil and readjust the oscillator condenser slightly. As you get further away from the oscillator, you will find that the tuning is sharpened considerably and that more accurate results can be obtained. When you have determined the oscillator setting for the lowest wave-length that the standard wave-meter will reach, leave the oscillator condenser at that point and replace the standard wave-meter with your home-made instrument. Turn the dial until resonance is reached as indicated by either the neon tube as in Fig. 1 or the galvanometer as in Fig. 7. You have then located one point on your scale and can start to make up a chart such as that shown in Fig. 8. Use cross-section paper for this work so that accurate plotting can be obtained. Now repeat the same process, setting the standard wave-meter at about 10 degrees higher. Continue this process until you have located five or six points after the manner shown in Fig. 8. If you have conducted this work correctly, carefully and accurately, you will be able to draw a smooth curve between all of the points. If, however, you find that one of the points is off to one side as indicated by XO in Fig. 8, take your readings over again and continue the work until your curve presents a smooth, even appearance. In the writer's opinion this method of calibrating a wave-meter is superior to making an engraved dial. In any event, it is easier for the average amateur to make.

The oscillator mentioned above may be your regular transmitter with the antenna coil removed from proximity to the primary.

After the wave-meter has been calibrated, it can be used in turn for measuring the wave-length at which any circuit is oscillating. If you have a wave-meter that is calibrated but is not equipped with a resonance-indicating device, you can use it on transmitters that have a plate milliammeter in the circuit. Merely couple your wave-meter coil to the oscillator inductance and turn the dial of the wave-meter slowly. A point will be found where the plate current will rise considerably. Now move the wave-meter a little further away from the oscillator and try again. The point where the current increases due to the setting of the wave-meter condenser will be found very sharply and by referring to the curve you can find at what wave-length the oscillator is working. This is a method used for tuning transmitters. After the oscillator is set at the correct wave-length, couple the secondary coil to it and tune the antenna circuit to resonance as indicated by the antenna meter.

If your wave-meter is equipped with a buzzer as shown in Fig. 4, it can be used for calibrating receiving sets or determining the wave-length of an incoming signal. Suppose that a signal is being received. Start the buzzer operating by closing the switch and couple the coil L quite close to the secondary inductance in your tuner. Vary the condenser C and at the point where the wave-meter is tuned to the same wave-length as the receiver, a loud buzz will be heard in the phones. The tuning can be sharpened by loosening the coupling between the coil L and the receiver secondary. You can then read the wave-length of the incoming signal from the chart or the dial, according to the type of wave-meter that you are using.

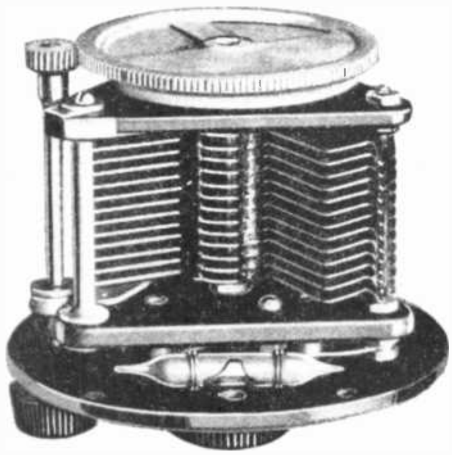
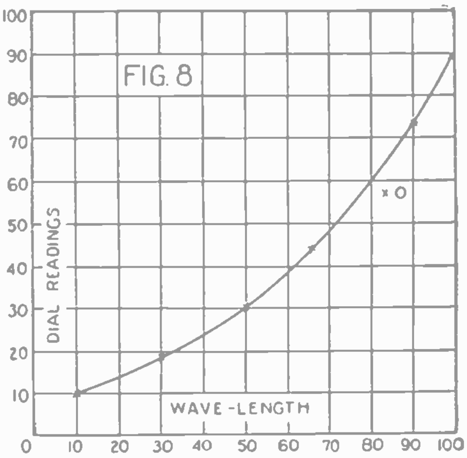


Fig. 3. Here is shown how to connect a Neon gas tube to the variable condenser of a wave-meter. Note peep hole.

In case you do not have any driver or buzzer on your wave-meter, it can still be used for calibrating receivers. When the receiving set is in oscillation, couple the wave-meter coil very closely to the secondary and vary the condenser. At some point on the scale a click will be heard in the phones and two or three degrees further on, another click will be heard. By loosening the coupling, the two clicks will be brought closer together and soon a point will be found where they sound almost as one. This indicates the wave-length to which the receiver is tuned.



This chart will not fit your home-made wave-meter but serves to show method of making a calibration curve.

With an ordinary amateur-built receiver having a variable primary and tickler coil, there is little use in attempting to calibrate the receiver accurately. This is because there are so many variables that must be taken into consideration. However, you can get a rough estimate of the range which your receiver will cover by one of the methods described above and that estimate will often come in very handy in tuning.

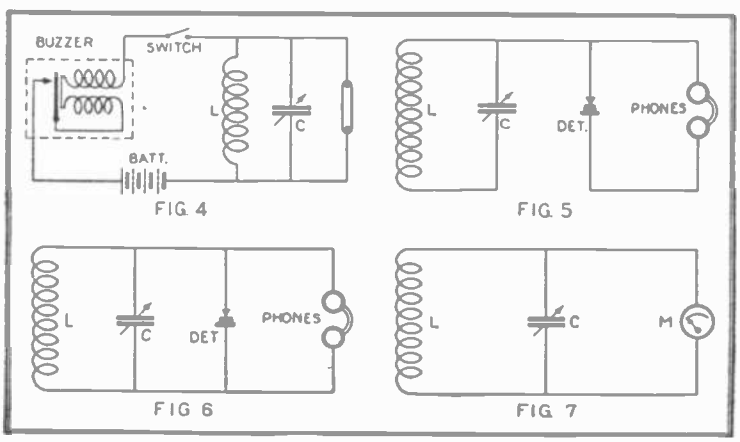
Of course, one can also calibrate a receiver or wave-meter, by using the harmonics from an oscillator or transmitter whose fundamental is known.

Thus you can see that a wave-meter is an almost indispensable adjunct to any experimental radio station. With it you can perform many experiments, can do your work quicker and more accurately and can be more sure of your results when you are through. When you start to tune a transmitter, you will be through much sooner if you have a wave-meter on hand. You will not have to tune it to what you *think* might be the wave-length upon which it is to operate and then call a half a dozen stations for reports. Instead, you will tune the set and then check the wave with the wave-meter. Thus you can set your transmitter at any wave that you desire without any trouble other than the ordinary balancing of the inductances and capacities.

Then again, when somebody calls you, and asks for a report on his wave, you can give it quite accurately and quickly by checking with the wave-meter against your receiver as described above.

We believe that we have covered the subject of amateur wave-meters quite thoroughly in this article, but if there are any questions that may arise in the minds of our readers regarding the construction or use of these most useful instruments, the writer will be only too glad to help them further.

As a valuable suggestion, it would be well for one to mark the corresponding frequency alongside the wave-length on the graph, thus saving later computation and trouble.



Four circuits of different types of wave-meters are given at the left. Type shown in Fig. 7 is most efficient, but, on the other hand, it is most expensive.

Modulated Oscillator for the Radio Experimenter

By Theodore H. Nakken*

ONE of the most useful appliances around the radio experimenter's laboratory is an oscillator, which has quite a number of applications for measuring and calibrating purposes.

Yet, most oscillators have to be used in conjunction with expensive apparatus and meters, because a pure oscillation cannot be detected by an ordinary radio receiver, unless another oscillator is used simultaneously and one works with the heterodyne method.

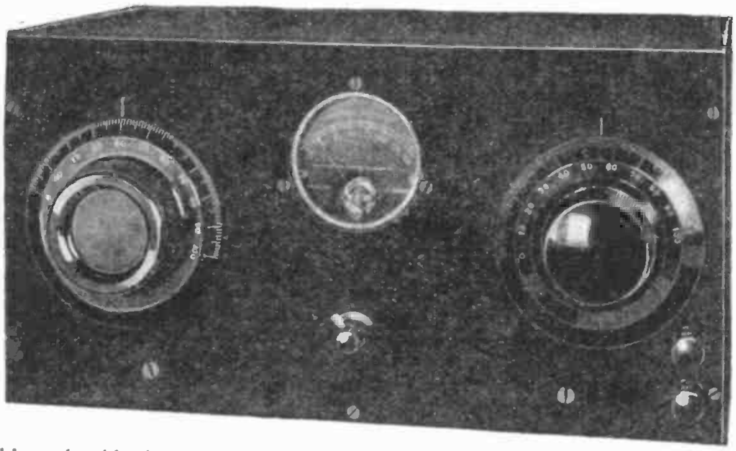
The modulated oscillator described in this article can be used to advantage by any experimenter, for calibrations, testing and comparing receivers and the like, determining wave-lengths covered, etc.

The instrument is extremely cheap and functions remarkably well, requiring only dry cells for its operation, if so desired.

The principle upon which it is built is to have an ordinary oscillator modulated by means of a small buzzer, such as made by several concerns. The buzzer used in this instance is a Federal Century buzzer, which is very cheap. If it be so desired, a more elaborate buzzer system, like the General Radio Co.'s 1,000-cycle oscillator, can be used, and the only change necessary in that case is to enlarge the cabinet.

The complete diagram of the oscillator is given in Fig. 1. It will be seen that the whole oscillator with batteries and all can easily be housed in a 7 × 18-inch cabinet, if the arrangement is built carefully.

The oscillator, to answer its purpose, should be completely shielded, and the cover should be so arranged that when it is screwed down in place and the box is closed, there is formed a completely metal-encased space. The easiest way to accomplish this purpose is to first mount all instruments on the panel and, this accomplished, to use the panel as a sort of template. After having cut out a piece of sheet copper generally used for shielding purposes exactly the size of the panel, we punch or cut holes to accommodate all controls, switches and fastening screws.



The modulated oscillator mounted in its hermetically shielded cabinet. The plate milliammeter on the panel shows whether the outfit is functioning properly. On the left is the tuning control, while on the right is the coupling dial. Ranges: 125-240λ; 185-590λ.

The cabinet should preferably be a plain one, where the front panel is fastened by screwing it to the front edges of the bottom and sides of the cabinet. The top of the cabinet should be removable, no hinges being employed, and should be screwed down after the oscillator is completed and after the tube and batteries are placed in the cabinet.

The cabinet is lined throughout with copper sheet which is soldered together wherever the sheets join. The copper should overlap all the front edges, where the panel will be screwed on. In this way the panel shield comes in metallic contact with the inner lining of the cabinet on all the edges. In the same manner the lining should be bent over the edges at the top of the cabinet, so that the upper edge, when later the cover is screwed down, forms a complete metallic surface to receive the cover.

We now shield the cover plate, the shield covering its entire surface and bend it over the edge where the same plate is later to join the panel. The panel is, of course, so arranged that it is fastened by means of screws to bottom, sides and cover of the cabinet.

After the whole instrument has been built and tested for oscillation after assembly, we will have a completely shielded container, so that the only place where the oscillations are effective is at the two output binding posts, which are provided for exactly that purpose. While in use the shield should be grounded, for which a separate binding post must be provided.

So far the shielding of the instrument—we will now shortly describe the instrument itself. See Fig. 1.

We see first of all coils L1, L2, L3. These coils can all be wound on a single 3-inch length of 3-inch tubing. Coil L1 consists of 43 turns of No. 26 double silk-covered wire, and is tapped at the 20th turn. Coil L2 is the plate coil, wound about ⅛-inch from coil L1, and has 15 turns. Coil L3, the pick-up coil, has 6 turns, and is spaced again about ⅛-inch from coil L2. All coils are wound with the same wire, in the same direction.

Coil L1 is tuned by means of a variable condenser of .0005 microfarad, and coil and condenser form a tuned circuit. The condenser is indicated at C1.

An ordinary switch, a battery switch for instance, S1, allows the lower part of coil L1 to be short-circuited, so that we obtain two tuning ranges. The one for long wavelengths is obtained when the switch is open, when the whole coil is used. The other range is obtained when the switch is closed and thereby 23 turns are short-circuited, so that only 20 turns are in service. This gives us a short-wave oscillator.

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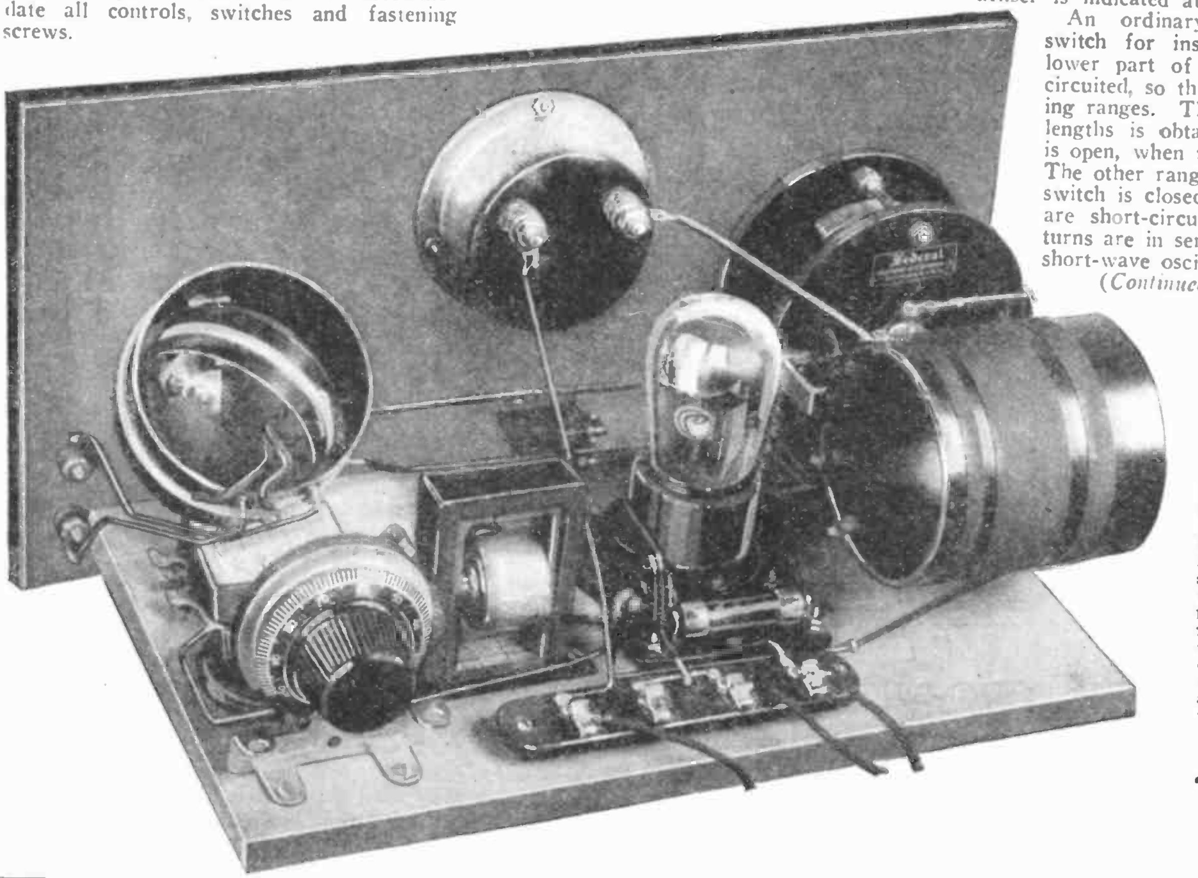


Rear view of the assembly showing the various parts and their relationship. Immediately behind the rheostat is a small Century buzzer which modulates the radio frequency currents generated by the tube. The rheostat is connected in series with the buzzer while the amperite controls the tube.

*Research Engineer, Radiall Co.

A Selective Receiving Circuit

By Donald E. Learned

A GOOD many radio fans nowadays are progressing from one set to another in a vain attempt to find a more selective receiver, which will at the same time bring in the stations with undiminished volume. Consequently, all kinds of "-dynes" have made their appearance on the market, and on the pages of the many radio publications, until one wonders that they do not run out of names. A great many of these "dynes" are not delivering the goods in accordance with the apparatus employed, and the number of the tubes used. It might be well to suggest that the same individual care should go into each unit of a multi-tube set as is used in making a single tube set, otherwise it is possible that the results will be no better than from the "single-cylinder" set.

The writer has used the hook-up here described for two and one-half years, in one form or another, and has tried out the bulk of the new hook-ups during that time, only to turn back to the old four-tube outfit.

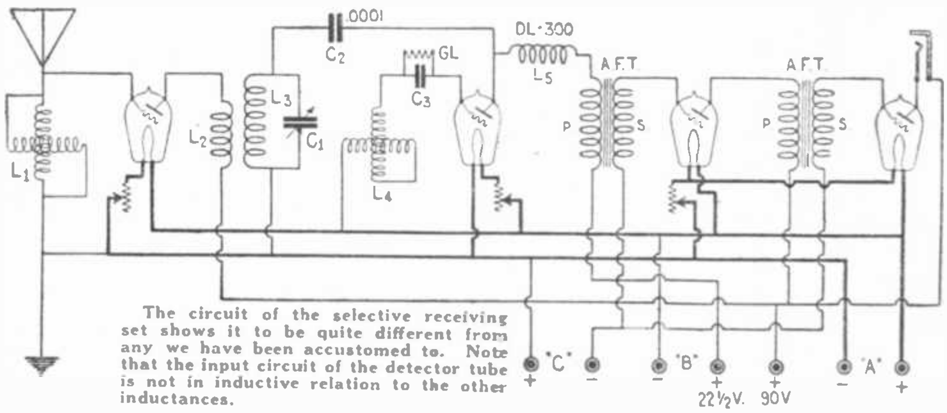
It is not intended to give the impression that this circuit is a "world-beater," but it brings 'em in in good shape, with plenty of volume, and is sufficiently selective to deliver the goods. The locals don't bother and (whisper it) the writer has forgotten that they were on many a night. The set may be logged easily, although the dials do not read together, and the set will not radiate on the average antenna.

A glance at the diagram will show something different, but at the same time not so extraordinarily novel. The output of the first or radio frequency tube is fed into the plate circuit of the detector tube, leaving the grid circuit free from any connection or coupling to the input circuit, except that provided by the detector tube. This last feature has earned the nickname "full-floating grid" for the set. Selectivity is gained thereby.

As to the theory of this circuit, all the writer can hazard is contained in this paragraph. The amplified signal at radio frequency is fed into the plate circuit of the detector tube and there rectified. The reaction of the radio frequency charges on the plate causes like variations of grid potential. These changes in turn react on the plate circuit, controlling the audio currents in the detector output circuit. The rectification of the R.F. output of the first tube tends to stabilize it, as a similar action of the first tube steadies the second. On strong signals the detector +B lead may be connected to —B and reception will take place very satisfactorily.

Any good standard apparatus may be used in constructing this set. The following list is suggested:

- 1 7" × 21" bakelite, hard rubber, Radion or Celoron panel.
- 7 Binding posts.
- 3 1" × 8" terminal strip.
- 3 Rheostats (Bradleystat for detector tube).
- 3 4" Dials.
- 1 Open circuit jack.
- 1 "A" battery switch.
- 2 Audio frequency transformers (4½ to 1 and 3 to 1).
- 4 Sockets.
- 4 Tubes.
- 1 4½-volt "C" battery.
- 1 Split variometer "L1".
- 1 Aperiodic R.F. transformer "L2 and L3" (neutroformer may be used).
- 1 .0005 mfd. condenser to match above.
- 1 Fixed mica condenser .0001 mfd. "C2".
- 1 Fixed grid condenser .00025 mfd. "C3".
- 1 Grid leak to suit tube.
- 1 600-meter variometer "L4".
- 1 D-L 300 coil "L5".
- 30-ft. hook-up wire.
- 2 oz. resin core solder.
- 7 7" × 19½" baseboard or to fit cabinet.



The circuit of the selective receiving set shows it to be quite different from any we have been accustomed to. Note that the input circuit of the detector tube is not in inductive relation to the other inductances.

Modulated Oscillator for the Radio Experimenter

(Continued from preceding page)

The system is connected as the grid circuit of a vacuum tube T, which conveniently can be a WD12 tube, as this tube only requires a dry cell as its "A" battery. No rheostat is used, an Amperite serving to control the filament. A small 22½-volt battery, "B", serves as plate supply.

The tapped coil is connected directly to the grid on one side, and to the filament on the other side over a small fixed condenser, C2, which may be of .001 microfarad. This condenser is shunted by the secondary of a transformer, Tr, which completes the grid return.

This appliance, Tr, is preferably made at home from an old burnt-out transformer. If such a transformer is not available, a core can be made from iron wire bunched together, as all we will use from the transformer is the core. On this core then both primary and secondary are wound with about 100 turns of No. 26 wire each, taking care that primary and secondary are well insulated by means of paraffin paper, empire cloth or the like. The transformer should be finished as nicely as possible.

The primary of this transformer is hooked up in series with the Century buzzer "Br" and the battery "A". Battery switch S2 then disconnects both tube and buzzer in its off position.

The pick-up coil L3 is now connected to a coil L4, which preferably is one of the two coils of a 180-degree variocoupler. This coupler, however, is rewound in such a way that both primary and secondary have but a few turns—8 each, for instance. The other coil is connected directly to the two output binding posts BP.

By varying this coupler from 0 to 100 the strength of the modulated oscillations available at these two binding posts is varied, while condenser C1 regulates the wave-length. By connecting the output binding posts to the antenna and ground connections of a receiver the modulated oscillations will act as an ordinary signal and the buzzer tone will appear in the head-phones or the loud talker, if oscillator and receiver are in tune.

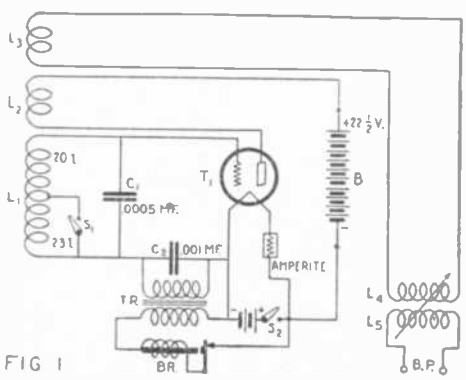


FIG 1

The modulated oscillator is a handy device which is certain to find numerous applications by the experimenter. It can be seen that the device covers two ranges of wave-lengths. Graphs should be made of these ranges.

Calibration of the oscillator is easily accomplished by means of a wave-meter or by means of comparisons with known broadcasting stations or amateur transmitters. The procedure is as follows:

If, for instance, WEAF is received at the locality of the experimenter, the receiver is tuned to that station. Now the oscillator is substituted and connected to antenna and ground binding posts. C1 is then tuned till the buzzer tone is heard in the receiver, which then is an indication that the oscillator is working at 492 meters.

The oscillator is now left as it is (still going), and on the receiver we retune till we have tuned it at the lower range to 246 meters, which is indicated because then we receive the buzzer signal once more, but now on the first harmonic of its wave. We now leave the receiver in this position and retune the oscillator till once more the buzzer is heard, and we know then that the oscillator is working at 246 meters, and in this way we have obtained two points of its tuning chart. Doing this with different wave-lengths, controlled by different stations, we will soon have a complete calibration chart of the whole instrument.

QRM—[I am being interfered with]

By George H. Turner
Asst. Radio Inspector, 9th Governmental District

"THERE is that amateur fellow again with the everlasting code playing with his radio and disturbing my radio reception. I shall have to report this interference to The Radio Supervisor." So sayeth the belligerent B.C.L. (Broadcast Listener.)

"Hang it all, here comes that inductive interference again. I wish someone would se about it." So sayeth the exasperated Ham. (Amateur.)

And I, who have had experience with both classes, know that they mean well even though they are very prolific in their denunciations of radio when their reception is interrupted in the slightest. They long for the cool nights in the spring or fall and the crystal clear, cold nights of winter when radio DX comes pounding in from all sides. For the broadcast listener who holds a charter membership in this greatest fraternity, this happened quite often back in the days when broadcasting was in its infancy.

The amateur, on the other hand, has been more fortunate in that he has passed out of an era of chaos which was made up of spark transmitters, arc lamps, sputtering spark coils and the like, into the era of practically pure C.W. (Continuous Waves) which is truly an approach to the ultimate. For the broadcast listener though, those good nights are few and rather far between these days, unless one lives in some secluded spot where conditions are more or less ideal, say for example, away out on the Kansas plains or in the middle of the North Atlantic. The broadcasting game is growing more and more complex for those who live in congested districts. The more you turn your dial the more convinced you are that it is growing worse and worse. Permit me to enumerate just a few of the causes of this trouble. And these apply to the broadcast listener and amateur alike. If the shoe pinches, you know it fits—an old proverb changed to suit present requirements.

First, and perhaps most aggravating, we have interference of an inductive nature caused by power leaks, conflicts, defective insulators or any interruption of an electrical circuit carrying sufficient voltage to set up radio frequency waves or waves whose harmonics extend into the radio bands at each interruption or break.

Second comes interference caused by oscillating receivers—applicable to B.C.L. and amateur.

Of third importance we have stations interfering with each other in the same band—as amateur with amateur.

Fourth, and practically a part of the third division, comes interference caused by one service to another. In this class commercial and naval interference must also be considered.

Fifth, and for brevity's sake, the last to be discussed is defective apparatus.

Now that a few of the more severe and various causes of interference to radio reception have been mentioned, it is time to take up the consideration of ways and means of locating these faults. However, first it is my duty to advise, instruct and warn my readers, that if they expect this article to furnish more than a passing thought, they must place themselves in a receptive state of mind, willing to retain the information that is to follow, for future use in locating and curing some of the above-mentioned faults when it so happens that their own reception is interrupted. It goes without saying that thought alone or profanity either, for that matter, can never remove that buzz from the ether nor that code from the church services. With this warning in mind we will now take up the method of locating interference of an inductive nature.

"The Thinker"—(with apologies to Rodin)

This young fellow needs a bit of sympathy. He is in evident perturbation and is apparently vexed by the reproduction of sounds similar to midnight feline serenades and breaking of dishes — in other words, music.

This is oftentimes very difficult, inasmuch as it is very intermittent in character. Such interference may come in on waves anywhere on the dial and usually with unbearable intensity. Because such interference is only of short duration and only occasionally at its worst, it requires special efforts to locate its source. For instance, one proven method would be by means of bearings taken by three or more observers using their receiving sets on loop antennae. Naturally, the observers should be as widely separated as possible and at the same time their reception of the interference should be with sufficient intensity to use a loop. It is now possible to remain at your own receiver and obtain a bearing on the source of the trouble.

A little hint regarding the swinging of a loop on interference: greater accuracy can be had by swinging for minimum signal rather than for maximum. In this case, of course, the interference will lie at right angles to the plane of the loop. Once this plane has been determined it can be verified by swinging for maximum intensity. This is necessary if an uni-directional connection is being used in order to determine the point on the compass from which the interference originates. Now, by comparing the findings of the different observers and extending the planes of greatest signal pickup or normals to the planes if minimum intensity is used, until they intersect, this intersection will be found to be geographically very near the source. It is then only necessary to make a visual inspection at your convenience in order to find the cause of all the trouble. Sometimes, it may be a "high line" passing through trees where the limbs have rubbed the insulation from the wire leaving it bare to spark to ground through the moist tree. Again, it may be a down-guy in conflict with a supply line. Or it can be anything electrical that makes and breaks contact, causing sparks that are oftentimes barely visible to the eye, but on an eight-tube "super," fairly wreck the ear. As an aid in locating outside interference the following list of general causes is given:

1. Conflicts as mentioned above.
2. Leaky and cracked high tension insulators.
3. Defective lightning arresters.
4. Transformer fuse block with corroded or loose contacts.
5. Unsoldered joints on primary or secondary wires.
6. Loose connections on old type 1,100-2,200-volt transformer terminal boards.
7. Failure to ground transformer neutrals.
8. Defective transformer bushings on 2,300-volt side.

Occasionally, our bearings indicate the trouble as originating from an electrical power station or sub-station. Therefore, a list of representative troubles of this sort are also given as follows:

Sub-station:

1. Broken or leaky high tension or low tension bushings.
2. Loose connections on transformer terminal board.
3. Fuse wire or fuse holders making poor contact with resulting arcing.
4. Disconnecting or sectionalizing switches making poor contact with resulting arc.
5. Charging of electrolytic arresters.

Power station:

1. Defective current and potential transformers.
2. Defective grounds on lead cable sheathes.

Again, it is possible for a telephone exchange to the the point of origin. Such interference often results from the operation of ringing devices in telephone exchanges. The machines responsible for most of the interference are those in which the A.C. for ringing is derived from D.C. supply, by an interrupter. The ringing current wave from such devices contains frequencies which extend over into the radio frequency band. For the reason that they oftentimes extend over the entire broadcasting band it is impossible to tune out the interference.

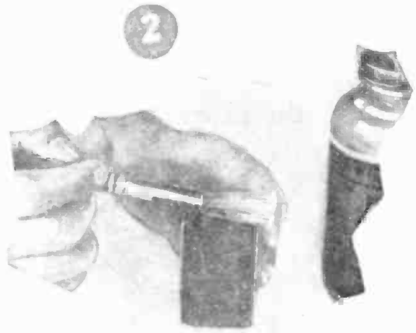
If, upon investigation, the interference appears to originate in a residence, the follow-

(Continued on page 47)

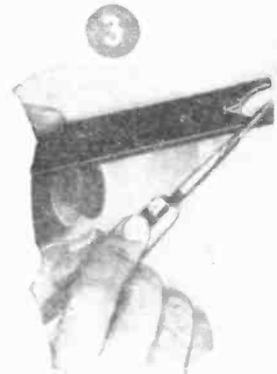
How to Make a Toroid Coil

By Herbert E. Hayden

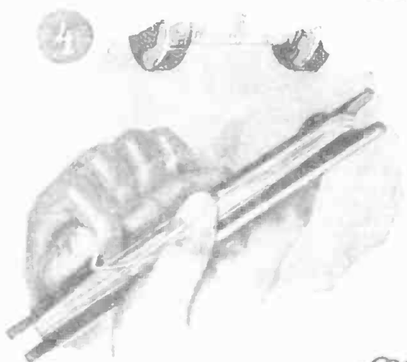
First, take a piece of cardboard tubing 3½ inches in diameter and saw off a ring 1¼ inches wide. Bakelite, hard rubber, celoron or formica tubing can also be used and results in lower absorption losses.



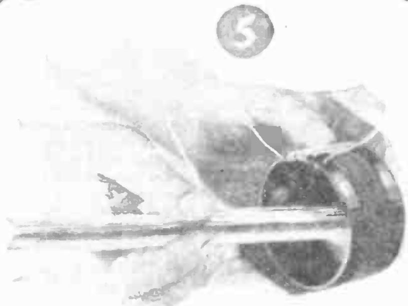
A good grade of orange shellac should be used and the tubing is given two coats and allowed to dry thoroughly. Do not use ordinary varnish as a substitute for shellac, as it is far inferior.



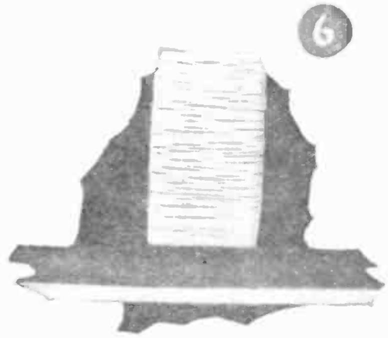
Next, take a wooden stick about 10 inches long and one inch wide and cut two deep notches, one at each end. The jack knife is pointing to one of these U-shaped notches at the end of the stick.



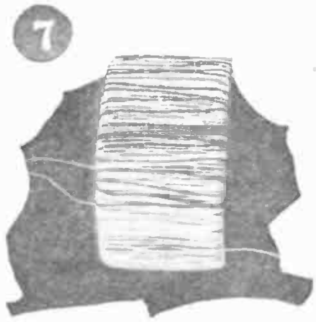
Wind 45 feet of No. 24 D.S.C. magnet wire on the stick as shown. With this simple appliance it becomes a far easier task to wind the coil than otherwise, as you will note in the next photo.



Having made two pin holes in the tubing, to anchor the winding, the wire is then easily wound round the ring as shown. The stick with the wire is passed through the core, over and through again.

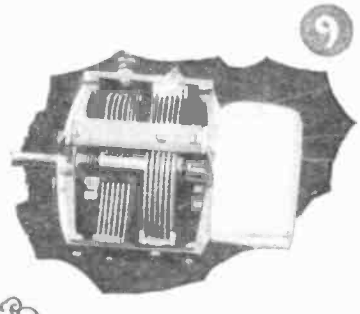


The toroid coil with its completed secondary winding of 250 turns. At least 6 inch leads should be allowed for terminal connections. The next step is the primary winding which is wound over the secondary.



Consisting of 45 turns of the same size wire, the primary is placed directly over the secondary and its turns are spaced so as to completely dispose themselves over the entire secondary winding.

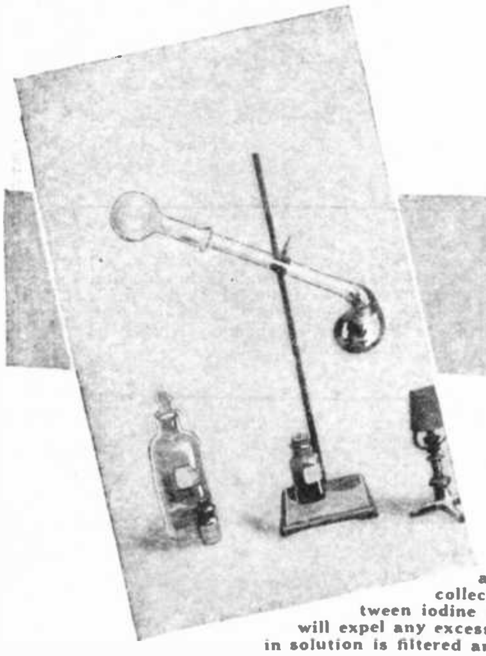
In order to protect the windings, the coil is covered with thin cotton tape one-half inch wide. The leads are allowed to project through, there being, of course, four of them.

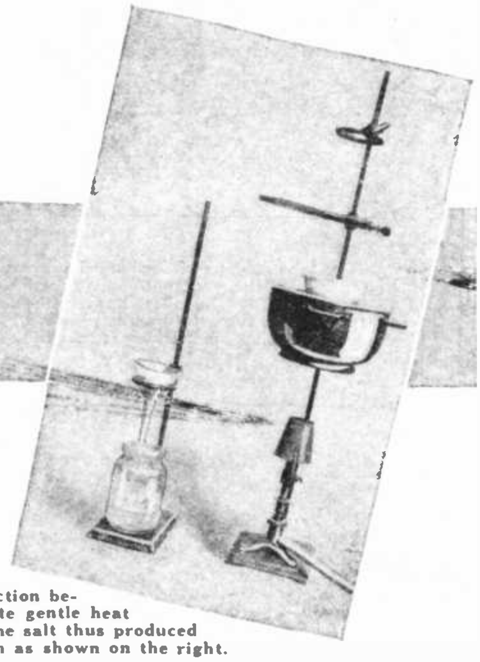


The completed coil is mounted on the back of a low loss variable condenser having a capacity of .0005 mfd. The toroid offers an excellent inductance since its external field is very slight.

Interesting Experiments with Iodine

By Eugene W. Blank





On the left is shown the apparatus for producing and collecting iodine. Manganese dioxide, sulphuric acid and an iodide are heated in the retort, and the sublimed iodine collects in the flask. In the center is shown the reaction between iodine and iron filings. After the reaction is complete gentle heat will expel any excess of iodine, and you will have ferrous iodide. The salt thus produced in solution is filtered and evaporated to crystallization on a water bath as shown on the right.

IODINE is a greyish-black, lustrous solid discovered in 1812 by Courtois who obtained it from the ashes of sea plants. It forms beautiful violet colored vapors when it is warmed to volatilization and this phenomenon is what led to its discovery.

It is found free in small amounts, being present in the waters of some mineral springs and in the sea. In combination it is found in larger quantities; the main source at present is the crude Chilean saltpeter obtained from South America. It is present in the sodium nitrate as sodium iodate and constitutes about 0.2 per cent. of the whole. The saltpeter is treated with sodium bisulphite and the iodine is precipitated from the solution. It is allowed to settle, collected and rendered pure by sublimation. Sublimation is the process of changing a substance to a vapor and then condensing the vapor on a cool surface. Non-volatile impurities are left behind.

Iodine readily dissolves in some iodides, and the solution is used as a counter irritant in medicine. Iodine is also administered internally in diseases which are caused by disturbances in the thyroid gland.

The experimenter can readily prepare iodine by placing in a retort a mixture of manganese dioxide and potassium iodide. A little sulphuric acid is then added to the mixture and the retort is gently heated. The liberated iodine passes into a dry flask inverted over the end of the retort and the iodine collects on the cool sides of the flask. The iodine in the flask can be dissolved in alcohol and used for some of the following experiments.

Iodine can readily be detected by the blue color it imparts to starch solution. To a little of the alcoholic solution of iodine just made add some dilute starch. A blue to violet color will appear. The starch solution can be made by heating some starch in a small quantity of hot water.

Iodine in combination, that is, united with some other substance, will not give this reaction. In that case we take the salt, potassium iodide for example, and add to it a little chlorine water This frees the iodine from its chemical combination and when carbon disulphide is shaken with the solution, the iodine will dissolve in it, giving a beautiful violet color.

Iodine reacts with many substances to form compounds known as iodides. This can well be illustrated by the action of yellow phosphorus on iodine. Place a small piece of yellow phosphorus on a ring stand base and over it place a few crystals of iodine. A violent reaction accompanied by flame will take place.

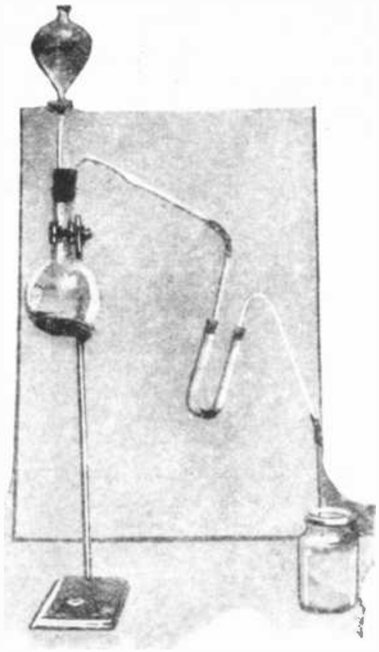
Iodine also combines very easily with iron. Place some iodine crystals and some iron filings in a beaker and add a small amount of water. A mild reaction will take place. Warm the mixture until all the iodine has disappeared and you will have a solution of ferrous iodide. Filter the solution to get rid of the excess of iron and to the filtrate add a small amount of iodine crystals. This excess of iodine will convert the ferrous iodide into ferric iodide. Now add potassium or sodium carbonate until all the iron is precipitated. Filter and you will have a clear solution of sodium or potassium iodide. Evaporate and when the liquid tends to become thick, set it aside to crystallize. The iodide can be used for the following and other experiments.

Many iodides are characterized by their brilliant colors. Thus, mercuric chloride solution with potassium iodide gives a scarlet red precipitate, silver nitrate will give a yellow amorphous precipitate, and lead salts give a yellow precipitate.

Some of these iodides change color when they are heated and hence are used as heat indicating paints. A double salt of silver and mercuric iodide is yellow at ordinary temperatures, but when heated to 50° C. (122° F.), it turns a deep red. When the temperature is lowered, it quickly returns to its original color.

To prepare it, make a solution of potassium iodide by dissolving 6.5 grams of the salt in 25 c.c. of water. Make another solution of 1.5 grams mercuric chloride in 25 c.c. of water. Mix the two and then add a solution of silver nitrate A yellow precipitate is formed. Filter the precipitate, wash with cold water and then dry on a water bath. When the solid is dry, place it in a tube and notice the color changes which occur as it is placed in hot water.

Iodine is also known in combination with hydrogen, in the form of hydrogen iodide, a colorless gas. Its formula has been determined to be HI. It can be made by placing a mixture of red phosphorus and iodine in a flask and allowing water to drop upon the mixture from a separatory funnel. The phosphorus iodide is decomposed and hydrogen iodide is evolved. If the reaction is slow in starting, gently heat the flask. The gas is passed through a U-tube containing a small amount of red phosphorus to absorb any excess of iodine vapor and the gas is collected in bottles. It is not very important, but the water solution, common-



Water is dropped from a separatory funnel upon a mixture of red phosphorus and iodine in a flask. This evolves hydrogen iodide which is passed through a U-tube containing red phosphorus and the purified gas is collected, either in water or by displacement. It is much heavier than air.

ly known as hydriodic acid, is of some use

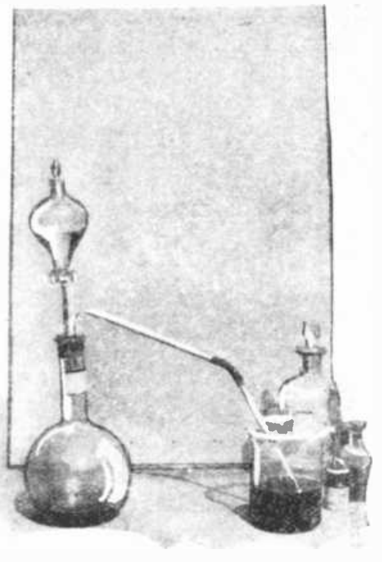
A water solution of the gas is readily made by passing hydrogen sulphide gas through a suspended solution of iodine. Add about 4 grams of powdered iodine to 250 c.c. of water in a large beaker and slowly pass through it a stream of hydrogen sulphide gas. In a short time all of the iodine will have dissolved. The reaction is as follows:

$$H_2S + I_2 \rightarrow S + 2HI$$

Hydrogen sulphide + iodine —> sulphur + hydrogen iodide

Add more powdered iodine and keep passing in the gas until the solution is colorless or nearly so. Then pass in a stream of carbon dioxide to remove all the hydrogen sulphide. Filter off the separated sulphur and the filtrate will be a water solution of hydrogen iodide. The hydrogen sulphide gas is made by slowly allowing hydrochloric acid to drop upon some ferrous sulphide in a flask. The carbon dioxide is made by allowing the acid to fall upon calcium carbonate or marble. Hydriodic acid acts as a monobasic acid and forms iodides with several metals. The acid character of the solution can be ascertained by placing a few pieces of zinc or magnesium in the solution. Hydrogen gas will be evolved and the metal will go into solution as an iodide.

If in performing the preceding experiments the experimenter has happened to stain his clothing with iodine, it can readily be removed by rubbing the spot with hypo solution and then dilute ammonia. When the hypo comes in contact with iodine, it dissolves the iodine forming a colorless solution of sodium iodide and sodium tetrathionate.



An aqueous solution of hydrogen iodide is made by passing hydrogen sulphide through iodine suspended in water, a most interesting reaction.

Match Experiments

By Leslie E. Raymond

Making reproductions of the first match; a mixture of sulphur, potassium chlorate and sugar constituting the head is ignited by being touched to fuming sulphuric acid absorbed in asbestos. By no means pulverize the sugar and potassium chlorate together, or you may have an explosion.

IT is strange, yet true, that some of the most indispensable things are given the least thought, yet when one pauses to consider the effect upon our lives, which the removal of some of these things would have, he is impelled to hail the chemist as a benefactor to mankind.

One of these products of the chemists' ingenuity is the modern match. It is a part of our lives, so much so that it is almost inconceivable that we ever managed to exist without it. Yet no longer ago than the year 1812 the first match made its appearance.

The asbestos soaked in fuming sulphuric acid is contained in a flask or tube and used to ignite the match.

Compared with the matches with which we are familiar, it was very crude; yet it was a decided improvement over the flint and steel which were the source of practically all fire prior to that time.

In 1812 a chemist named Chancel produced the first match which was made as follows:

A small quantity of sulphur or "brimstone" is melted in a porcelain or iron dish over a small flame, and the sticks dipped into this, forming a "head" of sulphur. This head is then (while still warm and soft but not hot) dipped into a mixture of equal parts of potassium chlorate and sugar (well powdered) and allowed to harden. In order to light these matches they must be brought into contact with fuming sulphuric acid, which was to be absorbed in asbestos and kept in a small vial. The reaction between the potassium chlorate and sulphuric acid produces chloric acid, which ignites the sugar. This ignites the sulphur which, in turn, ignites the wood of the match stick.

It was not until some fifteen years later that the first friction matches appeared and five years more before the first match containing phosphorus. The last matches alluded to were made by dipping the ends of the sticks into a mixture of potassium chlorate and phosphorus made into the proper consistency with glue. About sixteen years later, or 1848, a Swedish chemist, named Böttger, invented a match which was the beginning of the present safety match.

The experimenter may collect the sticks from burned matches or use toothpicks which are dipped in the following mixture:

Soak one gram of glue in a little cold water for about twenty-four hours and rub in a mortar until smooth. Now add two or three grams of antimony trisulphide (this occurs in nature as the mineral known as stibnite) and six grams of potassium chlorate (both previously finely powdered) and stir with a glass rod or wooden stick in the mortar until thoroughly mixed. This mixture is for the heads of the matches. For the friction surface take four grams of the same glue and soak in cold water as before, rubbing in the mortar until smooth. Now add ten grams of red (amorphous) phosphorus and eight grams of manganese dioxide (powdered) and continue the stirring until thoroughly mixed. This mixture is spread thinly on cardboard or any other surface on which the matches may be conveniently scratched. It is better to first coat the surface thinly with a mixture of glue and fine sand, allowing this to dry, and then to apply the phosphorus mixture.

The sticks of matches are dipped into a solution of some salt, such as alum and dried before being tipped. This prevents their being dangerously inflammable.

Formerly yellow phosphorus was used for

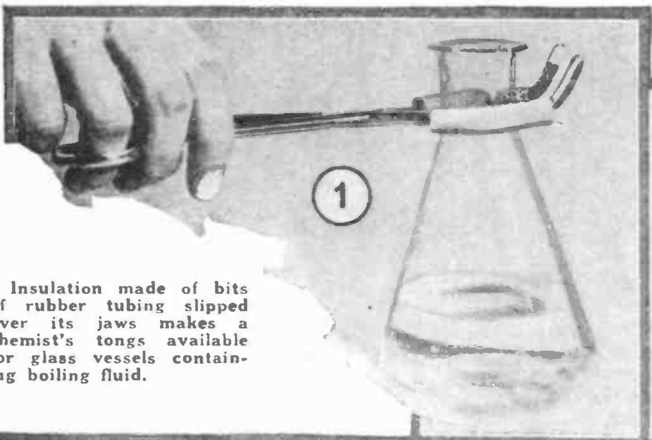
Making the friction surface on which safety matches are scraped in order to make them ignite.

all matches, which gave rise to serious diseases, principally of the jaw-bone among the factory workers—the so-called "phossyjaw." Its use has been entirely supplanted by the use of the amorphous or red variety which is not poisonous and does not oxidize in the air, making it unnecessary to keep it stored under water as was the case with the yellow form. The diseases peculiar to match workers have gradually disappeared and the use of yellow phosphorus in the manufacture of matches is now prohibited by law.

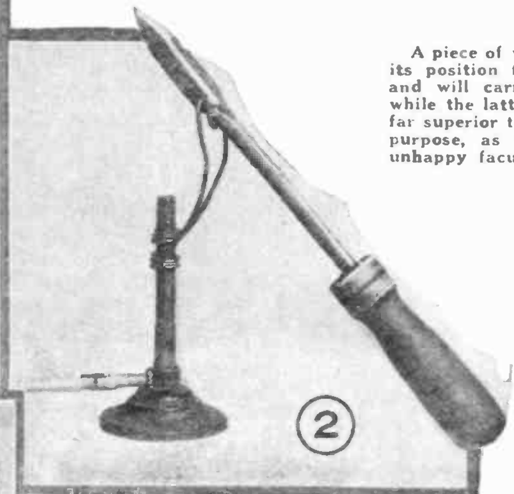
Mixing the semi-liquid solutions in a mortar with which the ends of safety matches are to be coated. Do not pulverize the mixture except when moist.

Kinks for Experimenters

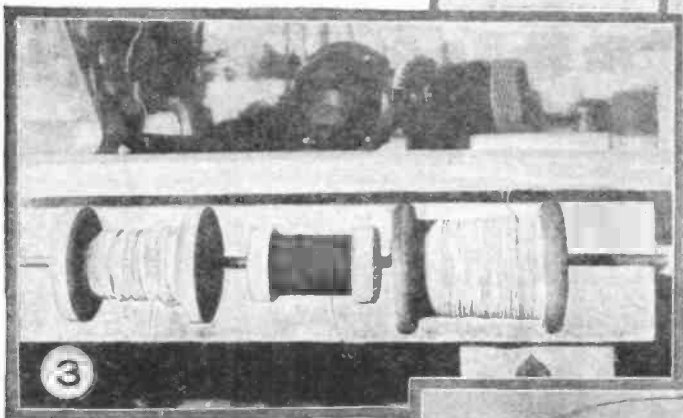
By Raymond B. Wailes



Insulation made of bits of rubber tubing slipped over its jaws makes a chemist's tongs available for glass vessels containing boiling fluid.

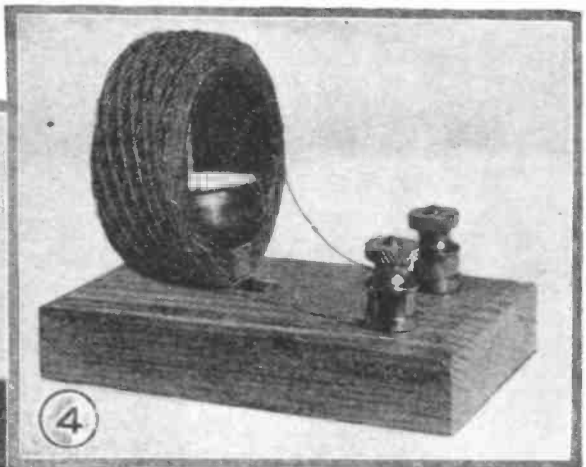


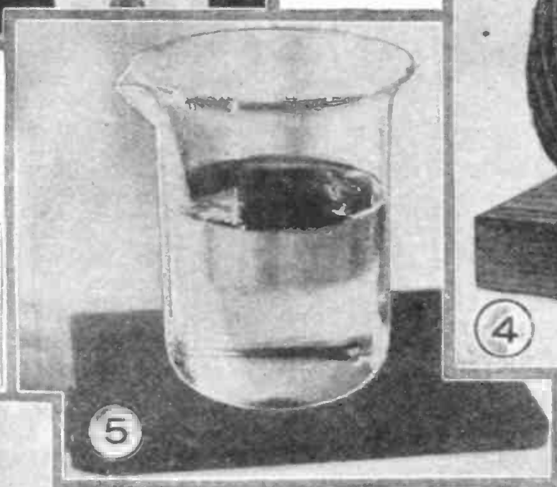
A piece of wire bent as shown will hold its position firmly on a Bunsen burner and will carry a heavy soldering iron while the latter is being heated. This is far superior to using a ring stand for the purpose, as the soldering iron has an unhappy faculty of rolling off.



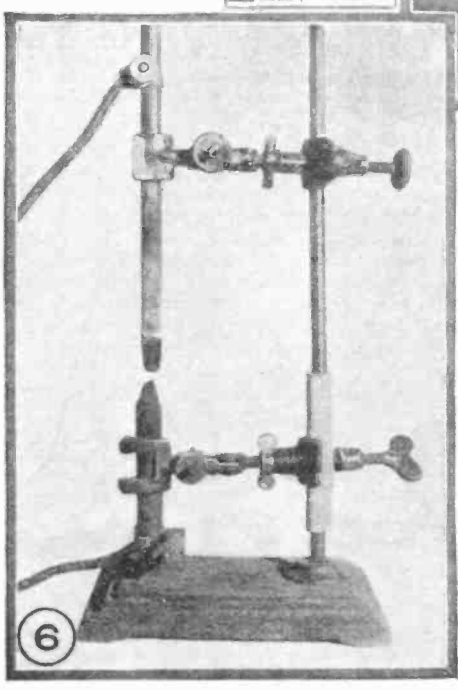
A curtain rod is held by brackets or screw eyes at its ends, under the edge of the working table or bench to carry spools of wire of various sizes as may be required by the experimenter.

An extemporized current detector, polarity indicator and galvanometer is made up with a common pocket compass and a honeycomb coil borrowed from the radio supplies. It can be permanently mounted and made a very neat piece of apparatus.

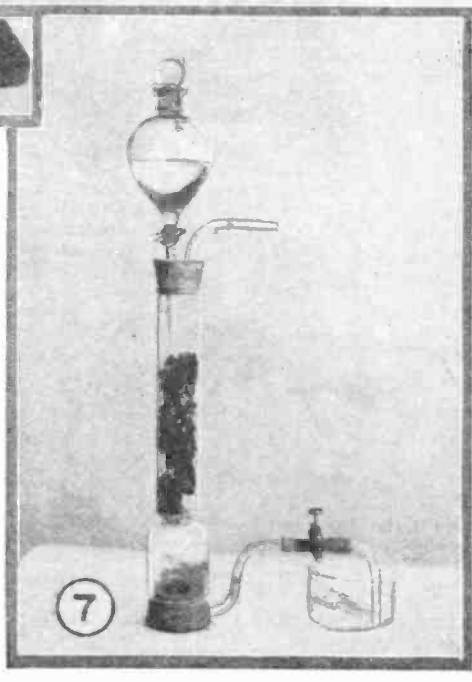




A cork mat is a valuable accessory in the laboratory if a slate top table, now so common, is used. The disadvantage of the slate top is that it cracks beakers. The cork mat will protect them.



On the left is shown an extemporized arc lamp; the carbons are carried by burette clamps and as the ringstand which supports the whole is of iron, rubber tubing is used as insulation.



On the right is shown a gas generating apparatus; this will work for generation of sulphuretted hydrogen very nicely. The one requirement is that whatever substance the gas may be evolved from must be in lumps large enough not to fall through a spiral of soldering iron which rests upon the stricture. The basis of the apparatus is this well-known students' lamp chimney.

Kinks for Experimenters

By Raymond B. Wailes

IN the first illustration our chemical readers will recognize the very familiar crucible tongs. This implement is designed primarily to pick up hot crucibles and similar objects between its extreme ends, using it just as we would an ordinary pincers. The bow back of the points of the jaws is for the purpose of gripping a crucible on the outside. The chemist finds it hard to resist the temptation, however, of picking up flasks and small beakers with it, and the metal against the glass is very apt to break it. Such a pair of crucible tongs may be used for removing boiling hot flasks from over the Bunsen burner. A short length of rubber tubing slipped over the prongs or jaws of the tongs will enable a very firm grip to be taken upon the neck of the flask and at the same time will keep the metal tongs from touching the glass, which might crack it.

A stand for heating the soldering iron over the Bunsen burner can readily be made from a length of heavy wire about No. 8 size. A little inverted saddle is formed in which the iron rests. The free ends of the wire are wound several times about the stem of the burner. The tip of the inner flame is the hottest spot of the flame. The old-time experimenter maintains his affection for the old-fashioned soldering iron, in the face of its competitor, the electric one. The stand as shown makes it fully as convenient as the last named.

A handy place for spools of wire is beneath the table, just at the edge. A length of curtain rod thrust through the spools and held away from the table by wooden blocks enables the spools to turn freely on the rod. The spools are never in one's way and wire can be instantly and conveniently taken off as needed.

The above arrangement speaks for itself. Instead of blocks of wood, screw eyes may be used to support the rod.

A simple current detector and polarity tester can be quickly made from a honeycomb coil and a compass. The coil is fastened to the wooden block by a copper strip. The compass is set within the coil and when a current traverses the coil, the compass needle will be deflected according to the strength and direction of the current. A pair of man-sized binding posts and a coat of varnish makes the whole instrument a handy addition to the experimenter's laboratory.

It would be a simple matter to calibrate this apparatus so as to make a sort of ammeter out of it, in which case it would be well to draw a new card for the compass, which card would be laid out in amperes or fractions thereof. With a small enough compass supported by a standard in the center of the coil tangential readings of approximate correctness might be obtained.

A cork mat is ideal upon which to place hot beakers, flasks, etc., with their boiling hot contents. You will never have a beaker crack if a cork mat is kept handy.

Here is an arc lamp which is very serviceable and easily adjusted. It is made from a laboratory support and two burette clamps. Both clamps grasp the carbon rods. The lower clamp is insulated from the support by being screwed to the support over a short length of tough rubber tubing. The arc is started by adjusting the thumb screw of the upper clamp. It will burn quite a while before having to be adjusted again. An electric flat-iron makes a suitable resistance to be used in series with the arc. A water rheostat can also be used. Binding posts are affixed to the carbons by metal bands.

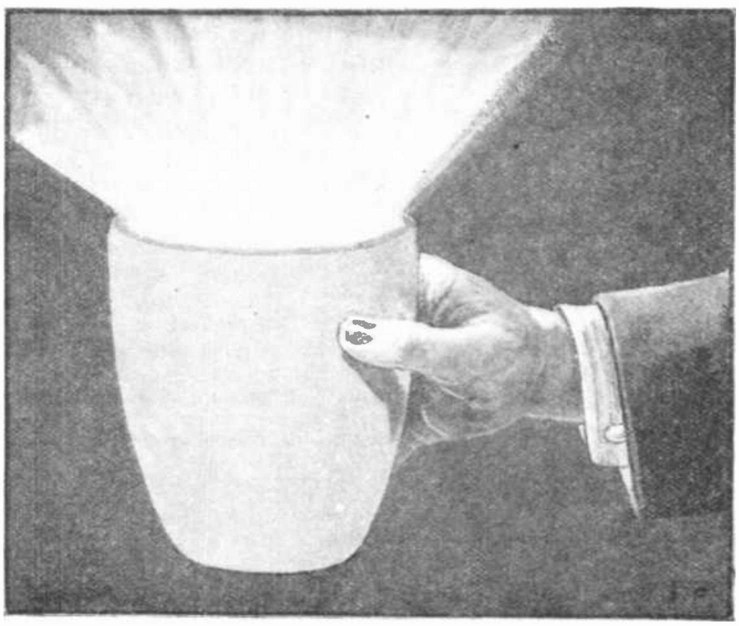
The soldering iron described above can be put to good use if the carbons are copper plated, for then the wires can be simply twisted around them and soldered for the upper and lower connections.

A student's lamp chimney affords the experimenter a very practical and efficient gas generator. It is fitted at the bottom with a stopper carrying a glass tube which is provided with a pinchcock and delivers the spent acid into a dish such as a chrystallizing dish, evaporating dish, or the sink in some cases. The separatory funnel at the top contains acid (1:3 sulphuric commercial quality serves well). The top stopper also carries the L delivery tube from which the gas is taken off. The body of the gas generator is filled with the gas generating substance—iron sulphide, zinc, marble chips, etc., according to the gas to be generated. The mass is kept from falling into the lower chamber by a spiral of wire solder. The acid trickles down upon the mass, expends itself and the solution formed falls into the lower chamber where it can be drawn off by opening the pinch-cock. If desired, the generator can be clamped to an iron laboratory support.

The student's lamp chimney with its stricture is quite suggestive for the chemist, for other uses than those shown in the gas generator. One trouble with it, however, is that the glass is rather thin and if the cork is pushed in too hard a piece will infallibly break out of the end. The writer is speaking from experience. The edges of the chimney which are disastrous to corks because they are so rough and almost sharp should be rounded off with a rat-tail file or if one is very sure of himself, they can be rounded still better in the flame of the Bunsen burner. But here there is danger of cracking.

A Curious Thermit Experiment

THE thermit experiments illustrated in our October issue have excited a great deal of interest among our readers. It is fair to say that ground is covered by this way of heating, which is practically unattainable by any other method. The process gives the operator a mass of iron in liquid fusion at an extremely high temperature, the point being that while the oxy-hydrogen or the oxy-acetylene flame or the arc welding apparatus may give as high a temperature, their total quality of heat is limited. But in the operation of the thermit process, hundreds of pounds of absolutely liquid iron may be produced, giving an amount of heat which can be accurately localized by sand moulds and flasks, so that iron can be added and welded to an article where desired, or can be used simply to give a very large volume of intense heat.



Iron is melted by the thermit reaction in a crucible of low heat conduction and the vessel can be held in the ungloved hand

In the illustration we show a hand holding the crucible in which iron has been produced by the thermit process. The crucible is made of magnesite composition, so called, whose coefficient of heat conduction is extremely low. It gives a peculiarly available crucible for thermit experiments, because the heat, practically speaking, hardly penetrates the walls or sides of the crucible, and it can be held in the unprotected hand as shown in the cut.

Of all ordinary substances, calcium oxide or quicklime, magnesium oxide or magnesia are among the worst conductors of heat known. This has made them very available for lights for projection and they were extensively used in the old days before the invention of the electric light. The writer has used them on several occasions in lecturing. While magnesia has very great advantages as giving a very small and intense area of light, lime was universally used by old-time projectionists. An oxy-hydrogen flame was made to impinge upon a piece of lime cut out in cylindrical shape about ¾-inch in diameter and quickly brought a small area to white heat. This formed an admirable source of light, projecting pictures by the magic lantern and stereopticon.

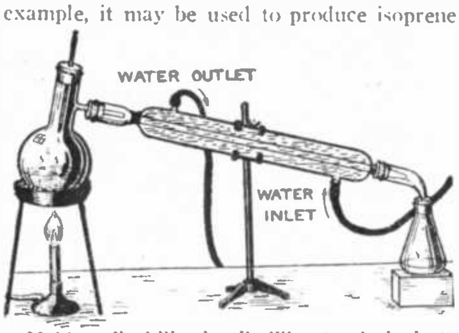
Magnesite crucibles can be bought at apparatus dealers, and an interesting variation on their use could be made by getting a large lump of quicklime, the harder the better, and drilling a hole in it so as to make a sort of rough crucible. Care should be taken in drilling not to split the block open, and the experiment of melting metals can be done with very small quantities of thermit composition in it.

Various Chemical Experiments

By C. F. Miller

Experiments With Turpentine

TURPENTINE is familiar to most of us only as a paint thinner, but to the chemist it has a varied interest. For example, it may be used to produce isoprene



Making oil of lilac by distilling terpin hydrate with sulphuric acid and water.

from which synthetic rubber can be made by treatment with metallic sodium, heat or acid; or terpin hydrate, used in medicinal preparations for coughs and throat affections or as a source of terpineol, the latter used in perfumery as the basis of lilac perfumes; and last, and perhaps most important of all, as a basis for the manufacture of synthetic camphor, which has of late appeared on the market in increasing quantities. Of these, terpin hydrate, terpineol and pinene hydrochloride (starting point of one of the synthetic camphor processes) can be easily prepared by the careful experimenter.

Terpin Hydrate

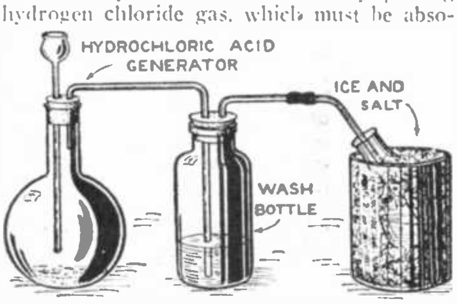
Terpin hydrate can easily be made from oil of turpentine by treatment with dilute nitric or sulphuric acid, the only necessary precautions being the use of fresh turpentine (acetic and other acids develop in the oil upon long standing) and a dilute acid, for concentrated acids will rapidly carbonize it with the formation of a resin. If about one-fourth its weight of dilute nitric acid is added to turpentine, it will be slowly converted to terpin hydrate and dipentene; the terpin hydrate may be crystallized out and stored in a clean, tightly stoppered bottle for further experiments. It is necessary to let the mixture stand several days before crystallization occurs.

Terpineol (Oil of Lilac)

Terpineol is usually prepared by distilling terpin hydrate with sulphuric acid and water. The crystals of turpin hydrate are placed in a distilling flask. They are covered with water after which sulphuric acid is added. The flask is then connected to a condenser and heat is applied. Terpineol and water distil over and may be collected in the receiving vessel. The terpineol may be recognized by its fragrant odor of lilacs.

Pinene Hydrochloride

Pinene hydrochloride is made by passing hydrogen chloride gas, which must be absolutely dry, into turpentine kept cool by surrounding the container with a mixture of salt and ice. The pinene hydrochloride forms as a white crystalline body with an odor like camphor. It so closely resembles camphor that it is sometimes sold as artificial camphor. Commercially it is used as a starting point for the synthetic preparation of camphor. The intermediate products are camphene, isobornyl acetate, isoborneol and then synthetic camphor.

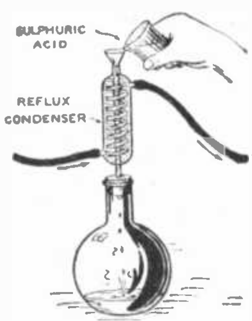


The production of pinene hydrochloride. Absolutely dry hydrochloric acid bubbled through sulphuric acid in a wash bottle, acts upon turpentine kept below the freezing point of water.

Turpentine readily reacts with oxygen, chlorine, bromine, iodine, acids and other chemically active substances.

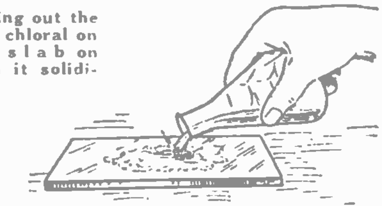
Carbon Tetrachloride

Carbon tetrachloride, commonly sold as carbona, a non-explosive, fireproof cleaning fluid, may be easily made by chlorinating carbon disulphide. It is prepared by passing dry chlorine gas into carbon disulphide in which a little ferric chloride or aluminum



Use of a reflux condenser, in making sulphuric acid react upon ethyl alcohol, which latter has been saturated with dry chlorine gas. This is the last step in the manufacture of chloral.

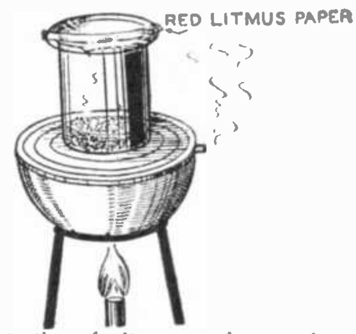
chloride is dissolved. Sulphur monochloride is also produced in the reaction and may either be separated by distillation or made to react further with the production of more of the tetrachloride and precipitation of finely divided sulphur. The crude tetrachloride is next treated with lime to remove all sulphur compounds and is then distilled, the fraction distilling from 71° to 77° C. (160°-171° F.) being collected as pure carbon tetrachloride. If it is desired to produce both sulphur chloride and carbon tetrachloride, a slightly different procedure must be followed. Chlorination is kept up only until sulphur begins to deposit, then the reacting flask is removed and distillation is begun. The fraction from about 70° to 80° C. (158°-176° F.) is collected, treated with lime and redistilled as above; the remaining liquid is heated still further to about 140° C. (284° F.) at which point the sulphur chloride distils over.



Pouring out the melted chloral on a cold slab on which it solidifies.

Chloroform

Chloroform can most easily be prepared from the carbon tetrachloride prepared in the last experiment. The reaction is simply the reduction of carbon tetrachloride with nascent hydrogen, generated within the liquid. The formula is $CCl_4 + H_2 \rightarrow CHCl_3 + HCl$. Part of the hydrogen combines with the freed chlorine atom to form hydrogen chloride. The hydrogen is usually generated by means of iron and hydrochloric acid added to the carbon tetrachloride. The action by which chloroform forms proceeds slowly. Chloroform may be separated from the other liquid by distillation, the chloroform distilling over from 61° to 63° C. (142°-145.4° F.)



Detection of nitrogen and ammonia salts in natural soil by treatment with an alkaline bath and testing with litmus paper. Such are an important element in fertility.

Chloral Hydrate

Chloral hydrate is prepared from alcohol, chlorine and water. Ethyl alcohol is saturated with dry chlorine gas with the formation of an alcoholate. Then sulphuric acid is slowly added preferably under a reflex condenser. Then the mixture is distilled, the distillate up to 100° C. (212° F.) being collected. This is then redistilled, the fraction above 94° C. (201° F.) being collected as pure chloral. This is mixed with water and poured on a cold slab where the mass soon solidifies.

Crystals may be formed by breaking up the mass, dissolving it in chloroform and crystallizing. If it is desired to use it in medicine, it must be remembered that 0.5 gram is the prescribed dose. Chloral is seldom used now as a hypnotic, as it is claimed to be a habit-forming drug.

A still more sensitive test for nitrogen and ammonia in soils by exposing a glass rod dipped in methanol silver nitrate solution to ammoniacal gas evolved.

Detection of Nitrogen in Soils

The powdered sample of soil is mixed with pulverized soda lime (mixed sodium and calcium hydroxides) and finely divided copper and heated. Ammonia, if present, may be detected by its odor, effect on red litmus, behavior with hydrochloric acid fumes, or more delicately, by the formation of a silver mirror on a glass rod dipped in menthanol silver nitrate solution and exposed to the escaping fumes.

Copper Test

If a cold concentrated solution of gallic acid is added to an alkaline sulphocyanate, copper salts will produce a distinct white coloration in it, even when present only as a one-thousandth normal volution.

$$\frac{N}{10,000} \text{ solution.}$$

An even more delicate test solution may be obtained by preparing a 2 per cent. solution of phenolphthalein in 20 per cent. solution of potassium hydroxide decolorizing the red solution by boiling with zinc powder. The addition of copper solution containing but one part of copper in 100,000,000 parts of water colors the solution pink.

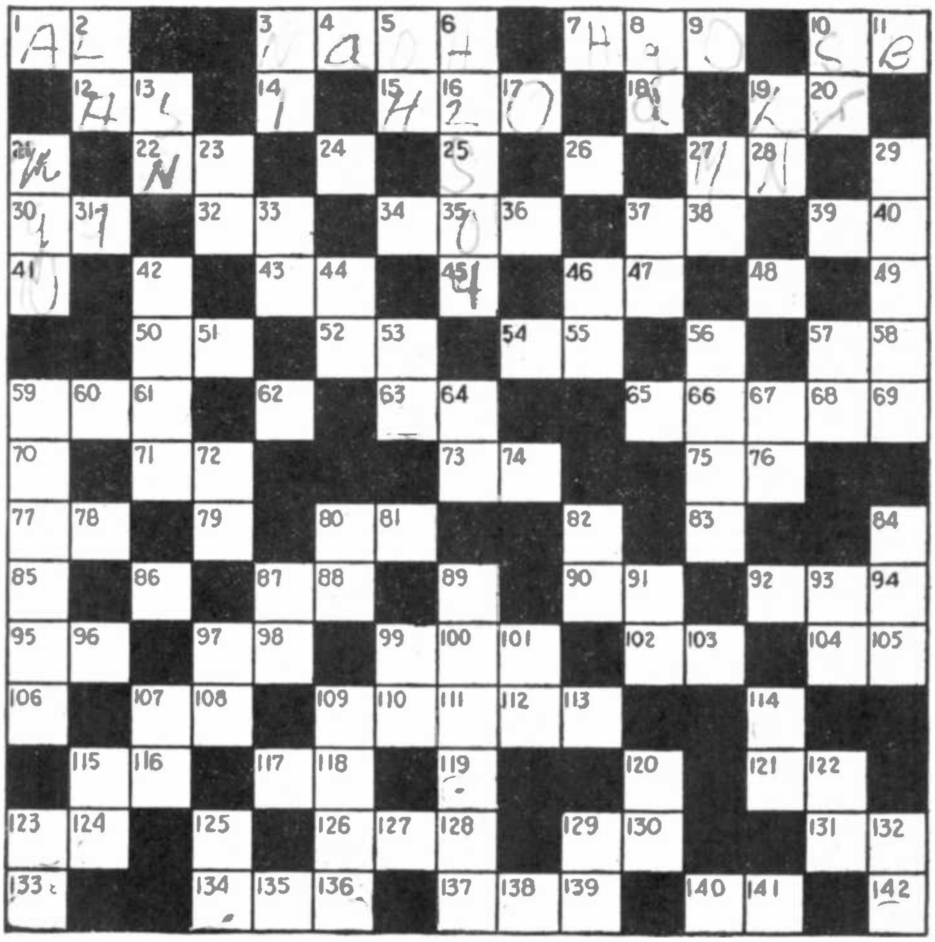
A Chemical Cross-Word Puzzle

Here is something for you fellows who dabble with chemistry, to cut your atomic eye-teeth on. (Not I-teeth — that would mean iodine teeth). Better get out your tables of elements and atomic weights before you commence on it, for a cross-word dictionary will be useless for solving this puzzle.

There are no words in the answers—merely chemical symbols and figures. If you know your "Chemical Short-hand" as you should you will speedily arrive at the solution without reference to either the solution or to the aforementioned tables. If you don't know the symbols, you will know more of them when you have worked out the solution to this puzzle.

To begin, No. 1 Horizontal is Al., the symbol for aluminum.

—Contributed by Philippe A. Judd.
Rep. 7297.



HORIZONTAL

1 Aluminum.
3 Sodium hydroxide
7 Mercuric Oxide.
10 Antimony.
12 Arsenic.
14 Atomic weight of H.
15 Water.
18 Argon.
19 Zirconium.
21 1000
22 Neodymium.
24 Vanadium.
25 Sulphur.
26 Tungsten.
27 Mangenese.
29 Phosphorus.
30 Gallium.
32 Ytterbium.
34 Potassium hydroxide.
37 Silver.
39 Columbium.
41 Zero.
42 Nitrogen.
43 Iridium.
45 Atomic weight of He.
46 Copper.
48 Flourine.
49 Atomic weight of He, less that of H.
50 Arsenic.
52 Helium.
54 Lead.
56 Carbon.
57 Cobalt.
59 Carbon disulphide
62 Argon.
63 Rubidium.
65 Plaster of Paris.
70 Same as 106.
71 Scandium.
73 Ruthenium.
75 Iron
77 H atoms in ammonium sulphocyanide.
79 Argon.
80 Thorium.
82 Oxygen.
83 Number of H atoms in formaldehyde.
84 Nitrogen.
85 ½ atomic weight of Mo.
86 Atomic weight of hydrogen.
87 Samarium.
89 Carbon.
90 Scandium.
92 Number of sodium atoms in sodium ferrocyanide.
95 Osmium.
97 Germanium.
99 Atomic weight of scandium × 10.
102 Europium.
104 Titanium.
106 1-17 of the atomic weight of V.
107 Cadmium.
114 Nitrogen.
115 Arsenic.
117 Sodium.
119 1/29 of the atomic weight of Lu.
120 Atomic weight of B.—2.
121 Thallium.
123 Mercury.
125 Number of Cl atoms in ferric. chloride.
126 Black copper oxide.
129 Number of H atoms in salicylic acid.
131 Indium.
133 Oxygen.
134 Boiling point of H_2O:(°F).
137 Atomic weight of Li. x 100.
140 Tin.
142 Iodine.

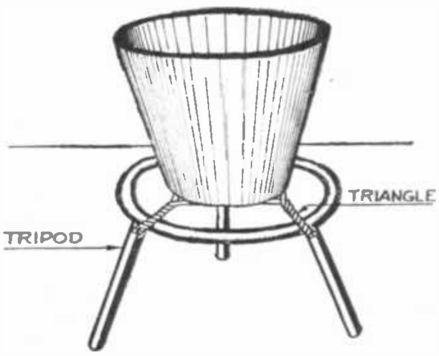
VERTICAL

1 Argon.
2 Lanthanum.
3 Nickel.
4 Same as 1 (vert.)
5 Hydroxide.
6 Sulphuric acid.
7 Hydrogen.
8 Gallium.
9 Freezing point of H_2O (°C).
10 Strontium.
11 Boron.
13 Tin.
17 Zero.
19 Zinc.
21 Magnesium oxide.
23 Dysprosium.
24 Vanadium.
26 Tungsten.
27 Magnesium.
29 Minium.
31 Argon.
33 Bismuth.
34 Potassium.
36 Hydrogen.
37 Gold.
39 Carbon.
42 Sodium sulphide.
44 Rhodium.
46 Columbium.
48 Flourine.
51 Sulphur.
53 Erbium.
54 Phosphorus.
56 Calcium fluoride.
57 Cobalt.
59 Glycerine.
60 Sulphur.
62 Argon.
64 Bromine.
65 Carbon.
67 Selenium.
72 Calcium.
74 Uranium.
78 Atomic eight of He
80 Thalium.
81 Hydrogen.
82 Osmium.
84 Sodium iodide.
86 Iodine.
87 Selenium.
89 Tartaric acid.
91 Cerium.
92 Atomic weight of He.
93 Niton.
96 Sulphur
97 Gadolinium.
99 1/3 the atomic weight of iodine
101 Atomic weight of O
103 Uranium.
107 Caesium.
109 Calcium carbide.
113 Zero.
114 Radium emanation.
115 Argentum.
117 Nitrogen.
120 Atomic weight of Mo.
122 Lithium.
123 Holmium.
125 Freezing point of H_2O (°F).
127 Uranium.
129 Number of H atoms in acetic acid.
132 Nickel.
135 Atomic weight of H.
138 Atomic weight of F—10.
140 Sulphur.
141 Nitrogen.

Watch for Solution in Next Issue.

Hydrogen Sulphide Without Acid

HAVING noticed in a recent number of the magazine an inquiry as to a method of generating hydrogen sulphide without the use of acid, I thought that the following might prove of interest.



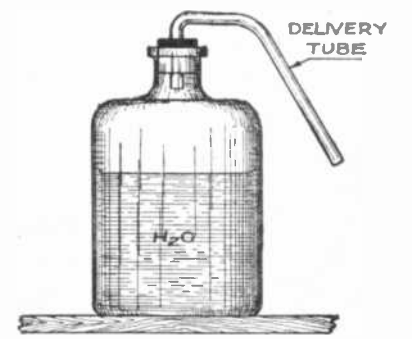
The fusion of sulphur and aluminum filings in the ratio of two atoms of aluminum to three of sulphur, for the production of aluminum sulphide, which gives off hydrogen sulphide on contact with water.

In chemical and metallurgical analysis in the laboratory, hydrogen sulphide is often used as in precipitating lead and other metals in the form of sulphides, and perhaps the best method for generating the hydrogen sulphide for this kind of work is by the action of water on aluminum sulphide.

Aluminum sulphide cannot be made the wet way, but can be made by direct fusion of sulphur and aluminum in molecular weight proportions. Thus by fusion of 54 grams of aluminum filings and 96 grams of sulphur, 150 grams of aluminum sulphide are formed. When the salt so produced is thrown upon water, hydrogen sulphide is immediately evolved according to the equation.

$$Al_2S_3 + 3H_2O = Al_2O_3 + 3H_2S.$$

In the laboratory a large bottle is half filled with water and a one-holed stopper with a bent glass delivery tube is inserted in the neck. Then whenever H_2S is needed a small lump of aluminum sulphide is thrown into the bottle and hydrogen sulphide is generated. *Contributed by Harry L. Elder.*



By dropping aluminum sulphide into water in such a bottle as above and immediately corking it, sulphuretted hydrogen will be evolved to be utilized in analysis, without the requirement of any acid.

How to Make the Electro-Mystic Crystal Globe

By Philippe A. Judd

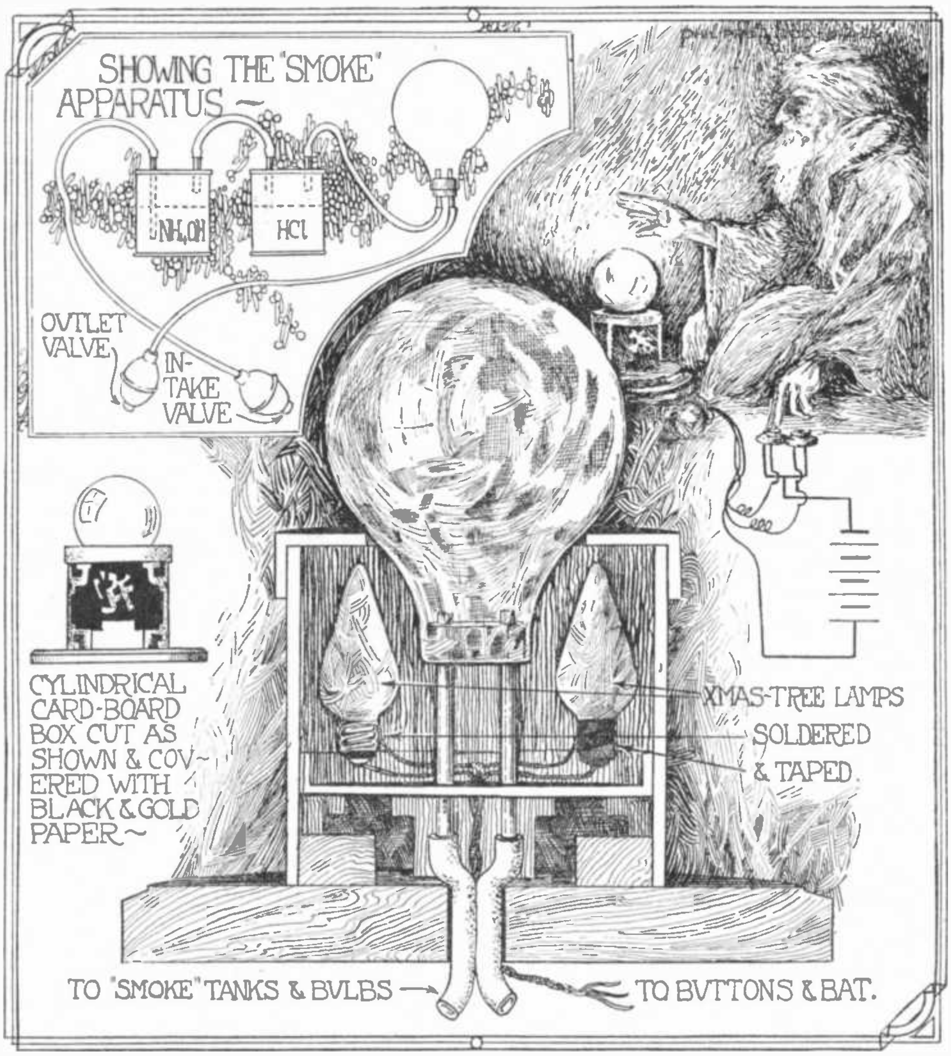
FOR the magician, the spiritualist, the pseudo mind-reader, and those of you who like to mystify visitors to your laboratory, the gazing crystal, herein described, will be found not only less expensive but also more interesting than the commercial crystals on the market. It may also be used in place of annunciators and doorbells, using a different colored lamp for each door. For this purpose, its highly ornamental character permits a prominent position in the hall or on the desk.

The sphere consists of a 150-watt nitrogen lamp, of the tipless type, from which the base has been cut. This is mounted upon the pedestal, as shown in the illustration, so that it has the appearance of a solid crystal orb.

The pedestal is constructed from a cylindrical cardboard box, cut as shown in the detail, and covered with black paper. It is then decorated by pasting Chinese characters cut from gold paper upon the black background. The cylinder is mounted on a hardwood disc, which serves to strengthen the pedestal and to prevent its tipping over.

Several variously colored lamps (those used for Christmas tree decoration are best) are mounted inside the pedestal, so that their light is thrown up through the crystal. A green lamp will produce a very spooky effect, while one of an orange color, when flashed quickly, gives one the impression of a flash of flame within the crystal. The wires from the lamps are run down through the base and are led to a concealed battery of push buttons. They may be supplied from a toy transformer or by a storage battery.

To further the magical effect produced by the colored lights, a means for filling the globe with a white vapor is provided. A two-hole rubber stopper, carrying two short glass tubes, is inserted in the neck of the globe as shown. Rubber tubing of a small diameter is led from these tubes through the base to the "smoke" jars and bulbs. The vapor-making apparatus is shown in the upper illustration. It consists of two glass jars, the connecting tubing and two rubber bulbs. One of the latter has an outlet valve in its outer end, while the other is provided with an intake valve.



A crystal gazing globe is made from a large sized discarded incandescent lamp bulb. Although of thin glass, it resembles a solid crystal and by using colored lamps flashing upon it, various effects can be produced which may be supplemented by filling it with ammonium chloride smoke.

The first jar is partly filled with aqua ammonium, the second with a strong aqueous hydrochloric acid solution. Upon squeezing the bulb (with the intake valve), a dense cloud of white vapor is injected into the hollow sphere, producing a lambent, opalescent appearance. The other bulb is for the purpose of removing the vapor from the globe.

Although the entire apparatus might be inclosed in a pedestal or taboret, the long tubes and cable permit remote control of the crystal orb and thereby add to the mystification of the uninitiated.

The production of smoke by bringing together gaseous hydrochloric acid and gaseous ammonia, is very familiar to the chemist. It is even used in the detection of ammonia and may be used in the detection of hydrochloric acid. Thus, if we suspect ammonia of being evolved from a solution a glass rod or a piece of paper may be dipped in hydrochloric acid solution and held in the mouth of the vessel containing the suspected liquid. If ammonia is being evolved, a very characteristic production of white clouds of ammonium chloride results. If hydrochloric acid is suspected, the paper or glass rod should be dipped in a solution of ammonium hydroxide, so it seems that there is some serious chemistry involved in this experiment.

One thing to be taken cognizance of is that the smoke will not continue to fill the bulb, but will gradually be deposited in its inner surface, so that after a while it will be pretty well clouded-up, giving the effect of a frosted bulb. Accordingly after each experiment the bulb will have to be washed out with water and a subsequent rinsing out with alcohol will cause it to dry more quickly. It is quite a problem to dry moisture from the interior of a flask-like vessel.

The article states that a tipless lamp must be used; this is for appearance sake; so many tipless lamps are now made that there will be no difficulty in procuring one. Again referring to the illustration, it will be observed that the inlet tube in the vessel containing ammonia dips down pretty well into the bottom of the liquid. It is most essential not to dip the tube into the hydrochloric acid, but only to pass the ammonia vapor over the surface of the acid. Otherwise the acid will be drawn back almost violently into the ammonia vessel, destroying the desired action. Above all, be sure that you blow it in the right direction.

The production of smoke is quite a problem; for lecture experiments the ammonium chloride smoke which we have just described is unquestionably the simplest and best. For smoke writing on the sky a more solid smoke, if we may use such an expression, is needed. But the ammonium chloride smoke is so easily dealt with and so readily cleansed from vessels that it is to be highly recommended for all such purposes as the one described here.

Experimental Galvanometer

By Herbert E. Hayden

MUCH has been written on the subject of galvanometers, and instructions have been given from time to time for the construction of these sensitive little indicating instruments at home.

It has been noticed, however, that the beginner has not been considered in the preparation of these articles, as the constructional data call for the use of many special tools, not always found in the average experimenter's kitchen workshop.

Therefore, in presenting this article to the experimenter who has a great deal of ambition but only a few tools, the author makes an attempt to tell the story in pictures and to deliberately use tools that the veriest novice would have.

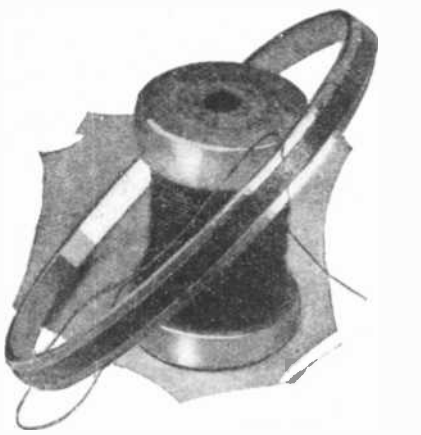


Fig. 1. An embroidery hoop serves as a convenient frame for the windings of a galvanometer which is of the tangent type.

It is known, of course, that if an ordinary compass needle is allowed to rest in its natural position, a piece of bell wire being held in line above this needle, and a current from a dry cell or other source passed through the wire (say, from north to south), the north end of the needle will be immediately deflected toward the west. If the wire is placed under the needle, the reverse of the foregoing holds true. This then is the fundamental principle of a galvanometer.

It is true that many types of measuring instruments are based on this simple operating principle. A simple galvanometer, however, consists essentially of a magnetic needle suspended in a magnetic field (coil of wire), the needle being free to swing over the face of a graduated dial of some sort.

Secure an embroidery hoop about 6 inches in diameter and wind about ten turns of No. 24 double silk magnet wire right around the outside of the hoop. This is shown in the photo.

After this has been completed, bring the ends through the hoop after first making two little holes with a needle or drill. As a matter of fact, it is not necessary to use an embroidery hoop at all, as a piece of cardboard can be rolled up into the shape of a ring, and the winding placed on it in the same manner, but it will not make as neat a job as will the embroidery hoop.

Fig. 2. Ten turns of No. 24 wire on an embroidery hoop will suffice for the tangent galvanometer.

In either case, after this simple winding has been completed, the whole thing should be covered with a light coating of orange shellac to keep the wires in place.

The next step is the magnetic needle. You can probably purchase a small compass in the five- and ten-cent store that will cover all needs, but it is not at all hard to make the needle without a compass.

Get about 2 inches of some old steel spring taken from the clock that used to hang on the wall, and with a pair of ordinary steel scissors (don't use a good pair) cut a little pointer-arrow as shown on the end of the future permanent magnet i nFig. 3.

Before placing it on the magnet to magnetize the steel, hit the center of the pointer lightly with the point of a wire nail as a punch, using the regular household hammer. The purpose of this little dert is to provide a recess or cup for a pivot on which the needle turns.

After this has been done, the needle is magnetized by slowly drawing it across the poles of a ten-cent permanent magnet as shown in Fig. 3. If the little needle is now placed on a brass pin point, it will immediately turn to a north and south direction, and of course the particular end that does point to the north is the "north pole" of this compass needle. Cheap pins are made of steel—do not use such.

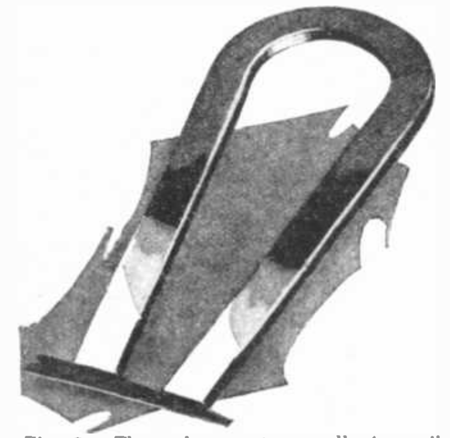


Fig. 3. The galvanometer needle is easily prepared from a piece of sheet steel magnetized with a horseshoe magnet. It must be short compared to the diameter of the coil to get tangent factors.

Now the next step is to mount the ring with its winding as previously described on a little block of wood about four inches square. This is easily done with two small brass wood screws, and a piece of thin brass as shown in Fig. 4. Two binding posts are also arranged and the ends of the wires are scraped and attached to these posts.

If you happen to understand what in these days seems to be the magic soldering art, it will be better to make sure of your connections by neatly soldering the wires to the post.

Now right across the center of the ring place a little strip of thin wood, or cardboard, if you can't find the wood. The strip need not be very wide, say about one inch will do very nicely. Mark the center of this strip with a fine lead pencil line.

Right over this line glue a little cork taken from some old medicine bottle, and after the cork is firmly cemented in place, cut the head off a pin and stick it in the cork so that the point of the pin protrudes upwards about 1/8 of an inch. This pin is going to act as the pivot for the magnetic needle. (See Fig. 5.)

The next step in the construction is to cut a small disc of cardboard, say about 2½ inches across, and after puncturing a hole in the center with a hat pin, place it on top of the cork with the pin protruding as shown.

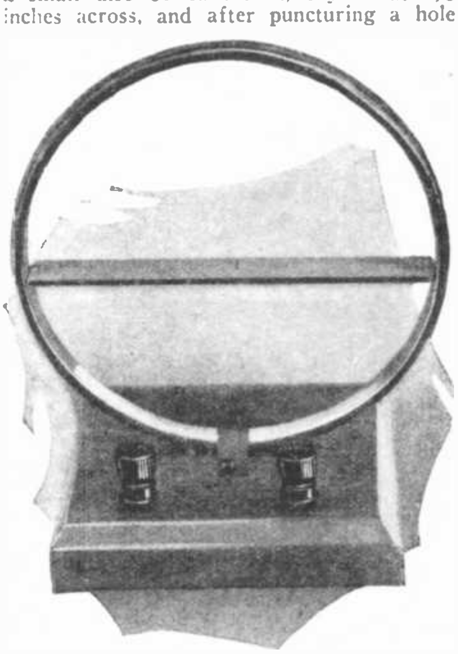


Fig. 4. The coil mounted on the tangent galvanometer base and ready to receive the magnetized needle.

This particular type of instrument is known as a "tangent galvanometer," but as the purpose of the article is to acquaint the beginner with a simple measuring instrument, no attempt is made to go into the detailed instruction of what a tangent is and how to mark off the scale for tangent readings.

The finished instrument is shown in Fig. 5, and if the experimenter will get a fresh, dry cell and just touch the terminals to the galvanometer coil he will find the needle will fairly spin, the action is so strong.

If the reader wants to put a "tangent" scale on the little dial, he can follow the instructions given in the EXPERIMENTER, page 616, July, 1925.

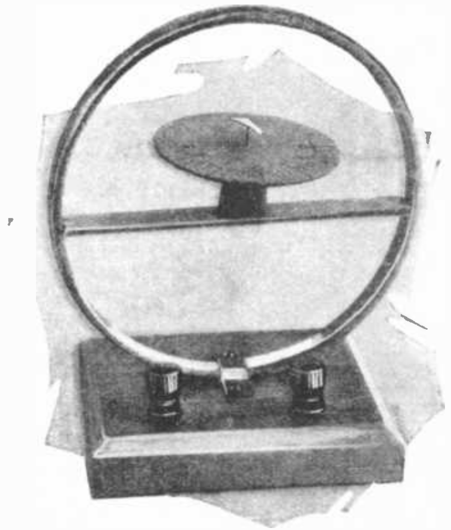


Fig. 5. The completed tangent galvanometer, with scale and needle in place. If the scale reads plain angular measurement, a table of natural tangents can be used for their conversion.

Electrified Butterfly Lives Twenty-five Years

By B. Vincent

Fig. 4. A butterfly swinging by a slender thread from the top of a glass globe keeps swinging back and forth from flower F to flower G and back again for years. The mystery lies in a concealed voltaic pile. The butterfly has a metallic surface which touches a metallized surface on the flowers, each flower being connected to a terminal of the battery.

THE outward presentment of the device is an oval stand, covered by a glass globe, and ornamented by artificial flowers and leaves, to resemble nature as closely as possible.

Two flowers are elevated above others at extreme ends of the oval, and a real or imitation butterfly suspended by a fibre of cocoon silk constantly oscillates between them until the mysteriously conserved force shall, after the lapse of a quarter of a century, be dissipated. Day and night, year in and year out, the butterfly will flit about three times per minute between the raised flowers.

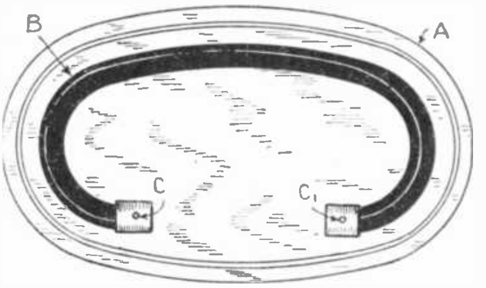


FIG. I

The curved battery or voltaic pile which is hidden among the artificial flowers and leaves beneath the glass shade. At CC are seen the metallic caps and the position of the wires is indicated on them.

The first thing required is an ordinary oval stand sold with the glass shades in common use. This may be of any quality, but as the apparatus is designed from the outset to be long-lived, it is best for it to be of good material. The extreme length of the oval stand (Figs. 1 and 4) may be about 15 inches. An ebonite or vulcanite tube (B) of 1 inch clear internal diameter and about 1½ inches external diameter, and 18 inches in length, is fitted with metal caps, (CC), preferably brass or gunmetal. They may be arranged to screw upon the ends of the tube (B), but in any case will have to be supported by screws or pins passing through them and the substance of (B) in order to withstand the strain to be imposed upon them. Provision should also be made for the attachment, by soldering or otherwise of pieces of wire to each of the caps (CC). These pieces of flexible wire should be ⅛ of an inch in diameter and should allow of bending freely to conform to the projected style of ornamentation.

The caps (CC) must be very firmly fixed, and every means should be adopted to secure this end; otherwise the whole apparatus is faulty. Having, therefore, secured one cap (C) safely, and provided for cap (C') presently to be also securely placed in position, we may proceed to make a punch (Fig. 3). A piece of seamless tube, obtainable of any large ironmonger, is cut off to about 3 inches length (C, Fig. 3). The upper end is fitted with an elm or other tough wood plug (B) and then the lower end is ground down at (D) so as to present a sharp circular edge, 1 inch in diameter. But if any difficulty is experienced in procuring such a form of tool, it is better to purchase a "leather-punch." Discs of card or paper, about 1 inch in diameter, may be cut, so as to easily fit within the tube (B), Fig. 1.

Now, most people know the paper in which tea and coffee is sometimes wrapped, which has a coating of metallic lead and tin upon one side and a rather rough paper surface upon the other. Grocers' stationers sell this by the quire or pound and it is usually made in two sizes, the sheets 14x16 inches being the most convenient. A quire of this paper will suffice, and each sheet must be carefully dried, and care taken that the metallic surface upon one side is not cracked or broken. A quarter of a pound of the black oxide of manganese (MnO_2) should be mixed with sufficient thin size (fish glue is excellent) to render the mixture of the consistency of ordinary paint. The backs of each sheet of the metallic paper should be coated without stint, and when the first coat is dry, the second may be lightly laid on, each sheet being placed to dry separately.

When all the sheets are thoroughly dry, they may be placed upon a soft pine board, some six sheets thick, and the discs punched out. The total number of discs required is 5,500, and one quire of paper of the size quoted amply suffices, allowing for all waste. The next thing is to pack the discs within the ebonite tube, which already has one metallic end firmly fixed to its end. This operation, although very simple, requires the greatest care and precision.

Starting with a disc manganese side downwards, this order must follow throughout—that is to say, a manganese surface must always lie upon a tin surface, and if the manganese leads when the first disc is put in, it must always follow that order until the last is placed. A wooden ramrod should be used from time to time to press the discs firmly home within the tube. Where the whole of the discs in their proper order are pressed and rammed into the ebonite tube (B) the pressure should be appreciable when the cap (C') is fixed in its place, or else the efficiency of the device will be impaired by reason of bad electrical contact.

When all the discs are in position within the tube, and both ends fixed, as shown by Fig. 2, two very flexible metal wires are attached. Then, marking out a plan upon the stand, as shown by Fig. 1, the ebonite tube (B) is warmed and bent carefully to correspond to the marks or lines made upon the stand.

Now comes the artistic part. The whole base should be made up to imitate nature as nearly as possible, the two flowers (F) and (G) in Fig. 4, being either of uncovered metal or presenting metallic surfaces in contact with the two wires of Fig. 2. The

(Continued on page 49)

Fig. 2 shows the voltaic pile with its terminal wires and caps before it is bent into an incomplete circle, as in Fig. 1. Its two terminal wires connect with the metallized surface of the flowers F and G.

Fig. 3 shows the tubular punch made of a tube C, sharpened to an edge D, and fitted with a wooden plug B, for punching out discs for the voltaic pile. The discs are made of what is sometimes called tea-paper.

Fig. 5 shows the butterfly as suspended by the delicate thread H of Fig. 4. There must be a metallic surface on the wings of the butterfly so that it will make good contact with the flowers F and G, as it swings back and forth.

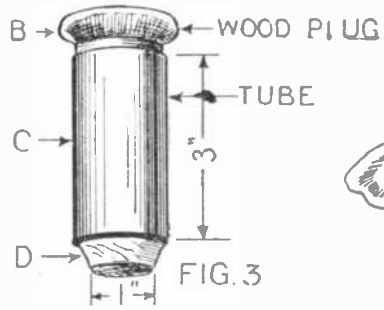


FIG. 3

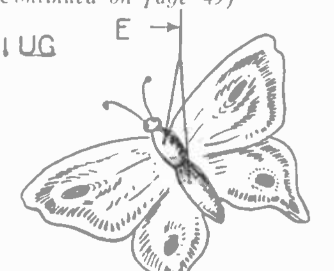


FIG. 5

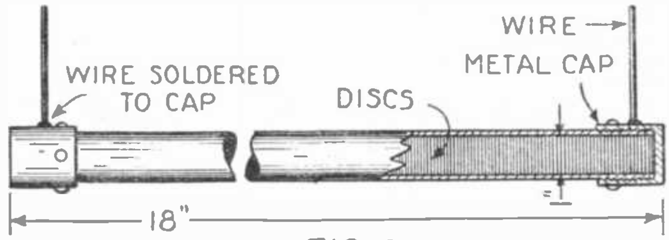
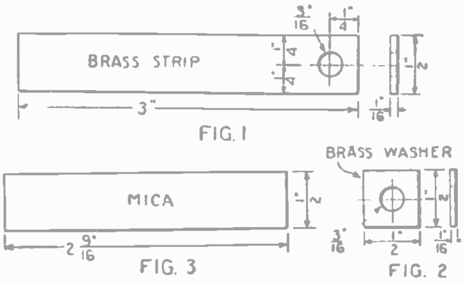


FIG. 2

Making a Selenium Cell

By Hymen Bushlowitz, E. E.



Dimensions of brass strips, mica dielectrics and washers for building up the frame for a selenium cell.

BECAUSE the electrical conductivity of selenium is dependent upon the strength of the light illuminating it, experiments with this substance are particularly interesting. Selenium is not the only substance possessing this property, but it is by far the most sensitive of any yet discovered. A "selenium cell," as the apparatus utilizing this property is called, may be constructed in the shop or laboratory at very little expense.

Two types of cells are used, one of comparatively low resistance, the other of a higher resistance. Both types possess a certain amount of inertia, developing lag—that is, they do not respond instantly to a slight change of illumination, and this characteristic is intensified with excessive or over-illumination.

It may be well to make a little study of the element selenium before building the cell, as the cell must receive a certain careful heat treatment after assembling. Selenium is a non-metal of the sulphur group and is generally found associated with it in nature. Like sulphur, it exists in several forms, the "A" selenium being that used for the cell. The "A" selenium is a dark grayish-black crystalline solid, possessing a metallic luster. It is unsoluble in carbon disulphide and has a specific gravity of 4.8. It begins to melt at 217° C. (422.6° F.) and is a liquid at 250° C. (482° F.) At higher temperaturs in the air it is oxidized.

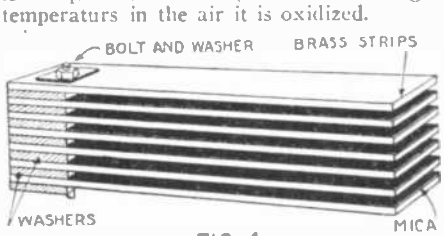


FIG. 4

Building up the brass strips and mica insulations to form the basis for the cell.

The "B" selenium, which is the most stable form, is of dark reddish-brown color, specific gravity 4.5, soluble in carbon disulphide, from which it crystallizes in prismatic crystals. It melts at 217° C. (422.6° F.) and boils at 700° C. (1,292° F.) A third variety, specific gravity 4.26, is found in two forms, the one electro-positive and unsoluble in carbon disulphide, the other electro-negative and soluble in carbon disulphide. It fuses at 100° C. (212° F.) and when suddenly cooled becomes vitreous. When heated to 270° C. (518° F.) and suddenly cooled to 180° C. (356° F.), at which temperature it is kept for several hours, it is converted to the "A" selenium. On heating the "B" variety to 150° C. (302° F.) it changes to the "A" variety with the evolution of heat. The chemical properties of selenium are very similar to those of sulphur. These properties are given here that the experimenter may better understand the heat treatment which the completed cell must receive in order to render it sensitive to light.

The material needed for a fair-sized low resistance type of cell is as follows:

- 15-foot strip of brass, ½-inch wide by $\frac{1}{16}$-inch thick.
- 2 brass or iron bolts, 4 inches long by $\frac{3}{16}$-inch thick, with 2 washers and 2 nuts each.
- ½-ounce selenium, stick preferred.
- 1 piece mica, 8 by 12 inches, very thin.

Cut from the brass 50 strips, 3 inches long, ½-inch wide, by $\frac{1}{16}$-inch thick, as shown in Fig. 1, each with a $\frac{3}{16}$-inch hole ¼-inch from the end. Fifty copper or brass washers, ½-inch square, with a $\frac{3}{16}$-inch hole in the center, should also be provided; they make a fair-sized cell, but the more strips in Fig. 2. Fifty strips and washers will make a fair-sized cell, but the more strips and washers the lower the resistance of the completed cell will be. From the mica cut 50 strips $2\frac{9}{16}$-inch long by ½-inch wide. One of those strips should be very lightly shellacked to each brass strip, as shown in Fig. 3, so that the end of the mica covers the end of the brass strip farthest away from the $\frac{3}{16}$-inch hole.

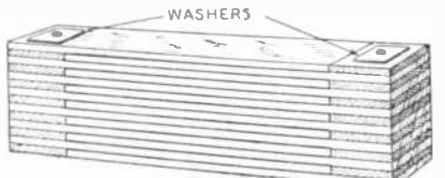


FIG 5

FIG. 6

Making up the cell from its two sections, using a clamp if desired, but this is not necessary. If the clamp is used, it must be insulated from the metal of the sections.

Twenty-five strips and 25 washers are then mounted alternately on each bolt, with the mica always on top, as shown in Fig. 4. The two sections are slipped together and the nuts tightened down, as shown in Fig. 5, so as to hold them securely. A clamp, as shown in Fig. 6, may be made to fit over the center, if desired, but it must be insulated from both sections by mica, or fiber, etc.

The top edge surface of the strips should be well smoothed down, with a file or otherwise, so as to be perfectly smooth. The two sections should then be tested with a voltage 5 to 10 times as high as that to be used in connection with the cell, so as to be sure that the sections are insulated from each other. If the insulation is perfect, the smoothed surface should be heated until the selenium melts freely when rubbed over it. Be careful not to get it too hot, so as to oxidize the selenium, yet it should be hot enough to cause the selenium to adhere well. The parts of the cell where the brass strips overlap should be given a thin, even coating of selenium, and while hot, the excess may be removed with a spatula, so as to leave a smooth, even surface.

The heat treatment is then given. The cell is placed in an oven and heated to about 260° or 270° C. (500° or 518° F.), at which point it is kept for about two hours. The cell is then removed and cooled in the air, the "A" selenium resulting.

The extra nut on each bolt may be used for connections. It is best to mount the cell in a small box with a glass lid, so as to protect it from injury, dust, etc.

The high resistance cell is made by winding two wires in parallel, or side by side, on a narrow strip of heavy mica, asbestos board, slate, or other suitable insulating material, as shown in Fig. 7. The edges of this insulating material may be notched before winding, so as to hold the leads of the coils in place. Holes should be bored in each end, through which the ends of the wires may pass, so as to secure them. A medium-sized coil is about 1 by 3 inches, with only the top side coated with selenium. It should be wound with copper, brass, silver

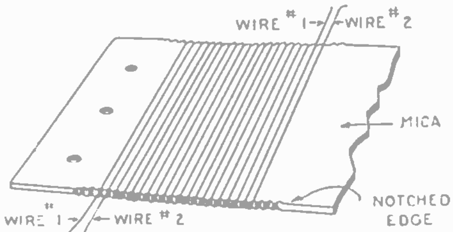


FIG. 7

Winding the mica with wire for a high resistance cell. The two wires are wound on, being held in position of parallelism by notches on both ends of the mica.

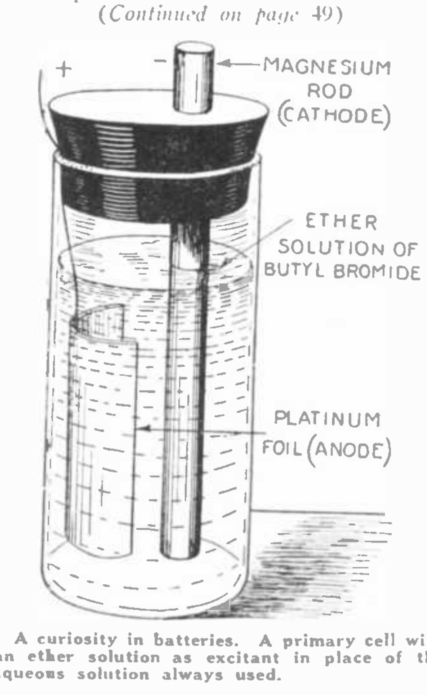
or platinum wire of about No. 35 gauge. The resistance of the cell depends on its size and the spacing of the wires. It is best to have the wire as warm as possible when winding it on the form, so that, as it contracts on cooling, it tightens, thus holding it more rigidly in place. A $\frac{1}{16}$-inch spacing or less is very often used. The closer the wires the less resistance. After winding, the selenium is applied in the same way, and the same heat treatment given, as in the construction of the low resistance cell.

Non-Aqueous Voltaic Cells

By Hubert Fairlee Jordan, B. A.

AN ordinary voltaic cell is made by putting two dissimilar electrodes in a solution of an electrolyte (i. e., acid, base, or salt) with water, as the dissolving medium. If such a cell is connected to a sensitive galvanometer, it is found that the galvanometer deflects, denoting a passage of electricity through the galvanometer coil. The voltages of these cells vary according to the positions of the electrode materials

(*Continued on page 49*)



A curiosity in batteries. A primary cell with an ether solution as excitant in place of the aqueous solution always used.

Simple High Capacity Accumulators

By J. F. Bront

POWERFUL storage cells can be readily constructed from simple materials, and with a minimum initial outlay in both cost and necessary parts.

It is well known that accumulator cells may be "formed" by charging and discharging a unit comprising two lead plates immersed in dilute sulphuric acid as an electrolyte. The alternate charge and discharge tends to bring about the same condition of the opposing plates as exists when positive and negative plates are "formed" by mechanical means, *i. e.*, by "pasting" the positive and "sponging" the negative plates.

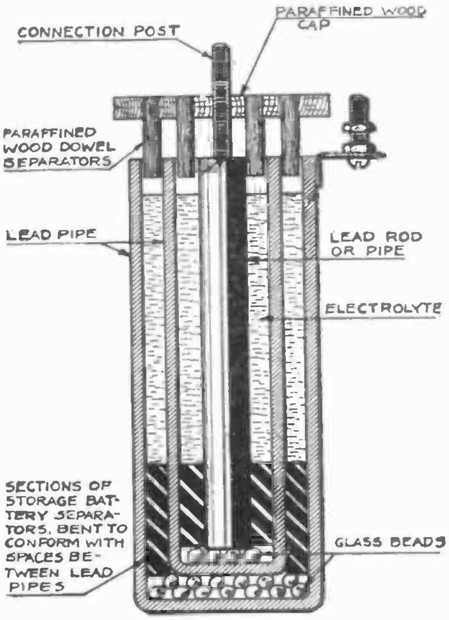


Fig. 1. A four-volt storage battery comprising two cells but utilizing only three plates. The plates are made of common lead pipe. The container acts as a plate.

For a variety of uses a comparatively powerful cell is readily adaptable and desirable. It may be for radio, signalling via wire and similar usages. Necessarily for a given rendered potential the capacity in amperes will depend upon the areas of the opposing plates which are immersed.

In Fig. 1 is shown a 4-volt battery comprising two cells, but utilizing only three plates. Both areas of the second plate are used—one side as positive and the other as negative electrode.

The plates are formed of three lengths of lead pipe, aligned concentrically. While separated at the bottom by a few glass beads (marbles will serve), the lateral separators are portions of the wood separators taken from old flat plate storage cells, and bent to fit the spaces between these plates (pipes) as shown in the figure. At the top a wooden cap carries two rows of dowels, running at right angles to each other, and thus placing a separator at each quarter point around the circumference of the pipes (plates).

Although the central plate is shown as a leaden rod, it may be another section of pipe. This carries a section of a machine screw, forming a binding post which not only secures the cap, but serves for purposes of connection to the circuit.

These cells may be formed of several lengths of pipe (lead), each telescoping within the other, but separated by the wood and glass bead separators and the electrolyte.

The cap and dowels should be treated with hot paraffin before final assembly. This is highly desirable. The external connection is made to the outer length of pipe at some convenient point.

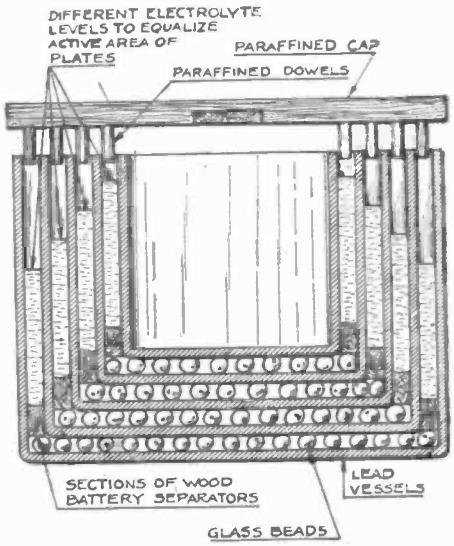
It is necessary that the lower ends of the pipes be sealed. The most satisfactory and dependable manner of accomplishing this is by beating down the open end of an ordinary piece of pipe, completely closing the opening and subsequently fusing any apparent breaks or opening. A hot torch blowpipe will accomplish this.

The pipe lengths will graduate in size according to the size of the bottom separators. The overall length (height) of the completed accumulator may be 12 inches (more or less), according to individual desires. The potential will be approximately 2 volts per cell (*i. e.*, 2 volts for each space filled with electrolyte).

Fig. 2 shows another construction, but the scheme is exactly similar to that of Fig. 1 with the exception that the height of the complete battery is reduced and its diameter greatly increased. The broad leaden vessels in Fig. 2 may be formed, if conditions require, from plain sheet lead, beaten to shape.

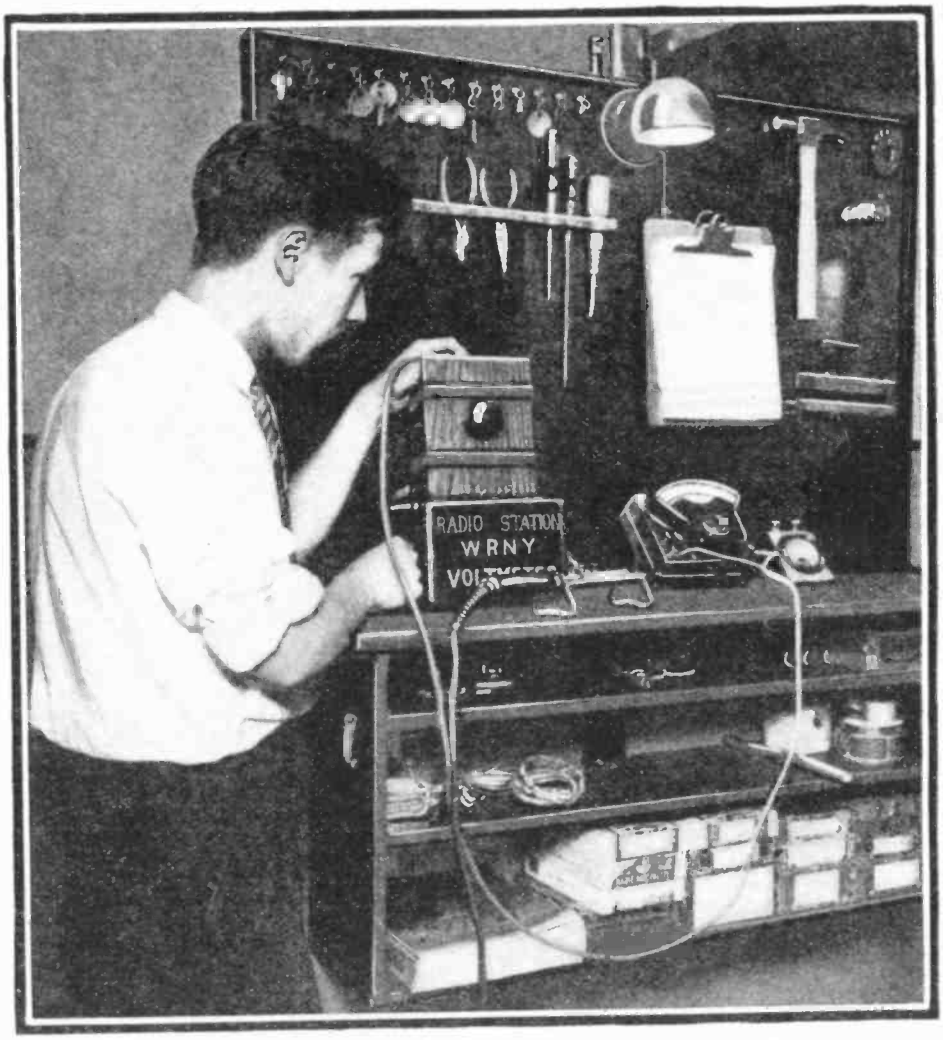
It is necessary that the battery be alternately charged and discharged a considerable number of times before strong currents and long discharges may be taken from it. The condition of the plates improves with use, and with every subsequent charge and discharge.

The 40 per cent. sulphuric acid solution may be used, pouring the *acid into the water and letting it cool to the room temperature before introducing it into the battery. Never add warm electrolyte to a storage battery.*



Another form of lead-pipe storage battery, whose elements are made of sheet lead. Glass beads and wood are used for separators, and cup shaped electrodes are employed.

WRNY Tool Table



The WRNY control room is provided with this tool rack and work bench which places all tools and repair supplies ready for instant use. Mr. H. Haddon, maintenance operator, is shown testing the equipment used in broadcasting code lessons from WRNY.

A Perplexing Convention

By HARRY R. LUBCKE

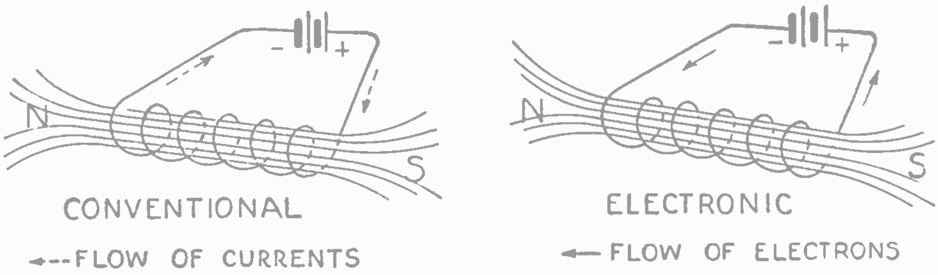


FIG. 2

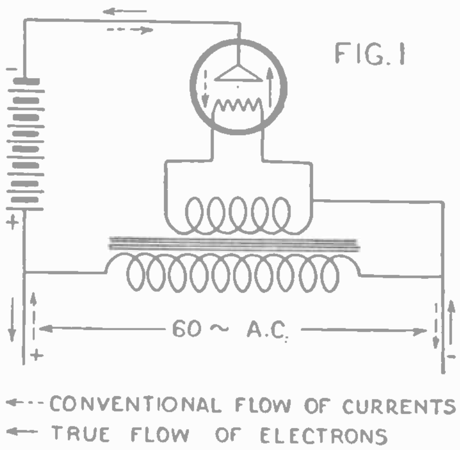
The same as shown in Figure 1 but on a different basis, involving the production of lines of force. If the current is made up of the flow of electrons the diagrams at the left which shows the accepted idea is wrong. A contradiction is seen to be involved.

ON the whole, the adoption of convention in the study of a science is beneficial. It gives an unchanging meaning and standardization and is valuable for comparisons of the work of different scientists.

Take for example, the extremely simple convention used in the indication of direction. We call the direction in which the sun rises east, and that in which it sets, west; this is the same all the world over, whether America, England or Australia. But imagine the confusion if some person turned it around and said that the sun rose in the west! If you were traveling in this country and asked for the direction and distance to a given town, he would give you instructions that would lead you in the reverse direction you wished to go in. Again, if a sea captain should wireless another ship, asking the distance to land (the other ship having arbitrarily taken west as the direction in which the sun rose) and received the answer, "Ten miles to the east," he might sail a hundred miles in the direction that was wrongly called "east" without meeting it.

If we consider the terminology used in electricity, you will find that we are doing the very same thing. You will recall that the smallest unit of electricity is an electron in motion. It travels in a certain direction around any circuit. We have said that currents move from positive to negative, but now we find that the electrons, which really constitute the *electric* current move in the *opposite direction.*

Benjamin Franklin, an early experimenter who knew nothing about electrons, arbitrarily considered that the electric current moved from positive to negative. At that time electricity was regarded as some sort of fluid that flowed from one place to another. It just happened that he picked out the wrong direction for it to flow. Now



A conventional diagram of the Edison effect rectifying cell, contrasting the presumably true and the conventional flow of the current.

we have a more complete knowledge of the electric current, but we still retain the antiquated convention.

According to the accepted theory of atomic structure, the atom is not the smallest divisible part of matter, but is composed of a number of smaller particles revolving about a common center, the nucleus, so that an atom is taken as similar to the solar system. The center, which is the positive nucleus, corresponding to our sun, consists of a number of negative electrons and positively charged protons. The charge of the protons is more intense and of such magnitude that the whole group constituting the nucleus is positive. The nucleus is the focus of the orbits of a number of electrons which revolve around it, in much the same manner that the planets revolve about the sun. Atoms of different substances have varying numbers of these "planetary" electrons.

The sum of all the positive charges equals the sum of all the negative charges in a normal atom, so that such an atom is neutral. But if one of the outside electrons breaks away from the nucleus, it disturbs this equilibrium. Since the electron is negative, it goes off as an independent negative charge while the rest of the system is left positive. This is the condition in any body which has an electric charge. If charged negatively, it has an excess of electrons, whereas if positive it suffers a deficiency of electrons.

The Tungar rectifier and the vacuum tube of radio depend essentially upon the flow of electrons through a rarefied medium for their operation. In a study of the action of these devices we come face to face with the utter ambiguity of the conventional flow of current. By referring to Fig. 1 this will be realized. Consider that at any given instant the polarities are as indicated. Now, following arrows, shown in solid line, we see that the current flows from (—) through the tube from filament to plate, then through the battery and out through (+). In the tube the current is carried by the electrons emitted from the hot filament which are attracted to the plate due to its positive charge. But, according to the convention that charges flow from positive to negative (indicated by the dotted arrows), the current would have to flow from the *plate* to the *filament!* Similar perplexing situations arise in the study of the three element vacuum tube.

In the study of physics or electricity the students are told to think entirely in currents, for clearly, if one were thinking of the current flow in a wire in terms of electrons, he would arrive at exactly the opposite conclusion to that deduced by one thinking in terms of conventional electric current. To some this is never wholly clear and leads to entirely unnecessary confusion.

Considering only the motion of the electrons, the right hand rule for solenoids, coils and magnetic field determinations would become a "left hand rule." This is clearly shown in Fig. 2. Similarly, all the rules for determining the relation between magnetic fields and the direction of current would be changed to the opposite hand; the motor rule would become the generator rule, etc. But then there would be only one *correct* representation of current flow and no difficulties could be encountered.

In the study of batteries and electrochemistry in general, with the adoption of electronic considerations throughout, much greater clarity would be obtained. In considering the inside reactions between the ions the electron view must be taken because it is the only convention in use, but to have to reverse all considerations when dealing with the external circuit to make them conform to the current idea is a nuisance.

A change, universal in extent, over to the electron view, which is the only correct conception, is worthy of the consideration of every influential person in the electrical field. The metric system was adopted universally for scientific work because of its extreme simplicity and utility, and it is high time that we should do likewise with the true motion of electric charges.

Thermal Telephone

By MORRIS CHERNOW

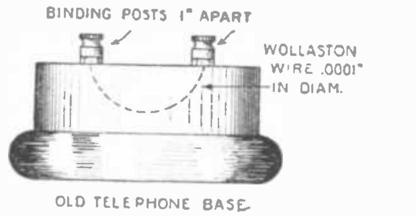
THE following is a description of a thermal telephone which can be constructed at a cost of sixty cents. This receiver differs from the magnetic type of telephone, and works on an entirely different principle.

The parts required are an old telephone case and about three inches of platinum wire —about .0001 in diameter—known as Wollaston wire. It can be purchased at any chemical supply house for about fifteen cents per inch.

Its action depends upon the heating effect of the electric current. Normally a small current passes through the receiver and fluctuation of the current, as from received signals, suddenly heats and cools the fine platinum and creates pulsations of the air in the telephone. These pulsations are transmitted to the ear drum through the opening in the cap of the receiver.

To construct a receiver of this type bore two holes about one inch apart through which the binding posts are mounted, first inserting some cardboard washers between the metal of the receiver base and binding posts, so that they do not touch and cause a short-circuit. Then take the piece of Wollaston wire and solder its ends to the two binding posts. The diagram below will make it all clear.

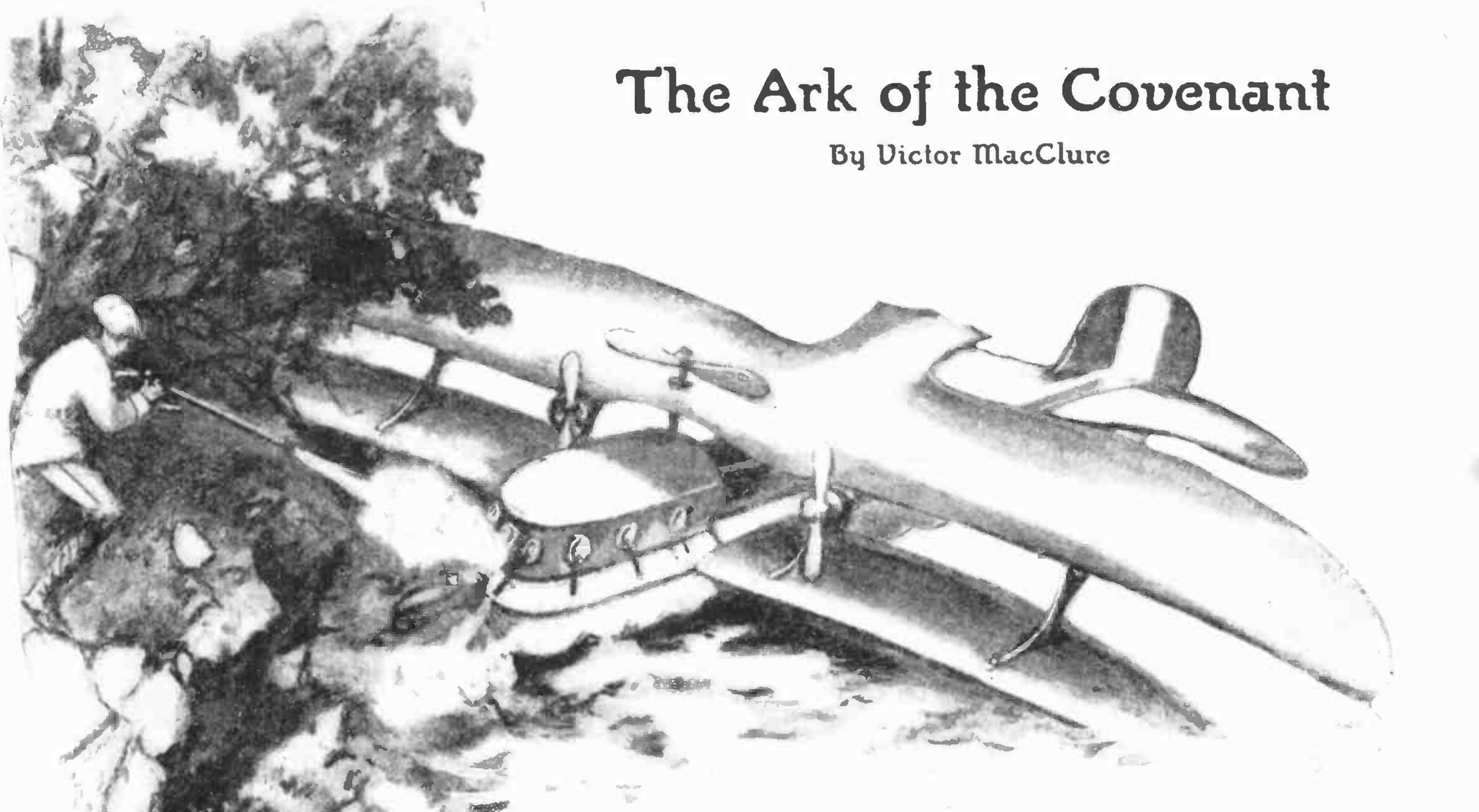
When tested it proved equal in volume and sensitivity to a pair of Baldwin phones, while having the advantage of being very much lighter and with no magnets or diaphragms. Magnetic telephones are always liable to deteriorate from loss of polarization of the permanent magnet. In the thermal telephone there is nothing to deteriorate. Great care is requisite in handling the almost invisible wire.



A thermo-telephone, depending for its action on the variation of current passing through a Wollaston wire of extreme thinness.

The Ark of the Covenant

By Victor MacClure



"From the bushes nearby two shots rang out—mighty good shooting, too, for the aerial snapped . . . . another two shots go bang, and from the noise I judge they've punctured the floats. Then I have a go with the mitrailleuse."

[What Has Gone Before]

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

They find that throughout the financial district everyone has 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.

Powdered glass is found in the street to add to the strange events. Little lead cases came into the Post Office by mail. Raduim salts were enclosed in them.

The airplane Merlin, the fastest of all airplanes, takes an active part in the story. The mystery deepens when it is found that some millions of dollars of securities have been returned to the banks, but a slightly larger amount of gold has been taken.

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

Lord Almeric, a well preserved man of 60, joins them. The crew recovers. A discussion ensues and it is concluded that the raiders used an airplane. The Merlin starts off after the ship's engines begin to turn, with Miss Torrance, Lord Almeric's niece.

Now news comes that Louisville has been attacked, and an hour and forty minutes takes the Merlin to Louisville, where the New York raid has been duplicated. Next the Atlantic is crossed to Europe.

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

A search for the mysterious airship or raider begins in earnest. The Merlin shortly after the take-off from England reaches American and Gardiners Bay without sight of the enemy. And now our hero wants a roving commission for a new Merlin to carry out his own and his associates' views as to the raider. He proposes to arm his airplane and go off prepared for attacking and for defense. An appointment with the President of the United States is made and the Merlin goes to the federal capital. The interview with the President follows, a very cordial one, as young Boon's father is a friend of Mr. Whitcomb, the President. Miss Torrance has been pleading the cause of the Merlin at the White House.

The search is prosecuted and the enemy is sighted. Eager to attack, a gas defense by the enemy threatens.

An airplane is launched from an English cruiser to join the attack. Signal flags transmit messages back and forth between the cruiser and the Ark of the Covenant. Then comes a description of the landing of the Merlin on the deck of the English cruiser, and the Ark of the Covenant meanwhile has disappeared at amazing speed. In England there is a business panic; the Government falls. The Merlin and her crew at last return to America. Information comes directly from the raider that she desires to stop all war.

The northern coast of South America is patrolled in search of the great dirigible—she is seen—but escapes the crippled Merlin. A strange desolate district is discovered by her crew in South America, and the presence of rhodolite, the radio-active mineral, accounts for the desolation. And now begins the story of Sholto Seton telling all about the history of the Ark of the Covenant and the efforts to annihilate war.

Now comes the story of the formation of the League and the gathering of a crew. A new element and a new gas have been discovered; the earth is drilled for the gas. The great dirigible proposed is described, and tests with the spectroscope and electroscope reveal strange substances in the earth of the South American cavern.

The story goes on to tell of the radium emanations, the anaesthetizing gas, and then the getting of recruits to use these powerful weapons in the adventures in the cabin. The story of the airship in her travels follows.

The Airship

I imagine the absurd spectacle afforded me in one particularly offensive politician, from whose obtuseness I had frequently suffered while in the air service, had a great deal to do with my complacence over the scheme. To see the pompous fat-head with his face blackened was complete solace for all the irritation I had experienced formerly through his fatuous ignorance.

The Chief, however, took another view. He considered that our mission had been degraded, and he gave Devonridge a wigging which, while it held no trace of anger, did not lack in point. But even the Chief was not proof against the gay, insouciant humor of Devonridge, and in the end I think he forgave the culprit fully. At any rate, the joy of the English members of the crew was worth any little lowering of tone we suffered by the exploit.

The raid on the House of Commons occupied little more time than it takes to write of it, and after operations on the Army and Navy Stores we dropped down the river to Purfleet, where we replenished our depleted store of petrol. Once again we took to the highest we could compass, and we drifted slowly west to be in readiness for our descent on Berlin.

The Berlin raid was accomplished without mishap, but it was at Paris that we were made fully aware of the preparations against us. We were comfortably settled on the top of the buildings in Rue Bailiff, and the burglary party was inside the Banque, when we heard the drone of aeroplanes. Fortunately, Thetford was on the ship's observation top in readiness for such an emergency, and in spite of the machine-gun fire the little fellow pluckily manipulated the ray for upsetting the electric circuits of the plane engines. He came out of the scrap without scathe, and had the satisfaction of seeing both his opponents go down out of control. We hastened the depositing of the gold, which was designed for creating further confusion in the minds of those after us, and left our usual quantity of radium before speedily taking to the air again. From Paris at a great height we bore due south until we were over the Pyrenees, where we swung sou'westerly in arched line for the plateau.

It was now apparent to us that we had put a very effective spoke in the wheel of the world's business, and had stirred Europe and America into a state of apprehension and mystified anger. It was plain, too, that drastic measures would be taken to run us to earth, now that it was definitely known the raids were accomplished by airship. We determined to demonstrate our powers by day-light, and give those who chased us every chance to meet us if they could.

Our raids on Europe took place on a week-end in April, and our next raid, which was by day-light on shipping along the South Africa route from England, took place on the first Sunday in May. We knew from the wireless messages which we picked up that many aeroplanes were after us, and later, when we had skipped back to the plateau, messages emanating from one particular plane, the *Merlin*, showed that we were being pursued by the fastest air machine ever known.

We took the trouble of recording the messages from this *Merlin*, and we began to note that not only could she get about from place to place in incredible time, but she seemed capable of extremely prolonged flights.

The following week-end found us raiding shipping on the North Atlantic, while the *Merlin*, we knew, was scouring the Canaries. News of our North Atlantic raids—which we took trouble to relay by wireless ourselves—brought the *Merlin* to the Azores, but by the time our most assiduous pursuer was sweeping the Atlantic for us, we were flying out of sight above him on our way home.

We now rested for another week, and in the late evening of the middle Saturday of May set out for further raids on the African shipping. We reached Madeira in the early hours of Sunday morning, and found a temporary mooring place on the Paul da Serra, that barren piece of desolation to the west of the island. There we lay snug until the first peep of day, when we unhitched to fly northwards to intercept a Union-Castle liner. This time we were unaware that the ubiquitous *Merlin* was close behind us.

"The immensity of the caverns was awe-inspiring. With the glare of the arcs, the shimmer of the great airships, an effect was created that gave one the impression of being in a dream."

III

How the "Merlin" Attacked the Ark of the Covenant

We had dropped our gas cloud and had swept the ship with it. We had grappled our gondola to her side. It was a raid of terror, merely, but we broke into the strong-room as a matter of course. We found little, not enough to justify abstraction, but we were helping ourselves to the ship's stores of food when the message came from aloft, "'Ware planes!"

To recall the crew was a matter of seconds, and we had the gondola into the ship and had cast off before the silver plane dived at us. Eastwards, now, we saw the approach of the British plane-carrying cruiser.

There was something divinely beautiful in the swift, brave swoop of that lovely silver shape. She came down at dizzying speed, so that it was useless to try our ray upon her, for she had the force of gravity to bring her. But we opened the gas-jets about the ship, making a cloud of anaesthetic envelop us. It seemed with the steady rise of the ship that the plane was bound to miss us, but we were sadly mistaken. The pilot knew his business. Before we realized what had happened, he had flattened in a fashion which would have shattered the average plane into her component parts, and we were opened fire upon with accurate bursts of shell-fire both fore and aft of the plane as she whizzed under us.

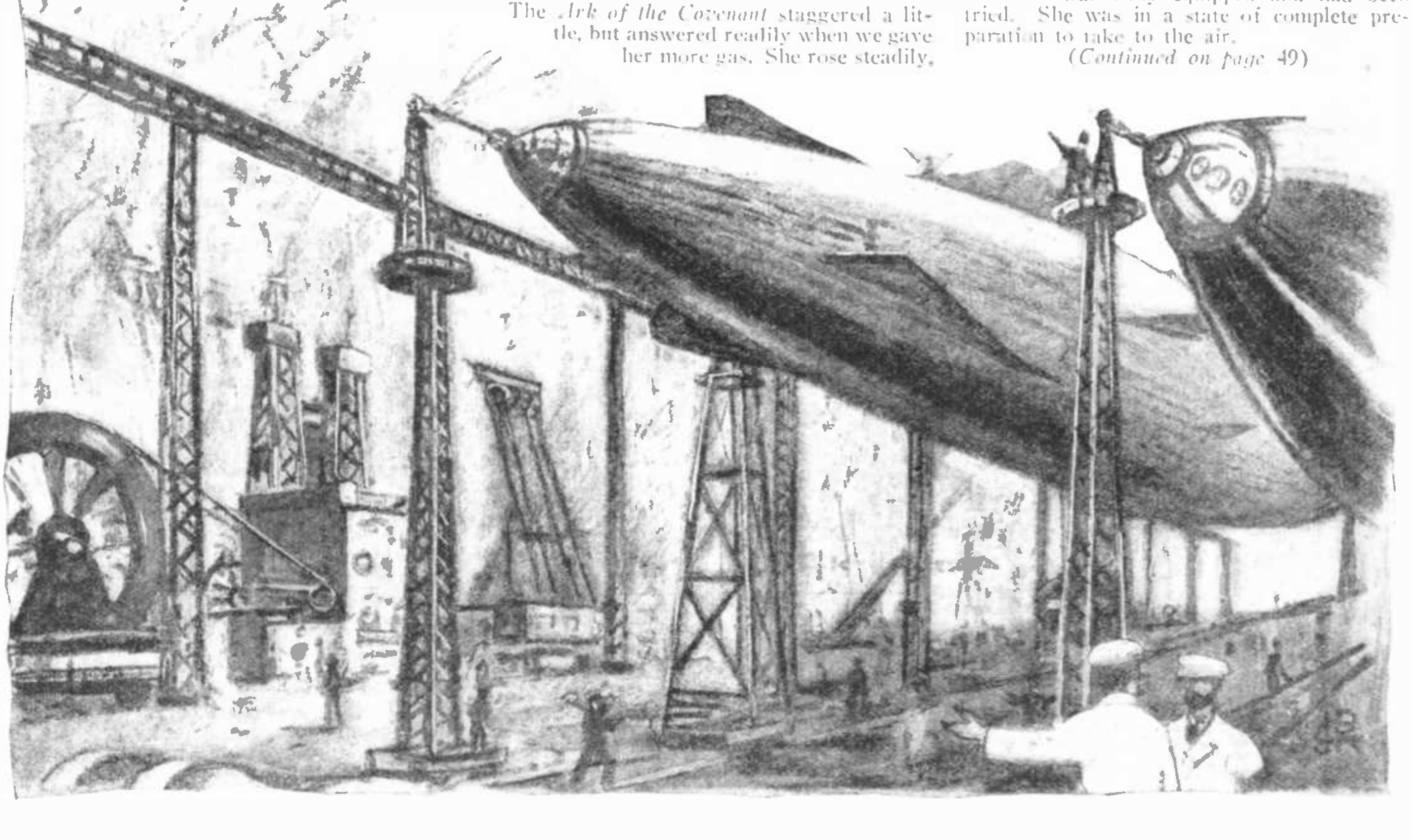
The *Ark of the Covenant* staggered a little, but answered readily when we gave her more gas. She rose steadily, foes had to climb. We saw that the *Merlin*—for so we supposed our attacker to be from her speed and her fine design—was somehow immune from our gas cloud. She swung after us into the cloud, but got off a burst of shell-fire none the less. She found she could not take us at her present angle and she spun quickly about. Her pilot was one in a hundred for knack. Machine-gun fire from her quarter, and another burst of shells from astern. We could not afford to experiment any further, and we put our ray on her. She slid back on her tail immediately, only to flip over into a well-controlled and peculiar hovering descent. To make sure of her we swept a gas cloud about her as she lay on the sea.

By this time we had to turn our attention to the cruiser, which was coming up on our position in great style. We saw a plane catapulated after us, and presently the cruiser opened fire with her heavy anti-aircraft guns. Then came a second plane. The remainder of the encounter was as has been previously described, down to the messages which passed between us and the *Brilliant*.

We could have cleared beyond range at any time after dealing with the *Merlin*, and our only reason for prolonging the business was to see that the pilots were picked up. We did not want any of them to be drowned after an extremely plucky flight. It was for this reason that we swept the gas from about the *Merlin* and told her her engines were all right. When we saw that all was well, we gave the airship her full lift of gas and made eastwards out of sight, where we turned south for a space before swinging westwards and home to examine our hurts.

The damage done to us by the *Merlin's* guns was not important, and we considered it valued at the measure we had taken of the plane's capacity against us. She had raked the dining quarters of the crew, wrecking them almost, and had pierced several of our ballonets, but had missed everything vital. There were no casualties to speak of, save that Billy Haynes took a machine-gun bullet in the leg, a mere graze which did not even make him limp. But, unimportant though the damage to *Ark of the Covenant—I* was, it was enough to put her out of action for a space and necessitate the commissioning of her sister ship. The *Ark—II* was fully equipped and had been tried. She was in a state of complete preparation to take to the air.

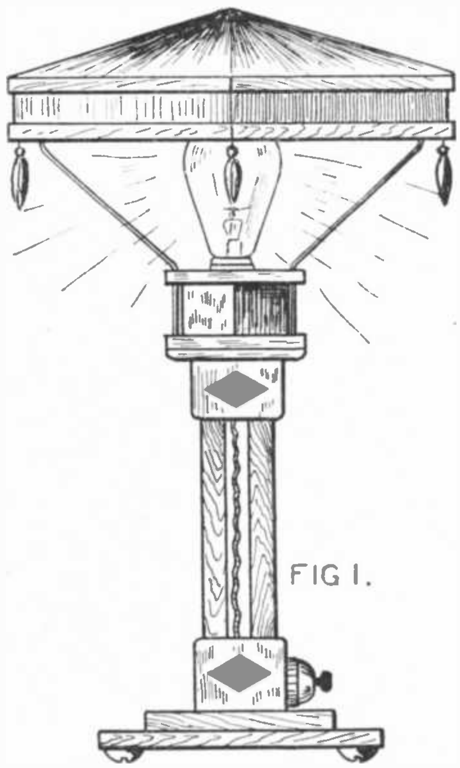
(*Continued on page* 49)



Mission Table Lamp

FIG. 1 shows a finished table lamp of home construction; Fig. 2 gives a sectional view. A square base or footplate, F, is cut from a ¼-inch board. Bore a hole in each corner and one in the center. The center one is for the passage of the wire, the corner ones for the insertion of the little knobs, which are the feet on which the lamp stands. For these you may use either small wooden knobs, or the "domes of silence" sold for use under chairs. For the latter no holes are to be bored.

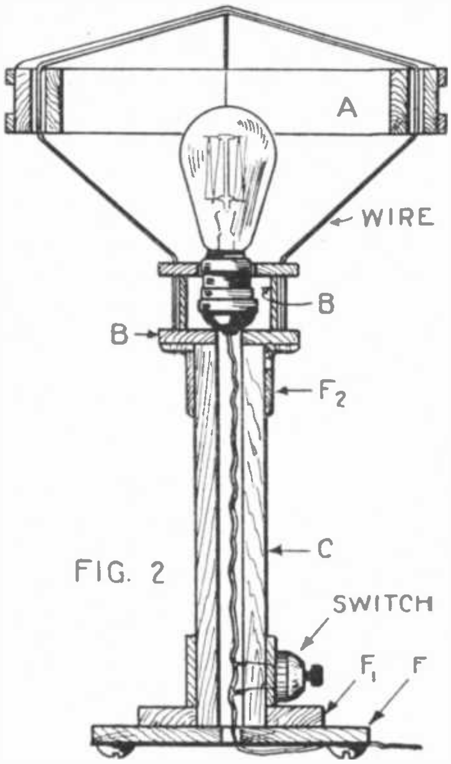
To (F) glue a smaller board (F_1) of the same wood and bore four square holes in the corners to take the four columns, C. The four columns are of ½-inch dowel



A very handsome table lamp made in a style of mission furniture; it will be seen that the idea of members of square and rectangular sections is well carried out.

sticks and can be from 6 to 7 inches high. On top of the columns fasten the "box" (B), which holds the socket. The best way to insert the socket is to let the small round tip fit into a hole in the bottom of the box, and to have the cover fit snugly around the neck of the socket.

The box itself needs no description. It should be of good quality wood, and have a small board glued to the outside of its bottom, to which the column tops are secured in the same way their lower ends are to (F_1). A pull-socket may be used, in which case a hole must be bored in the "box" to let the chain pass, or a switch can be placed at the base, as shown in the sectional view. The shade is made of a square frame (A) of thin wood, oak veneer or something similar. To the inside of the four corners four blocks of wood are glued. Into these fit two wire "arches" or bows, bent according to the illustration, and their free ends are brought down and fastened to the box; they are passed through holes in the lid and bottom, or fastened to the sides by small brass collars, as preferred. These two wires



A sectional view of the lamp, making its construction still clearer than the preceding elevation, which is only part section.

cross each other and form the framework of the shade.

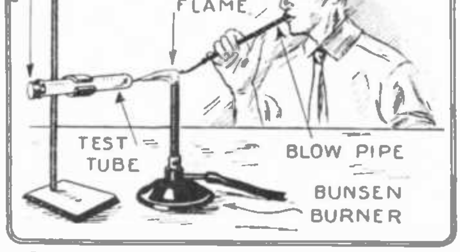
Test Tube Perforating

THE illustration explains how to make a tiny hole in a glass tube. The test tube is corked tightly, and a very sharply pointed blowpipe flame is directed against the spot where the hole is to be.

The blowpipe may give enough heat or a Bunsen burner may be used in addition.

When the air inside the tube is heated it will expand and force its way through the melted point, and a small hole is formed with a feeble explosion. Both ends should be corked if an open ended glass tube is to be perforated.

Contributed by K. Liu, Shanghai, China.



Simple and effective way of making a small hole in a test tube; by plugging up the hole another can be made by the same process, and in this way any number of perforations can be made in the tube.

Making a Geissler Tube

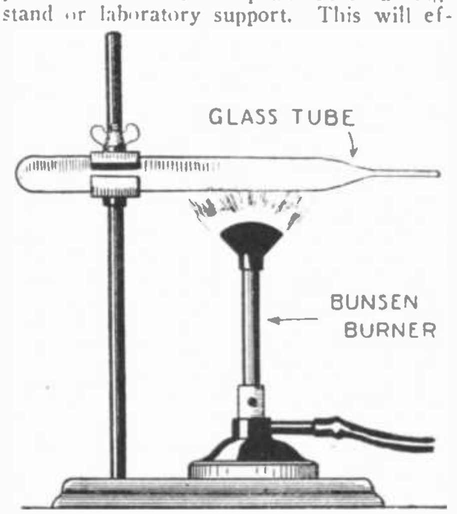
By Raymond B. Wailes

A REALLY good Geissler tube can be made by the experimenter without the slightest knowledge of glass working.

Geissler tubes are made with electrodes sealed in at each end and the air within removed by means of a vacuum pump. The type of tube illustrated here has no internal sealed electrodes; neither is a vacuum pump used to create the diminished pressure within. The body of the tube is made from a test tube of any size.

First hold the open end of the test tube in a Bunsen burner flame, rotating the while, until the glass softens and tends to collapse. At this point draw out the plastic end with a pair of tweezers or forceps. The drawn out end should now be broken off; about an inch of it should remain on the body of the test tube.

The tube is now evacuated by simply heating to a temperature just below the softening point of the glass. This is accomplished by waving a Bunsen burner fitted with a fish tail attachment slowly back and forth under the tube while it is held in the jaws of a burette clamp affixed to a ring-stand or laboratory support. This will ef-



A suggestion for making a Geissler tube without any pump, using heat to produce rarefaction.

fectually drive out the air. But to seal the tube!

This is accomplished by quickly fusing the drawn out tip with the aid of a pointed Bunsen flame from another burner. The heating flame must continue its work during this sealing-off process, and subsequent cooling, or the tip will collapse and be sucked in when the tube cools, due to the removal of the evacuating or heating flame. This sealing-off process is not at all difficult. After the end has been sealed, the sealing off flame is removed and when the seal has become somewhat cooler, but while the whole tube is still hot, the evacuating flame is slowly lowered and finally removed altogether.

Electrical connections are made with the Geissler tube by means of a ring of tinfoil wrapped at each end. The tube will work very well with a half-inch spark coil, lighting up with a blue glow.

By using different sizes of tubes, evacuated glow tubes can be made which will fit the handles of the many so-called "violet ray" machines on the market.

High Voltmeter Resistance

IT is quite expensive to possess a variety of voltmeters. Here is a little idea that works well.

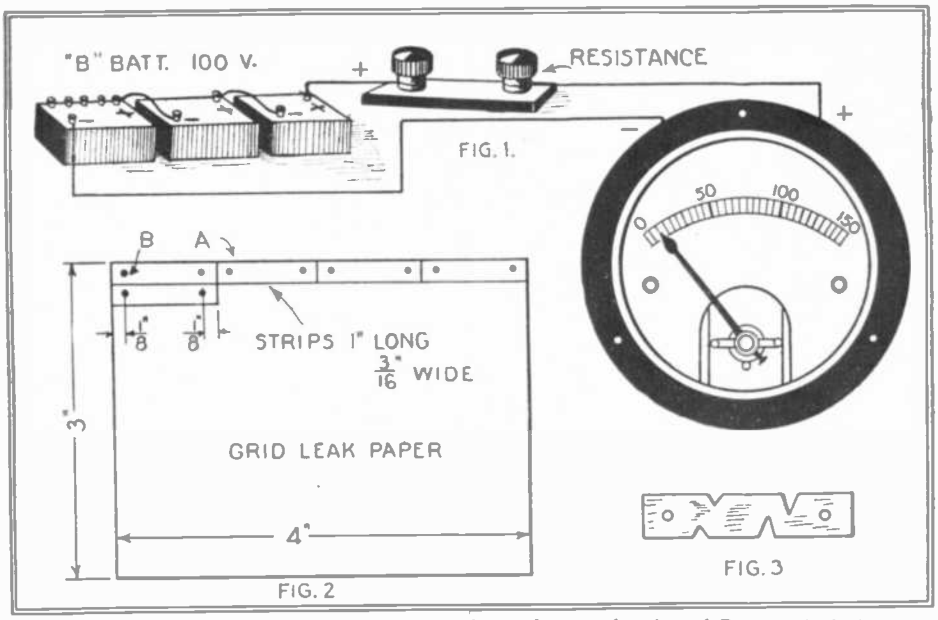
A voltmeter having a reading of from 0 to 150 volts with external resistor was used and a high resistance was added as shown in Fig. 1. The high resistance was made of Rasco grid leak paper. A sheet of the paper 3 in. x 4 in. was marked off as shown in Fig. 2. Five strips are needed, each 1 inch long and 3/16-inch wide, as shown at A in Fig. 2. In each strip two holes were made, 1/8 inch from the end, just large enough to let a binding post go through fairly tight.

A binding post as shown was used to make contact with the five strips of resistance. It may be that five strips will not be enough, but these were found sufficient by the writer.

The voltmeter is to have a reading of 0 to 1,000 volts. One hundred volts are used to set the voltmeter by. With 100 volts the voltmeter will show a reading of 10 volts if the resistance is right. A sixth strip may be cut as shown in Fig. 3 if needed.

The writer has used the voltmeter up to 500 volts with excellent results. It will show a reading of 50 volts when you have 500 volts on the circuit. No higher voltage than 500 has been used; if the voltmeter will stand a higher voltage, it will show a reading of from 0 to 1,500 volts.

Contributed by De Forest Urey.



A very convenient voltmeter multiplier can be made out of strips of Rasco grid leak paper. Fig. 1 shows the finished form of voltmeter resistance. Fig. 2, the method of varying the resistance of a strip. By cutting small pieces off the strip, its resistance is increased.

Wind Storm Alarm

IN rural districts where winds of high velocity are often disastrous, warning of the storm's approach is highly desirable. The obtaining of this warning is the object of the device here described.

Placed at distant points, the alarm will instantly sound an alarm—or it may be used locally for night signals.

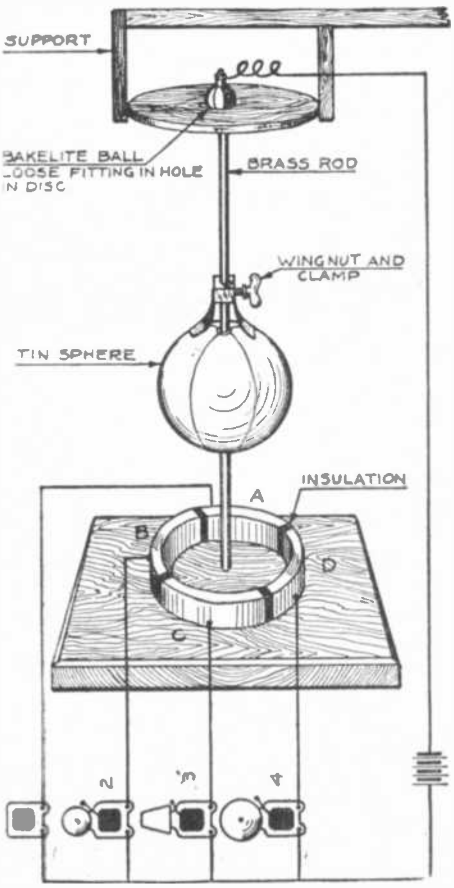
Primarily the device consists of a brass rod swinging on a universal joint. On the rod is a pressure area, in this instance formed by a sphere (it may be practically any shape), the height of which is adjustable to conform with a given wind pressure, the rod being deflected to different angles by different pressures of air on the sphere, depending on the height of the sphere along the rod. A clamp and thumb nut secures the sphere, so as to provide adjustment.

The "universal joint" may be formed by loosely seating a pool ball in a socket formed by shaping a hole in the supporting disc to the proper dimensions.

For simplicity the lower contact fixture, touched by the rod in operation, may be a metal ring—brass, copper, galvanized iron or other fair to good conductor. The illustration shows the ring cut into segments which latter are separated by insulating blocks. This is done to provide means for sounding different alarms so that the approximate direction of the high velocity winds is desired to be made known.

The pendulum hangs perpendicular in still air and under stress of light breezes does not make contact with the conducting ring

Contributed by J. F. Bront.



Wind acting on the suspended ball brings the brass rod in contact with one of the segments (A, B, C, or D), ringing one of the bells which gives an indication of its direction.

For a rheostat a five-gallon jar partly filled with water and with copper sulphate (blue vitrol) dissolved in it, is used. Iron plates are the electrodes.

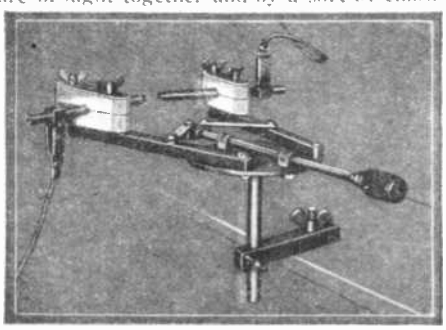
The holder can easily be regulated for height and distance by thumb-screws, and when once set requires very little adjustment.

The iron electrodes in the solution rapidly precipitate the copper and iron replaces it, giving iron sulphate solution as the final electrolyte. *Contributed by L. R. Lamborn.*

Arc Light for Bromide Enlargements

THE photograph represents an arc light with its carbon holders, which was designed for enlarging photographs. The operation of the device is shown in the illustration.

By pushing the handle inward, the carbons are brought together and by a sort of elbow-joint action are thus regulated. The carbons are insulated by ordinary porcelain cleats with notches ground in their centers.



The carbons of this handy arc light are removed by the longitudinal motion of the central rod provided with an insulating handle, operating elbow-joint levers.

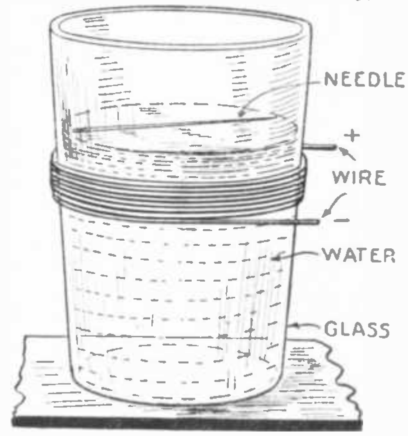
Another Oscillograph

IT occurred to the writer that it is about time for another article on the oscillograph. This one is certainly a simple one, and if not looked at from the standpoint of efficiency, will do very well.

All that is needed is a vessel of water, a needle and some wire. Wind the wire around the vessel and place the needle, which has been dipped in oil, on the surface of the water. When an alternating current is sent through the wire winding, the needle will start vibrating, which will cause the water to ripple. If a light is focussed on the water and the film is properly placed, something of an idea can be had of the nature of the current alternations.

The ripple will necessarily be small, but if the vessel is placed in such a way that the light strikes the surface, they can be seen.

Contributed by Jess B. Prouty, Jr.



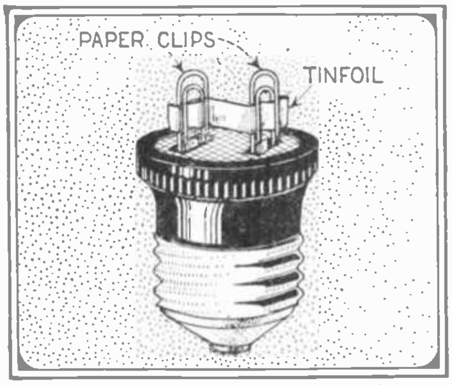
By oiling a needle it may be made to float upon the surface of the water owing to surface tension. Winding a wire around a tumbler in which such a needle floats, an alternating current will throw the needle and consequently the water into a very delicate vibration which can be observed by letting light fall upon the surface at the proper angle.

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

First Prize, $25	Second Prize, $15	Third Prize, $10	Honorable Mention
Ronald T. Symms, 237 S. Helena St., Spokane, Wash.	C. L. Hard, 1422 North 9th St., Quincy, Ill.	L. Russell Rohr, 449 E. Carrol St., Kenton, Ohio	Claude H. Slaney, 59 East St., Walton, N. Y.

First Prize
Renewable Fuse Plug

THE devices used to save the price of fuses are many and varied, but the one here shown is, to my idea, the best both



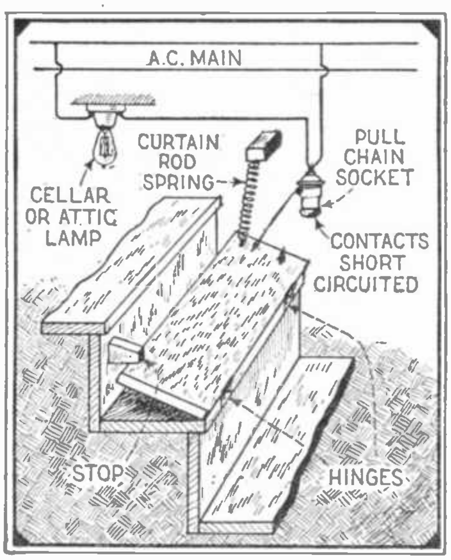
Two common paper clips are soldered respectively to the two terminals of a plug fuse and by springing them so as to hold a piece of tin foil extending across them, a temporary and perfectly efficacious fuse is made.

because of its cheapness and its ease of construction. The only items necessary are a detachable plug, two paper-clips, and an occasional strip of tinfoil, of which every experimenter has a plentiful supply.

One can easily determine the sizes needed to carry various currents, but a strip about three-eighths of an inch wide is the correct size for the ordinary house circuit of ten or fifteen amperes.

After placing two of these plugs in the fuse-box, the experimenter can experiment to his heart's desire without continually emptying his nearly empty pockets to buy fuses.

Second Prize
Automatic Switch



A step on a stairway hinged as shown and its play restricted by a stop, operates a pull socket; its contacts are short-circuited by a piece of wire soldered to them. The socket is in circuit with a lamp which is lighted when the step is trodden on, and stays lighted until the step is trodden on again.

ALMOST everyone forgets his cellar or attic light and leaves it burning perhaps for days at a time. The step-switch depicted here has worked perfectly for over a year and has well paid for the outlay and work of installing it.

The device is merely a hinged step that operates a pull chain socket. As the step is hinged at the outside there is no danger of tripping; because of its simplicity it will work well for a long while and is very easy to construct. The one point to watch is to make sure that the hinged step moves only enough to operate the pull chain socket, and then rests firmly on its base, otherwise the weight of a person on the hinged step would break the chain.

$50 IN PRIZES

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

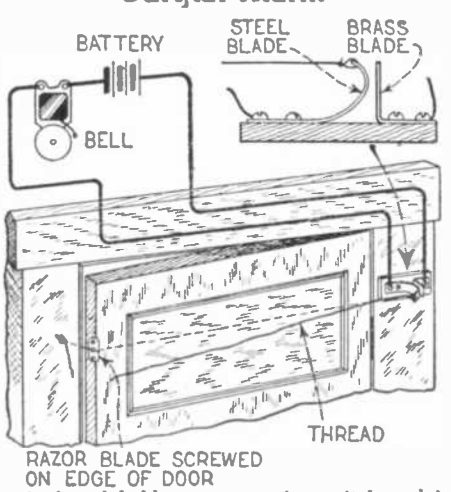
First Prize	$25.00 in gold
Second Prize	$15.00 in gold
Third Prize	$10.00 in gold
Total	$50.00 in gold

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

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

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

Third Prize
Burglar Alarm



A thread holds open a spring-switch and is carried across a door which is to be protected. A razor blade is screwed to the door so that when it is opened the string will be cut. The spring switch then closes and a bell starts to ring continuously.

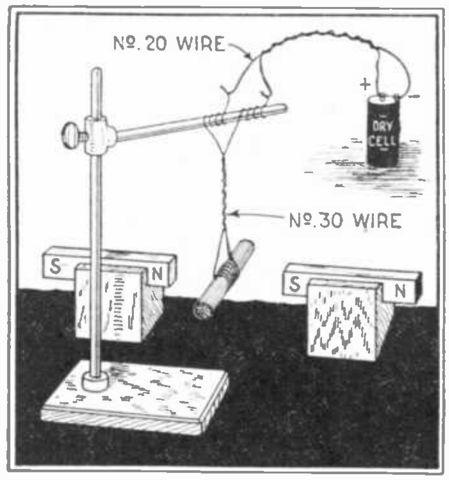
AN efficient burglar alarm can be built at a low cost by following these details. On a piece of wood (5"x3"x½") screw a stiff strip of brass bent at a right-angle (Fig. 2).

A strip of spring steel or spring-tempered brass should be screwed to the wood so that it will form a contact, as shown in Fig. 2. A piece of thread is tied to the steel and is drawn across the door and tied to a nail, holding the circuit open as shown in Fig. 1.

A safety razor blade is screwed to the end of the door so that it will cut the thread when the door is opened, causing the circuit to be closed. Either a bell or a buzzer can be used.

Honorable Mention
Simple Galvanometer

WHILE experimenting in the laboratory one day our galvanometer broke. Being very anxious to finish the task in hand and being unable to repair the broken one, we decided to make or extemporize one. This we did; of course, ours would not tell us the exact amount of current passing through but it did give us an idea that there was



An extemporized galvanometer; a bundle of soft iron wires wound by a number of turns of No. 30 insulated wire is suspended between opposite poles of two magnets; the arrangement is a useful testing galvanometer that can be extemporized in a few minutes.

some, also the direction, and that was the main thing we needed to know.

We hastily took a ring stand with a clamp and attached the clamp about a foot above the table. Taking some No. 30 insulated wire, we made a number of turns (about sixty in all) around several soft iron nails. We attached this No. 30 wire to some No. 20 which we had twisted around the clamp to hold it in position and then extended the nds of the No. 20 wire to the battery. Now our coil was freely suspended from the clamp.

Taking two bar magnets, we placed them in supports about one inch away from the suspended bunch of nails. A magnet was placed on each side of this suspended coil with the unlike poles facing each other. The No. 20 wire was then connected to the battery. There was quite a twist, showing us that plenty of current was passing. We immediately attached this simple galvanometer and completed our work.

What Our Readers Think

Efficiency in Experimenting

Editor, THE EXPERIMENTER:

I cannot refrain from relating how timely your article "Efficiency in Experimenting," came to me. To begin at the beginning, I want to say that I derive very much pleasure from experimenting, and have been at it more or less for twenty five years.

As you will notice from our letterhead, I am a cleaner, and while this business is now coming to the front, for years the industry in general groped in the darkness and ignorance of proper methods and equipment. During this time I have worked out many experiments which have been decidedly to my advantage in my business.

However, only once have I become so enthused as to try for a patent, and then I learned that many devices of similar principle had gone through before.

Now I have another proposition which I have been working on more or less for a couple of years and have brought it to a point where I want to find out if it has been anticipated by some one else. And this is where your article came in so timely. Yesterday morning I was turning over in my mind the method of how to proceed without unnecessary expense when I thought I would try the newsstand first and there my eye fell on THE EXPERIMENTER, and after noting all that Electrical Radiance shooting from that boy's head, I said to myself: "Hello, I was just looking for you," and handed the dealer a quarter. But the climax came when I discovered the article, for now I know how to proceed.

M. E. KISER.

Rapid City, S. D.

Mr. Esten Moen and the Railroads

Editor, THE EXPERIMENTER:

I bought my first EXPERIMENTER magazine a few days ago and I find myself very much interested in your wonderful magazine.

Tonight when reading your magazine I came to an article in the "Junior Experimenter" by Esten Moen, his first article where he explains how to use a radio rheostat to determine the rate of speed at which a train is traveling. This article appears on page 552 of the June issue.

From my point of view this method may be used on some small branch line or logging railroad. But I think it should not be used on the main lines of the principal railroads of this country where high speed trains are being operated, or on dangerous grades in the mountains. The reason why this method should not be used I will now explain.

Almost all of the important railroads of this country employ some electric safety signal system, such as the block system, the staff system and others. Many electric systems are operated by an electric current continually flowing through the rails for a certain distance from one signal pole or station to the next one.

A person not familiar with the actions of these systems would probably use this article published in your magazine. If he was not careful he would short the current in the rails causing the safety signal to go into action and perhaps delivering a message to a speeding train to stop or to slow up as the given signal may indicate. We will now take one of the well known trains in this country and use it as an example.

The San Francisco Overland Limited from San Francisco to Chicago is one of the longest train runs that I know of. Now if one of these devices were placed between each and every signal, causing the signal to show the stop—then proceed to next signal, etc., as ordered by the safety laws of the railroads, keep in mind that the train would have to stop at every signal pole and then start up again. If the time were to be figured for every stop between San Francisco and Chicago the train would be traveling like the covered wagon.

Now may I ask you what your opinion on this subject may be?

I remain as ever one of EXPERIMENTER readers,

WILLIAM H. GLEZINNUS.

Sacramento, Calif.

(Mr. Moen's suggestion would probably, as carried out, involve so slight a bridging of the rails that it would do no harm. There certainly never will be a set of these connections distributed from the Pacific Ocean to Lake Michigan.—EDITOR.)

Insulating Induction Coils Periodically

Editor, THE EXPERIMENTER:

In the July, 1925, issue of THE EXPERIMENTER I wish to call your attention to the article on "A Four Inch Spark Coil," page 619. In the fourth section it directs the maker of the coil to take the greatest care in insulating well every year.

What the idea is in insulating well every year is beyond me! Wouldn't insulation the year the coil is made be sufficient for years to come?

I am much interested in your honored magazine, especially the chemistry department. I would suggest having more formulae and experiments in this section. I have a home laboratory and am guided by THE EXPERIMENTER and copies of the good old *Electrical Experimenter* procured from a former follower of science.

Hoping you will keep up the good work, I remain,

Respectfully yours,

JOHN J. WEBER.

Omaha, Nebraska.

(Our author is responsible for the suggestion you refer to. He does not want you to rewind your coils but to give a fresh coat of shellac or other varnish once a year.—EDITOR.)

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

—EDITOR.

Our Many Topics

Editor, THE EXPERIMENTER:

I am now doing something I should have done long ago but just been puttin' it off. To begin with THE EXPERIMENTER is the best magazine I ever read, no, I'll take that back, *Science and Invention* is; no, *Radio News*; well, one is so good I can't tell how good the others are, so I'll drop the matter.

But one thing I do like is Mr. Charles Shaw's letter in the August issue of THE EXPERIMENTER because he said articles on home-made variable condensers and audio frequency transformers, etc., are foolish. He wants articles on physics, mercury vapor arc, ultra violet light and phosphorescence, and ain't a bit more interested in that apple sauce than a—— O, I don't know what, but gimme some more articles on home-made variable condensers, grid leaks, crystals, novel crystal hook-ups, V.T. sockets, motors, movie cameras and all sorts of things like that, because my pocketbook doesn't digest such things.

Now I guess Mr. Shaw sees one experimenter's fancy is one thing and another's is another thing.

Congratulations to *Science and Invention* and his (or her) grandchildren, and the whole Experimenter Publishing Company force and not leaving out WRNY.

I am, sincerely yours,

GEORGE N. BUNTIN.

Hermitage, Tenn.

(We try to reach a somewhat extended range of scientific interests, and strive to get a good selection and proper proportions of each division. But your point of view is a comfort to us and we appreciate your kind words.—EDITOR.)

Vacuum Insulated Condensers

Editor, THE EXPERIMENTER:

Since you seem to welcome comments on THE EXPERIMENTER, I feel at liberty to make a few sarcastic remarks.

For instance, the article "Vacuum as Insulator," by G. Lagerquist, which appeared in the September issue, would bear some comment. I have always been of the opinion that the charge in a condenser was stored in the dielectric and that the greater density per given resistance of the dielectric the greater the resultant capacity. Now he defines vacuum as gas at any pressure below that of the atmosphere. I believe that when he removes the air from his condenser the capacity will become practically nil.

I have seen ideas for electrocution published under "Short Circuits," some of them prize winners, which are neither possible nor probable and I can name them on request.

If you have read this far I wish to thank you for doing so and to state that in general your magazine is very good.

Very truly yours,

JAMES CORN.

Detroit, Mich.

(We welcome comments favorable or the reverse; the latter we consider valuable as suggestions for our guidance. Of course we may not follow them. The charge in a condenser is a surface effect and the dielectric operates to prevent the charge on one surface escaping to the opposite surface. The vacuum idea appears most interesting to us, we cannot say how it would work. The more improbable short circuits are the better it is in one sense, as it would indicate less danger to the public. But our warnings are all the better if improbable situations are taken up.—EDITOR.)

Appreciation from England

Editor, THE EXPERIMENTER:

May I take the opportunity to congratulate you on your very fine paper. For many years I have wanted something like this magazine and when I bought your August issue I at last found I had got what I wanted. With *Science and Invention*, and *Radio News*, THE EXPERIMENTER makes a combination hard to beat (for the experimenter). I have seen things in your books about experiments in England which had not yet been published in any English paper. Wishing all kinds of success to you in THE EXPERIMENTER.

Yours truly,

C. POSTLE.

London, England.

(Our London correspondent's congratulations are most acceptable. The English reader is apt to be a stern critic, but we seem to have pleased one of our friends abroad.—EDITOR.)

More Friendly Suggestions from England

Editor, THE EXPERIMENTER:

A handshake for Ernest Carpenter, Worcester, Mass., whose letter is in the September issue. I endorse all he has to say. Why not put in THE EXPERIMENTER another page for the beginner; it will show that you take an interest in the young experimenters.

As for pictures, a good picture or diagram is better than a hundred words for explaining matters. I look forward to this feature, which I am sure will satisfy all would-be experimenters. Another feature which I think would be appreciated would be a page each month for the explanation of electrical, radio, chemical and scientific terms used in the present day, after the style of a dictionary or "The Experimenter Radio Data Sheets."

Perhaps you may consider this at some future date. THE EXPERIMENTER is quite passable as it is but there surely is room for a little corner for the young bloods.

I take this opportunity to wish THE EXPERIMENTER and its companion papers the success they deserve. Hoping you will take my criticism as a good editor should.

With best wishes,

JOHN H. VARLEY.

Lancaster, England.

(This criticism or rather suggestion from across the pond is taken "as a good editor should," we assure you. Our difficulty is the question of room for everything, but we shall certainly keep your suggestion in mind for the future.—EDITOR.)

Crystal Set Owners, Note

Editor, THE EXPERIMENTER:

I am writing to thank you for your promptness in sending me a copy of the June EXPERIMENTER which I wrote you about a short time ago.

I am saving all of the magazines, as there are many articles which I treasure very much. I am more of a reader than an experimenter, but perhaps you could run this in your column. I think a few crystal set users would appreciate it. One evening when listening in I found that there was something wrong with my crystal, as it had been getting fainter gradually for about three or four weeks. I put enough mercury in the crystal cup so that when I replaced the crystal all the space between the walls of the cup and crystal were filled.

Upon trying the crystal you can imagine my surprise to find that reception was louder than when it was new and five times as efficient, there being loud spots all over the whole surface of the crystal, whereas when it was new only one-quarter of the area could be used.

Hoping this will prove of interest to you and a few crystal users.

Respectfully yours,

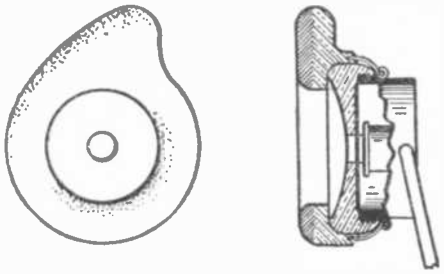
RALPH MARRIOT.

Detroit, Mich.

(Mr. Marriott has again come upon an almost forgotten kink in working with crystals. The introduction of the mercury not only connects with the surface of the crystal and cup, but the potential differences between the dissimilar metals may have a great deal to do with the increase in volume and selectivity. It is suggested that experimenters try small voltages regulated by potentiometers with this stunt.—EDITOR.)

Latest Electrical Patents

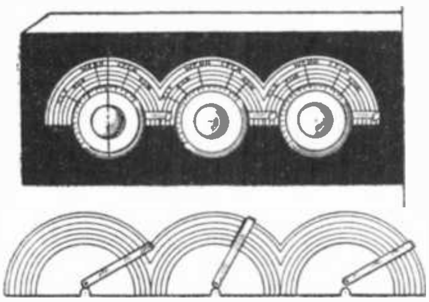
Telephone Receiver With Cushion



This is an attachment for telephone receivers shaped in general conformity to the human ear, and made of hard rubber with a felt pad. The latter acts as a cushion between the receiver body and the ears.

Patent No. 1,536,712 issued to F. K. Hehnly, Madera, Pa.

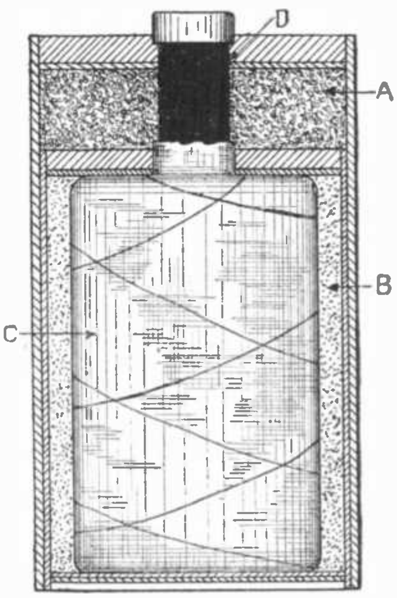
Automatic Radio Log



The invention provides for a chart readily attachable to the dials of the panel as shown, on which may be entered a log for quickly and automatically tuning-in and recording different stations.

Patent No. 1,546,675 issued to Lyleton E. Renney, Stockton, Calif.

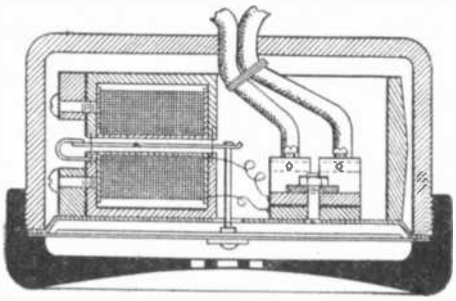
New Dry Cell



The inventor claims a dry cell, free from the effects of creeping salts and local short circuiting. (A) is an insulating filling material of sand or sawdust or the like, (B) is the electrolyte paste, (C) contains the depolarizing paste, (D) is the carbon electrode. The container as usual is made of zinc.

Patent No. 1,546,461 issued to S. Apostoloff, New York, N. Y.

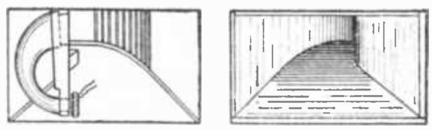
Two-Way Radiophone



This simple apparatus for wireless telephony can be used for both sending and receiving at the same time, and, it is claimed by the author, that it supplies maximum power effect with the least possible apparatus and at minimum cost. An interesting feature is the utilization of the same tubes for transmission and reception.

Patent No. 1,524,413 issued to N. W. Sterns, New York, N. Y.

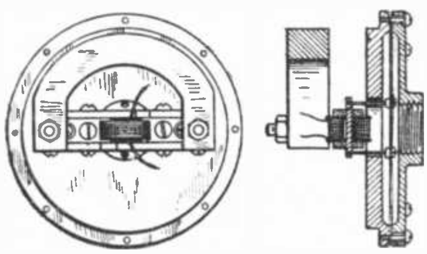
Loud Speaker Horn



The inventor claims a horn of proper shape and design for faithful reproduction and amplification without distortion. The material of the horn is notched at points of curvature to relieve strains which would lead to distortion of vibrations.

Patent No. 1,546,537 issued to Carl Bornmann, Binghamton, N. Y.

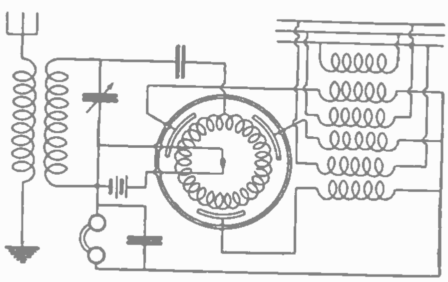
Novel Loud Speaker



This new Brandes loud speaker is claimed to have moving parts of very low mechanical inertia. It employs a floating armature eliminating friction at fulcrum points.

Patent No. 1,533,372 issued to Cecil E. Brigham, E. Orange, N. J.

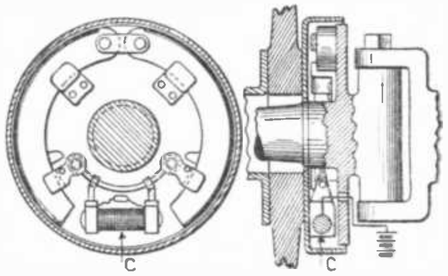
Telephone Repeaters



Two-way telephone repeaters which are provided with tuned circuits so as to enable them to be used on carrier frequency lines, on which a number of such systems, each responding to a different frequency, may be employed.

Patent No. 1,533,842 issued to H. Fassbender, et al, Berlin, Germany.

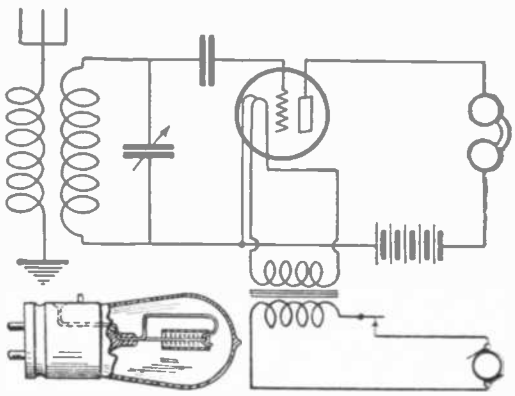
Electric Car Brake



When excited by an electric current controlled by the engine driver, the electromagnet (C) adheres to the stationary housing and causes the brake straps to distend and grip the rotating wheel.

Patent No. 1,546,864 issued to T. B. Patch, Brookline, Mass.

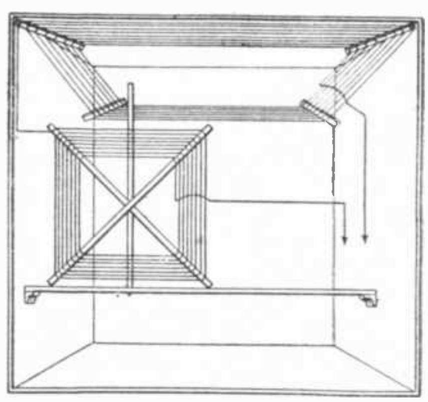
A. C. Vacuum Tube



The inventor has provided an additional lead connected to the center of the filament to permit the use of alternating current for heating the filament.

Patent No. 1,546,696 issued to James F. Yates, Massillon, Ohio.

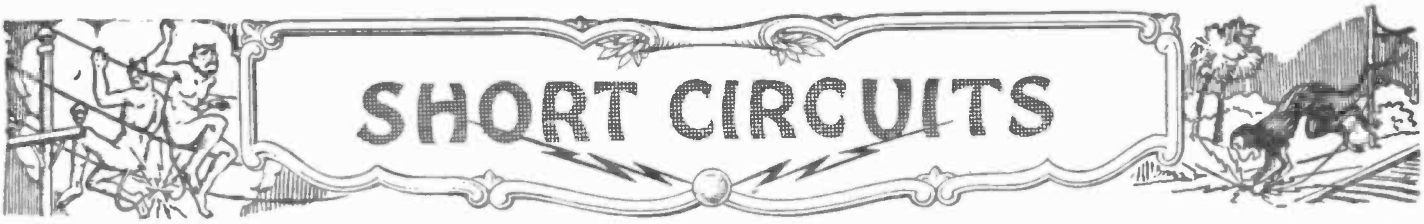
Unidirectional Loop



The usual loop antenna is bi-directional giving maximum reception in either of the two directions in its plane. The inventor claims that by a certain combination of a fixed horizontal loop and a rotary vertical loop, he achieves a purely unidirectional effect.

Patent No. 1,546,731 issued to John H. Herzog, Brooklyn, N. Y.

SHORT CIRCUITS



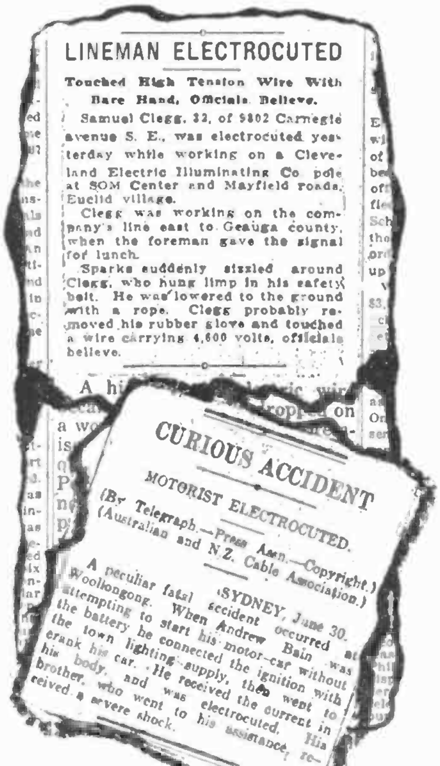
THE idea of this department is to present to the layman the dangers of the electrical current in a manner that can be understood by everyone, and that will be instructive too. There is a monthly prize of $3.00 for the best idea on "short-circuits." Look at the illustration and then send us your own particular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

Damp was the death
Of poor John Van Camp,
He viewed his flooded cellar
With a trouble lamp.
—*Joe MacDonald.*

'Neath this somber spot
Rests Willie Baitor
He grounded his soldering iron
On the radiator.
—*E. S. Washburne.*

Beneath this weeping willow
Lies Mrs. John Hink,
Who put her electric iron
Into the sink.
—*J. W. Collins.*

This tells the tale
Of trackman McCrum.
In lifting a rail, he used
A third rail as fulcrum
—*George Lanier.*



LINEMAN ELECTROCUTED

Touched High Tension Wire With Bare Hand, Officials Believe.

Samuel Clegg, 32, of 9802 Carnegie avenue S. E., was electrocuted yesterday while working on a Cleveland Electric Illuminating Co pole at SOM Center and Mayfield roads, Euclid village.

Clegg was working on the company's line east to Geauga county, when the foreman gave the signal for lunch.

Sparks suddenly sizzled around Clegg, who hung limp in his safety belt. He was lowered to the ground with a rope. Clegg probably removed his rubber glove and touched a wire carrying 4,600 volts, officials believe.

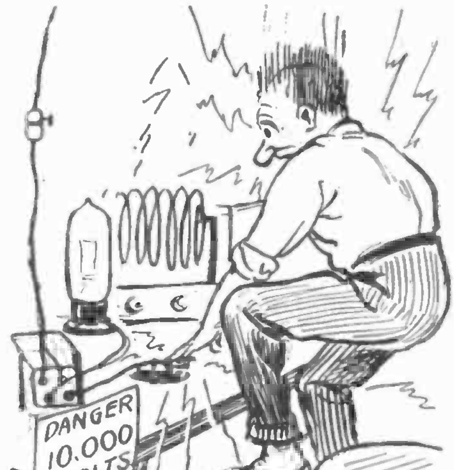
CURIOUS ACCIDENT

MOTORIST ELECTROCUTED.

(By Telegraph.—Press Assn.—Copyright.)
(Australian and N.Z. Cable Association.)

(SYDNEY, June 30.

A peculiar fatal accident occurred at Woollongong. When Andrew Bain was attempting to start his motor-car without the battery he connected the ignition with the town lighting supply, then went to crank his car. He received the current in his body, and was electrocuted. His brother, who went to his assistance, received a severe shock.



Peace be with the soul
Of Pieter Van Yew!
His key was in the H. T.
Of his C.W.
—*Ted Farrell.*

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.

Gramme Ring

(541) Berthold Gross, Brooklyn, N. Y., writes:

Q. 1. I see in the older books on electricity a good deal about the Gramme ring as being an important invention and step in the development of the dynamo. Can you explain it to me and tell me why it is not used any more?

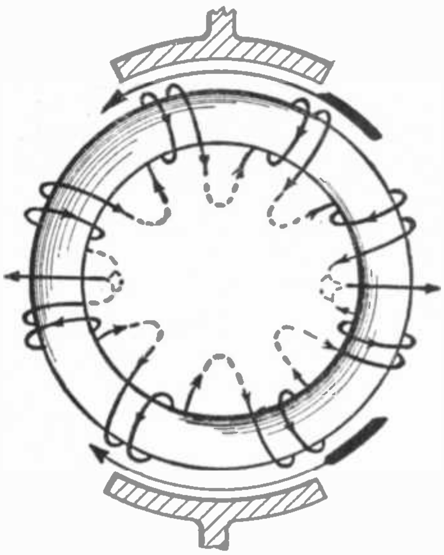


Diagram to illustrate the operation of the Gramme ring, a historical armature. The dotted line suggests where connections may be made to the commutator and the small arrows show the neutral points where current may be taken off were it not for armature reaction. The large arrows show the direction of the current.

A. 1. The diagram gives a representation of the winding of this armature. If a coil of iron wire such as shown in the cut was wound around with a continuous coil of insulated wire of copper, and if the whole is then rotated in a magnetic field as indicated, the points opposite the poles of the magnet will be points of maximum excitation where the most lines of force are cut in a second by the wire. At the one pole the induction will be the opposite of the other, so that opposite polarities, as it were, will join at points at right angles to the line connecting the points of maximum excitation.

If a wire is kept in contact with these points by brushes and extends from brush to brush, making a closed circuit, a current will flow through the coils out at one so-called neutral point and in at the other, as it may be expressed. As a matter of construction, leads from the coil are carried to a cylindrical commutator upon the shaft. Such is the Gramme ring, and it is a very difficult one to wind, and most of the work is done by the wires on the outside of the core. Its high magnetic reluctance and difficulty of construction have caused its abandonment. The drum armature is the direct evolution of this one, as it replaces the ring core of rather high reluctance with a large cylindrical core, filling the gap as nearly as possible between the poles of the field magnet; and this with its commutator is the regular construction familiar to all, and it acts like the Gramme ring. The winding of the drum armature represents the outside layers of wire of the ring armature.

Referring to the diagram, the loops projecting inwards from the ring suggest points to which the commutator should be connected. The straight arrows at the top and bottom of the ring indicate the points of zero excitation, from which points the current is taken off.

Selenium Cells

(542) Thomas W. Wootton, Schenectady, N. Y., asks:

Q. 1. I require the use of a cell sensitive to light of the selenium type. I have just received quotations from two firms who manufacture these cells; one costs $50 and the other $30, which is more than I wish to pay. Can you give me references as to how to manufacture a simple cell embodying the following features: a, sensitivity to daylight and darkness; b, compactness; c, low resistance?

A. 1. We have given a number of articles on this subject and beg to refer you to the following copies of THE EXPERIMENTER and *Practical Electrics*, in which you will find them very fully described:

The Experimenter, March, 1925 issue, page 328; Practical Electrics, December, 1922, page 74; and ditto February, 1924, page 193.

D. C. Transformer

(543) Ernest Phillips, Alexandria, Ind., asks:

Q. 1. Can a person obtain a transformer to step up and step down a direct current?

Q. 2. How can a 6 volt direct current motor be changed to run on a transformer through 110 volt A.C. house circuit?

A. 1. What is known as a rotary transformer is what you need. This is a machine which has on the same shaft a motor turned by direct current, and this turns a dynamo which generates a direct current of any desired potential according to its winding.

A. 2. We refer you to Mr. Secor's very exhaustive article on A.C. and D.C. motors in the July and August issues of THE EXPERIMENTER.

Photo-Electric Cells

(544) M. Kidgel, Brooklyn, N. Y., asks:

Q. 1. What is the best method of constructing a photo-electric cell? The cell is to be used for experiments only but must be very sensitive.

A. 1. For a description of such a cell we refer you to *Radio News* of September, 1925, in which you will find an article on that subject. If a selenium cell would answer your purpose, you will find several of them described in *Practical Electrics* and THE EXPERIMENTER of the following months: Practical Electrics, Dec. 1922, page 74 and Feb. 1924, page 193. The Experimenter, March 1925, page 328.

Gravity Battery

(545) M. Granbert, Syracuse, N. Y., asks:

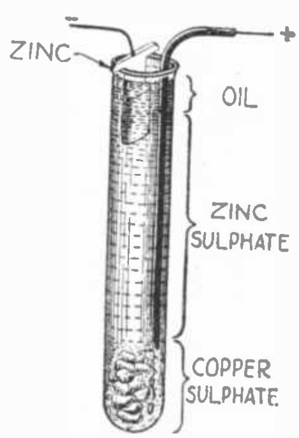
Q. 1. What is the principle of the gravity battery? I refer to the one using copper sulphate as the excitant. It seems to me that as zinc sulphate makes a solution of higher specific gravity than does copper sulphate, the battery will not work.

A. 1. We received from a contributor some months ago a suggestion for making a gravity battery in a test tube which will give an answer to your question. The copper sulphate lies at the bottom and an insulated wire connects with a coil of wire, the latter buried in it. At the top there is the zinc plate. The battery is filled with water to which a small amount of sodium sulphate or zinc sulphate may be added.

As the battery works, zinc sulphate accumulates in the upper layers, while the saturated solution of copper sulphate lies at the bottom, but after a while the action you predicate in your question will take place. The zinc sulphate solution will become of equal or higher specific gravity than that of the copper sulphate and the two will mix, and the battery will be put out of action.

In practice this is avoided, by removing the zinc sulphate solution from time to time before it has a chance to get too strong, and replacing it with water. This may be very conveniently done with a large glass or India rubber syringe. Oil is sometimes placed on top to prevent creeping. Like practically all batteries, the gravity battery is an expedient and is far from perfect.

One trouble is that metallic copper precipitates on the zinc plates if the battery is idle. Sometimes this is avoided by keeping the battery on closed circuit of high resistance. Enough current is supposed to pass to prevent mixture of the two solutions and to preserve the zinc from accumulating copper on its surface. If it does so accumulate, scrapping the zinc plates is the only remedy and this is a disagreeable operation



A gravity battery contained in a test tube, quite applicable for some purposes. It will give a good voltage within a reasonable volume on account of the smallness of the tubes, but has the disadvantage of high resistance.

QRM—[I am being interfered with]

(Continued from page 22)

ing causes should be considered:

1. Fan motors.
2. Washing machines.
3. Sewing machines.
4. Vibrating reed battery chargers.
5. Mercury arc rectifiers.
6. Tungar rectifiers.
7. Vacuum cleaners.
8. Loose fuses.
9. Defective entrances or circuit switches.
10. Stator coil open or grounded in phase motors.
11. Dirty or worn brushes or cut slip rings.
12. Induction type electric furnaces.
13. X-ray machines and violet ray machines.
14. Electrically operated refrigerators.
15. Defective sockets.
16. High frequency apparatus.

If the interference appears to originate in a factory, besides everything mentioned above, consider the following:

1. Smoke and dust precipitators.
2. Electrical flour bleachers.

Providing the interference cannot be located by taking bearings from fixed locations as previously mentioned, it would then be necessary to load a portable set operating on a loop into the family flivver and tour the neighborhood.

Regarding a receiver, someone is sure to ask which type is to be preferred and will one set work to the exclusion of all others? My answer is emphatic in that any sensitive receiver will serve satisfactorily. I have used anything from a crystal set to a six-tube super-heterodyne. And on one occasion very satisfactory results were obtained using a crystal reflex. To prove my statements, I have heard amateurs on code with regenerative detector and two step audio operating on a two-foot loop over a distance of a thousand miles or better—and broadcast stations almost as good.

When operating any type of receiving set in an automobile, you will find that the ignition system will generally play havoc with reception of anything else, so it will be necessary to institute the policy: "Drive—Park—Listen" or else "Drive—Coast—Listen." A Ford is more easily adapted to the latter method than most other cars and people will not think anything unusual is happening.

"Aha!" he laughs in joyous abandon. "It works fine, now that the trouble is cleared up. Those amateur fellers are pretty good skates at that."

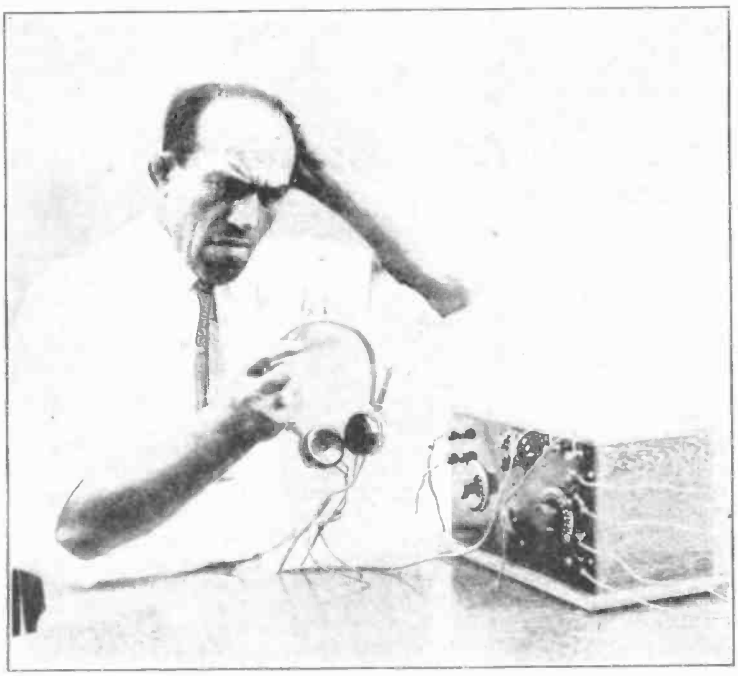
Growing reminiscent, I pause to smile at some past experiences down in Kansas. The Ford was being used and we were looking for faulty insulators on a high tension line carrying hot stuff—about forty kilovolts. Such a high voltage acts up mighty peculiar sometimes and will spark to anything if given the least opportunity. For that reason it was necessary to check every pole for trouble within the city limits. Our "modus operandi" was to get the old bus going down a "lead," and give her plenty of gas between poles. Just as we approached a pole we would kill the engine and coast past listening for all we were worth with the loop set at right angles to the line. You can easily picture the resemblance to a balky mule or some ancient Ford in distress!

A little information as to what may be expected when out on interference will not be amiss. It does not matter whether the source of the trouble is a part of an electric line such as faulty insulators, transformers, or some electrical device attached indirectly to the supply line such as a vibrating battery charger—the existing interference will lead you a merry chase unless you are experienced in this kind of work. Such interference has an exasperating way of following every electrical conductor or circuit directly connected or even in inductive relation. For this reason interference may be picked up on a circuit which itself is entirely clear. On the other hand, a loop or leg off the circuit connected to the circuit on which is located the defective apparatus would also carry these radio frequency currents that continually go astray.

Now that I have told you how to get started, the rest is up to your ability as an operator and to the patience of the chauffeur. Proceed as outlined in a preceding paragraph using the method of triangulation—obtaining as many different bearings as possible and at the same time noting the intensity of the signal.

On a difficult case it is often possible to solicit the cooperation of the local light company and have them kill supply circuits or arc circuits in the neighborhood affected, and then by trial and error the faulty circuit is easily discovered. By referring to the company's circuit drawings, this defective circuit can be traced from its source to its end including all its loops and taps.

These little side-lights are interesting and often of much assistance. With this in mind, I offer another. It is easily possible that the interference you are experiencing can be caused by some defective wiring or defective apparatus in your own home. In order to determine whether such is the case it is only necessary for someone to open the main switch located at the meter while you listen-in. If the interference disappears entirely, it is practically certain that the trouble exists very near at hand. If the interference is considerably reduced but does not disappear, it would seem as though the trouble was on your supply line but not in your house wiring or attachments.



He removes the phones in the expectation of locating the trouble, and quizzically rubs his cranium. "There is that amateur fellow again . . ."

This is part 1 of two articles dealing with the problem of interference. Mr. Turner, who is well fitted for the task of writing on the subject, as he is in constant touch with the situation, will continue with the other sources of trouble in the next issue.—Editor.

The Luludyne

(*Continued from page 15*)

Both set to work and prescribed a certain date upon which they were to compare their craftmanship—on that date, the virtues and outstanding qualities of their work would be revealed.

With a diligence and persistence that is part of his complex anatomy, Frank carefully rounded his receiver into shape, and then when he finally exhausted everybody's patience, appeared on the scene at the last moment and with his well-pronounced ego, acclaimed himself conqueror of conquerors. And he had SOME set with him! Knobs and dials galore; switches and meters and bezels; pilot lights, petite clock and panel lamp—all decorating the panel and giving it a resplendent air.

Fred had already surmised what Frank was going to create—a veritable bunch of *junk*—an expensive array of entirely and wholly unnecessary apparatus which, although improving the appearance of the radio set, did not in any way improve its operation, its simplicity of control, or its distance-getting ability and quality of reproduction. Frank's set was a 5-tube tuned radio frequency affair, which, after a brief test, was no mettle to Fred's, for Fred had produced a set which was also *some* set!

With a unanimity that was spontaneous, the glory of the occasion went to Fred, who named his receiver "The Luludyne." Even Frank bowed in acquiescence. He had been beaten and Fred's masterpiece, *The Luludyne*, entered the Valhalla of Fame.

It certainly does "produce the goods," and if you could see Lulu twirl the dials in exuberant delight! She has finally found a diversion of which I am glad to say she will never tire. At least she told me so. And as for Fred, he is more than content to build Luludynes for his appreciative and thankful friends and neighbors. He'll build one for you, too.

Constructional Details of the Luludyne

The Luludyne, as can be seen in the accompanying photos and diagrams, consists of a low-loss regenerative tuning arrangement to which audio frequency amplification of the highest quality is added. One stage of transformer-coupled and three stages of resistance-coupled amplification comprise the faultless amplifier which gives such splendid reproduction.

It is surprising to note with what regularity and clarity distant stations can be brought in. And the other great features of the set are that, first, it is primarily a single control set, in which the added optional controls of antenna coupling and tickler feedback adjustment, for the reception of local stations, are incorporated. It thus becomes a simple matter to accurately "log" stations.

Alongside a five-tube radio frequency circuit, straight, neutralized, reversed feed-back or other modification, the Luludyne can easily run rings around it. To be convinced, you need but build one for yourself and see the vast superiority it has over the "freak" sets now on the market.

To begin with the following necessary parts will have to be procured:

- 1 7" × 24" panel.
- 1 6" × 22" baseboard.
- 1 Lopez low loss coupler.
- 1 General Instrument low loss .0005 mfd. condenser.
- 5 Standard sockets.
- 1 20-ohm Yaxley rheostat.
- 1 6-ohm Yaxley rheostat.
- 1 Federal double circuit jack.
- 1 Federal single circuit jack.
- 1 Cutler-Hammer key type filament switch.
- 3 4-inch dials.
- 1 .00025 mfd. grid condenser.
- 1 2-meg. grid leak.
- 3 Dubilier .006 fixed condensers.
- 1 3½ to 1 ratio Erla audio transformer.
- 2 Rasco binding post strips.
- 7 Binding posts.
- 3 Veby grid leaks, 1,000,000, 500,000, 250,000 ohms.
- 3 Veby resistor couplers, 100,000 ohms each.
- 1 Cabinet.

It is the conviction of the author that the three-circuit tuner and the very excellent audio frequency amplifier as described, added to it, make it the very best radio receiver that has as yet ever been built.

The tuning unit will be described first. The primary and tickler coils are both wound on a rotor form, 3 inches in diameter. Twelve turns of No. 16 D.C.C. constitute the primary winding. The tickler coil has twenty turns of No. 22 D.C.C. For the secondary, which is wound in the well-known low loss method, forty-four turns of No. 12 D.C.C. comprise the coil formed by thirteen pins placed in a 4½-inch diameter circle.

The coupling of both the primary and the tickler coils can be varied by means of a shaft attached to the rotor form of each. The tuning is resolved into a purely single control, the .0005 tuning condenser providing ample accuracy and ease of tuning. Note from the photo that the tuning coupler is placed away from any other apparatus. This in itself prevents any undesirable feed-back and allows perfect control of regeneration.

Proceeding from the detector tube, the next device is the audio transformer. This must necessarily be of a low ratio, one in the order of 3 to 1, serving the purpose very nicely. If a higher ratio is used, slightly better amplification may result, but the control of regeneration becomes hampered and the quality of the music may be affected.

It will be found best to employ no more than twenty volts or so as plate voltage for the detector tube. Remember, a small overload or slight distortion in the detector tube circuit becomes greatly amplified in the amplifier circuit. It is, therefore, better to satisfy one's self with lesser volume and greater clarity will then ensue.

The resistance coupled amplifier has long been known for its superior reproducing qualities. The three stages incorporated into the Luludyne have proved no exception to the rule and do their work to perfection.

Nothing more need be said concerning the amplifier except that as little deviation as possible from the given values be allowed.

One 20-ohm rheostat is used for the detector tube and affords an extremely fine control of filament current. For the amplifier tubes, a 6-ohm rheostat furnishes sufficient degree of control.

Note the slight length of the wire leads from the grid leak and grid condenser to the grid terminal and tuning condenser, respectively. In fact, the word length cannot be properly used, for the connections are direct to the terminals themselves, no wire being used. This is a salient feature that goes a long way in keeping the efficiency of the set at its highest.

From all outside appearances the Luludyne looks exactly like a neutrodyne, but as a matter of fact it is by far superior, both in performance, looks and all-around efficiency. It is one set which its owner can truthfully acclaim as the best.

All the parts of the very best materials can be procured for less than thirty-five dollars, and this incentive of low cost for such an exceptional receiver should prove a determinant factor in persuading you to duplicate it.

The Luludyne is here. Long live the Luludyne!

Sound and Audio Frequency Amplification

(*Continued from page 17*)

this amplifier the fact was stressed and used as a recommendation that the resistance coupled amplifier modulates down—meaning that when a milliammeter is placed in the plate lead it indicates a decreased current as soon as signals are being received. Now it happens that one of the best and most reliable ways of discovering if an amplifier is distorting is just this procedure, and if the meter indication is not steady, proof is had that the amplifier distorts. A non-distorting amplifier will show an absolutely steady plate current, because the meter is a direct current meter, which does not show an alternating current of pure alternating current characteristics, as the signal should be.

We can now readily realize how such an amplifier should be built in practice, for almost ideal results—a diagram is given in Fig. 5.

The only points that should be brought out appear to be the following ones: the diagram represents a detector tube with four stages of resistance coupled amplification. On all of the tubes amperites are used as filament controls, first because these assure the operation of the filament at the right temperature, and prevent so-called volume control by means of the filament current, as is done on only too many commercial receivers. As explained in the preceding article, the duty of the detector is the separation of the audio frequency component from the carrier wave frequency, and for this reason the plate circuit of the detector is provided with a by-pass condenser of either .001 or .002 microfarad, as indicated in the drawing.

To enable the user to control the volume obtained in the loud talker it will be seen that the grid leak of the last tube is indicated as a variable one: This resistance should preferably have a range of from 50,000 to 500,000 ohms. If a greater control of volume is still desired, the scheme shown in the previous article, a stage control switch, can be employed, in which case it is recommended to have a variable resistance of from 10,000 to 100,000 ohms across the loud talker.

Of course, there is one drawback—and a fairly serious one—to this type of amplifier: the fact that a very high resistance is used in series with the plates of the tubes, so that in order to obtain sufficient actual plate voltage it is necessary to employ unduly high "B" battery voltages. This prompted experimenters to seek and find means which overcome this drawback completely: the use of choke coils in the plate circuit instead of resistances. We will consider these amplifiers in more detail in the following issue.

The Experimenter's Bookshelf

Building and Taking Care of Your Home

HOME OWNER'S HANDBOOK. By A. C. Lescaboura. ix. 494 pages with index. Scientific American Publishing Company, 1924. $2.50.

The author's name is familiar to many of our readers. It is fair to say that many people have a laudable ambition to own their own house, and especially is this the case with those of limited means. In nearly five hundred pages Mr. Lescarboura covers what may be fairly called the entire field of home construction. He has followed what must be conceded to be an excellent plan, going to such authorities as the Bureau of Standards, the great Weyerhaeuser Forest Products Organization, Brick Manufacturers Associations, the Portland Cement Association and many others. An allusion is made to these in the preface and as the leaves of the book are turned over the illustrations will be found credited to their sources, largely to technical concerns.

One of the movements of the day is the issuing of high grade literature by commercial supply houses; so the use of such sources gives this book a particular value. As a typical section, we might refer to the rather too short description of heating with oil, but short as it is it covers the ground quite satisfactorily and two authorities are here referred to, so that anybody who wishes to cope with the numerous coal strikes can address the firms cited under the illustrations and get the last word on the subject of oil in the home furnace.

It would exceed our space to tell all that is in the book, but we feel that we can recommend it warmly.

Notes on Dynamos

FUNDAMENTAL PRINCIPLES OF GENERATORS AND MOTORS: EXAMPLES. By Professor F. E. Austin. vl, 108 pages, including index. Lancaster Press, Inc.

This book whose author treats his subject largely from a mathematical standpoint, which is preeminently the right way to do, using calculus as required, does not lend itself to review. All we can say is this: that the general aspect of the work is such as to make us feel that it is worthy of warm commendation, and within its 108 pages the reader will find an immense amount of practical information concentrated. Unless he is willing to regard each page as possibly involving some hours of work, he will fail to get the right conception of it.

Elementary Chemistry of the Day

SMITH'S ELEMENTARY CHEMISTRY. By James Kendall. xvi, 423. Index. The Century Co., 1924.

Professor James Kendall of Columbia with the collaboration of five instructors in five different states of the Union has revised and edited this book originally by Professor Alexander Smith which is specifically a school or college text book. The writer of this review has always found that the lucid treatment of the elements of a subject makes most agreeable reading and to write a book for the student is like writing a story for children. It requires the exercise of the greatest ingenuity. The mathematician and logician of Oxford University made his reputation by two fairy books as they may be termed, and while we do not know whether the Professor Alexander Smith who originally wrote this book, could write fairy stories, he has produced what is a very interesting treatise on the subject of such absorbing interest at the present day, and which is brought so well up-to-date that we heartily commend it to our readers. An instance of its advanced text and treatment is given by a few words on fused quartz, which seems only a few days old in its last developments, yet it is described and illustrated here. Organic chemistry, radium and atomic chemistry are given in brief. Eleven pages of index are given, in itself a good example of book making.

The editors of THE EXPERIMENTER were far from sure how its section on *Experimental Chemistry* would be received by its readers. Numerous letters have shown us that our readers are greatly interested in the science, and we are glad to have the opportunity of reviewing some elementary treatises on the subject.

Non-Aqueous Voltaic Cells

(*Continued from page* 35)

in the electromotive series, but are in general of the order of one and a half or two volts. In the case where an acid is the electrolyte, such as hydrochloric acid (HCl) or sulphuric acid (H_2SO_4), the one metal goes into solution as the salt of the acid and hydrogen is given off at the electrode of the other metal or carbon. Thus in the case of zinc and copper in hydrochloric acid, the zinc goes into solution as zinc chloride and liberates hydrogen, and the current flows from the copper (positive) electrode to the negative zinc electrode along a wire connecting the two outside the solution.

The same kind of thing is reproducible by taking solutions of organic substances in dry ether. If a platinum electrode is inserted as the positive anode, and a magnesium electrode as the negative cathode, in a solution of one part of ethyl bromide (C_2H_5Br) containing a trace of crystalline iodine in 20 parts of dry ether, a current will flow from the platinum to the magnesium along a wire connecting the two outside the solution. This cell has a voltage of about 1.5 volts. The reaction in this cell is a little different from that in the aqueous solution, the magnesium going into solution as follows:

$$\underset{\text{magnesium}}{Mg} + \underset{\text{ethyl bromide}}{C_2H_5Br} = \underset{\text{ethyl magnesium bromide}}{C_2H_5MgBr}$$

As the cell has a rather high internal resistance, it furnishes very little current, although it has a voltage equal to that of the corresponding aqueous cell. If other metals are used instead of magnesium, voltages are obtained as follows:

Electrodes	Voltage range
Platinum and Aluminum (Al)	.71 - .89
" " Cadium (Cd)	.72 - .93
" " Zinc (Zn)	1.02 - 1.08
" " Nickel (Ni)	.027- .098
" " Chromium (Cr)	.09 - .142
" " Lead (Pb)	.40 - .607
" " Mercury (Hg)	.40 - .45
" " Iron (Fe)	.13 - .20
" " Magnesium (Mg)	.80 - 1.6

In the above measurements butyl bromide (C_4H_9Br) was used in place of the ethyl bromide because it is less volatile. For those cells made up with ethyl bromide, however, the same values were obtained as for corresponding cells using butyl bromide.

In making the cells mentioned above, it is absolutely necessary that the ether be as dry as possible, or the reaction will not take place, and the voltages will, of course, not be produced. The ether may be dried as follows: Put the portion of the ether to be dried in a flask with a tight fitting stopper and shake up with ten or twenty grams of dry calcium chloride ($CaCl_2$) and let it set for a few days to make sure that all the water and alcohol have been taken up. The calcium chloride may then be removed by filtration. A small piece of metallic sodium is then put in the flask to react with any alcohol or water that still remains. The Grignard reagent (i. e., the ethyl magnesium bromide) is decomposed by any water that may be present and prevents the reacting of the magnesium, so this precaution is necessary.

The great similarity of galvanic cells in which ether is the solvent, to those in which water is the solvent, is at once perceived.

Electrified Butterfly Lives Twenty-Five Years

(*Continued from page* 34)

larger the surface and the smaller number of sharp edges presented the more efficient will the apparatus be. The prominence and good metallic connection of the flowers (FE) with the wires (AA) must be considered carefully so that nothing may resist the passage of the slight electric current.

A butterfly (H) is suspended by two fragile fibres of cocoon silk to the top of the glass shade so that when it rests it hangs centrally between the flowers (F and G), which latter form the ends of the connections (A and A'). To be bifilarly suspended by a fibre thread may seem impossible, but a reference to Fig. 5, showing the two fibres joining to form one suspensory fibre is a sufficient explanation of the term. The butterfly may be a dried specimen or one made of thin paper; in both cases the lower part of the thorax under the head should be coated with bronze or other metallic paint. The length of the fibre should be adjusted to allow the insect to touch both flowers in its swinging, and when this is satisfactory the glass shade may be finally fixed in position, and before the chenille border ring is placed on, the glass should be well warmed and the edges sealed with glue, or other compound, so as to preserve a dry atmosphere within it.

This done, the only remaining thing is to cant the stand sharply, so as to set the butterfly in oscillation; and if every part of the construction is carried out as here described, the indefatigable insect will hover from flower to flower without ceasing for at least 20 years, and under exceptionally favorable circumstances, 25 years.

The Ark of the Covenant

(*Continued from page* 39)

CHAPTER I

Prisoners in the Great Cavern

Dan Lamont and myself were neatly trapped. We found ourselves looking down the muzzles of three rifles and a pistol, the latter held by Sholto Seton.

It would have been useless to give way to my first impulse, which was to pull my gun. I calculated the chances of shooting, but it was certain that the men facing us were putting up no bluff. Surprise and anger robbed us of speech, and for a moment or two Dan and I faced the threatening muzzles without a word, our hands in the air. Seton stepped aside and quickly deprived us of our weapons. I found my tongue then.

"So," I said hotly, "you are the leader of the damned pirates, after all!"

"If you like to put it that way," Seton replied quietly, "yes. You may put your hands down now."

I thought of the kindness that Seton had received from Kirsteen Torrance and Lord Almeric, of the friendly reception of him at the White House by the President, and I choked with rage. I took a look at Dan, and from the whiteness of his face I could see that he was sharing my feeling. But we said nothing further.

It looked as if our capture had been fully expected by the other side. The movement on the part of Seton's men was just about automatic. They closed in on us, and our eyes were quickly bandaged. We were ordered to march.

For a yard or two we were directed through scrub, then we found ourselves descending some rough steps. From the air and from the sound of our feet as they crunched on the rock under us, it was evident that we were in some sort of tunnel. The crude steps gave place to a rambling downward incline, and the air blew cool about us with a smell of ozone. Our guards were silent, but the touches by which they guided us along this winding subterranean path were kind enough. Once, on a piece of rocky going, I stumbled, and the fingers on my arm tightened to a grip that saved me from falling. But no word was spoken.

There was a steady descent of about half a kilometre which brought us into a wider passage, it seemed, and the sound of falling water came to our ears. There was the hum, too, of machinery, and a distant clang of hammers. We began to go down some steep steps, some scores of them, and it felt as if we were descending into a great hall or cavern of vast proportions. There was the sound of voices. Somewhere a man was singing a sort of coon song with a most haunting lilt, but as we with our captors came down the steps, the voices fell silent, and we did not need our eyes to tell us that men were looking at us with curiosity all about. The rushing sound of falling water was louder now, and the hum of machinery in good bearings more insistent.

We reached level ground, and threaded our way among machines—we could smell the lubricant—then our feet rattled hollow on a wooden bridge. Solid ground again, and another flight of wooden steps, a rocky path, and then we were halted with a touch, and the bandages were whipped from our eyes.

Dan and I were blinking at each other in a biggish cave whose rock walls were cream colour. Well-scrubbed tables stood in regular pattern on the roughly levelled floor, with crudely-made benches about them. In one corner of the chamber, shelves of lumber held a number of books, cheap editions of novels mostly, and on the walls were targets for dart games, and boards for wall-quoits. Here and there on the cave walls were pasted coloured and half-tone illustrations from American and English magazines, reprints of drawings by Kirchner and Fontain that made one think of dugouts on the Western Front years ago. A big hewn opening in one of the cave walls gave light and ventilation and through it was a view of what I took to be the cup-shaped basin to the north of the plateau. I would have crossed to the opening to look out on the scene, but one of our guards pointed his rifle.

"No, don't do that, Mr. Boon," he said, and he added whimsically, after a pause: "Sit down and make yourself miserable for a bit."

The Americans Appear on the Scene: the Prisoners Get Synthetic Lemonade

He was an American, a lean and lanky individual with a twinkle in his eyes. The other, for now there were only two, was a stout man with that irradicable air of the sea about him which always tells the British seaman.

"Give me your word that you'll make no fuss," the American went on, "and I'll slack this guard on you a morsel. It would do you no good, anyhow, to try and escape. You're corralled."

I was desperately anxious about Milliken and the *Merlin*, but it was plain that to attempt dropping from that high opening or to rush the door, would be the height of folly, so after a look at Dan I nodded.

"That's fine," said the guard, "and now you can have a drink. It is only synthetic lemonade, but you'll find it good and cold. What say?"

"Sounds like home to me," I replied. "What about you, Dan?"

"I'm with you," said Dan.

The stout seaman waddled out, and by and by returned with two long glasses full of an iced bubbling liquid. After our adventures on the plateau top, it was delicious.

"You look after yourselves here, then?" I suggested to the guard.

"Sure. We don't have to deny ourselves much."

"Ice, too?"

"As you see."

Questions seemingly were barred. In silence, then, Dan and I seated ourselves in two camp chairs, and fell to our drinks. As may be judged, we were both a bit dazed, and feeling dead foolish at having walked so neatly into the trap that was closed on us so firmly. I had a faint hope that Milliken had seen our capture from the bluff, and that he had had the sense to get off with the *Merlin* immediately. If he had, it was only a question of time until armed hordes were swooping down on the pirates' lair. But as I considered the idea, I began to see that it was next to impossible. At the time of the hold-up, Dan and I had been deep enough in the trees round the sinter cones to be screened effectually from view from the bluff.

With that hope in the discard, I began to formulate another, which was that my mechanic would have the time to get off a broadcast message of our whereabouts if the plateau party tried to hold him up. But even as I was turning over in my mind that and other schemes for Milliken, my calculations were pulled up by a distant noise.

Two rifle shots in the distance, a pause—and then the unmistakable "rat-tat-tat! rat-tat-tat!" of a machine-gun.

Milliken was fighting for it!

My heart leaped at the sound, and I felt myself quiver with excitement. We jumped to our feet. Danny and I, and my friend's eyes were ablaze.

The Sound of Battle: Milliken at the Gun

"Oh, you, Milliken!" yelled Danny. "Atta-boy!"

We both knew the mechanic's deadly skill with the machine gun, and the likelihood that his attackers would be wiped out if they were anywhere in his reach. We shook hands on it.

"I sympathize with your feelings, Mr. Boon—Mr. Lamont," the cool drawl of our guard came to bring us back to reality. "But don't you let them feelings take you an inch nearer the window for instance."

His rifle was in the crook of his arm, and he was smiling at us grimly. It was galling to have to stand there and listen to the noise of our comrade's lone fight. Now Milliken had brought one of the half-kilo guns into play. The steady "crack-crack!" of it was shattering the air about the plateau. From the attackers no sound came, except twice—two deliberately separate shots from a rifle. There was a last drum of fire, despairing in sound somehow, from one of Milliken's lighter guns, and then—dead quiet.

The silence held through an hour and a half of suspense. Had Milliken managed to get away? I saw difficulty in this, even supposing he had so effectually disposed of his attackers as to let him get out of the *Merlin's* cabin. Before he could make off, he would have to turn her nose away from land, and then there would be the difficulty of starting without some one to flip over the propeller. There was just a chance that he had managed this, though the operation was difficult and dangerous, but I cursed myself that I had not thought of arranging a self-starter for the plane.

Dan and I discussed the probabilities in low tones. We knew the determination and resource of our comrade by a hundred experiences. We pinned our hope to those stout qualities of Milliken, and began to think that we had a chance of rescue. But when ninety minutes had passed, we found our hope was vain.

The curtain over the cave entrance was thrown aside, and Seton entered, leading our mechanic blindfolded.

"Here's your man, Boon," said Seton. "He put up a jolly good fight, but the dice were against him. Cheer up, Milliken—no man could have done better."

"I don't want any certificates from you." Milliken said grimly, the bandages off his eyes. "That's just about the last thing I'll stand for."

"Come, come, Milliken," said Seton gently. "You can't bear all that ill-will."

"You sink the *Merlin* and capture me—well, I can face that!" said Milliken thickly. "But you dope women—a girl like Miss Torrance—who's given you her hand to shake and looked into your eyes! Ill-will! Hell!"

"I see," Seton said quietly. "Well—perhaps you're right, Milliken!"

He turned on his heel and left us with the guards.

Milliken faced Dan and myself then.

"I did my best," he said miserably.

"I'm certain of that, old Milliken," said I.

"If you'd only fired a shot or something—to give me warning——"

I thought with shame that I might have risked a wound to draw the fire of our ambushers, and I felt pretty sick, I can tell you. But I only nodded to him to go on.

Milliken's Story After His Capture

"I was cleaning up, before turning her to be ready for making off," Milliken said, "when I heard somebody call, 'Oh, you, Milliken!' It sounded like you, Mr. Boon, but I thought it was mighty queer that you should call at all. Opening the front screen, I answered the hail. 'Oh, you, Milliken,' the voice sings out again, 'come here a minute!'

"Thinks I to myself, that's mighty queer—and then I catch sight of somebody dodging among the trees—and he was wearing clothes of a different shade to yours or Mr. Lamont's. I get wise to the fake, and not knowing what would come of the fight that was due — the *Merlin's* nose being hard up against the trees—I start lowering the aerial of the radio to send off a quick message. There wasn't much chance of it being picked up, what with us being on the water, and with the trees and stuff around, but I thought it was the first move in the game——"

"Good for you, Milliken," said Dan.

"But I'd no sooner lowered the wire than from the bushes near two shots rang out—mighty good shooting, too, for the aerial snapped and the loose end came coiling up into the cabin. That finished the first trick. I made a jump for one of the machine guns. It wasn't much use. From the position of the boat, I couldn't get the arc of fire I wanted. So I tried the forra'd gun. That wasn't any use. I couldn't get the depression. But I loosed off at a big tree trunk, hoping the shell fragments coming back might do a bit of damage. I brought the tree down.

"All this time the others hadn't answered. But another two shots go bang, and from the noise I judge they've punctured the floats. That is right. The old lady begins to settle, swinging sidewise, then I have a go with the other mitrailleuse. But she's settling by the head, and by and by her propellor is buried in the mud. I thought of having some gun play with my automatic, but they'd got me corralled for sure, with no chance of relief coming, so when the blasted pirates wiggled a white flag and I saw who it was I was up against, I chucked in my hand——"

"It was the only thing to do, Milliken," I said. "They'd have starved you out, or riddled the boat. Don't you think so, Dan?"

"Sure," said Dan. "We'll work better three together, anyhow—now we're here."

At this moment Seton came into the cave again, with two or three men—not the least bit piratical, any of them.

"Sorry to disturb you," he said, "and that I must blindfold you once more. You are wanted elsewhere."

There was nothing for it but to submit, and presently we were led along a short passage into another cave.

The bandages were taken from us, and we found ourselves looking into the strangest pair of mild blue eyes ever seen.

II

The Chief of the League of the Covenant; A Remarkable Character

The Chief of the League of the Covenant, who stood facing us, was the merest wisp of a man, physically. Seton would have made four of him, and myself probably three. He was smaller than Dan Lamont. But if the man's physique was insignificant, there was nothing small about his personality. A pale-faced, one-armed little fellow, with a biggish head ornamented with thin brown hair and a silky beard, some keen force jumped out of him that was like a bright blade. The eyes that at first you took to be so extraordinarily mild had depths in them that were blue flame. The eyes held you, mastered you, and in the still placidity of that gentle face you read of a soul that was above pain, sorrow, joy—everything that influences the thought and actions of the ordinary human. It held a sense of bravery, too, relentless courage that made you shiver to think of, for behind it lay a will and a power that nothing human

(*Continued on page* 54)

To Our Readers

THE publishers of THE EXPERIMENTER have decided to put the contents of this magazine to a popular vote by its readers. This magazine is published and edited *solely for our readers*; and we are more than anxious to give them exactly what they desire. For that reason, we thought it best to put the matter to a popular vote, and let the majority decide. You will readily understand that it makes no difference to the editors and publishers what matter is printed as we can have no preferences in the matter. The readers must be satisfied *first!*

We hope every reader will see it as his duty to fill in the adjoining voting blank, and send it to the editor. The blank can be cut out and pasted on the back of a postal card. In case you do not wish to mutilate the magazine, just copy the blank on a postal card and mail.

The editors pledge themselves to abide by the result, which will be published as soon as a sufficient number of votes are in.—EDITOR.

Voting Blank

My vote as to the contents of THE EXPERIMENTER appears in this ballot. I have placed a cross in the blank spaces showing either my preference for or dislike of the various subjects enumerated.

Name...

Address...

More ☐	Less ☐	Experimental Radio
More ☐	Less ☐	Experimental Chemistry
More ☐	Less ☐	Experimental Electrics
More ☐	Less ☐	Junior Experimenter
More ☐	Less ☐	What Our Readers Think
More ☐	Less ☐	Latest Electrical Patents
More ☐	Less ☐	Short Circuits
More ☐	Less ☐	How and Why?
More ☐	Less ☐	Stories
More ☐	Less ☐	Experimenter's Patent Service

I would like to see additional departments as follows:

....

....

EXPERIMENTER'S PATENT SERVICE

EDITED BY JOSEPH H. KRAUS

ON this page every month we will give our readers the benefit of our experience on patents and questions pertaining to patent law. Years of our treatment of the subject of patented, patentable (and many unpatentable) devices has proved satisfactory to hundreds of thousands of experimenters. The writer, who has handled the Patent Advice columns of SCIENCE AND INVENTION MAGAZINE for the past seven years, will answer questions pertaining to the experimental side of Patents in this publication. If you have an idea, the solution of which is puzzling you, send it to this department for advice. Questions should be limited to Electrical, Radio and Chemical subjects. Another of our publications, SCIENCE AND INVENTION, handles patent advice in other branches. Address "Experimenter's Patent Service," c/o The Experimenter, 53 Park Place, New York City.

Auto Water Heater

(21) Leo Watson, San Francisco, Calif., asks whether we advise him to apply for a patent on a heating coil operated by electricity from the storage battery of an automobile, which is to be inserted into the radiator of the automobile. The circuit to the same is closed by means of a thermostat whenever the water in the radiator reaches the freezing point. In this way he hopes to avoid cracked radiator or cylinders.

A. Although your system of heating the water in a radiator, so that it will not freeze, is of some value, it is not by any means as effective as you believe it to be. The amount of heat developed by a small resistance coil operated from the storage battery of a car is not great enough (over a period of twenty-four hours) to heat the water in the radiator without seriously running down the charge in the battery. If a heating coil developing a great amount of heat is employed, then that heating coil consumes a large amount of current. If the coil gives only a little heat, the current consumed is not so great and the battery is kept in a better condition.

It is just as difficult to start a car with a run down battery as it is to start a car when cold. The starter itself will often fail to operate when the battery is low.

One can easily heat the gases in the intake manifold for starting cold engines by inserting a small resistance coil at this point. Of course, such a system would not prevent freezing but administering a small quantity of alcohol to the water or substituting kerosene for the water will lower the freezing point of the fluid in the radiator.

It is true that water containing alcohol boils at a much lower temperature than ordinary water, and on warm days this water containing the alcohol would not be as efficient for cooling the engine as unadulterated water. On cold days this same theory cannot be held. Often water containing alcohol in a radiator will cool the engine as efficiently as straight water.

Even assuming that an electrical heating coil is to be placed in the water through the radiator cap, the possibility is that the water in the radiator would freeze. The reason is simple. The position of the heating coil in the top of the radiator does not provide for a convection of the water currents. The water in the immediate vicinity of the heating coil is heated. Warm water remains at the surface, whereas the colder water sinks to the bottom. This is true until the temperature of 4 degrees Centigrade has been reached, when the cold water no longer goes to the bottom of the container. The possibility is that the water remaining in the engine water jacket would not get the benefit of the heat produced by the coil and would freeze. A better system would be to place the heating coil at the bottom of the radiator. The difficulty of installing such a device there is readily apparent.

We doubt if applying for a patent on this latter suggestion would be advisable. Taking the system all in all, it presents a sort of gambling venture, and we do not advise anyone to undertake the manufacturing and selling of a device in which the possibility of sale is so limited and the chances of loss are so great.

Mercury Vapor Lamps

(22) H. W. Phillips, of New York City, requests patent advice on a mercury vapor lamp embodying a chain fastened at the top to an iron core, which core slides up and down in a solenoid surrounding the lamp. The chain makes contact with the mercury.

A. The mercury arc which you have devised is not as practical as those mercury arcs now in use. The arc which your particular device would throw is so small as to make the system impractical. The arc in a mercury lamp rarely breaks down. Consequently the application of a solenoid and a chain is not particularly advisable. There are, however, a great many automatic lamps on the market which start their arcs very simply, quickly and easily, and which do not have to depend on a dangling chain for the making or breaking of the arc. An oxide coating on this chain would undoubtedly soon form and make the chain a non-conductor. We would not suggest that you apply for a patent on the idea.

The Ark of the Covenant

(Continued from page 50)

could thwart. Here was a man one could not bluff, for the mind that looked out of him was analytical of your faintest motive.

I'm afraid that I put down very badly my own impressions at first meeting the Chief of the League. Many a time since I have asked Dan Lamont to turn his uncommon power of analysis on the subject, but even he fails in describing the sensation he felt when he first looked into those extraordinary eyes. The nearest we can both get to it is simply contained in one word—power—power to the *n*th degree.

He took us all in, one by one, then he bent his gaze on me.

"Mr. Boon, I take it?"

I bowed.

"You have pursued us long, Mr. Boon," he said, "and tenaciously. It was inevitable that we should meet. I am afraid that, now you have found us, we must detain you."

Milliken was the next in order.

"I hear, Mr. Milliken, that you are a doughty fighter and that you gave your captors some trouble. If your guns had had position, you probably would have created some carnage. We shall know each other better by and by. Meantime, we must keep you also. Remains then Mr Lamont——"

He turned to Danny, and one would have said his still look changed slightly as he gazed at my friend. As for Danny, his eyes were alight with a queer excitement—for round the room, or cave, were disposed instrument upon instrument, of all queer shapes—the very stuff that Dan keeps his

Orchestra Volume from Phonograph

One of the great drawbacks with phonographs is lack of volume when a number of people are to be entertained. This has been overcome in the newly devised instrument that is fully and completely described.

Other Interesting Articles To Appear in November Issue of SCIENCE AND INVENTION

Chemical Tricks
By Dr. Ernest Bade

Lamp Chimney Experimental Apparatus.
By Raymond B. Wailes

A Continuous Time and News Broadcast Service
By C. A. Oldroyd

A Novel Six-in-One Receiver
By L. Ringer

Five Tubes With Simple Tuning Control
By A. P. Peck

nose amongst normally in his laboratory in New York.

"Mr. Lamont," said the Chief of the League, "I do not know what feelings you have about this capture, but I hope I may be able to dissipate your resentment by showing you some interesting sidelights on your own vein of research. I have read your interesting little book on pleochroic halos, together with other of your works. I have long had a bone to pick with you on the subject of thorium disintegration. Forgive me, then, if I welcome the happy accident that brings you."

"You're very good, sir," said Dan, red-faced as always by any reference to his work.

"Why, that's well," said the little man. "I do not despair of making friends with you—with you all. Now, gentlemen, it is obvious that I cannot release you until the task of our League is finished. We cannot afford to have our secret laid bare. I do not wish to keep you in close captivity, and you will, therefore, give me your word that you will not attempt to escape?"

Danny and Milliken both looked at me in inquiry. It was obvious that the man in front of us had charmed them as much as he charmed me, but the question of giving parole was one that could not be decided at a flash. The Chief picked up the thought.

"Naturally, you will need time to consider the question. To sit down quietly in the present situation might savor of cowardice. Let me put it to you, however. If I do not have your word, gentlemen, you will be closely confined, except for brief periods when you may exercise. Your machine will be dismantled where she lies and brought to some other place, so that that means of escape will be cut off. The country round about us is nearly impassable without bearers and

stores. I may tell you that—I who have tried it, and I have an accurate knowledge of the dangers and difficulties that beset the traveler through the dense Amazon jungle. If you are ignorant of them, these dangers will not daunt you. They daunt me. But take your time to consider the matter, by all means. Let me hear from you when you decide."

He turned back to his work at one of the instruments, and the guards blindfolded us once more.

This time we had a cave to ourselves, a little cave, well enough lighted and ventilated by a winding crack in the outer wall, through which, however, it would have been impossible to make any exit. Three beds were disposed about the cave, and a rough stool or two. We found all our clothes and stuff, brought down from the *Merlin*, but they had not left us even a pocket-knife by way of a weapon, or even a watch by way of a compass.

Food was brought to us by the stout seaman who had been guarding us in the bigger cave—fragrant tea in enamelled mugs, with excellent white bread and jam the first time, and later a savory stew of venison of some sort with vegetables. The stout seaman was most unloquacious. He waddled in and out without a word, hardly ever looking at us, but staring glassily in front of him or beyond us. He was, we found out later, one Smithers, formerly a warrant officer in the British navy. Only once did this strange attendant speak to us. Apropos of nothing, he suddenly fixed the trio of us with a comprehensive and basilisk glare. A hoarse rumble mounted apparently from his feet to his short throat.

"Does any o' you gen'lemen know anythin' about toucans?" he rumbled.

The inappropriateness of the question beat us into surprised silence. We simply gazed at him.

"I thought not," he said complacently. "Well—you soon will!" And with a portentous nod to the company in general, this strange fellow heaved himself from the cave.

We were well treated. Games of sorts were offered to us, and we had the use of powerful electric lights when night came, but we were strictly left to ourselves. No guard was left in our cave, but a peep around the curtain over the entrance showed a fellow with a rifle sitting a little along a well-lit passage. It was a trifle disconcerting to peep out and find ourselves winked at serenely by a perfectly wide-awake and obviously competent sentinel.

Escape Through the Wilderness Impossible

The three of us thrashed out every possible scheme of escape, but everything we tried in imagination brought us up with a round turn. Milliken and I reconstructed a map on the floor of the cave, and came to the conclusion that we were somewhere on the borders of Colombia, Venezuela and Brazil, hundreds of kilometers away from any reasonable civilization. Without food or any weapons for providing it, with no sense of our direction once we left the plateau and began to traverse the sunless forest or follow equally sunless rivers, escape seemed impossible. South of us lay league upon league of dense forest and swamp, north and west high barriers of mountains, and to the east a ramified veinwork of rivers, apparently tributary to the Amazon. I did not feel competent to lead my companions through any of these ways, granting that we escaped from the plateau. My paths are in the air. I have no skill in woodcraft and jungle work. I felt lost.

This sense of being lost was shared not only by Dan Lamont, but even by the resourceful Milliken. Had I been competent to lead, he

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PRICE per set—No. 701 .... $3.00

HAND DRILL

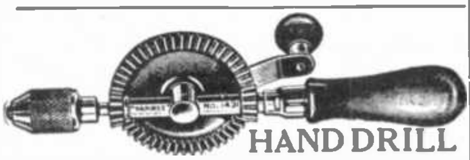
The hardwood handle is hollow to store drills. Iron frame, nickeled parts, ball bearing three jawed chuck holding and centering accurately round shank drills from 0 to 3-16. Length of drill, 12 inches.
PRICE—No. 303 .... $2.25

WIREBENDING TOOL

For making eyes, loops, bends, and offsets on Bus Bar wire. With this device any Radio Constructer can wire his set to compare favorably with any factory made set. Easier to use and more accurate than pliers. Full directions in box. Made of heavy steel, blued and finished.
PRICE—No. 203 .... $1.00

CIRCLE CUTTER

Especially designed for the Radio Constructor. Made of the finest material and equipped with the highest grade high steel cutting bits. It does three things at once. It drills its own pilot, cuts out plug and puts bead or scroll around the hole in one operation. Cuts holes ¾ to 1 in. in diam.
PRICE—No. 402 .... $3.00
401. Same tool but smaller and not fitted with bead or scroll in one operation.
PRICE—No. 401 .... $2.00



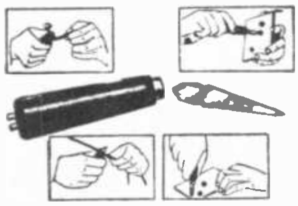
HAND DRILL

Especially designed for Radio Work by the makers of the famous "Yankee' Tools. A beautiful balanced, small, powerful drill with 4 to 1 ratio of gears for speed. Special chuck 9-32" capacity, to take largest drill, mostly furnished with drill or tool sets. Length over all, 9⅓ in. Weight 1½ lbs.
PRICE—No. 302 .... $2.75

Three-in-One Nut Wrench. Consists of hardle with hollow stem 6 inches in length and three interchangeable sockets fitting popular sizes of nuts. The hexagon sockets grip the nut solidly.
PRICE per set—No. 301 .... 65c

Side Cutting Nipper. Lap Joint. For cutting all kinds of wire. Jaws hardened and oil tempered. Natural steel finish with polished jaws. Length 6 inches.
PRICE—No. 201 .... 75c

'RADIO HANDI-TOOL



Bends Bus Bar or wire strips and scrapes wire, bores and reams holes, etc. Tool consists of 4 in. black japanned handle, to which is attached wire bending device, with nickeled ferrule and 3 in. long two sided reamer.
PRICE—No. 702 .... 50c

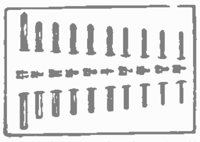
TOOL CHEST

Set consists of "LOCK-GRIP" master handle, 5" long, black Rubberoid finish with steel chuck, nickel plated, buffed and with the following 9 tools: Saw, bradawl, large screwdriver, file, scratch awl, gimlet, reamer, chisel, small screwdriver. Each tool of fine steel, drop forged tempered, hardened, and nicely finished. Set comes in leatheroid box with tray.
PRICE—No. 703 .... $1.85

SCREW STARTER and DRIVER

Holds any screw by its slot with a firm grip, makes it easy to place and start screws in difficult places. Just the tool for the Radio Constructor. All parts heavily nickeled and polished.
PRICE—No. 304 .... $1.00

RADIO DRILL SET



Composed of 10 straight shank twist drills, fitting all hand and breast drills. The selection of these drills has been especially made for Radio Constructors and consists of the following sizes: 1-16, 5-64, 3-32, 7-64, ⅛, 9-64, 5-32, 11-64, 3-16, 17-64. Drills are mounted on white Holland Linen with sizes clearly marked.
PRICE—No. 305 .... $1.25

ELECTRIC SOLDERING IRON

A perfect tool for Radio Work. Operates either on 110-volt A.C. or D.C. The heat element is of Nichrome, which prevents overheating and assures the desired even temperature. Size of Iron, 10½ in. long. A 4-ft. cord and plug is furnished.
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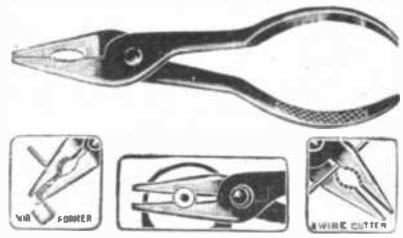
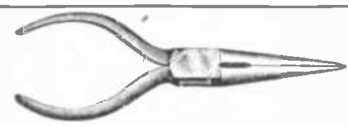


Combination Plier, Wire Cutter, Wire Former and Wrench. Drop forged, slender but exceptionally strong, 6 in. long.
PRICE—No. 202 .... 75c



Long Sharp Nose, Side Cutting Pliers. Just the pliers for the radio constructor. Bends and cuts all kinds of soft wire. Nose 1½ inches long, black body, polished jaws. Length [illegible]½ inches.
PRICE—No. 200 .... 75c

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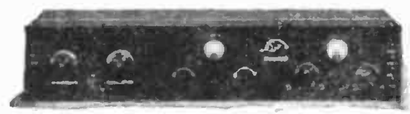
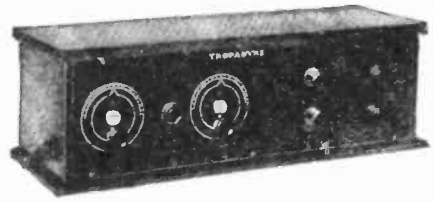


THE TROPADYNE



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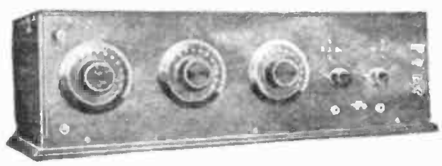
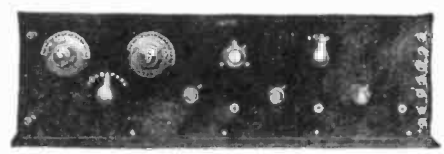


5-TUBE COCKADAY



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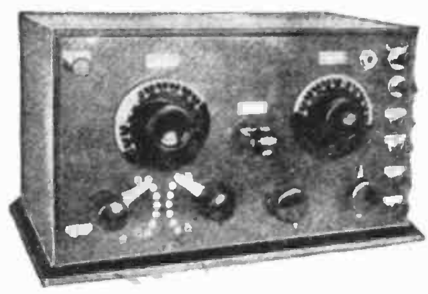
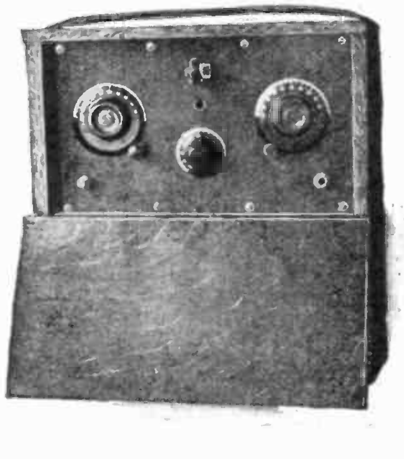


THE PORTABLE



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Consrad

EVERYTHING IN RADIO BOOKS, PATTERNS AND DIAGRAMS would have followed, but taking the lead himself he felt to be out of the question. It must be remembered that in our approach to the plateau, the *Merlin* had covered hundreds and hundreds of kilometres in wide circles without bringing into our view the slightest trace of human occupation. We had to discard the idea of escaping by land entirely.

We had a vague notion of one of us stowing away in the airship and escaping from her on some raid, but consideration of the plan soon showed us that it was impossible. There remained the breaking of our parole. We did not discuss that. At length we decided to give our word not to attempt to escape.

To this moment, when I look back and wonder a little that we did not make a bid for freedom, I hold the belief that the dominant and persuasive personality of the Chief of the League had much to do with our acceptance of the situation. For myself, I became avid to see the ship and the weapons which had fooled me so completely on my *Merlin*, and Dan Lamont was in a fever to be nosing out the scientific facts that gave the raiders such power. In the laboratory of the Chief he had seen much in the way of instruments and plant that was unfamiliar even to his skilled eye, and he considered that his object in joining my party was gained in having reached the workshop of the man who had planned the raids. Milliken saw no means of escape. He was downcast about it, but he accepted the situation, and shared the desire to look closely at the airship—though in a slighter degree than myself, since he had a rooted contempt for so-called lighter-than-air machines.

When morning came we all three desired an interview with the Chief, which was immediately granted.

"You have acted wisely, gentlemen," he said. "Escape was impossible. Even if you had eluded pursuit, the chances were all against you ever reaching civilization. Let me explain to you, partly——"

He went over to a cupboard, and brought out a linen bag containing something roughly round in shape, little bigger than an orange.

"Of all the men who have joined the League of the Covenant," he said quietly—"and there are close on to fifty men here, some of whom have been in these caves for three years—only one fell short of absolute loyal and devoted service. One man—a traitor. We do not say his name, nor do we mention his nationality. He is forgotten as if he never existed. This man forgot his allegiance. The world pulled at him, his desire for the fleshpots—he deserted the company and tried to make his way back to civilization."

With a solitary hand the Chief was undoing the strings of the linen bag with a singular deftness.

"On his journey out—it was two days before we started in pursuit, for he had been hunting—he fell in with a tribe of Indians, the Mandaruen, who have one curious art. The story we heard afterwards was that this traitor insulted one of the native women—he was that sort of man—and he was taken and killed.. Months later, two of our hunters came upon the same tribe. In one of the huts they found this."

The Head of a Traitor—Mummied and Shrunk by the Indians

He let the sides of the bag fall away, and he pulled out a miniature head. This was longish haired, highly varnished, and the lips had been sewn together with brightly colored threads which hung down in long strands far below the severed neck.

"Good lord, sir!" I exclaimed. "It isn't the traitor's head?"

"That, Mr. Boon," said the Chief, "is just what this object is. It is the head of our traitor, shrunk to this little measure by the art of the Indians."

"I have heard of the process, sir," Dan Lamont put in. "They take out the bone structure, and shrink the flesh with hot pebbles——?"

"That is the process, I believe. The lips are sewn together to prevent the victim cursing his captor. The preservation of the lineaments is quite remarkable."

The Parole

The Chief gently replaced the head in its cover and turned to us.

"I do not insult you by suggesting that, having given your word, you would endeavor to escape, and that is not why I have shown you this curious relic of one who attempted it. You will be free to explore round the plateau as you like, and to examine all our caves. But I warn you not to stray too far. It is dangerous to be bushed in the Amazon forests, and to fall victim to the curious pickling art of the Mandaruen is perhaps the least painful of the fates that might overtake you. I warn you solemnly to take care how you go."

"Thank you, sir," I said.

"One other thing I must request of you," he went on. "You are granted the freedom to go outside the caves on the obvious condition that, in the event of aircraft flying over the plateau as your *Merlin* did, you will not make any signal or reveal your presence in any way. If you sight aircraft while in the open and out of fair reach of cover, you will stand quite still at once and not look up. As an airman, Mr. Boon, you will appreciate my reasons for that request?"

"Yes, sir. Quite."

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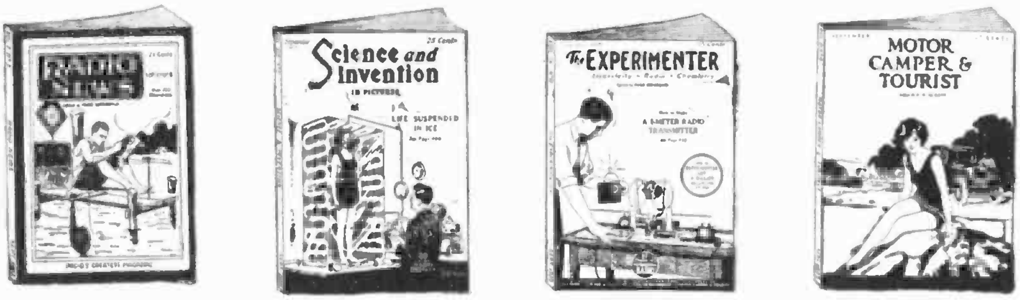

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"I put it briefly. In the event of anything happening hostile to the purpose of the League of the Covenent, you will act as if you were members of the League, short of joining in any retaliatory measures we may take against our enemies. Do I make myself clear?"

"Yes, sir," we said.

"And I have your promises?"

We all assented.

"That is well. You are free to move about as you please. If you wish to go hunting, guns will be provided you. I advise you, however, to join with either Lord Devonridge or Mr. Haynes to begin with. Or perhaps Mr. Greensleeve or Mr. Whittaker might guide you. These are our most skilled *shikaris*. You must not allow yourselves to be without anything necessary for your comfort. We are your hosts."

We were amazed at such reliance on our simple word, and we could see how it was that the little leader had gained the unswerving loyalty of his band. We thanked him.

"Not at all," was the reply. "We want you all to have a real idea of us, to see that we are honest men banded for a great purpose. To subject accidental prisoners to close captivity is no part of our scheme. And now, my good Boon, you are no doubt anxious about your beautiful seaplane. Commander Seton will supply you and Milliken with all the tackle and the men necessary for raising her. When she is reconditioned, bring her down to the north basin and into the cavern. We shall find a place for berthing her in safety."

He turned to Dan.

"Mr. Lamont," he said, "I have much to show you, but you may go with your friends if you desire——"

"I'll stay with you, sir," said Dan, his face aflame.

III

A Great Machine Shop in the Depths of the Mountain, and the Repairs to the "Merlin"

I must not say much about the interior of the great system of caves under the plateau. Seton has given a full description. But the amazement of Milliken and myself, and later of Dan Lamont, on seeing the marvelous equipment of the League, the splendidly organized machine shops and power stations, may easily be guessed. It seemed incredible that a mere handful of men had so secretly collected that mass of material and had created such an efficient depot for the erection and docking of the two marvelous airships.

The immensity of the caverns was awe-inspiring. With the glow of a furnace here, the hum of the dynamos there, the rush of water to the big hydraulic mains of the turbines and the splash of the excess to the basin of the cavern, the glare of the arcs, the shimmer of the great airships, an effect was created that gave one the impression of being in a dream. Truly, it was difficult to persuade oneself that one was awake.

As Seton conducted Milliken and myself about the caves, showing us everything that was to be seen, we met many members of the League. There was not a man among them who could not look you squarely in the eye, or who had not every appearance of sterling honesty. In Milliken and myself, as the pilots of the *Merlin*—the only air machine to get within real fighting distance of the *Ark of the Covenant*—the men in the caves showed a keen interest. We had to fight the battle off Mogador over and over again with new groups as they collected round us in the various departments. Even Milliken began to lose his resentment. To harbor ill-feeling among so many specimens of decent citizens was impossible. Here were clean-limbed, keen-faced young Americans and Englishmen, and older men, graver of mien than the younger fellows, but all clearly good types of intelligent humanity. A crew less piratical could not have been imagined.

That every man among them was imbued with a sense of high purpose was not obviously apparent, but that it was there could not be denied. The eager questions that were shot at us about the effects of the raids were a clear indication of the keen interest that was taken in the object of the League.

I will say that Seton had a splendid way with the men under his command. He knew just the right thing to say, and the right way to say it, to get the best out of each man.

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EDITOR.

The gang he picked to help in the refloating of the *Merlin* could not have been bettered. They seemed to be sailors mostly, and among them was that stout and silent mariner of the question about toucans, specially called out of the commissariat for the job. The gang collected material for the purpose, and with Milliken, myself and Seton, set out for the top of the plateau.

We climbed by a high staircase to a tunnel entrance, and began to ascend that passage by which Dan and myself had been brough blindfold into the cavern. This passage was a natural one, the track, we were told, of an ancient underground stream. It was lit up at intervals along its length by electric globes, and emergence to the top of the plateau was gained by an opening which was concealed among dense undergrowth. Near here stood the sinter cones that Dan and I had been examining when we were captured.

The raising of the *Merlin* was done in very seamanlike fashion. A tree was felled close to the plane, and was lopped and trimmed into the arm of a rough derrick, and this was hoisted by means of cables reeved to standing timber, firmly stayed, till its upper end hung over the *Merlin*. From this point was depended a tackle of two double blocks, the lower of which was hooked to the ring-bolt on the *Merlin's* cabin-top. When all was set, the gang "ran away" with the cable, navy fashion, and the hull of the seaplane came out of the water. Pumping out the water from the floats and patching the bullet-holes took very little time, and at last the *Merlin* floated on the lake, very much herself again, except for a muddy nose and a scratch or two.

Her engine, in spite of the ducking, was in such a condition that only half an hour's work was needed to put it in order, and when Seton had given instructions to the gang to remove all traces of our operations before returning, he joined Milliken and myself aboard the plane. Presently we had taken off from the lake and were circling above the plateau.

I don't think I need tell of the feelings that held me when I found myself in the air with the old bus again, or of the temptations that possessed Milliken and myself. I think Seton gauged the turmoil in our hearts with fair accuracy, for he smiled whimsically at my mechanic and myself with a nice air of sympathy.

"Let her out for a bit, Boon," he said. "I'd like to see how she goes. No hurry to return yet."

I took him at his word and swung the plane into a northerly course, stunting to show her paces. In the interest shown by Seton in the bus, we went further north than we intended, and I was just about to let him take the controls to try her when, dead ahead of us, the speck of another plane came into sight!

Seton saw the approach of the other machine as soon as I did.

"Keep to your course, Boon," he said quietly. "And answer her signals."

"You forget that our radio aerial's shot away," I replied.

"Haven't you a spare?"

"Rig the spare aerial, Milliken," I told the mechanic, whose hands were working convulsively and whose face was white.

Milliken silently snipped the cords binding the coil of wire and quickly attached the spare weight, which he lowered through the aperture. He then connected the slack to the drum.

"I'll do the lying that's necessary," said Seton, and went to the keyboard of the radio.

On came the machine, heading for us, and we heard a voice in the open phone.

"Hullo, *Merlin!* Anything doing this way?"

"Use the key," Seton tapped. "Phone attachment dis."

"Anything doing this way?" the question came in Morse.

"Not a thing," Seton buzzed back. "We've been wastng time here."

"Where are you heading for?"

"Don't know—Caracas way, likely. Been on a false scent. Try eastwards."

"Thanks, *Merlin*. Good hunting!"

And with that the stranger swung east, while we kept to our course.

All this time Milliken had been standing behind Seton, with plenty of loose tackle about that would have made a weapon for attack. One blow with a spanner, for example, on the back of the big man's defenceless head would have given him his quietus and us our freedom. When at last Seton turned, my mechanic was staring out of a porthole on the opposite side, pale of face and his lips working.

"Thank you, Milliken," Seton said quietly. "But I beg your pardon. I had no right to expose you to that temptation."

"Mr. Lamont was left in the cave," the mechanic said hoarsely, still looking out of the porthole.

"I don't think it was that, Milliken," Seton said, and he thrust his hand past the mechanic, so that he could not help seeing it. Milliken turned with a fierce gesture.

"Hell!" he almost snarled. Then with something of a gulp:

"You gave me the back of your head, Seton—and me with a spanner handy——!"

He snatched at the extended hand. Seton wrung the other hard, and turned to me.

"May I have that chance to handle her, Boon?" he asked, "when we turn south again?"

(To be continued)

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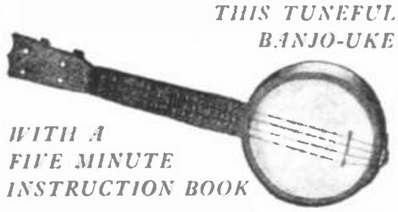

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