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Electricity ~ Radio ~ Chemistry

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Radio Experimenting

By Hugo Gernsback

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

THIS title is perhaps somewhat misleading, for the reason that experimenting in Radio is not necessarily restricted to that branch only.

The radio art has grown to such tremendous proportions that it has endless branches today. For instance, an engineer who is familiar with all phases of broadcasting does not necessarily know anything about manufacturing a radio set. As a matter of fact, he probably does not. An expert in vacuum tubes may not have the slightest knowledge of the intricacies of the construction of a telephone receiver.

I might, therefore, say that experimenting in radio embraces a very large field. It is no longer possible today for any one person to know radio in all its many phases. The so-called radio engineer is expert in one particular phase of radio, and has all he can do to keep up to date in it. One can, to be sure, have a slight acquaintance with almost all branches of radio, but this will only skim the surface, so to speak, and will not make him expert in all the different branches.

Particularly in this country, specialization is constantly becoming greater. Our big corporations, as well as every intelligent employer, demand, as a rule, an expert, and this the experimenter should keep in mind at all times, even though he may never be in need of employment.

If you hope to strike out for yourself and not work for anyone else, it is even more imperative that you become an expert along one particular line, because if you are not, it is almost certain that with rare exceptions you will not survive.

There are naturally many branches in radio in which the young experimenter may interest himself. It is an excellent idea in starting out to acquire radio experience through experimentation with every possible thing you can think of, from the building of your first crystal set, on through the various tube sets.

I must insist here that nothing is more destructive than radio "book" experimenting. I have mentioned this before in one of my talks, and this is particularly true in radio. You may think you know all about radio when studying books, but it is quite impossible to master the art in this way. Practical experience counts more in radio than in any other art. It is one thing to build a set in your imagination; and totally different to build one with your hands, using your head to guide them. You will discover a thousand different things in the course of the building of such a set, that are not contained in any books.

There are many worth-while experiments that the experimenter can conduct, and I give a few herewith which may take you out of the beaten path and direct your thoughts to new channels as far as radio is concerned.

Many experimenters are apt to scoff at the humble little crystal detector, but nevertheless it has big potentialities. I demonstrated this recently when I developed a number of new circuits termed "Interflex," whereby the crystal detector was connected directly in the grid in various circuits.

Not that this was a revolutionary discovery, or anything like it. On the contrary, it was made many years ago, but the characteristics had not been studied systematically until I took up the subject again, making no less than 800 different experiments in connection therewith. In these researches I discovered at least twenty new things that had never been done before, many of these points being brought out in articles to appear in *Radio News* from time to time.

Nor is this subject exhausted. There are many more possibilities with a crystal detector in conjunction with the vacuum tube. I do not, of course, refer to reflex sets, but placing the vacuum tube in a circuit to obtain amplification. In other words, I get the results of two tubes by using only one. I may say here that the surface has hardly been scratched.

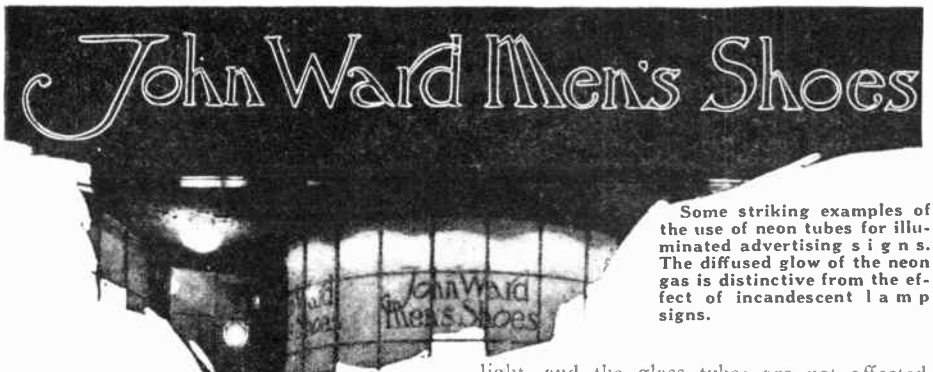
Recently, in an article in the December issue of *Radio News,* I opened an entirely new line of thought by a simple little device which I termed "The Radio Dancer." Up to this time the power output of a radio set was used only for one purpose; namely, a pair of headphones or a loud speaker. No one had ever thought of utilizing this rather large energy for other purposes. The Radio Dancer is simply a large-diaphragm telephone receiver, the diaphragm being some five inches in diameter. When connected to a 3- or 5-tube radio set, we get quite a strong vibration of the large diaphragm. Small, light, 3-legged dolls, when placed upon the diaphragm, will now begin to dance in a very amusing manner.

Now you can see what I am leading up to. We have a certain power from the output of the average radio set, which we should be able to use for other purposes, be they amusement, instruction, or what not. We can create vibrations, we have a fair amount of power, and the field for experimentation along these lines is very large. It has as yet not been touched. Mr. McFarlan Moore, the well-known inventor, must also have thought along similar lines, because recently he informed me that he placed a small neon lamp across the output of a radio outfit and in the dark he could "see" the music, or, rather, let us put it that he could see by means of the neon lamp that the current of the radio outfit turned the neon lamp off and on in exact unison with the music or talk that came from the radio outfit. Any number of lamps could, of course, be used, giving a very pretty effect of actually seeing the radio vibrations—a good stunt for exhibition purposes, window displays, etc. Hundreds of other similar ideas can, of course, be worked out, and I hope that the ball will keep on rolling.

We are still in want of a really good, as well as cheap, loud speaker. I have mentioned many times that a loud speaker with a diaphragm is a monstrosity. I would advise those who wish to delve into this experimentation to study up first in physics and then acoustics, before tackling the problem. Only an expert in these two subjects will be able to solve the problem in time to come.

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

Lighting With Neon Lamps



Some striking examples of the use of neon tubes for illuminated advertising signs. The diffused glow of the neon gas is distinctive from the effect of incandescent lamp signs.

THE Neon Luminescent Tube Light is the newest and one of the most beautiful forms of electric display lighting. It is known as the Claude Neon Lamp, as derived from the name of the famous French inventor, Georges Claude, and neon, the rare gas used as the illuminating medium for the tubes.

Many of our readers have no doubt seen the pleasing soft glow of a neon lamp and have wondered at its fascinating color and cold light. No doubt, too, they have been interested in the process involved in making such a lamp. The following information should prove of more than passing interest to everyone.

Neon is a rare inert gas present in the air in very minute quantities, one part in 66,000 parts of the atmosphere. This rare constituent of the air is extracted by the liquefaction process as a by-product of the oxygen industry. It was first discovered by Ramsay and Travers in 1898 and resembles helium and other members of its type in being chemically inert, no compounds being known. Neon (symbol, Ne; atomic weight, 20.2) is a colorless and odorless gas which can be liquefied below—210° C. (—346° F.). Its molecules, like those of argon, helium, krypton, xenon and other rare gases of the atmosphere, are made up of single atoms.

The neon tube contains no filament, having electrodes at each end; being filled with neon, which is itself a conductor, light is produced by passing an electric current through the tube. The so-called "breakdown potential" is higher than is supplied by the 110-volt A.C. line, and thus it is necessary to employ a step-up transformer and choke coil in connection with the operation of the tubes. Direct current cannot be used as the tubes will not act with it.

The voltage required depends on the length and diameter of the tubes. Thus, for a one-foot length of a 11-millimeter diameter tube it is necessary to use 200 volts for successful operation.

On passing an electric current through such a tube, the neon gas produces a deep orange-red color having very lasting and penetrating qualities and properties. This basic orange-red color may be turned into a brilliant blue by introducing a few drops of mercury into the tube before sealing. The mercury vaporizes gradually and the color becomes blue. However, the neon light is so nearly a cold light that when the atmospheric temperature drops below 40° F., it is difficult to maintain vaporization of the mercury, and when freezing temperature is reached, the tube reverts to the neon red color. With a rise in temperature, the tube becomes blue again, going through the successive stages. This accounts for the variation in color of certain accounts for the variation in color of certain tubes during the winter months. The neon orange-red color is not affected by temperature changes, and gives practically a cold light, and the glass tubes are not affected by sudden temperature changes.

Aside from the novelty and advantages of using a continuous tube of light, which is adapted to being shaped to any desired design or letter, the light is exceedingly attractive and compels attention because of its brilliant glowing color.

The amount of neon gas necessary for the operation of a tube gives a pressure of not more than 5 millimeters, indicating a very insignificant amount of neon. Thus, the tube, although slightly more expensive than a corresponding set of electric bulbs, is much cheaper, both in operation and efficiency.

The air within the tube is exhausted to as high a degree as desired and a small quantity of the gas injected. The degree of evacuation is not specifically an important issue, but generally as much air is taken out as is possible under manufacturing conditions.

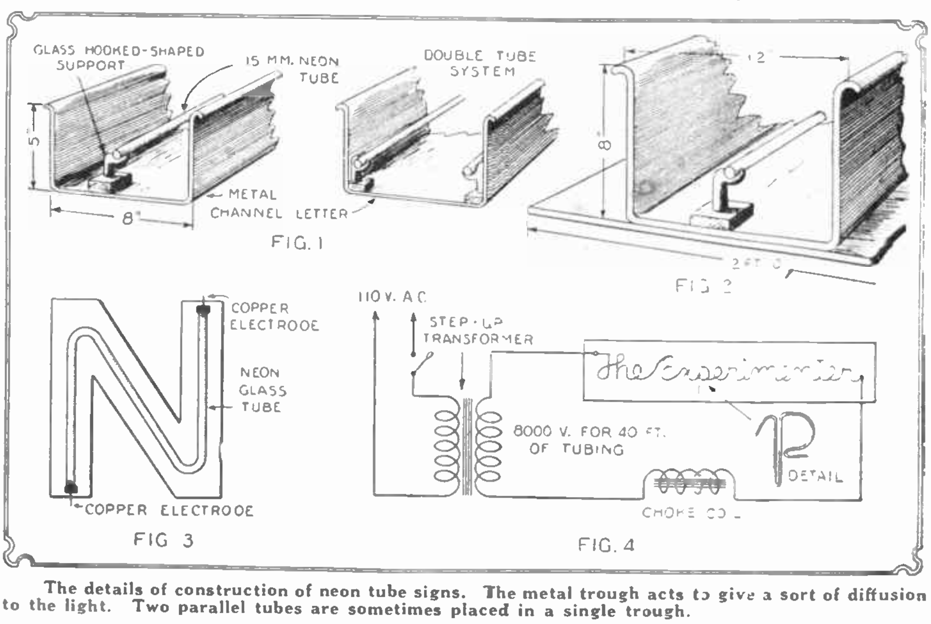
The neon light has greater visibility than any other form of light. The light from incandescent lamps is very brilliant at its source, and without proper direction of the rays soon expends itself, causing a glare and blurred effect at any great distance. The neon lamp, however, owing to its diffuse nature due to the fact that it is an ignited cylinder of a half-inch or more in diameter, and not a tiny filament, produces an apparent effect of increasing the light when seen at a distance. A half-inch diameter neon tube appears several times its true diameter at a distance of a few hundred feet. In fact, due to the greater penetrating power of the neon light throufh heavy fog, lighthouses in the English channel are being equipped with them, and we can expect that many other uses will be found wherein a cheap, cold and efficient long-lived source of light is necessary.

The neon method of lighting is very economical, the power consumption being one-third to one-tenth that of incandescent lamps in the usual method of illumination. At the present time, the lamps are used mainly for sign illumination. As the average life of a neon lamp is considerably over 5,000 hours, one can readily see the great advantage they present in durability.

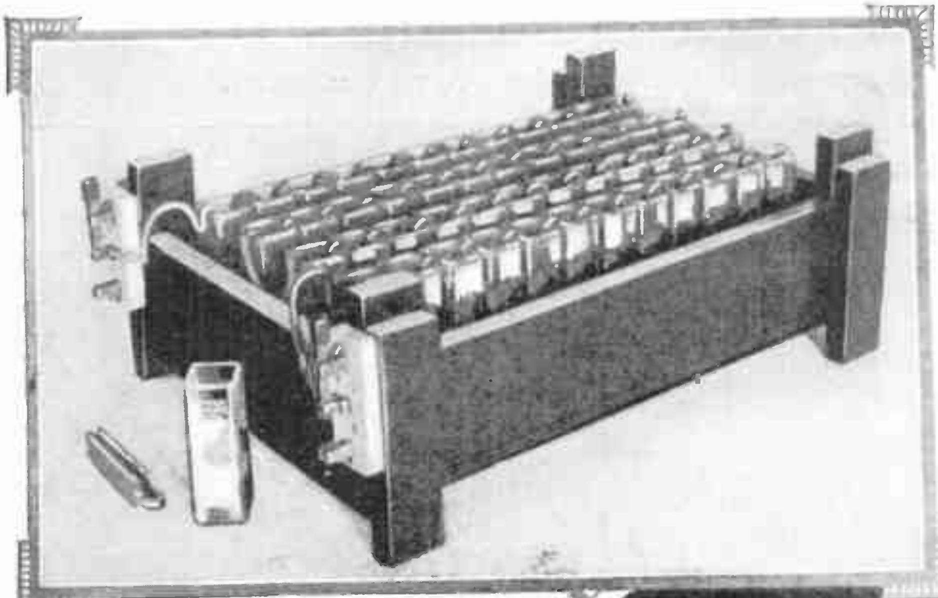
The letters are formed of channel-shaped metal 10 or 12 inches wide and the neon tubes of shapes corresponding to the various letters is secured to them. The width of the channel is virtually the width of the letter.

As an illustration of economy and adapta-

(Continued on page 110)



The details of construction of neon tube signs. The metal trough acts to give a sort of diffusion to the light. Two parallel tubes are sometimes placed in a single trough.



A 100 volt unit of a battery used by the Bureau of Standards as plate supply. The battery is of the lead-acid type.

Testing Insulating Materials

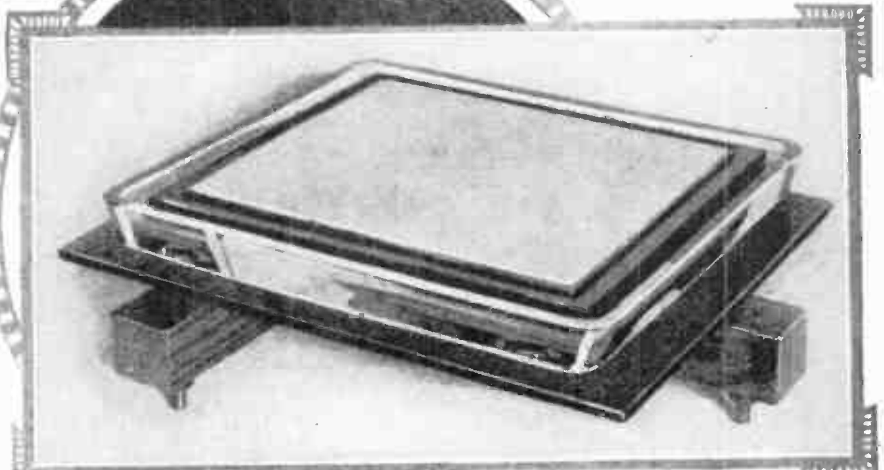
By Allen P. Child

THE insulating qualities of insulating materials are not always perfect, and it is claimed that there is a certain amount of power absorbed in them when they are used in or near a circuit in which alternating current flows.

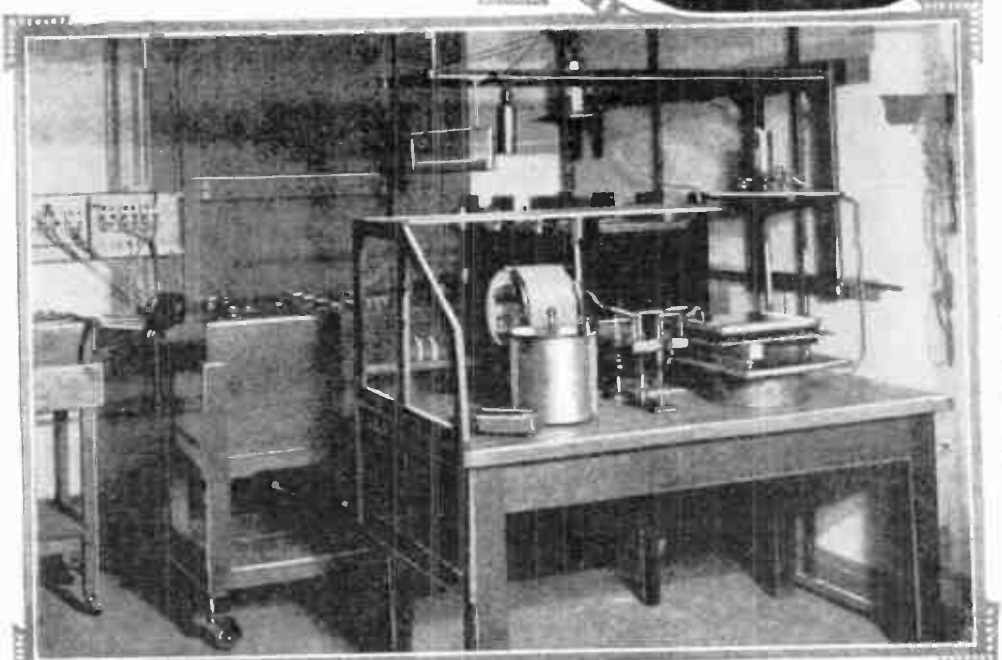
The power loss can be simply expressed by the phase difference and when the phase difference is small it equals the power factor. Either of these quantities is obtained by measuring the equivalent resistance and capacity of a condenser made up of the material and the frequency of the alternating current used. An interesting apparatus for conducting these tests has been devised by the experts of the Federal Bureau of Standards.

A test specimen for the measurement of phase difference and dielectric constant at radio frequencies consists of a sheet of the insulating material placed between metal plates so that the whole combination constitutes an electric condenser. The sheet of material is floated on mercury and a pool of mercury is formed on top of the sheet, confined by strips of copper.

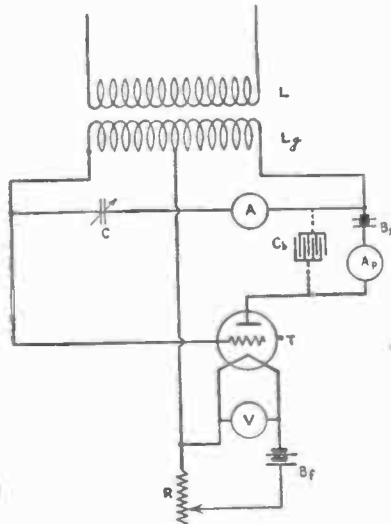
The measurements require a generating circuit and a measuring circuit. In the generating circuit is an inductance coil, a variable air condenser and a 100-volt plate or B battery as well as necessary ammeters and voltmeters. A variable air condenser and a special switch with mercury wells for contact terminals is used in the measuring circuit, and the condenser formed by the test specimen floating on mercury has the same kind of terminals.

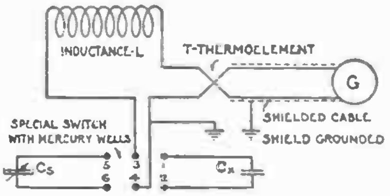


The test specimen is made the dielectric of a condenser with mercury plates The capacity of this condenser is compared in the test with that of a standard variable condenser.



A general view of the apparatus for measuring phase difference. In operation, the whole is enclosed in metal screens. Note the standard inductance and standard variable condenser. On the right side of the table is the test specimen condenser and above it the sensitive galvanometer. The connection of this apparatus is given in the diagram at the right.





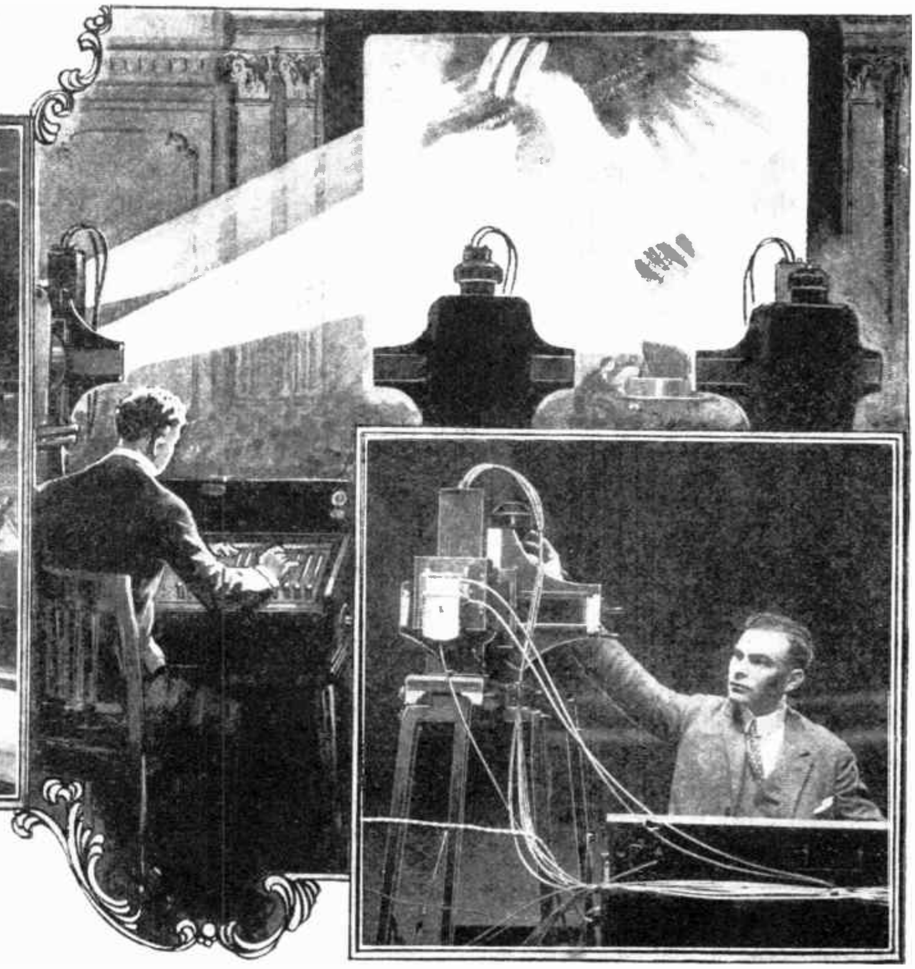
Above is shown the generating circuit employed by the Bureau of Standards for the production of radio frequency currents in the measurement of the dielectric constant of insulators. The diagrams are reproduced from No. 471 of the Scientific Papers of the Bureau of Standards, where the methods for measurement of the factors of electrical insulating materials is fully discussed and the processes used are described.

Dielectrics in condensers are playing so important a role in electrical work, notably in high frequency experiments and in the construction of radio apparatus, that these investigations are very timely.

The Color-Sound Piano

A Combination of Music and Painting by Dr. Alfred Gradenwitz

Below is shown the keyboard and performer, the latter playing on the color-sound piano which has been recently developed in Germany. The projection apparatus is back of the musician, if we may so call him.



The central picture shows the color projected on the screen. The tints may be supposed to compare in their color relations with the relation of the musical notes. On the right, the projection apparatus with the connecting wires are shown and the performer seated at the keyboard. The back of the keyboard in this case is toward us.

THOUGH presenting at first sight some analogy to the clavilux or color organ, Alexander László's *Color-Sound Piano* is not actually its competitor, for, not superseding the vocal harmonies of music by color symphonies, it aims at a combination of the two.

It is perhaps not generally known that many persons on viewing a painting will receive a musical impression, that is to say, will with their inward ear seem to perceive actual sounds, while on the other hand, listening to a piece of music often gives rise to an accompanying perception of motion, color, light and darkness.

Though this evident relationship of the two arts seems to point to a feasible combination, no success worth speaking of has so far been achieved in this way, the eye proving unable to grasp and enjoy the ultra-rapid succession of colors individually associated with as many sounds of music.

Our senses of vision and hearing being based on radically different physiological conditions, the eyes absorb colors in slow changes, soft transitions or, in the event of a sudden appearance, at proper intervals; whereas the ear has no difficulty in perceiving even the most rapid succession of sounds. Each color perception should, accordingly, be associated with a sequence of several sounds (as in a melody), with several sounds produced one above another (as in a chord) or, finally, with a succession of sounds superimposed upon one another (as in a melody comprising harmonies).

Alexander László, a Hungarian pianist, living in Munich, has been the first to elucidate this law, which is in close agreement with artistic reality and which holds out unexpected possibilities for the future. A plurality of sounds, *i. e.*, a musical *motif*, is the counterpart of each individual color.

After many years of painstaking work during which he had to contend with all the difficulties generally placed in the way of inventors, though entirely unacquainted with the technicalities of the problem, he succeeded in perfecting an apparatus which on the screen reproduces his compositions of color and light, that is to say, picturesque illustrations of the strains of music.

This apparatus, as constructed by the Ernemann Works, comprises two main, two secondary and four foot-light instruments all of which are controlled from one playing desk not connected with the musicians (pianist, singer or orchestra) and operated by an artistically trained player in close agreement with the intentions of the combined music-color composition. Thirty-two color switches, four levers in connection with diaphragms and two switchout levers operating instantaneous shutters serve to actuate the Color-Sound Piano, thus causing color paintings of an abstract character simultaneously with the music to appear, unfold, vanish or shift color and brightness on a large three-sectioned screen.

The combination of sound and music entails a common dynamical and rhythmical adjustment, musical qualities, "piano" and "forte," corresponding to "soft" and "strong" colored lights respectively.

The succession of colors appears in a given rhythm by double, triple or quadruple projection (*i. e.*, from two, three or four objectives respectively) on the same screen. Colored light is like music, it is played in a given cadence, *e. g.* 2/3, 3/4 or 4/4.

The color projector or Sonchromatoscope as the apparatus is termed, enables the colored light to be produced from and spread out in all directions, from right to left, or left to right, from top to bottom or inversely, emerging from and vanishing into nothingness. The equivalent of timbre in the musical part, would be the different color shades as produced either by addition or subtraction of transparent diapositives.

Inasmuch as the combined art for its reproduction obeys the same laws as music, it requires a similar system of annotation for the proper playing of a piece of music-color, and following which the operator of the sonchromatoscope, independently of musical instruments, will be able to play the color composition in the same manner as he would an ordinary piece of music.

There is an analogy between sound and light, as both are produced by frequency action. Generally it is said that they are due to waves. The waves of the air are the usual vehicle for carrying sounds through space, while the phenomena of light are referred to ether waves, which move through space at enormously higher velocity than that attained by waves in air. It is, therefore, quite natural to try to carry out the analogy, and it has often been done, by assigning a sort of octave relation to light of different colors. If one light is due to the double frequency of another light it is one octave above it. It is not stated how far this idea, however, is carried out in the instrument we illustrate. The color combinations which it gives are said to be quite fascinating and it is easy to see that music can be written for them. Owing to the structure of the eye, the range of light waves on the octave basis is very small as the range of visual rays is small.

A Local Electro-Plater

By Earnest Coler

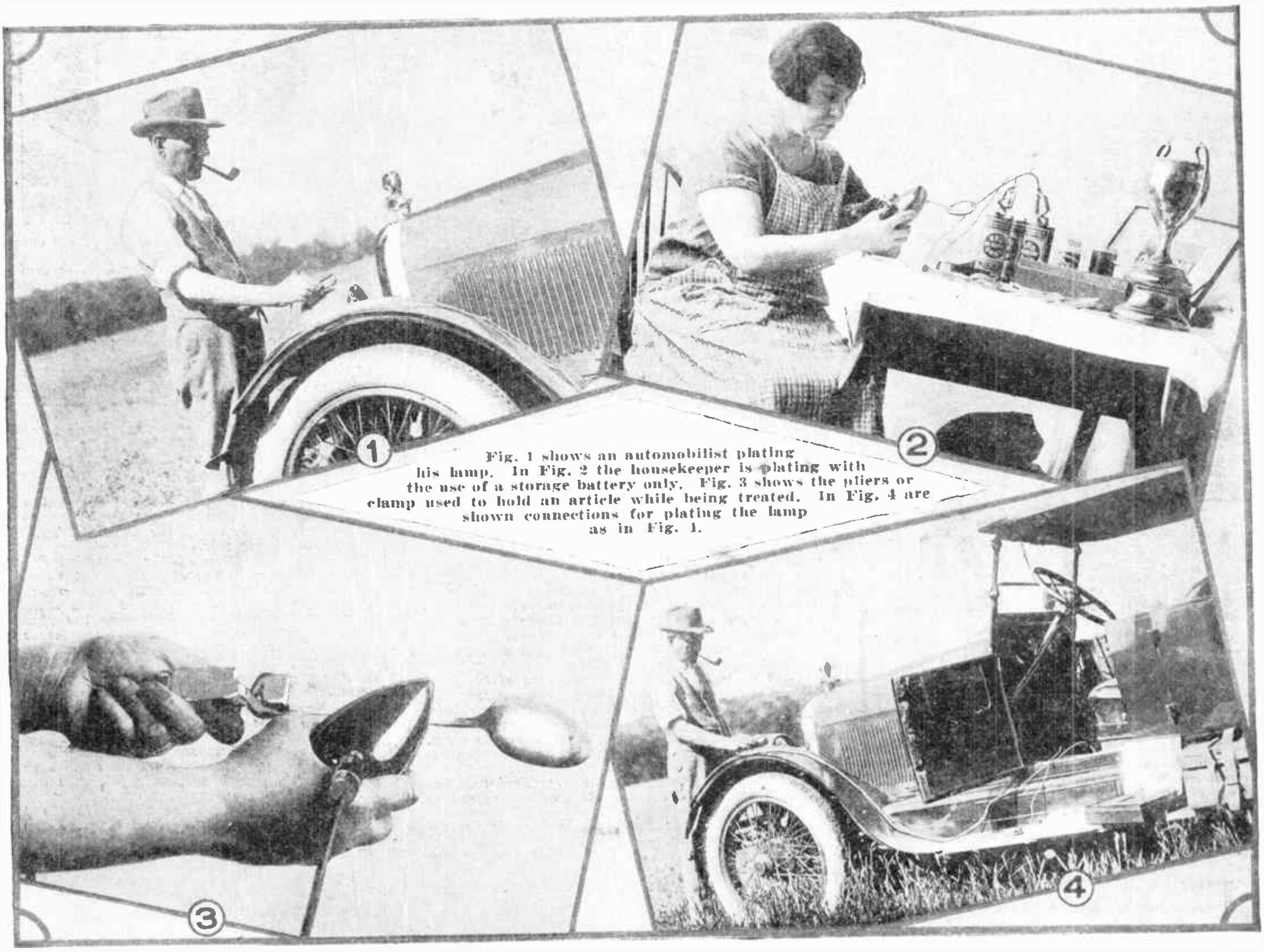


Fig. 1 shows an automobilist plating his lamp. In Fig. 2 the housekeeper is plating with the use of a storage battery only. Fig. 3 shows the pliers or clamp used to hold an article while being treated. In Fig. 4 are shown connections for plating the lamp as in Fig. 1.

A PORTABLE, low-voltage electro-plater has been invented which, in spite of the fact that it employs the same working principle as the commercial bath process, does not require the use of tanks and is so compact and simple that any one may plate table ware, household and lighting fixtures and other metal objects with nickel, copper, silver or gold.

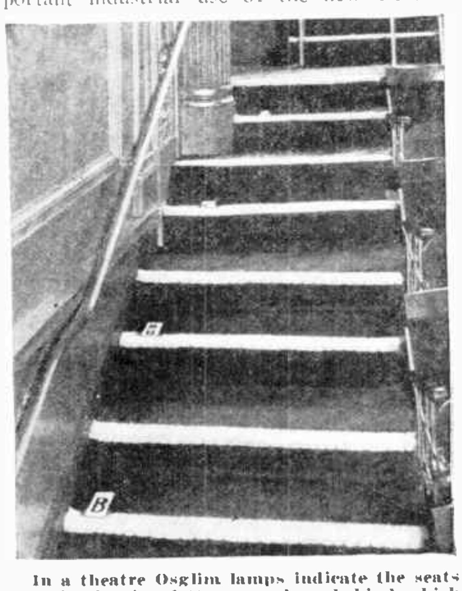
The necessary electric current may be taken from a pair of ordinary dry cells or from the automobile or radio battery. In plating automobile parts, such as head-lamps, radiators or dashboard instruments, it is not necessary to take them from the car. The only precaution necessary in this case is to make certain that the negative side of the battery is "grounded" to the car, and not the positive side, as is the common practice.

The plating outfit proper consists of a so-called plating pad and two insulated cables provided with clips. When secured to the battery the negative terminal is connected to the previously cleaned article that is to be plated. The positive wire is led to the plating pad, which within a fabric container holds a dry compound made up of acids and the finely powdered pure metal that is to be deposited.

After being soaked in water for five minutes, the pad is slowly passed over the surface, the electric circuit being completed when the moist pad touches the object. The thickness of the coating depends on the time given to the operation. A deposit heavy enough for practical purposes is obtained in about three minutes.

The manufacturers claim that the wiping action of the pad has a burnishing effect so that no oxidation can take place during the process. This, it is said, makes it possible to electro-plate iron and steel without first coating it with copper, as is now necessary with the conventional tank system.

The promoters also point out that an important industrial use of the new electro-plater is in the ease with which steel that is to be case-hardened may be plated in spots that are to remain unhardened so that they may be drilled or machined without having to be spot-annealed. The local plating prevents the combination of the surface layer beneath it with the carbon of the case-hardening compound. This ensures local soft spots exactly where required.



In a theatre Osglim lamps indicate the seats by illuminating letters on glass, behind which the lamps are placed. It will be observed that there is one letter for each second step, as there are two steps for one row of seats.

Seat Indicators for Movies

THERE is some difficulty in finding one's seat in darkened theatres, especially moving picture houses. All of us are familiar with the theatre usher and her ubiquitous flashlight with which she picks out the number of the seat.

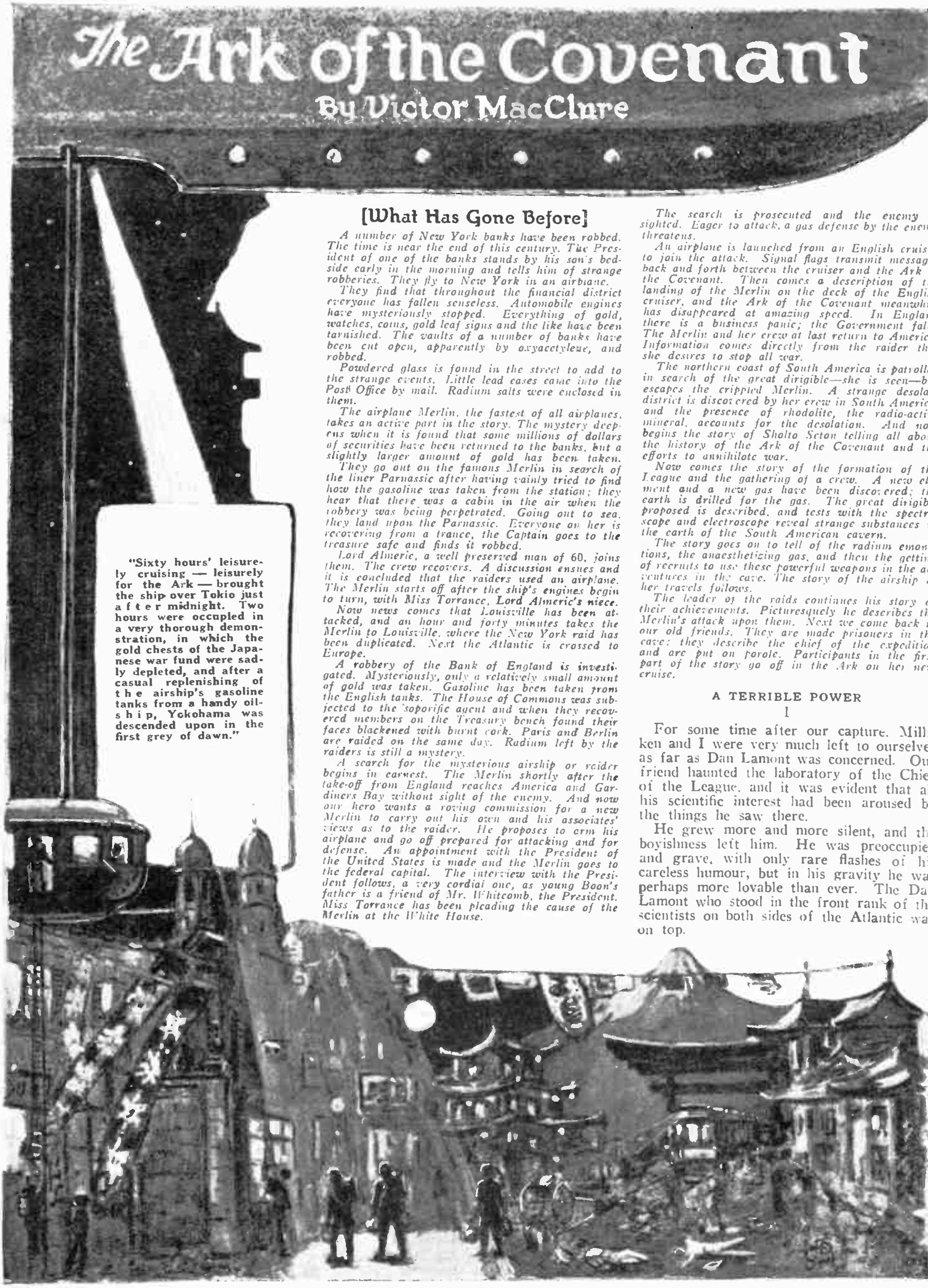
In London a system has been adopted for indicating the rows of seats, not the specific numbers, and this is shown in our illustration. We quote from our contemporary, the *London Electrician*:

The indicator consists of a lighting unit composed of an Osglim lamp, which is fitted at the back of a special rectangular shaped diffusing glass. One unit is recessed into, and is flush with, the top of the steps in line with each row of seats.

Index letters indicating the row are painted on the under side of the glass, and when the lamp is lighted the letters stand out black against a background of soft and well-diffused illumination. The whole of the steps down towards the auditorium can be clearly seen from the top of the circle, and each indicator can be seen some steps before it is reached.

The Ark of the Covenant

By Victor MacClure



"Sixty hours' leisurely cruising — leisurely for the Ark — brought the ship over Tokio just after midnight. Two hours were occupied in a very thorough demonstration, in which the gold chests of the Japanese war fund were sadly depleted, and after a casual replenishing of the airship's gasoline tanks from a handy oil-ship, Yokohama was descended upon in the first grey of dawn."

[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. Radium 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 America 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 emonations, the anaesthetizing gas, and then the getting of recruits to use these powerful weapons in the adventures in the cave. The story of the airship in her travels follows.

The leader of the raids continues his story of their achievements. Picturesquely he describes the Merlin's attack upon them. Next we come back to our old friends. They are made prisoners in the cave; they describe the chief of the expedition and are put on parole. Participants in the first part of the story go off in the Ark on her new cruise.

A TERRIBLE POWER

I

For some time after our capture, Milliken and I were very much left to ourselves as far as Dan Lamont was concerned. Our friend haunted the laboratory of the Chief of the League, and it was evident that all his scientific interest had been aroused by the things he saw there.

He grew more and more silent, and the boyishness left him. He was preoccupied and grave, with only rare flashes of his careless humour, but in his gravity he was perhaps more lovable than ever. The Dan Lamont who stood in the front rank of the scientists on both sides of the Atlantic was on top.

The Chief gradually fell to treating Dan as a big fellow scientist, there was no doubt of that. We would often see the pair of them strolling about the caves, absorbed in deep discussion, and while for the most part Dan's share seemed to be in listening, we could see that his opinion counted with the amazing leader of the League. If Milliken and I encountered our friend while he was in the company of the Chief, the greeting we got was an absent-minded smile and nod, nothing more.

My mechanic and I were content enough with the arrangement, for Milliken shared the lively respect I had for Dan's ability, and we argued that Dan was after stuff that neither of us could begin to grasp. So we waited with patience until Dan was ready to speak to us of his discoveries, or of the revelations made to him by the little leader.

That we should have something to hear was plain from what we had seen in the airships themselves. Seton in showing us over the vessels kept nothing back. We only saw, however, the instruments and apparatus used for controlling the mysterious powers of the League. Seton did not pretend to any deep knowledge of the means by which these instruments were worked.

The Wonderful Airship—More Than a Match for the Merlin

The airship was a constant marvel to Milliken and myself, and it was clearly shown what little chance our *Merlin* would have had against her in our encounter if her full powers had been exerted. Apart from any weapon of offence, her mere power of climbing—by reason of that extremely light gas used to buoy her and the marvellously adjusted apparatus for suddenly expanding it in her ballonets—would have taken her far out of our reach at any moment. This, in combination with the engine-stopping ray, would have made our best manoeuvres on the *Merlin* quite ineffective.

Even if we had succeeded with our contemplated quick dive in smashing the stern engines and controls, the airship would still have had ample power and manoeuverability to rise to a great height and proceed home. Even a swarm of *Merlins* would not have been able to master the ship. Seton hinted at other weapons to be used as a last resort, weapons that in a few seconds could have disposed of the biggest air fleet imaginable, leaving no trace of man or metal. Yet, understanding all this, Milliken and I were even then hardly prepared for the revelations Dan made to us one night when we had been in the cavern some weeks.

We had seen nothing of Dan all day, and when he appeared Milliken and I were about to go to bed. Our little companion was white and almost shaking, as if he had just seen a vision, and he looked old.

"What's the matter, Dan?" I cried, and ran to help him.

He sat down on his bed, and looked at me wanly.

The World is Beaten by the Discoveries of the Master

"Jimmy," he said, "the world is beaten! It will have to surrender to the League of the Covenant! That little man—my God! —how big he is!"

"There's no doubting that, Danny," I said quietly, "his bigness, I mean."

"It takes a man trained in science to understand fully how great that little fellow is," said Dan, "though even then it is difficult to believe what he says is true. But I have seen proofs, Jimmy—proofs that must convince the veriest sceptic amongst us, among men of science. You know I'm reckoned to be no smouch at my job—I can say that for myself?" he pleaded.

"Sure, Danny," I replied soothingly, he was so painfully modest in making the claim. "All the world knows you're a wizard."

"I'm glad if I count for something," he said—"glad because they may take my word for it that we're beaten. They'll *have* to take my word for it—they'll just *have to!* We can't let the League exert its greatest power. If the peoples don't believe—then it's all up with the earth as we know it. God knows what will happen!"

"Will the Chief push that power?" I asked.

Dan looked at me pityingly.

"Can you doubt that determination—the will that's behind that personality? My dear Jimmy! Don't let the fact that the Chief has been so careful of human life up to now blind you to the real issue. If humanity does not come to heel and behave, humanity will be destroyed. If anything is sure, that is. The Master is a scientist, when all's said and done, and is probably inclined to look upon man at long last as 'merely small crawling masses of impure carbohydrates.' That's all man will be if he refuses what the Master offers. Then there's the will of him! Why, I believe the man we know as the Chief has been dead for years. The torture he has endured for years no human could endure and live! There's nothing there but the Will—and, by God!—what a force it is! Only the will keeps him alive with that mighty big hole in his side—and he won't die until his task is finished. Finished it will be, too, even if it means the destruction of the earth. It might mean the destruction of the solar system—of the universe!"

He broke off in a whisper. For a minute or two he remained silent, while Milliken and I sat gazing at him, in awe of his unwonted vehemence. Then he looked up with a hint of his usual grin.

"Think I'm mad, I suppose, old Jimmy?" he smiled. "I don't blame you if you do—but I'm sane—as sane as any physicist could be after to-night's experience. What do you know about the atomic theory, Jimmy?" he broke off.

"Oh, just layman's knowledge," I answered—"the nucleus and the odd electrons, and the periodic law kind of thing——"

Dan nodded, and turned to Milliken.

"And you, Milliken?"

"About the same, sir," said Milliken. "Enough, anyway," he added surprisingly, "to realize that this light gas the League has is likely to upset the present table of atomic weights."

More About Aithon, the Lightest of All Gases

"Good for you, Milliken," Dan laughed through his gravity—for indeed one never knew what Milliken had stored in that head of his. "But it still has to be shown that the table has been so greatly upset. So far, the Chief has not been able to determine absolutely the constitution of the aithon unit, except that it has no valence—that its system is a satisfied one——"

"Is that the same as inert, sir?" asked Milliken.

(*Continued on page* 110)

"Jamaica, though we could see nothing of it or of the sea, lay on our port bow ahead. Quickly the light grew, and the clouds under us, now paling to delicate green, began to break up into patches and to disperse."

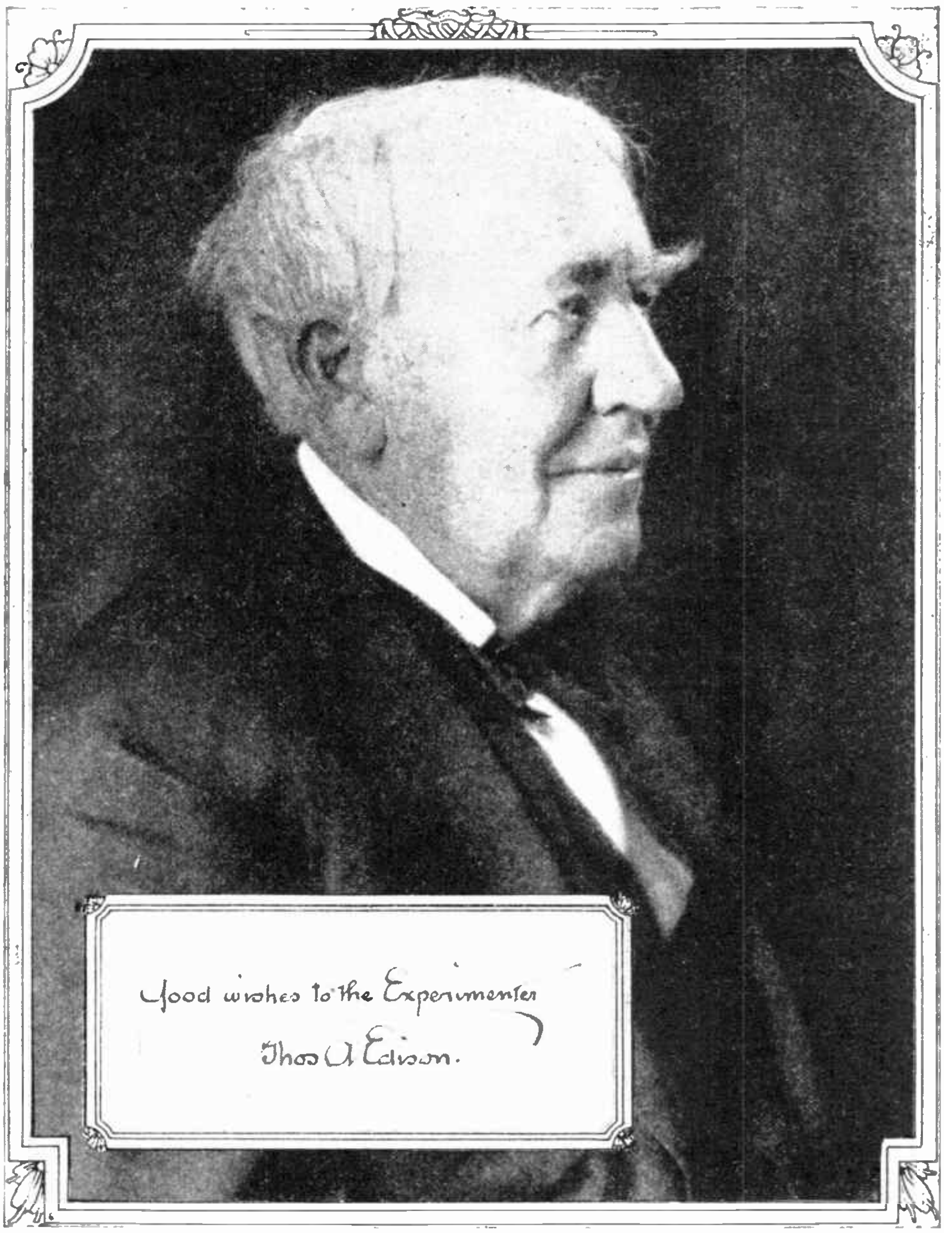
"Then in a flash of time we saw through a break in the veil of cloud an arc of bright scintillating spots against the dark blue of the sea. The spots were planes, no doubt, thrown out to intercept the passage of airships should they approach that way!"

EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

The Evolution of the Vacuum Tube

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



The world's greatest inventor—Thomas Alva Edison—at 78.

WE DO not make too broad a statement when we say that "*the three-element vacuum tube is the most wonderful electrical device ever created.*" For, is it not true that our trans-continental telephone, our radio broadcast stations, public address systems, transmission of photographs by radio, and other very important necessities of modern life depend upon the vacuum tube and the controlling actions of its elements on electric currents, which are sometimes of inconceivably slight intensity?

And to think that at the base of all these wonderful inventions lies the so-called "Edison Effect," a discovery made years ago and at so early a date that it was little thought of for several decades afterward!

The actual circumstances in connection with Mr. Edison's discovery of the wonderful phenomenon and its adoption by Fleming in his two-element valve and later by DeForest in the three-element tube are described in the following paragraphs:

The discovery of the "Edison Effect" came as a by-product of Mr. Edison's work in investigating the peculiarities and behavior of the incandescent lamp. His work led him into study of the physical and chemical actions which take place in highly evacuated glass bulbs containing an incandescent filament, and the discovery of the effect was incidental to his scientific insight and intellectual audacity in pursuing to completeness a heretofore entirely unknown problem.

By "effects," physicists have long designated phenomena or groups of phenomena which are new in themselves and which fail to arrange themselves into any given theoretical classification or to admit of an explanation under existing theories. Thus we have in physics a large number of effects, to which have been given the names of their discoverers, all of whom have been distinguished in the field of pure science, such as, for instance, the Peltier effect, having to do with the absorption and evolution of heat at the junction of two metals carrying current; the Thomson effect having to do with thermo-electrical currents in a given metal; the Hall effect, having to do with the deviation of currents in a thin film under the influence of a powerful magnetic field; the Purkinje effect, having to do with the variation of sensibility of the eye for the red and blue ends of the spectrum with high and low illumination; the Zeeman effect, having to do with the displacement of spectral lines when a radiating gas is submitted to a powerful magnetic field, etc. Of all these effects, none has been so prolific in practical consequences as the Edison effect.

In patent No. 307,031, filed by Thomas A. Edison on November 15, 1883, will be found the following statement:

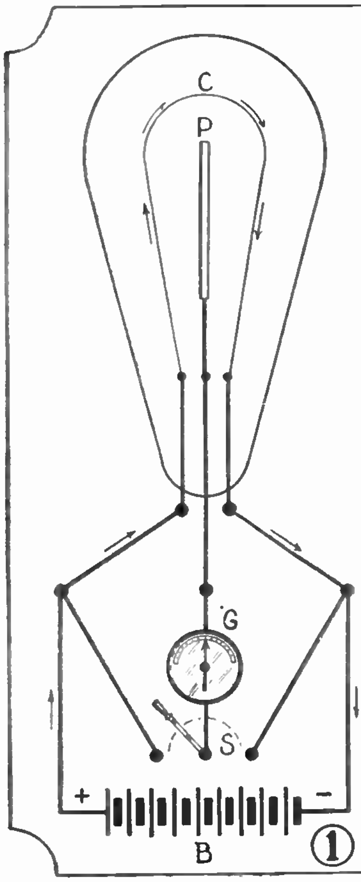
"I have discovered that, if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candlepower of the lamp."

In his endeavor to give the world a cheap and efficient electric lamp, Edison conducted numerous experiments and spent much money. He sent men to all corners of the globe to gather materials for the filaments of his lamps.

Carbon was used quite extensively and his close observations showed that the glass globe became discolored or blackened by an opaque deposit.

Very naturally, Edison tried to find out the reason for it. Further investigation disclosed that frequently there was on the bulb in the plane of the filament, a line which was not blackened and which looked like a negative of the shadow of one leg of the filament. It was also noticed that the leg of the filament which cast the shadow was the one connected to the positive side of the circuit. It seemed as though the negative leg of the filament shot off minute carbon particles which went past the positive leg and deposited themselves everywhere on the glass bulb except behind the positive leg.

Spurred on, Edison conducted some experiments to determine the electrical condition of wires and plates set up between the two legs of the filament and with such an ar-



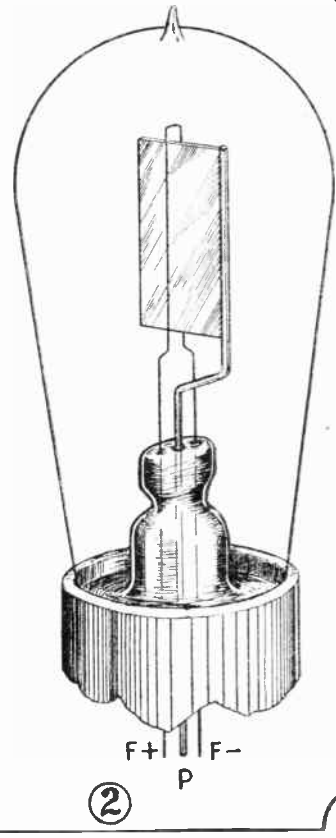


Fig. 1. Illustrating the "Edison Effect." When the galvanometer switch is thrown to the positive side of the battery, there is a constant deflection of the needle. No reading occurs when the switch is on the negative side.

Fig. 2. The Edison bulb of 1883 used by the great inventor in his early experiments. Note that the plate is supported between the legs of the filament.

rangement as in Fig. 1, found that a current passed through the vacuum or rarefied atmosphere of the lamp when the filament was incandescent. A galvanometer in the circuit showed that when its terminal was connected to the negative leg of the filament, no current passed. Here was something distinctly new and interesting and which was later destined to revolutionize the world as far as long distance intercommunication is concerned.

This phenomenon, although somewhat irrelevant to the pursuance of the plan to perfect an efficient electric lamp, was not thoroughly investigated as the following words by Mr. Edison will show:

"As to the 'Edison Effect' let me say that I was investigating to find the reason why such black shadows were cast by the filament. This led to the experiment.

"My theory was that the residual gas coming in contact with the filament, and part of the filament itself, became charged and were attracted by the glass and discharged themselves. As the polarity was unchanged, I thought this should give a constant current. The extra pole was put inside afterward to increase the current, as my first experiment was with only a piece of tin foil pasted on the outside of the bulb. This gave a good deflection on the galvanometer. In fact the needle went off the scale.

"On putting wires and plates on the inside of the bulb the effect was greatly increased, so much so that at the Philadelphia Exposition I put a telegraph sounder in circuit and it worked well.

"As I was overworked at the time in connection with the introduction of the electric light system, I did not have the time to continue the experiment."

And the writer feels quite safe in saying that had Edison pursued his experiments and investigations further, the art of radio might have been advanced by fifteen years. For we all know with what persevering thoroughness Edison tackles a problem. Are not the brilliant inventions of the phonograph, the electric light, the multiplex telegraph, the telephone microphone, the moving pictures and hundreds of other humanity-benefitting inventions, the result of the untiring and never resting brainwork of the world's greatest genius—Thomas Alva Edison? We are all indebted to Edison and his work will go down to posterity—a lifetime of work which proves that he has given more to the world than any other man, living or dead.

But to get back to our subject again. After the announcement by Edison of the new phenomenon, several contemporaries took up the study. Among them Professor J. A. Fleming who introduced metallic shields around the filament at various places and thought he had shown conclusively that the effect was due to projected particles negatively charged, quite in accordance with Edison's earlier belief. It was not until the modern theories of the conduction of electricity by gases, that the nature of these particles, now known as electrons, and which carry the current or rather constitute the current, was understood. Richardson's formulas governing the laws of emission and Langmuir's supplementary work showing the influence of the "space-charge effect," have now been generally accepted as the final development of the theory. It goes as follows:

In the interior of a metallic conductor, free electrons are supposed to exist, the motion of which constitutes the conduction of an electric current. A force exists, which in some substances is stronger than in others and which keeps these electrons within the body of the conductor. If the temperature of the conductor is raised, such as may occur when an electric current is passed through it, the activity of the electrons is increased and some of them break through the surface and escape from the conductor as free, minute charges of negative electricity.

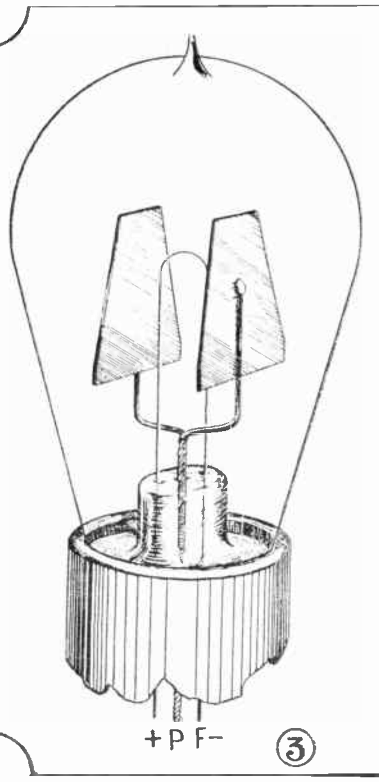
If no means are employed to carry away the free electrons from the vicinity of the surface of the heated conductor, the so-called "space-charge," or repulsive charge in the vicinity of the conductor retards the emergence of further electrons. Again, some of the electrons in remaining close to the conductor, are drawn back to it. When such a state is reached, where the number given off equals the number returning, a condition of saturation is obtained.

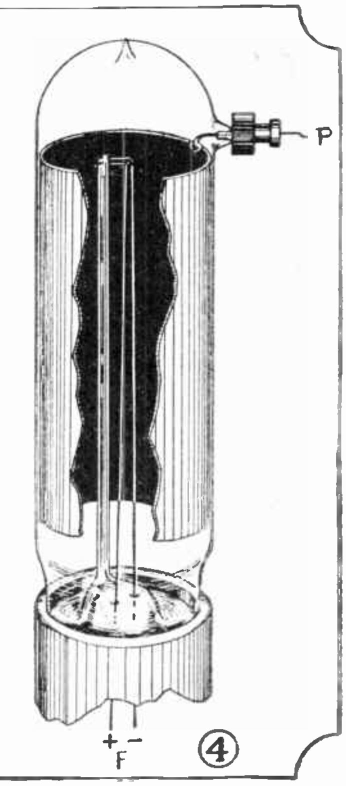
In order to increase the number of electrons emerging from the conductor, it is only necessary to remember that unlike charges of electricity attract each other. Thus in the "Edison Effect," the negative electrons are attracted to the positive leg of the filament or other plate which is connected to the positive leg. The resulting current of electrons which flow is called a thermionic current, which passes from the negative leg to the positive leg of the filament. The introduction of the plate between the legs of the filament, as shown in the Edison patent, enables this current to be detected. In strik-

(*Continued on next page*)

Fig. 3. Showing an early type of Fleming valve of 1905. Fleming placed single and double plates around the filament and experienced only a fair degree of success in using the valves as wireless detectors.

Fig. 4. The commercial Fleming valve of 1913, showing the cylindrical plate. This design was the forerunner of the tubes used at the present day, DeForest inserting the third electrode around the filament, between the latter and the plate.

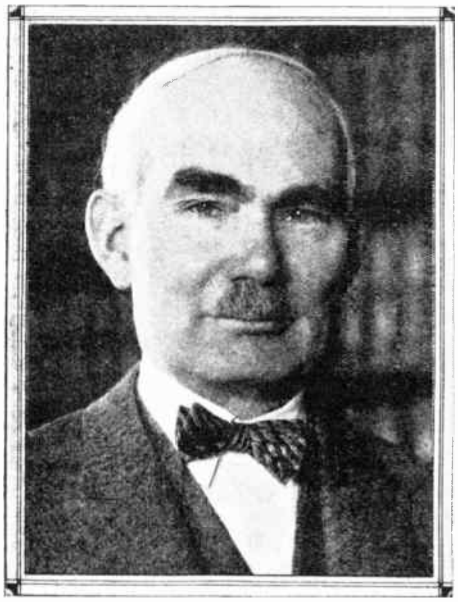




The Evolution of the Vacuum Tube

(Continued from preceding page)

ing the plate, the electrons give up their charge to it. This charge is conducted by a wire to a galvanometer which is connected to the positive leg of the filament and a current can be detected flowing from the positive leg to the negatively charged plate. It is evident that no current would result if a connection were made to the negative leg.



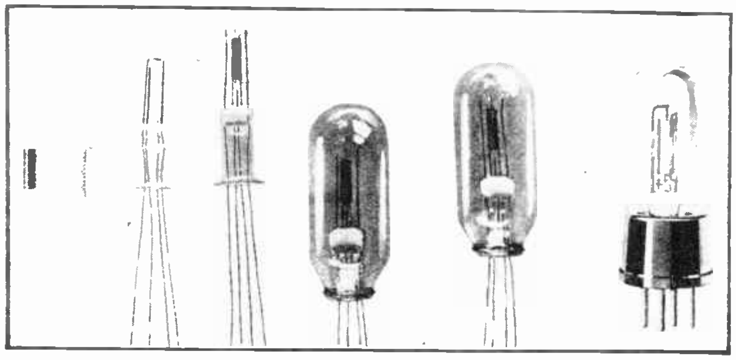
Dr. Lee DeForest, the inventor of the three-element vacuum tube. DeForest is still in his prime, being 52. His latest invention is the Phonofilm—the talking movie film.

Right here we have the susbtance of a rectifying valve which will conduct currents in one direction only. And again stressing the point that Edison was too busy with the development of the electric lamp, and that the world was not ready to utilize his discovery, his invention was not applied practically until Fleming took advantage of the "Edison Effect" and of its rectifying property when wireless telegraphy was in process of growth, and applied it to the reception of signals in wireless telegraphy. In Fleming's own words in "The Principles of Electric Wave Telegraphy," he states that: "A third method of utilizing the properties of rarefied gases for the purposes of a cymoscope was discovered by the author in 1904 based upon a fact discovered by him in 1890* in the course of some investigations upon incandescent electrical lamps."

This statement would lead one to believe that Fleming was responsible for the discovery of the fact that electronic emission takes place when a filament is heated and that the electronic stream is conductive in one direction only. Instead the full credit belongs to Edison, since what Fleming did was merely to apply the known principle to the rectification of wireless waves. The fact that no mention of the "Edison Effect" has been made in Fleming's book has been erroneously construed by some to indicate that Fleming first came upon the principle, but it is hoped that the situation has been clarified for our readers.

In a paper read before the American Institute of Electrical Engineers at Philadelphia in October, 1884, entitled "Notes on Phenomena in Incandescent Lamps," Professor Edwin J. Houston brought forth some very interesting facts concerned with the "Edison Effect." It was asked for the first time and it has remained unsatisfactorily answered: " * * * whether the current is flowing from the positive or from the negative?" However, the majority of scientists have accepted the statement that an electric current is a flow of electrons, and therefore, since it is accepted as true that the emission is from filament to plate, the current flows from filament to plate, disregarding the fact that convention calls for the flow of current from a positively charged body (one at a higher potential) to a negatively charged body (one at a lower potential).

It was not until 1904 that Fleming used the "Edison Effect" in what was termed the "Fleming Valve," but as a wireless detector, the lamp was not particularly effective.



Showing the various steps in making a three-element vacuum tube. Note the plate; grid; filament assembly; positioning of all elements; ready for exhausting; sealed tube and final product ready for use.

It remained for DeForest in 1906 to make the great step in advance by introducing between the filament and plate, a third element, the grid which could regulate the passage of the electrons—a most remarkable step forward.

In this connection it is apparent that Fleming does not recognize DeForest's marvellous invention as original, for in his book he writes:

"As a radiotelegraphic oscillation detector precisely similar or else closely resembling the author's oscillation valve has been denominated by Mr. Lee DeForest an *audion*, and claimed by him as a novel invention of his own, it may be well in the interests of scientific history to recapitulate the facts on which the author relies in support of his own priority of invention. As far back as 1889, the author had independently noted (see *Proc. Roy. Soc. Lond.*, vol. 47, p. 118, 1890) the unilateral conductivity of rarefied gases when one of the electrodes (the cathode) was rendered incandescent. * * * In November, 1904, the author discovered that a glow lamp with a metal plate sealed into the bulb carried on a third insulated terminal sealed through the glass, might be used to rectify electric oscillations. * * * It is therefore abundantly clear that before October, 1906, a glow lamp having a metal plate sealed into the bulb was described, used and patented by the author as a radiotelegraphic receiver. Yet at this date, Mr. Lee DeForest described identically the same device as an invention of his own under the name of an *audion* in a paper read before the American Institute of Electrical Engineers. Since that date, he has employed a modification of it in which a metal plate and a grid are enclosed in the bulb in place of a single plate." (All the difference in the world!) Continuing:

"Although the scheme of circuits is somewhat different from that used by the author yet the operation of the glow lamp with metal plates inserted in its bulb is essentially that of a rectifier of trains of oscillations depending on the fact of the unilateral conductivity of rarefied gases when one electrode of the gaseous conductor part of the circuit is incandescent and the other cold. The audion is not therefore essentially a different invention from the author's oscillation valve, no matter how used."

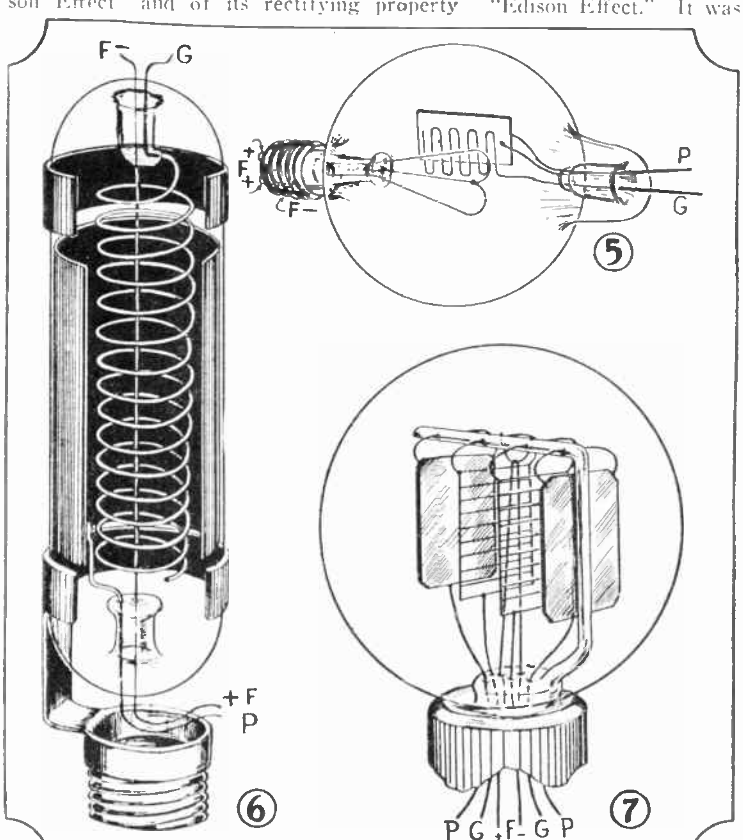


Fig. 5. DeForest audion of 1908. Note the single grid, plate and double filament. It marked a tremendous stride forward.

Fig. 6. The famous "audiotron" of 1917, heralded by many as the most sensitive detector tube ever produced.

Fig. 7. An early type of double grid and double plate telephone repeater tube of 1914. These tubes are now the best type of tube made.

*It should be borne in mind that the "Edison Effect" was discovered by Edison seven years before this date, and was made the subject of a paper read October, 1884, by Professor Edwin J. Houston, at a meeting of the American Institute of Electrical Engineers.—T. A. E.

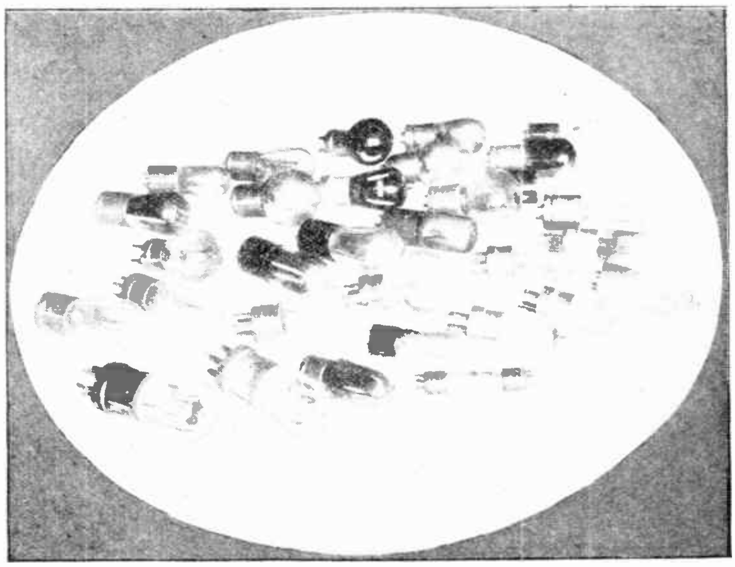
In the face of these written statements, it would appear as though Fleming were responsible not only for the discovery of the unilateral conductivity property of the Fleming valve, but also for the audion as conceived by DeForest!

The audion or three-element tube, in its property of operating as a detector or rectifier of signals, as an amplifier and as a generator of alternating currents of any frequency is a most wonderful and versatile piece of apparatus. It is these three valuable and characteristic properties which make it so indispensable to our everyday needs.

Since its inception by DeForest, it has undergone some very remarkable development, much of the work being done in the Bell Telephone Laboratories at the instance of the American Telephone & Telegraph Company. From the small and unpretentious "peanut tube" to the 100 kilowatt water-cooled power tube is a long stride which has been made in a relatively short space of time.

We owe much of our progress in the so-called process of evolution, to the fulfillment of dreams made possible by the three-element vacuum tube. We must remember Edison as the pioneer who discovered the basic principle, and DeForest as the brilliant engineer who added to this basic principle with such remarkable success—a success crowned with the achievement of bringing together the peoples from all corners of the earth, and conveying to them the thoughts and activities of the world's leading minds. We must also remember that the whole art of radio rests upon another Edison foundation stone, namely, the carbon microphone, which was wholly and entirely his invention.

What the future will bring is a matter for conjecture, but it is certain if one can judge from the advance made in the past score of years, that there are no known bounds—that that which was seemingly impossible has been found completely possible and that those sceptics who shook their heads in disbelief and exclaimed, "It can't be done," will have been banished from this earth.



An array of tubes of all descriptions made by various manufacturers in different parts of the world. No matter what shape, size or form is reverted to, the basic principle remains the same.

Doubling the Volume of Your Set

By Harry M. Wright

ALL radio amateurs are desirous of increasing the volume and clarity of reception. In general, there are three ways of doing this, either improving the set by the addition of more tubes, or by constructing a better circuit, or by employing a more efficient and accurate loud speaker. The first two methods are expensive and to the average young enthusiast who finds radio a drain upon his pocketbook, it is a means he tries to avoid as far as possible. With this in mind, let us turn our attention to the phone unit.

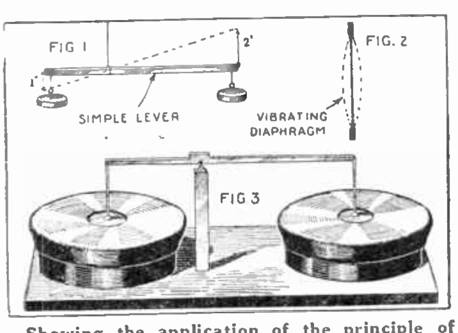
A really good loud speaker is costly, but the results are worth the initial outlay. One of the most successful ideas for increasing the volume was to make use of extra electrical power to excite a magnetic field and thereby augment the signals. This scheme received practical application in several types of speakers, but it has the bad feature of consuming too much of the "A" battery current. Other units merely utilize better electro-magnets or have as their outstanding features an improved winding, a better core, or a more sensitive diaphragm.

While performing some experiments with levers, I hit upon another means of bettering the speaker. Before describing the result of my effort, it would be best to explain a few principles of physics upon which the device depends.

Volume, in the field of acoustics, depends upon the amplitude of vibration. This varies with the distance between the points of maximum refraction and those of maximum condensation of a sound wave, or as shown in the figure of a vibrating diaphragm, the distance between A and B. In simple language, this means that the greater the diaphragm vibrates, the greater will be the intensity of the sound. To realize this, a simple fundamental law of mechanics was put into play. The waves of the ocean have their amplitude defined by their height.

Were we to push down an inch on one side of an evenly balanced lever, the other side would rise an equal distance. But if we move the fulcrum away from the center, we realize a mechanical change. Now were we to press down at A, B would go up considerably more (Fig. 1). This is practically known to everybody, but has been little used in radio. It was reasoned that if the diaphragm of a unit could be attached to one end of such a lever, a greater amplitude of vibration would be received on the diaphragm of the other (Fig. 3).

It was quite a job to properly devise a satisfactory apparatus that would accurately transmit the sound vibration. The difficulty lay in the requirement of a very rigid and minutely adjusted fulcrum, which was necessary to avoid distortion and loss. I overcame the drawback when I thought of the phonograph and its splendid sound arm. An examination of the machine will show that it has approximately a mechanical "stepping up" of 1½ to 1 when the needle is inserted. I had an ideal apparatus before me and I set out to use it.



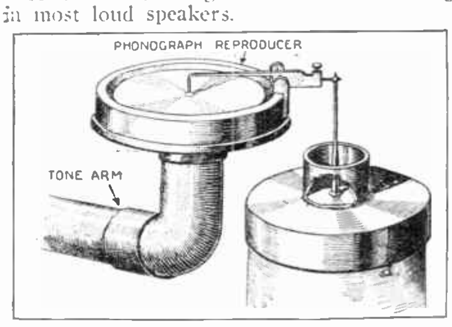
Showing the application of the principle of levers to the loud speaking arrangement suggested by the writer. This is an excellent idea which we recommend to our readers.

Actual Construction

Remove the top of your loud speaker unit so that you can have free access to the diaphragm. Procure an old sewing machine needle, for it is made of the finest steel and just right for our purpose. With the aid of a hot iron and some solder, connect the points of a phonograph needle and the sewing machine needle so that they are at right angles to each other. Then, as is seen in the illustration, solder the free thick end of the sewing machine needle to the centre of the loud speaker diaphragm. See to it that it stands perfectly vertical. The cover can now be replaced on the loud speaker and everything is complete except a small stand to rest the unit upon. Insert the needle in its proper place in the phonograph and, while still holding the unit, measure the distance from the bottom of the case of the speaker to the record disc. With this measurement you can build a correct sized rest for the device. I made mine from a round loop of stiff brass wire, to which were soldered three wire legs of the proper length. A few pieces of felt or rubber tubing, such as spaghetti, stuck on the ends of the feet act as cushions to avoid any scratching or moving of the stand. When finished, the unit is attached to the sound arm by means of the needle that is tightened by the talking machine screw, and the support is properly adjusted.

Advantages of the Device

Besides materially increasing the volume of the signals, their clarity is greatly improved. The phonograph is the result of many years of work, and at one stroke we take advantage of the experience of many experts. We actually utilize the sound arm itself and not only the horn as other phonograph attachments do. By employing the sound arm, we use the machine's resonance chamber, a big factor that is missing in most loud speakers.



The completed reproducer showing needle soldered to center of phone unit diaphragm and also to phonograph needle. Using the tone arm in this way results in excellent quality of reproduction.

Visualizing Radio Circuits

By Sander Stern, E.E

IT is surprising how few people understand the true workings of radio. Thus our radio experts advocate low-loss apparatus and when the public asks, "Why?" they are shown diagrams of flat topped tuning curves, proving that resistance in radio circuits causes broad tuning and a decrease in signal strength. This explanation is accepted by the average person, but reasoning individuals logically contend that though resistance undoubtedly will decrease the signal strength, why should it also cause broad tuning? The honest radio expert must admit the truth of this logic and at best, resorts to a mathematical demonstration involving calculus to explain the above experimental results.

Many who are interested in radio, such as radio amateurs and radio constructors, are therefore, handicapped in their efforts to get a clear conception of the science. Developments are being made by radio specialists at such a pace as to outstrip the leisurely minds of the public. For this reason, the author has developed the following mechanical analogies which give a simple descriptive and qualitative analysis of radio, to satisfy the needs of radio constructors who are in most need of this knowledge, especially when they attempt designing.

To begin with, the first clear conception of radio was originated by Clerk Maxwell in 1873, from experiments on electricity and magnetism made by Faraday some time previous. This was accomplished by Maxwell through the use of a form of mathematics known as vector analysis, which treats of forces by their representation as lines, virtually circular functions, whose lengths depend upon the magnitude of these forces. Maxwell was thus able to formulate the effects of electricity into the laws that govern it.

It therefore becomes apparent that since electricity was formulated according to our experiences of forces involved in mechanics, electricity must necessarily be analogous to mechanics. Unfortunately, this viewpoint is soon lost sight of by the many to whom electricity appears in the form of amperes, volts, inductance and other factors; magnitudes, which, even after they are defined, remain difficult to understand simply because we do not recognize at first glance the familiar mechanical form which they represent. Although previous attempts have been made to explain electricity by hydraulic analogies which are sufficiently simple to explain direct current phenomena clearly, these become complicated and difficult to handle when applied to radio circuits. The author has thus reverted back to the simple lines with which radio was first conceived by its first law maker, Clerk Maxwell.

Consider first an ordinary battery circuit, indicated in Fig. 1a. When this circuit is represented by the new method, it changes slightly to the form shown in Fig. 1b and the mechanical equivalents for the different electrical magnitudes and parts are as follows:

The electrical circuit of Fig. 1a is represented in Fig. 1b by the circuit of the string passing over the pulleys.

The conventional representation for the direction of current flow as made in Fig. 1a is similarly represented in Fig. 1b.

The battery of Fig. 1a may be in Fig. 1b either one of the pulleys, which may be considered as the driver.

An ampere has for its equivalent the velocity of the string, so that a quantity of electricity or coulombs has for its equivalent a length of string.

The voltage has for its equivalent the force with which the string is moving.

The resistance or ohmage of our mechanical model is determined by the friction offered by the pulleys against the motion of the string.

When the circuit of Fig. 1a is broken, no current will flow. The same thing happens when the circuit of the string in Fig. 1b is broken, its velocity of motion is halted.

Thus far, there has been given an exact and equally simple representation of a direct current circuit of the series type. A circuit of the parallel type as conveniently shown in Fig. 2a gives the diagram shown in Fig. 2b. In the latter, the driver pulley (A) is taken as the battery and (B) and (C) as the parallel branch arms. It is not difficult to see that the equivalent mechanical representation will exhibit the same properties as experienced in the similar electrical circuit.

Proceeding now to circuits including inductances and capacity, it would be just as well that we consider alternating circuits in which they are commonly found.

Thus in Fig. 3a we have the conventional representation of an A.C. circuit having an inductance (L), a capacity (C) and an alternator or oscillator (A), all connected in series. Its equivalent representation is shown in Fig. 3b, where the following analogies are made:

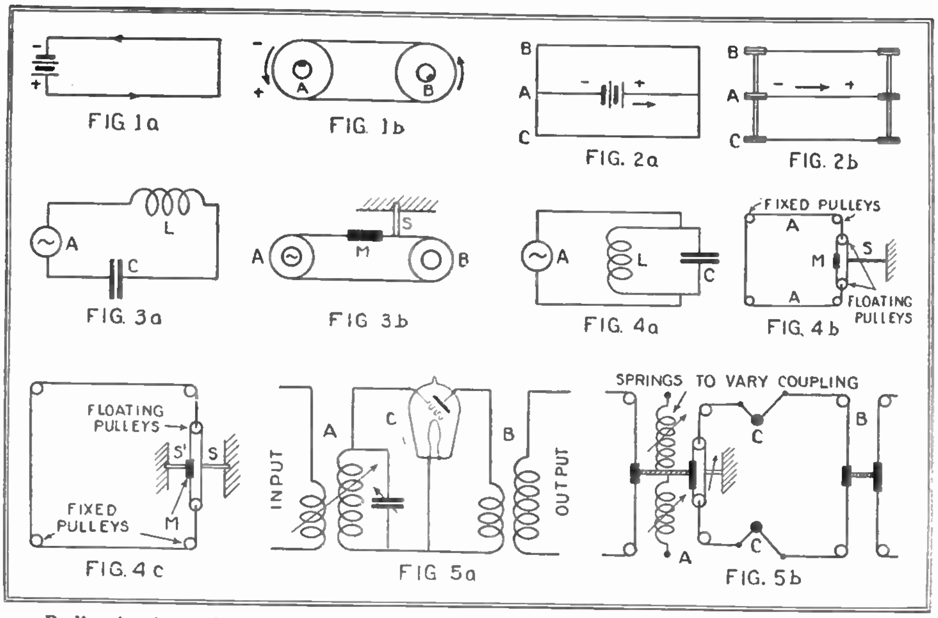
The inductance (L) has for its equivalent the mass (M).

The capacity (C) has for its equivalent the cantilever spring (S), held firmly in place at one end and secured firmly to the string line circuit at the other end. The value of the capacity in this spring will depend upon its length, the electrical charge upon the amount of deflection of the end secured to the line circuit, and the difference in potential by the difference in tension of springs placed on each side of the cantilever spring in the line circuit.

Considering the electrical circuit indicated by Fig. 3a, we know from experiment that at resonant frequency the maximum current will flow through the circuit and at frequencies above and below this, the current quickly diminishes. This fact is clearly shown by the mechanical analogy in which at low frequencies the stiffness of the spring opposes the slow motion of the string circuit, thereby decreasing the velocity. At the higher frequencies it is the mass due to its inertia that opposes the motion of the string circuit, and as before, the current or string velocity is decreased. When the frequency is brought in resonance to the mechanical circuit, the mass and the spring move violently back and forth showing that we get our greatest velocity at this frequency, and therefore in this respect, the mechanical model represents the electrical circuit.

In the first paragraph it was stated that there was no reason why resistance in the circuit of Fig. 3a should cause broad tuning. To verify the truth of the electrical experiment, resistance may be introduced conveniently in the mechanical model of Fig. 3b, by simply putting sand on the pulley shafts or bearings. First, the effect will be to decrease the current or string velocity. Secondly, it is found that the resistance is not affected by any variation in the frequency, so that at frequencies near the resonant frequency the resistance predominates over the possible effects of the mass and the spring. Thus there is a tendency for the current or circuit velocity to be the same at frequencies near the resonant, which effect, when plotted, gives a flat-topped tuning curve. This, besides verifying the electrical experiment, gives the experimenter a clearer insight into the nature of resistance as compared with the reactance effect of inductance and capacity.

To show a complete similarity between Figs. 3a and 3b, the tuning relations must be the same in both cases. That is, when the inductance (L) or the capacity (C) is changed in Fig. 3a, the wave-length of the circuit is also changed and there will also be a new resonant frequency. To prove this, the same changes must be made in Fig. 3b, where an equivalent wave-length will be the distance covered by one forward and one backward movement of the string circuit. Thus, if the capacity is reduced as by decreasing the length of the spring, it is known from experience that the frequency of vibration will be greater, with a corresponding shorter deflection of its vibrating end. This should reduce the amount of forward and back motion of the string circuit, thereby reducing its wave-length. Increasing the capacity will, of course, result in an in-



Radio circuits and their analogies. Fig. 1 is an ordinary series circuit; Fig. 2 is a parallel circuit; Fig. 3, a circuit comprising inductance and capacity in series; Fig. 4, an inductance and capacity in parallel; Fig. 5, a radio frequency amplifier circuit.

(Continued on next page)

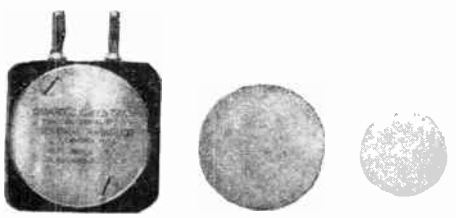
A Piezo Quartz Wavemeter

By Alfred B. O'Hara 2OG

ONE of the most interesting of the recent developments in the laboratory side of the radio art is the use of polished disks of crystalline quartz to provide a wavemeter standard. This form of primary standard is more reliable than the conventional type of precision wavemeter, as its frequency cannot be changed. The quartz plate may be carried from point to point, shipped, handled and used for years without changing its frequency. A severe shock or overvoltage will destroy the calibration, to be sure, but only because it destroys the plate.

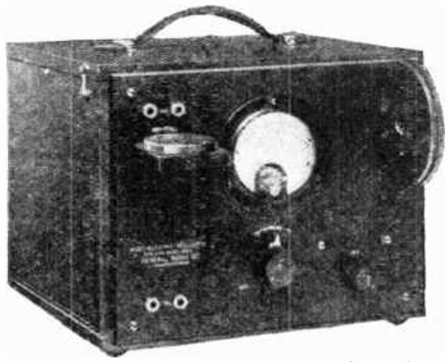
The commercial form of the quartz standard is shown in the illustration. The panel contains a meter which indicates when the circuit is oscillating, a coil for coupling to other circuits and provision for plugging in various sizes of quartz plates. The cabinet contains the tube, batteries and associated equipment, making an entirely self-contained unit.

The great reliability of this instrument is due to the fact that the frequency at which



The quartz crystals are cut to varying thicknesses and diameters, these physical dimensions being directly responsible for their fundamental frequency of vibration.

the quartz plate allows the circuit to oscillate is governed by the dimensions of the plate. The plate may be ground and polished for the proper frequency, which it will maintain as long as the plate itself lasts.



The cabinet containing the complete piezo-quartz oscillator. Such a device offers unlimited opportunities for experimenting.
Photos Courtesy of the General Radio Company.

Pure crystalline quartz must be used for the oscillator. The fused variety is worthless for this purpose. Blanks cut from quartz are checked as they are received and the frequency at which they oscillate is recorded. When an order for an oscillator is received, the nearest blank is selected. If it is near enough the desired frequency to meet the requirements it is polished and mounted. Usually, however, it is necessary to grind the blanks to obtain the desired frequency.

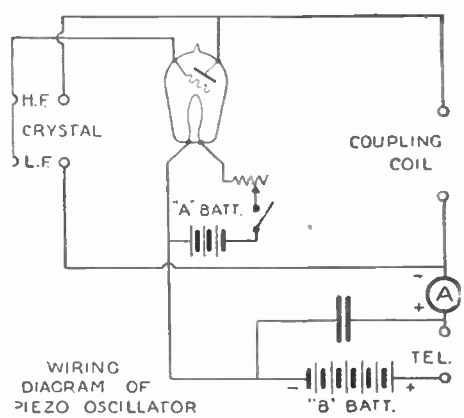
Grinding is an extremely difficult and critical operation. The plates are by turn ground and checked for frequency. As the desired frequency is approached great care must be taken lest too much material be ground off, for if this occurs, the work must be begun over again on another piece.

Once the plate has been ground, polished and mounted, it may be carried anywhere and plugged into an oscillator, always producing the same frequency.

A great many harmonic frequencies also occur in the tube output. These are of the same constancy as the fundamental, so that each crystal may be used as a standard for a number of frequencies.

A number of the large broadcasting stations are experimenting with piezo control of transmitter frequency. Developments along this line may mean a great deal to broadcast listeners. Broadcast wave-length assignments are at present so close together that to avoid interference each station must stay exactly in the center of its channel. It is not possible to do this with the present equipment of most broadcasters. Another difficulty is that the standards used in different districts differ somewhat.

The quartz plates, by providing a means of holding the station to a standard which is the same for all districts, give great promise of relieving broadcast congestion and interference.



The circuit used by the oscillator. The coupling coil can be placed in inductive relation to an amplifier system to produce a powerful carrier wave whose frequency will be governed by that of the oscillator crystal.

Visualizing Radio Circuits

(Continued from preceding page)

crease of wave-length. Changing the wave-length by varying the inductance or the mass (M) will bring about the same change. Thus, increasing the mass (M) will add weight to the end of the spring (S), which will give a greater deflection to it, in this way increasing the wave-length as desired. Decreasing the mass (M) will naturally result in a decrease of the wave-length. It will also be noticed that a decrease in the wave-length produced an increase in the frequency and a decrease in the frequency produced an increase of the wave-length, which shows the reciprocal relation between the wave-length and the frequency. Therefore, the model of Fig. 3b has completely duplicated the properties of the electrical circuit of Fig. 3a.

When the combination of an inductance and a capacity are put in parallel as shown in Fig. 4a with its mechanical equivalent in Fig. 4b, it becomes necessary to introduce two floating pulleys, in order to preserve the continuity of motion of the main line circuit (A). These two floating pulleys therefore act as connectors or terminals for the mass (M) and the spring (S). If it is desired to add a capacity in series with the inductance or mass (M), this is done as shown in Fig. 4c where S is the series capacity.

This type of circuit will have different operating characteristics from that of Fig. 3b. At low frequencies it is known that all the current will pass through the inductance (L) of Fig. 4a. This will be repeated in the mechanical model of Fig. 4b, where the stiffness of the spring will only allow for the motion of the mass (M), showing that all the current passes through the inductance. At very high frequencies, it is known that all the current will pass through the capacity (C) of Fig. 4a. This time, it is the great inertia of the mass (M) against sudden changes in motion that makes it necessary for the spring to vibrate, which in turn shows that at high frequencies, the mass (M) acts as a choke, while the capacity readily passes current through its branch of the circuit. At resonant frequency, in Fig. 4a, the line current is practically zero and the currents in (L) and (C) are a maximum and equal. The same is found to hold true for the mechanical model of Fig. 4b. Here at resonant frequency, the sudden string circuit changes are not so great as seriously to bring into play the inertia of the mass (M) but these changes are sufficiently great to overcome the stiffness of the spring. Therefore the mass and the spring move back and forth violently with equal current velocity, while the motion of the line circuit is hardly perceptible, being just sufficient to overcome the losses in the branch circuits. This shows that the mechanical model of Fig. 4b is for all electrical purposes identical with that of Fig. 4a.

Since these mechanical model analogies represent faithfully the fundamental radio circuits, they may be applied to analyze our common radio circuits. In Fig. 5a and Fig. 5b, there is shown a diagram of a one stage tuned radio frequency circuit and its mechanical analogy. To produce the amplification effect of the tubes, lever cranks are added at (CC). In the previous diagrams, no mention or method of coupling was shown, but may readily be inserted by putting stiff rods between the coupling masses. Should it be necessary to vary this coupling, this may be done by placing springs on either side of the coupling bar, which retards the coupling motion of the bar and gives the same effect as weak coupling in an electrical circuit. When both (A) and (B) are tuned to the incoming frequency of electrical current or circuit velocity, if there should exist any coupling between these two circuits, it is obvious that the amplified motion of the combination (B) will be fed back again into that of (A). This process of re-feeding will build up until the original frequency is destroyed and the whole combination will move very erratically unless there is put somewhere in the circuit, a neutralizer, or a proper resistance to limit the amount of feed-back. This stray coupling nuisance is experienced often in this type of circuit and a study of the analogy will give a solution for the trouble more readily than is possible with the actual radio circuit.

The reader by this time must have already become aware that this form of analogy opens up a great number of possibilities for the discovery by logical means of new radio circuits and new radio devices. He will get qualitative and quantitative results of his ideas, thereby giving him a greater insight into the actual workings of the radio theory.

Notes on Transmitters

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

A Few Tips to the Transmitting Amateur Which Will Aid in Getting the Best Possible Results.

NOT only should the amateur be concerned with having a set work fairly well and being able to reach out a little ways with it, but he should be constantly and usually is, on the alert to make changes and improvements that will result in better operation from all standpoints. It is surprising to see how many changes are possible in the average transmitter, which will invariably aid in clearing up some troublesome point. The writer has often been asked questions regarding various phases of transmission and the solutions have been such that they have led to the collection of data on various points; such data is presented in this article. The writer does not claim that everything contained here is original, but all of the kinks described and illustrated will be found helpful.

FIG. 1

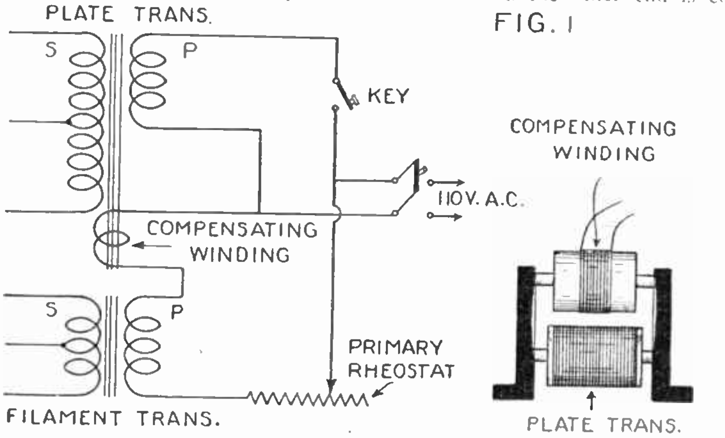


Fig. 1 at left shows the necessary connections for the installation of a compensating winding on the plate transformer of a C.W. transmitter. The illustration to the right of the circuit shows one method of placing this compensating winding directly over one of the transformer coils.

Compensating Winding

In the average transmitter, where two transformers are used, one to supply the filament voltage and one for the plate voltage, a drop in filament voltage is almost invariably noted when the key is pressed. This is because of the fact that a load is placed on the secondary of the plate transformer by the action of closing the key and, therefore, there is a correspondingly greater load placed on the primary of the plate transformer. This primary then takes some of the current that would otherwise be used by the primary of the filament transformer and causes a drop of voltage in the secondary of the latter. Sometimes, particularly with home-made or poorly designed transformers, the resulting filament voltage drop is so great as to be troublesome and cause a variation in the transmitted note. This is, of course, most undesirable, particularly on the short waves where changes of this nature are more noticeable. It has been found that this trouble can be reduced and usually eliminated by means of what is known as a compensating winding. For the data on this system, the writer is indebted to the operator of stations 2QS who is using the system and who finds perfect satisfaction in it.

The idea in essence is illustrated clearly in Fig. 1. A few turns of wire are placed on the plate transformer and constitute a second secondary. The number of turns in this winding are comparatively few and must be determined by experiment. As seen from the drawing, this auxiliary or compensating winding is connected directly in series with the primary of the filament transformer and the 110 volt A.C. line. When the load is placed on the plate transformer, this compensating winding will have a current set up in it that will add to the current in the primary circuit of the filament transformer. The additional winding is so designed that the current furnished by it will exactly overcome the filament voltage drop in the secondary of the filament transformer. With a correctly designed winding of this nature, it is possible to key the circuit without any drop whatsoever in the filament voltage.

The construction of this winding is very simple. No. 18 bell wire can be used and a suggestion for the placing of it is shown in Fig. 1. Here, a standard type of Acme plate transformer is shown and the compensating winding is placed directly over one of the secondary windings. It is located on the outside of the insulating cover. One end of it is connected to what was formerly the common connection between the primaries of the plate and filament transformers and the other end is connected to the filament transformer as shown.

Probably the best way to design this auxiliary winding is by the cut and try method. Place 5 turns of wire on the plate transformer, then connect up the circuit and press the key. Note whether or not the filament voltage drops. If it does, you do not have sufficient turns on the compensating winding. Increase them until placing of the load on the plate transformer does not cause a decrease in filament voltage. When you have reached this point, you can fasten the compensating winding in place by means of a few drops of sealing wax and then it can be forgotten entirely. Do all this work with the entire transmitter in operating condition.

"Audible" Transmission

When the change was made from spark transmitters with their accompanying noises to the quiet C.W. sets of today, many operators found difficulty in manipulating the key, because when pressed, there was no corresponding crash of the spark across the gap. A good many beginners also find trouble in operating the quiet C.W. sets because they are not sure of what they are transmitting. This can be overcome in a very simple manner by using an arrangement such as that shown in Fig. 2. The key proper is screwed to its base or to the operating table, preferably the latter, as it makes a more permanent installation. Then a spring tempered brass bracket is made of the shape shown and is screwed to the table directly in back of the key but insulated from any part of that instrument. The insulation afforded by the wooden top of the table will be amply sufficient as only a low voltage is carried in this circuit. The upper horizontal arm of the spring brass bracket is drilled and a nut to take an ordinary 8/32 thread thumb screw soldered over the holes. The end of the thumb screw is filed off perfectly smooth and square. The top of the space adjustment thumb screw on the key is also filed perfectly clean.

The auxiliary contact screw is turned down until it is the correct distance from the thumb screw on the key as shown in Fig. 2. This spacing must be determined by the distance which separates the contacts on the key. The bracket is made of spring brass of rather light construction so that the spacing there can be made slightly less than that between the contacts. Then when the key is manipulated, the auxiliary contact will be touched by the adjusting thumb screw on the key and a circuit will be made through the buzzer and battery. If rigid material is used for the bracket, it will be found almost impossible to adjust the two sets of contacts so that they will work together correctly. Therefore, use thin yet strong and springy material.

Now it is obvious that when the key is depressed and the current is sent through the C.W. transmitter, the current from the local battery will also pass through the buzzer and cause it to operate. In this way, faithful reproduction of the C.W. signals that are being sent out will be made audible to the operator. If the power switch is left open, this arrangement can be used for practicing transmitting, as the buzzer is always connected in the circuit and to operate it it is only necessary to press the key. Therefore, we find that an arrangement of the type shown in Fig. 2 has a twofold use. It takes the place of a separate buzzer practice outfit and also aids in steady transmission by allowing the operator to hear his own signals with the same spacing that will be audible to the receiving operator. It is preferable to use a constant tone high pitched buzzer in this circuit as it gives a more pleasing note and will be less disturbing.

Filters

This subject seems to be a great bugbear to all transmitting amateurs, judging by the A.C. notes that are heard on the air today. Some show an absolute lack of filter and others show that the transmitter is using a filter entirely too small for the purpose. It

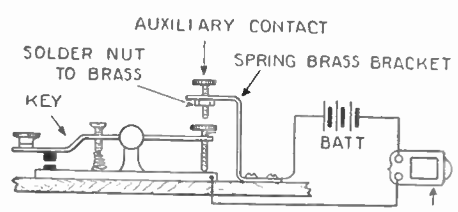


FIG. 2

How an auxiliary contact is arranged for code practice, it can reproduce signals being transmitted.

is quite true that filter choke coils are rather expensive when purchased on the open market, but everyone can find near at hand a mighty good substitute in the form of Ford spark coils. In these coils, only the secondaries are used and it is preferable to use two, one on each side of the high voltage line as shown in Fig. 3. The filter condensers, C, are then connected on either side of the two choke coils as shown. Condensers having a capacity of 1 to 2 mfd. should be used in this position and they should be amply strong enough to withstand the voltage used in the transmitter.

A filter system of this nature is quite practical for 5-watt transmitters but should not be used on higher power. The wire in the Ford spark coils is too small to carry an excessively heavy current and if you try to make them do so, they will only burn out and cause trouble. However, for all transmitters carrying up to 50 or even 60 milliamperes in the plate circuit. Ford spark coil secondaries will be found quite satisfactory. Do not attempt to use the primary coils as they are not necessary. Leave them in place but do not connect any wires to them.

Key Thumps

Key thumps, key clicks and key hits as they are variously called in different localities are often a source of great annoyance to nearby B.C.L.'s. They are nothing more or less than little clicks that can be heard in broadcast receiving sets even though the sets are tuned to comparatively high wavelengths. There are two clicks to every depression of the key, one when the circuit is made and one when the circuit is broken. It is not necessary, however, for a transmitter to radiate clicks of this nature if proper precautions are taken to eliminate them. Improper methods of keying will lead to the production of key clicks to the annoyance of all concerned. If, therefore, you would keep the good will of your neighbors look to your keying system and if it is not correct, change it so that the trouble will be entirely eliminated.

In Fig. 4 we show part of a standard transmitting circuit that will serve to illustrate the various points where keying should or should not be used. The four points indicated by X1, X2, X3 and X4 are probably the worst offenders. It is not advisable to key in any one of these positions. Now, aside from these positions, there are only about two others where keying can be accomplished and they are the two that should be used. If, for instance, you use a transformer that supplies both filament and plate voltages, you will have to resort to the position indicated by X5. In other words, insert the key in series with the rectifier and the filter system. Then the key clicks will be partially or totally absorbed by the filter system and they will not get out on the air to cause trouble. However, aside from all these positions, the very best of them all is what is known as primary keying and is illustrated in Fig. 1. Here the key is placed in series with the primary of the plate transformers, where two separate transformers are used. It is almost impossible to get key clicks with this system. If you do, however, you will find that they are probably localized and caused by sparking at the key contacts. In such a case, fixed condenser with a capacity of 1 to 2 mfd. should be shunted directly across the key so as to absorb these sparks.

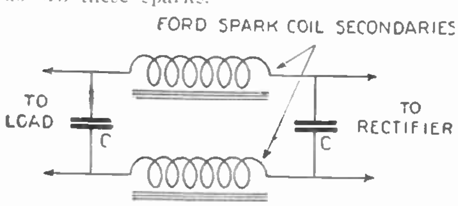


FIG. 3

How two Ford spark coil secondaries and two condensers are arranged in a filter system.

A good rule to follow in keying for C.W. transmission is to use a system that does not allow the high voltage to be applied to the plate when the circuit is not in oscillation. Any one of the keying methods indicated by X1, X2, X3 and X4 will allow this to take place as the high voltage circuit is not broken. Such systems often tend to make the tube heat up above normal temperature and this of course shortens the length of its life. Therefore, always be sure to break the high voltage circuit with your key and this can only be accomplished by keying at X5 in Fig. 4 or at the point indicated in Fig. 1. Try keying at the filament center tap, shown at X6.

Variable Grid Leaks

Often, the standard fixed grid-leaks sold for radio transmission purposes are not of the correct value to give the best results in a transmitting circuit. A variable grid leak is a decided asset as a tube can be worked at its greatest efficiency when the grid leak is at the correct value. However, transmitting grid-leaks of the variable type are quite expensive to purchase and home-made ones are seldom satisfactory. Therefore, it is necessary to resort to a substitute and one has been found that will give quite excellent results. Use a Bradleyohm No. 5 or No. 10 having resistance ranges of from 1,000 to 10,000 and 10,000 to 100,000 ohms respectively. Connect it either across the standard grid condenser or from the grid to the filament as indicated by dotted lines in Fig. 4. Tune the set. Then increase or decrease the resistance slightly and note the results. Small changes in the resistance of the grid leak and of other variable factors of the set will bring about highly desirable results. The addition and proper use of a variable grid leak in a transmitting set will often clear up a poor tone and aid immeasurably in working more "DX." The latter is because of the fact that it is well known that a clear tone will carry much better through QRM and QRN.

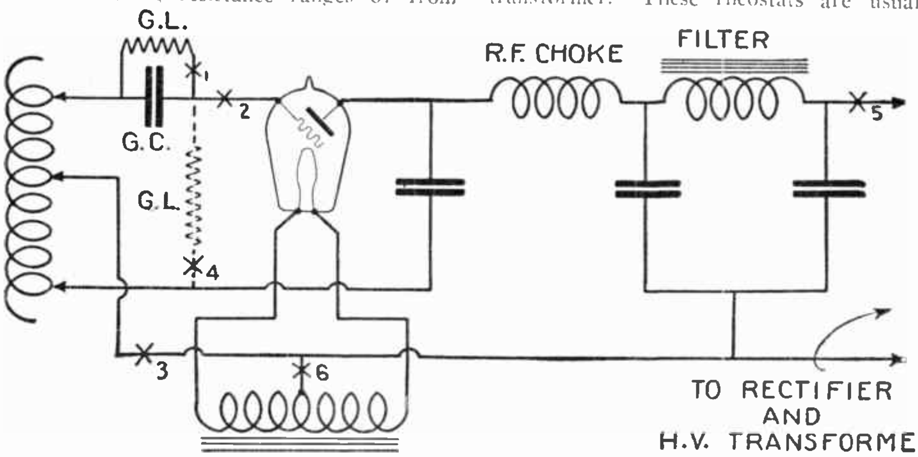


FIG. 4

This simplified circuit diagram indicates the various points at which C.W. transformers may be keyed. In the text will be found a full explanation of the best places to accomplish this work in order to prevent overloading the tube and to avoid key clicks.

Primary Rheostats

A good many amateurs are struggling along without the use of primary rheostats and in this way are subjecting their tubes to hard usage or else are not operating them at a high enough filament voltage to obtain the best results. Here again, substitutes can often be found and one or two of them will be mentioned here. Particularly with the new transmitting tubes rated at 7.5 watts and drawing only 1.25 amperes for the filament, can a substitute be employed. A standard receiving Bradleystat, if connected in series with the filament as in Fig. 1, will control the output of the filament transformer quite nicely. Even when used over periods as long as an hour, they do not show any particular tendency to heat up excessively. True enough, the rheostat will get warm but not enough to cause any particular damage. Such a primary rheostat is comparatively cheap and probably every amateur has one lying around somewhere and not in use.

Even one of the old type of wire-wound rheostats designed for use on the one ampere type of tubes can be of service, particularly if the secondary of the filament transformer supplies only a slightly higher voltage than is desired.

For higher powered sets or for installations where a comparatively large primary rheostat is necessary in order to cut down an excessive secondary voltage in the filament transformer, old motor controllers can often be used. Some of these take the form of large rheostats and these can often be picked up at second-hand electrical stores for a very small sum. Obtain one that has a comparatively high resistance, or else get one that is large enough physically for your purpose and rewind it. Take off the wire on it and obtain a quantity of resistance wire heavy enough to carry the primary current supplied to the filament transformer. Then wind enough of this wire on the sector of the power rheostat to give sufficient resistance to properly control the primary of the transformer. These rheostats are usually well made and their sliding contacts are good. You should have no trouble in reconstructing one of these instruments to suit your own purposes.

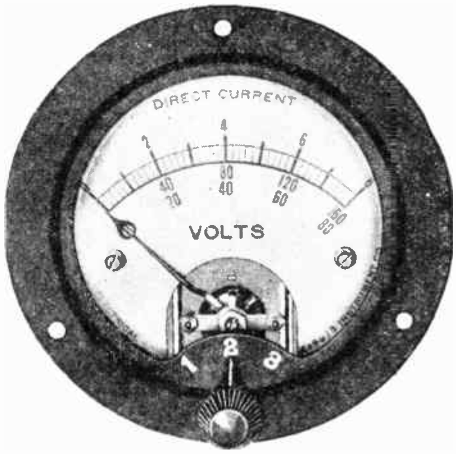
The use of a primary rheostat is always advisable inasmuch as the placement of a control device in series with the filament and secondary tends to throw out the center tap so that it is of no use whatsoever. The unbalancing effect obtained in this way often causes an otherwise good transmitter to emit a very poor note. Such a note is hard to read due to its characteristic low uneven tone. If you would work your transmitter at its greatest efficiency, employ some type of primary rheostat in your filament circuit even

John L. Reinartz, one of the United States' foremost experimenters, is shown working with his short-wave transmitter and receiver above.

though it be only a make-shift. It will be far superior to any secondary rheostat. It is of prime importance that detail of this nature be carefully considered in the construction of a transmitter.

A Circuit Tester De Luxe

By Jack Holloway



Photos Courtesy of the Jewel Electrical Instrument Co.

The three-range voltmeter used in the testing outfit described in the article.

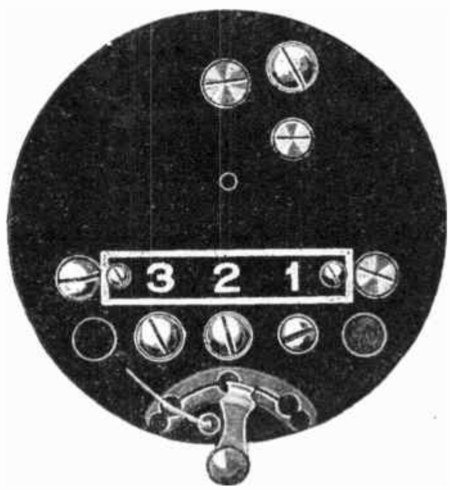
FOLLOWING is a description of an instrument devised to shorten time required, and make more certain in result, the ever growing problem of testing continuity of circuits in the more complicated broadcast receivers of today. Although primarily of interest to the service man, it will submit to adaptation and should prove valuable to the constructor. Whether it be used by the technical expert or the non-technical "Trouble Shooter," its low cost, and diverse usage will surely appeal to both.

The parts needed are:

- 1 Jewel No. 55 voltmeter with triple reading.
- 1 UV199 or C299 tube.
- 1 UV199 or C299 tube base.
- 4 Lengths No. 18 or No. 20 solid copper wire, cut 1½", 2", 2½" and 3".
- 4 30" lengths of flexible stranded insulated wire, each length of different color—red, green, yellow and black are recommended.

Obviously, if the sets to be tested are of the storage battery tube variety, the tube and tube base should be of the 201-A type. It is possible, however, to make the instrument for 199 type sockets, and by use of an adapter to make its use universal. In this instance, the filament circuit should not be tested, unless the voltage can be kept below three volts, otherwise the tester tube may be blown out. Method of assembly follows.

Solder the four flexible leads to the base of the 199 tube using the suggested color guide as follows: Red to plate, green to grid, yellow to A+ and black to A—. This is done to avoid confusion later. Then solder the four solid wires to the terminals. These can be inserted in the contact pins in the base through the holes in them. Insert for about 3/8-inch and solder firmly. Be sure these and the connections of the flexible wires are firm. For the placing of these leads, see Fig. 1. The connection for the 201-A type tube are shown in Fig. 2. The prepared tube should then appear as shown in Fig. 3, ready for mounting on the base. This base should be well cleaned and the contact pin holes freed of all solder. As shown in Fig. 4, there should be a notch filed in the side of this base at a 90 degree



Rear view of the voltmeter showing binding post terminals and switch.

angle from the bayonet pin. This notch should be made 3/16" deep and 3/8" wide. It is for the accommodation of the four flexible wires which are to be brought out, and should be a snug fit.

Now take the prepared base, and one by one insert the four solid wires through the holes. Then bunch the flexible leads on the slot side of the tube base and push up firmly. Be sure you have the bayonet pins on the two bases in line, and solder the four solid wires where they come out of the little tubes in the base. Do this well, using the soldering work on the base of a new tube as a model. Lumpy soldering at this point will cause trouble. Cut off the protruding wires and make the joint smooth. Next solder the junction of the two metal bases as depicted in Fig. 5, or, if you are using the bakelite type of base, cement well before pushing the two bases together, then let the cemented joint set.

Now connect the four flexible wires to the meter as shown in Fig. 6, and cable them with waxed cord. Cabling consists of a series of half hitches spaced about one inch apart. The instrument is now complete, and we are ready to test any set which we may think defective. The process is easy, consisting of inserting the tube in the sockets in succession and reading: filament, grid and plate circuits. These circuits make up over 90 per cent. of the wiring and include the majority of the apparatus in any vacuum tube receiving set manufactured today. The following general outline of the readings is subject to revision to meet the constants of the particular set under test.

Radio Frequency Grid Circuits

Reading here should be a violent negative deflection unless the circuit is reflexed, when it will include the resistance of the secondary of the reflexed Audio Transformer. Under this condition, the deflection should be about ½-volt negative. If the deflection is slight on straight R.F. there is a high resistance connection in the circuit. A reading of zero will denote an open circuit. Under the reflexed condition, the presence of a violent deflection will tell of a grounded audio transformer or a short-circuit, in the secondary of the transformer, or by-pass, condenser while reading will denote an open circuit, probably in the secondary of the A. F. transformer. Potentiometer controlled circuits are checked very efficiently; insert tester in the socket, turn to point 2, and the potentiometer should give a smooth variable voltage of from 3½ volts positive to zero.

Detector Grid Circuits

Owing to the presence of the conventional grid condenser in the broadcast receiver of today, it can be safely said that there should be a zero reading at this point. Any deflection, whether positive or negative, will mean either a defective condenser or grid leak.

Audio Frequency Grid Circuits

Reading of about ½-volt negative is correct here. If higher, the secondary of the transformer is shorted or grounded; lower, there is a faulty connection. Zero reading indicates open secondary or broken wire in circuit.

Radio Frequency Plate Circuits

About 85—90 volts is the correct range for the reading. If the reading is lower, look for high resistance leak, or leaking by-

(Continued on page 109)

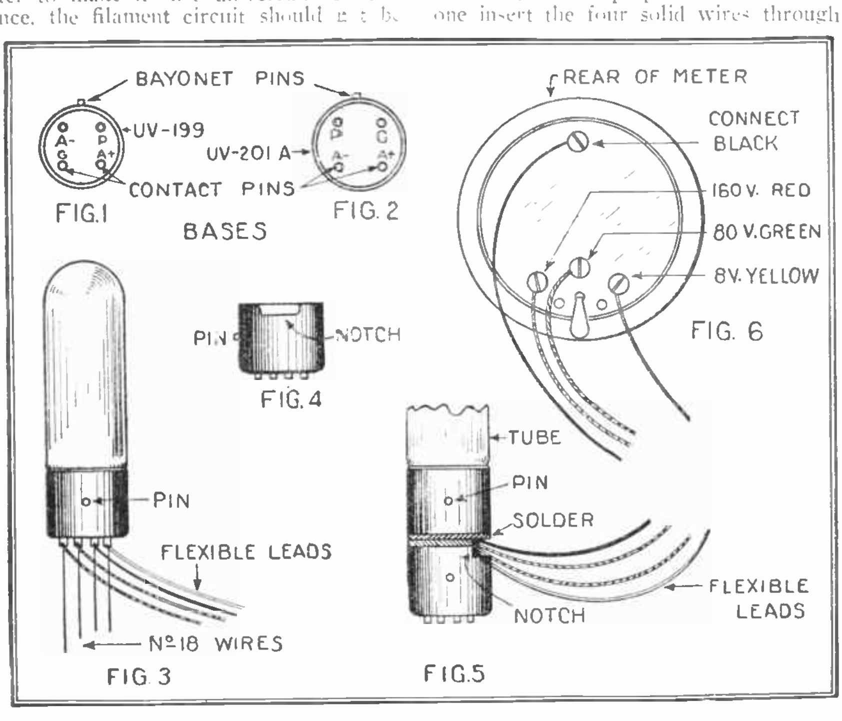


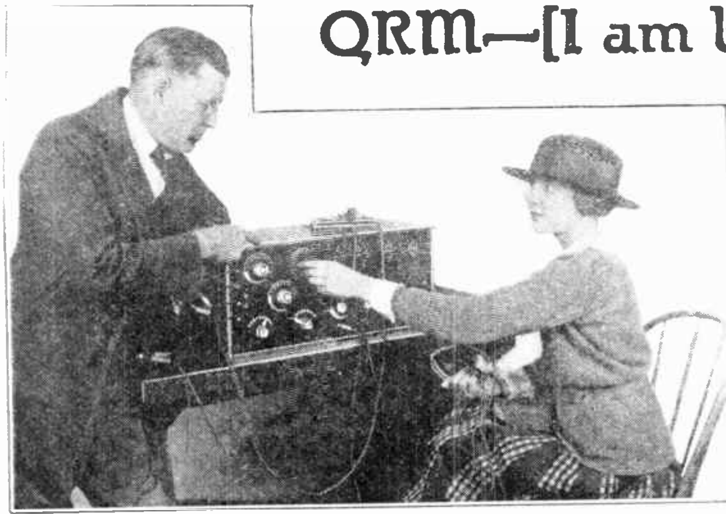
Fig. 1 shows the relative position of the terminals on the base of a type UV-199 tube, while Fig. 2 is of the type UV-201A. Fig. 3 details explicitly the method of fastening the flexible leads and bus-bar wire. In Fig. 4 is shown the exact position in which to file the notch in the base of the tube. The complete assembly is depicted in Fig. 5, while Fig. 6 shows the connections to the terminals of the meter.

QRM—[I am being Interfered with]

PART II.

By George S. Turner

Asst. Radio Inspector, 9th Governmental District



The radio expert points out wherein the trouble may lie with the receiving set. A poorly soldered joint, a loose connection, or other faulty electrical contact often results in much noise.

YOU will note that I have mentioned oscillating receivers as next in importance to be considered. This type of interference is not so severe, but it is with us continually, unless we are so remotely removed from neighboring radio listeners as to be outside the range of the interference thus created. But this is rarely the case, rather it is the exception to the rule. This is because radio has advanced to the point where practically every community, no matter how small, has a number of radio enthusiasts operating some sort of regenerative receiver. And wherever we have a radiating receiver, unless steps are taken to suppress oscillations in the set or the continuous waves set up in the antenna, we are certain to have this type of interference.

As is generally known, single circuit tuners are in the majority of cases the cause of all the whistles, chirps and squeals which interfere with amateur and broadcast reception. However, thanks to the current periodicals, this type of receiver is rapidly being modified or replaced entirely. The radio public is at last being educated toward non-radiating receivers. However, this change is slow in the making and I am very desirous of adding impetus to the movement if I may.

Those of you who are using regenerative receivers, please, oh please, use your receiver so as to cause no interference to your neighbor.

The broadcast listener can accomplish this by tuning for broadcasting stations with the receiver in a non-oscillating condition. This can be done by proper adjustment of the output to input; in other words, do not permit your receiver to whistle at you, for if you do it will whistle likewise for your neighbor. That indicates, as I have mentioned above, that means have not been taken to prevent these local oscillations from being transferred to the antenna. A few of these preventive methods I have in mind are the changing of the coupling of the antenna to the receiver from conductive to inductive or in the case of the average neutrodyne, the capacity feedback in the tube must be neutralized by proper adjustment of the neutralizing condensers, plate circuit resistance, etc., to prevent oscillation over any part of the broadcasting bands.

It sometimes happens that users of superheterodynes who are of an experimental disposition, have found that an increase in distance and volume is sometimes possible by coupling the local oscillator loosely to an antenna system, thus aiding or possibly entirely supplementing the loop as a collector of radio waves. However, they do not discover the fact that they are actually blotting out for their neighbors, whichever station they may be listening to, and even some who are literally so far removed that it would be a stretch of ones imagination to classify them as neighbors. This super receiver is no longer in the receiving class but closely approaches a transmitter. Luckily, owners of supers are not usually experimenters and also luckily, supers do not ordinarily require any outside assistance such as a pretentious antenna system. As a warning to a few who might be foolish enough to want to try this scheme, don't do it! It is possible that signal strength is increased but at the same time the noise level is raised enormously and the questionable benefits derived are not benefits at all because the resulting programs will be seriously interrupted and interfered with and that is just what we are trying to get away from.

The amateur, at the present time, is using very loose coupling between the antenna circuit and the secondary—either inductively or capacitively coupled—oscillations being set up in the input and output circuits, necessitating the use of such loosely coupled circuits. This is very necessary now that everyone is using continuous waves. These feeble chirps must not be interfered with by any superfluous waves and as amateurs, with few exceptions, are mostly cooperative in their relationship one toward the other, they each do their part toward clearing the air in their respective wave bands. Another point in their favor is that the smaller current consuming tubes as the UV-199 or C-299 have proven superior on the high frequencies to most others as oscillating detectors. Such tubes are far removed from the power tube class and therefore can radiate but little in any type of circuit. And, while I am on this subject, beware in your use of the type 201-A's and 301-A's. They are excellent power factories, so noticeable, that oftentimes they are used by amateurs for transmitting tubes, setting up relatively enormous disturbances in the ether. In passing, allow me to suggest to those who are using semi-power tubes, high "B" battery voltage and boosted filament current in circuits such as are being generally used at the present time: aren't you hindering those weak signals by passing them into this power factory of oscillating energy when with less current consumption and maintenance you could rectify those feeble impulses more efficiently and effectively by use of well-designed circuits and apparatus properly operated? Wouldn't such operation permit maximum signal to stray ratio in the passing of this valuable iota of energy into a delicately balanced and properly functioning detector, the heart of the amateur receiver? You would not use a receiving set to talk to Europe—then why an approach to a transmitter to receive them? Even a fool may be consistent but it takes the successful radio man to be logical!

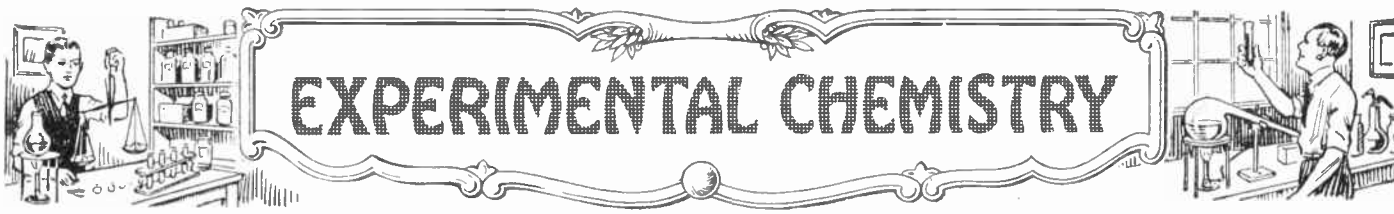
And now we come to our next subject which is that type of interference caused by one transmitting station interfering with another. This is caused by the frequencies of two stations approaching one toward the other with a separation for broadcasting stations, of less than five or six kilocycles, depending upon the modulation and receiving system. For amateurs, stations using unmodulated continuous waves may approach very much closer.

It is the present practice in the broadcasting band to separate each channel by ten kilocycles. By way of explanation, KYW is ten kilocycles higher in frequency than KSD and WOAW ten kilocycles higher than KYW—each being separated by the ten kilocycles. This has been found to cause no audible heterodyne or beating as it is sometimes called. However, because of the large number of broadcasting stations and the proportionately small number of available channels in the broadcasting band, the Department of Commerce has found it necessary to duplicate waves of certain stations which are widely separated geographically, over 500 miles apart, depending on the power used. As an illustration, Washington, D. C., and Los Angeles, California, are using the same channel without any division of time. It is to be expected, therefore, with a very sensitive receiver located anywhere in the broad middle-west and with both stations operating simultaneously, a beat note of low audible frequency can be expected. This is ordinarily and naturally taken care of by the wide variance in time between these stations or else by varying atmospheric conditions governing radio reception.

Another cause for heterodyning is a shift or variation by a station from their assigned frequency. With only a ten kilocycle separation it is absolutely necessary for a station to maintain its frequency under all conditions. The reason for this is self-evident. However, for certain station owners who are prone to vary from thier own "straight and narrow" occasionally, I shall elucidate. For instance:—if K Y W, whose frequency is 560 kilocycles should get off wave by so much as 2 kilocycles and this variation should happen to be a decrease in their frequency, then they would be operating on 558 kilocycles. Further, if K S D whose frequency is 550 kilocylcles should get off wave by as much as 2 kilocycles and their variation on the other hand should happen to be an increase in their frequency, then they would be operating on 552 kilocycles. Now compare the frequency of the one station to that of the other and you will find they are no longer separated by the required 10 kilocycles but by only 6. This is usually what has happened when you tune into a station and find a continual whistle there to greet you.

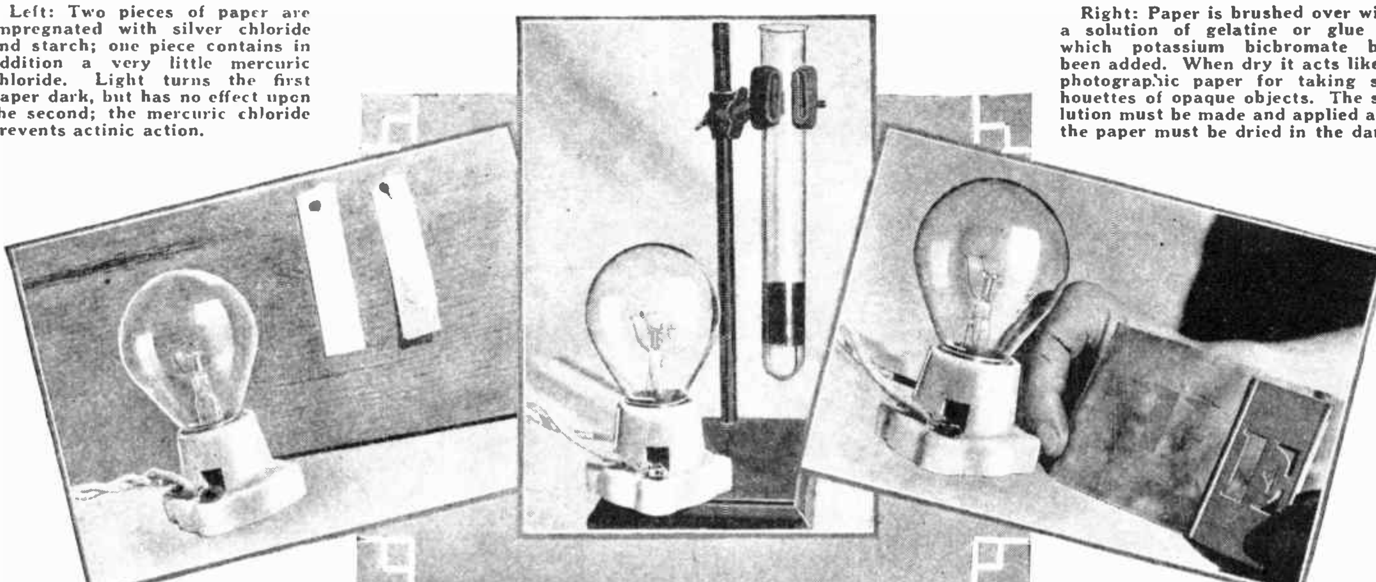
Amateurs, luckily, are not troubled with this type of interference for the simple reason that they are only operating spasmodically and then their transmitter is only in use for a fractional part of the entire time they are at the set. The nature of amateur communication proves my statement; he opens up, calls his man—signs off. If answered, he again transmits and then there passes a few words of friendly chatter or, perchance, a message or two and they sign off. The entire transmission has been of a limited duration. Another important element in favor of the amateur is the wide choice of waves at his command. In terms of meters, his choice is rather limited but in terms of frequency which is really the determining factor, his is the wealth of the air. And if he so desires, he may be licensed for any or all of the available frequencies. These are some of the reasons

(*Continued on page* 108)



Chemical Fun with Light Rays

By Raymond B. Wailes



Left: Two pieces of paper are impregnated with silver chloride and starch; one piece contains in addition a very little mercuric chloride. Light turns the first paper dark, but has no effect upon the second; the mercuric chloride prevents actinic action.

Right: Paper is brushed over with a solution of gelatine or glue to which potassium bichromate has been added. When dry it acts like a photographic paper for taking silhouettes of opaque objects. The solution must be made and applied and the paper must be dried in the dark.

Center: Bromine and toluene when exposed to the light react almost instantly, combining chemically, but the action takes place very slowly in the dark.

ACTINO-CHEMISTRY or light chemistry affords much amusement. It is very peculiar and interesting to mix several light reactive substances and then expose them to a source of light and see a wonderful transformation take place before your eyes.

It is true that there are not very many chemical reactions which are produced by light rays, but one in particular, the slow conversion of carbon dioxide of the air into oxygen by green leaves in the presence of sunlight—and only in the presence of sunlight—is almost the most wonderful actino-chemical change in the universe.

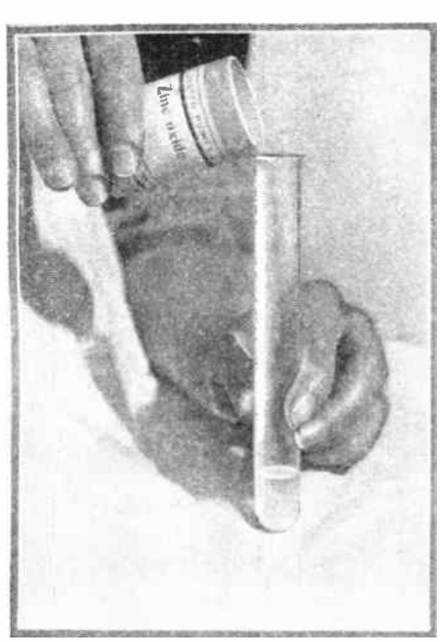
By many simple chemical reactions which progress by the aid of light rays are possible right in the experimenter's laboratory as will be shown.

Place several cubic centimeters of toluene in a test tube and add several drops of bromine water to it. Place the tube in the dark and prepare another tube identical with the first. Expose the second tube to the sunlight or the light from a 200-watt lamp. The bromine will become almost immediately decolorized, having combined with the toluene only in the presence of light. This will be found to be true by examining the tube in the darkened room. It will be found to have suffered no change.

A test tube containing a solution of ferric chloride and another tube containing oxalic acid solution will produce carbon dioxide gas when the contents of the tubes are mixed together after saturating both with carbon dioxide gas and exposing the mixture to sunlight or artificial light from a high voltage lamp. Sometimes it will be found best to expose each of the tubes to the light before mixing them.

Bichromate photographic paper always works very well in making sun pictures of leaves, plants, flowers and designs.

This chemical reaction is between glue, or gelatin, and potassium bichromate. To make the sensitive paper, a solution of gelatin in hot water is made, and finely pulverized potassium bichromate, or bichromate of potash, as it is sometimes called, is added to it. Coat sheets of cardboard or paper with this mixture, which should be thin and watery-like, and must have dissolved all of the bichromate added, and dry the coated sheets in the dark. To expose, hold a leaf, stencil, or other object, in contact with the sensitive or coated side of the paper and expose the whole to sunlight or to a high wattage lamp. Continue this for several minutes and then wash the coated paper thoroughly in running water. The portions unaffected by light wash away, while the bichromate renders the glue, which has been exposed to light, insoluble and leaves the design on the paper.



A solution of silver nitrate will become rapidly darkened approaching blackness, if a few particles of zinc oxide are added to it, when it is exposed to light.

To make regular blueprint paper, prepare the following solutions:

Solution A: Potassium ferricyanide, 5 grams; water, 40 cc. Solution B: Ferric ammonium citrate, 7 grams; water, 40 cc. Mix equal parts of the above solutions, A and B, and coat paper with them. Dry in the dark. Designs, drawings, leaves and opaque or partly opaque objects, when laid against the sensitive or coated side of the paper, should be exposed to the sunlight or to the electric arc for about a minute. The paper should then be immersed in running water, which will "develop" the image forming a blue background.

For a brown background, coat a sheet of plain white paper with a solution of 4 grams of uranium nitrate in 60 cc. of water. Dry the paper and then coat it with a solution of 1 gram of potassium ferricyanide in 30 cc. of water. Dry and use as above for blueprint paper and the print will be brown.

If several drops of a chloride or of hydrochloric acid are added to a solution of silver nitrate, silver chloride will be precipitated. This white precipitate will become purple and then black when exposed to a strong light. A peculiar fact here is that if a small amount of mercuric chloride be mixed with the silver chloride, it will not turn purple or black. Mercuric chloride solution can be used as the retarder here.

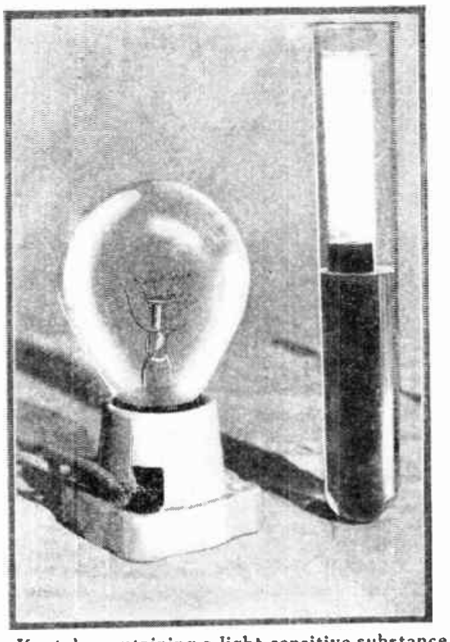
The same effect can be seen if silver chloride and starch water are spread on a strip of paper and exposed to the light from a 100- or 200-watt lamp. The paper will turn dark. Another strip of paper similarly coated but mixed with a few drops of mercuric chloride solution will not be affected by the light.

Four grams of ammonium oxalate dissolved in 10 cc. of water and mixed with 10 cc. of a 5 per cent. solution of mercuric chloride will give a white precipitate when exposed to a moderately strong light. The white precipitate is mercurous chloride (calomel). Ammonium chloride and carbon dioxide gas are the other products of this actinic chemical reaction.

If a ¾ x 6-inch test tube is filled with the above two solutions and suspended within a 1 x 6-inch test tube containing water, the light rays will pass through the water of the outer tube and still produce the chemical change. If the water in the outer tube be replaced by some of the mixture which is contained in the smaller tube, the outer tube only will be turned white, showing that the chemical light rays are cut off by the solution and not by water.

If a silver nitrate solution is exposed to sunlight or artificial light no change will be observed, but if a bit of zinc oxide is added the mixture will become dark colored, due to the separation of finely divided metallic silver.

Pulverized iodine crystals, when shaken with strong ammonium hydroxide solution, yield nitrogen iodide crystals when the whole is dried. These crystals, by the way, are extremely sensitive to friction, exploding, usually harmlessly, when touched by a fly or a feather. If the solution of the substance in ammonium hydroxide in the test tube before drying is exposed to the light from a 100-watt lamp, bubbles of nitrogen gas will be seen to be evolved. If the test tube is immersed in a larger test tube filled with water, and then exposed to the light, the bubbles will still come off, showing that heat is not the cause of the decomposition, but light, for the water will cut off much of the heat radiated from the lamp.



If a tube containing a light-sensitive substance is placed within another tube containing water, the water will shield the action of the light rays, and no reaction will occur.

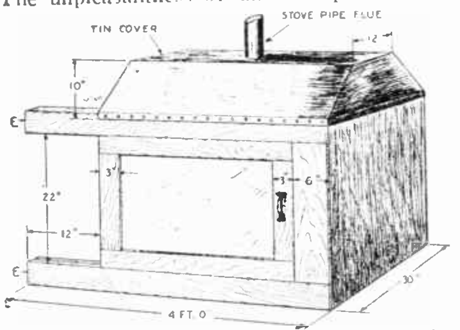
Cupric chloride is sensitive to light rays. Dissolve several grams of cupric oxide in about 10 cc. of strong hydrochloric acid. Coat a sheet of clean copper with the solution and allow it to stand for about 10 minutes. Remove the copper, wash with a gentle stream of water and lay a leaf or other design against the now grey side. Expose to the light for several minutes. The unexposed portions under the leaf will be lighter in shade than the exposed portions.

The experimenter can vary the experiments contained herein and conduct a bit of investigation on his part. For instance, different colors of light can be used as the exciting source. This can be done by interposing colored glasses between the light and the sensitive substance. Different screens and tanks of different colored solutions can be interposed between the source and the object and the effect of light absorption studied. A thin battery jar can serve as the screen, filling it with colored dye solutions, etc.

Chemical Hood for Laboratory

By Raymond B. Wailes

EVERY experimenter knows the advantage of a fume closet, or chemical hood. This item, I dare say, is absent in more than 99 per cent. of the workshops and laboratories. But it should not be. The unpleasantness of an atmosphere laden



A very nice hood or evaporating chamber for the laboratory. It has a sliding shutter which avoids the annoyance of a door sweeping across the table and upsetting apparatus.

with such gases as sulphur dioxide or trioxide, hydrogen sulphide, chlorine, etc., makes a hood a welcome addition.

A simple inside hood is not difficult to construct. Although it does take up much room and looks like an indoor dog house, it is professional-like and effective in every sense of the word. The writer for several years has used one as described herein and has found it very serviceable. In every instance, the natural draft of the flue carried the gases completely out of the hood.

The body of the hood is made of wood of 1½" stock. The building needs no stress here, although the dimensions given will be found to serve well for ordinary work. If the hood is to be used for distillations, it should be made wider, for a condenser and distillation flask cover up several feet of space.

The door slides in two grooves, one groove in each of the guides EE. It has a glass front and is equipped with a handle.

The main objection to a hood of this type is that it requires indoor space. The guides EE add to this objection, for they stand out in air as it were. The whole case can be set upon a table which will make the hood about the correct height.

The top is of galvanized sheet iron, or sheet "tin" of the sheet metal workers. It may be bevelled as shown, or have a flat top. The flue pipe, which should extend outdoors and serves as an exit for the gases, can be made of 4" spouting. Solder the seams, together with the stack take-off near the top of the hood. The top of the hood is fastened to the body proper by means of large-headed nails about an inch long. Copper nails would be better than iron ones. Any crevice here does not particularly matter so long as it is fairly close fitting.

Don't fail to install gas, water and electric light in the hood if possible, for they will be a convenience.

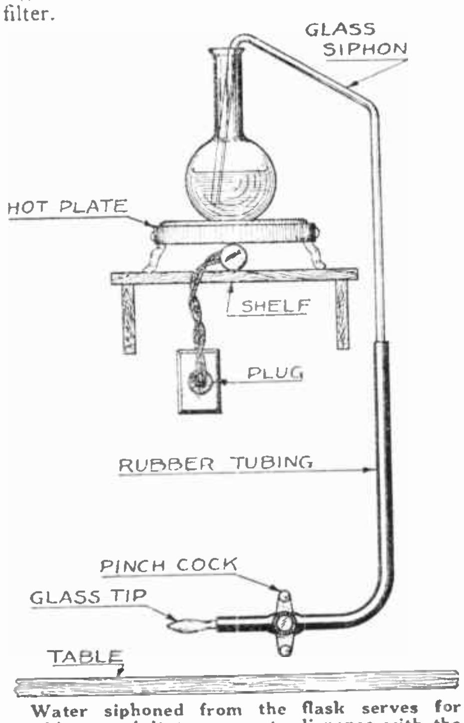
Substitute for the Wash Bottle

By Harry L. Elder

A READY supply of hot distilled water for washing precipitates, etc., is a great convenience in the laboratory and saves the time required for heating water in a wash bottle. The ordinary wash bottle is of limited capacity, and if much washing must be done, soon requires to be refilled. The constant blowing becomes fatiguing if long continued. For these reasons the writer long ago discarded the old-fashioned wash bottle for use with anything except for such special washing solutions as are rather seldom used. The plan adopted was as follows: The distilled water supply is contained in a 6-liter Florence flask (Pyrex), upon a "Simplex Quality" 3-heat electric hot plate mounted upon a shelf about 4 feet above the work table.

A length of Pyrex tubing suitably bent is used to siphon out the water as needed to its lower end, being attached to a four- or five-foot length of small rubber tubing with a pinch-cock and a glass tip. The whole outfit is firmly clamped to a support screwed to the shelf. The writer pours fresh, distilled water into the flask as needed, seldom oftener than once a day. If a great deal of water is required, the supply may be kept in a 5-gallon bottle, slightly elevated above the flask, an arrangement of glass tubes after the principle of the Mariotte bottle maintaining the constant level in the flask. The lowest heat will maintain the water at a temperature, but little below boiling, and the second heat will boil the water in the flask, according to the writer's experience. The third heat will boil a flask full of cold water in one-half hour.

If not too fine a tip is used for washing, the temperature of the water delivered is only a few degrees below boiling, at least as hot as that usually furnished by the ordinary wash bottle. The stream of water from this tip is much more easily controlled than that from a wash bottle, and may be directed in any way desired without danger of spurting or risk of throwing precipitate from the filter.



Water siphoned from the flask serves for washing precipitates so as to dispense with the use of the ordinary wash bottle.

Home-Made Chemical Apparatus

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

IN order to conduct serious experiments in chemistry, a considerable amount of apparatus is required. To purchase all of this apparatus from the scientific supply companies means quite an outlay of money. Buying a great deal of this apparatus, however, is entirely unnecessary, as the experimenter can easily construct the larger proportion of it. Again better yet, some of this home-made apparatus is superior in strength and durability to the purchased article. Several articles of this kind are shown in the illustrations. The only articles that must be purchased are beakers, flasks and similar glass objects.

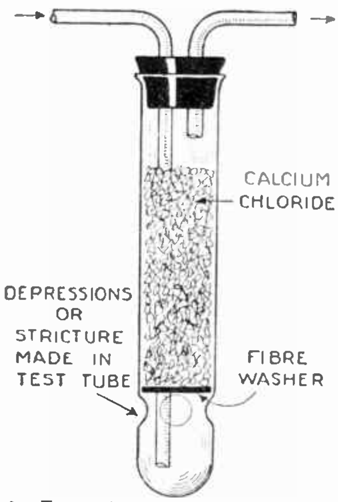


Fig. 1. Test tube with depressions or stricture near its bottom connected up as shown gives an excellent drying tube and if soda-lime is used in it, it will absorb carbonic acid gas.

In making the apparatus listed below every effort should be made to do neat and clean-cut work. Properly-made apparatus and a neat laboratory lead to productive experimenting.

U-tube Substitutes. Figure I shows an effective substitute for the U-tubes so often required in performing experiments with gases. An ordinary test tube (the larger, the better) is taken and heated near the bottom in a Bunsen burner flame. When the glass has become soft, four depressions are made in it with a pointed piece of wood or better yet, a uniform groove or stricture is formed around it. This supports the fibre washer as shown in the figure. This can be made of fibre or of rubber and is perforated with small holes together with a larger central one for admitting the glass tube as shown.

The glass tubes are cut and bent to the proper shape in a gas flame and fitted in place with a cork or rubber stopper. The tube is to be charged with a suitable material. Usually these tubes are employed for drying gases and granulated calcium chloride is placed in the tube. Broken pumice stone soaked with sulphuric acid may also be used as an effective drying agent. Needless to say, several of these tubes can be hooked up in series and when used in this way take far less room than U-tubes.

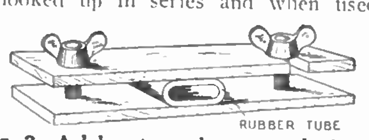


Fig. 2. A laboratory clamp, a substitute for the pinch cock, and really superior for the larger rubber tubes.

Clamps for Rubber Tubing. Clamps are necessary articles for regulating the flow of gases and liquids through rubber tubes. These are made from brass or iron strip, preferably the former, and with suitable bolts and wing-nuts. The illustration shows the method of construction. A clamp made in this manner is stronger and more efficient than the purchased laboratory clamp.

Sand Baths and Air Baths. A sand bath is simply a dish filled with dry sand heated from below on which are placed beakers and dishes for boiling and evaporation. A sand bath lessens the chances of breaking fragile glass apparatus. A simple bath can be made by using a pie plate or graniteware dish carried upon a ring stand. A larger sand bath can be made from iron baking pans which are mounted upon suitable iron supports. The latter are conveniently made from iron piping or strip.

Air baths are simply drying ovens or hollow boxes heated by a burner. These are necessary adjuncts for drying chemical preparations. Any convenient metal box can be made to serve this purpose. Holes must be left for the circulation of air and one to insert a thermometer held in a hole in a cork. Neat drying ovens can be made by mounting a pie plate upon a tripod stand and placing over this a large, clean flower pot. The hole in the top of the pot can be used for inserting a thermometer also provided with a cork.

A Rose Burner. The illustration shows a burner for giving the wide spreading flame often needed in heating large objects. This is made by drilling holes in a brass door knob or making cuts in it with a hack saw. This can then be mounted upon a Bunsen burner or on the burner base by proper filing and fitting.

A Laboratory Condenser. The chemical laboratory must be equipped with condensers for making distilled water, for purifying other liquids and for use in experiments. At least one good condenser is indispensable. The usual form is made almost entirely from glass. Besides being expensive this kind is especially liable to breakage.

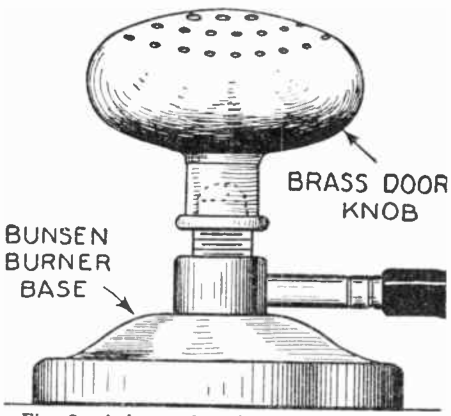
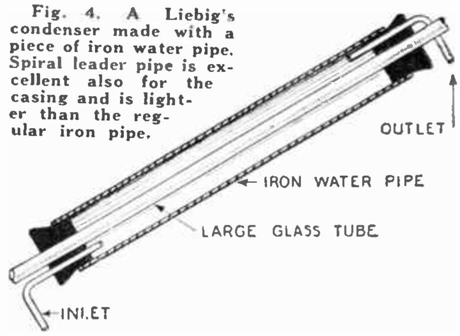


Fig. 3. A brass door knob is drilled full of holes and mounted on a Bunsen burner base. This gives a divided flame of excellent effect.

A home-made condenser is shown that is easy to construct and very satisfactory in service, outlasting the usual all-glass form. The outer jacket is made from a length of galvanized water pipe of seamless steel tubing or of large brass tubing. A glass tube is fitted into this with rubber stoppers along with two other smaller tubes which serve as outlet and inlet for the cooling water.

Water Baths and Steam Baths. These are devices for heating vessels by contact with steam or hot water. Ordinary enameled dishes make excellent water baths. It is preferable to buy one with straight sides made out of white enameled iron. These can be used for both water and steam baths. In the former case breakers or other vessels are placed in the pans which are partially filled with water and heated with a Bunsen burner. For use as steam baths metal covers should be made for the dish, having different sized holes in them. The vessels to be heated are then placed over these holes, the enameled dish is filled with boiling water and the rising steam plays on the bottom of the vessel being heated. The steam bath is heated with a Bunsen burner. In using these steam baths care should be taken to provide a vent for the excess steam.

Fig. 4. A Liebig's condenser made with a piece of iron water pipe. Spiral leader pipe is excellent also for the casing and is lighter than the regular iron pipe.



In line with apparatus of this nature should be mentioned the often needed pneumatic trough which is used in the preparation of gases. This is merely a box that holds water, having in addition a movable shelf. These can be improvised from metal pans using a strip of metal for the shelf. Excellent ones can be neatly made of wood. These can be coated with parraffin to make them waterproof.

Graduated Test Tubes and Graduates. The careful measuring of all solutions differentiates the real experimenter from those who simply play around with chemicals and never discover anything. Measuring vessels are usually expensive, but this expense can be reduced to a minimum by the exercise of a little ingenuity. A standard measuring pipette must be obtained. Small ones are obtainable at a small cost from an apparatus dealer. They are tubes graduated to hold a certain amount and to deliver a certain amount with great accuracy. The best size is one holding five or ten cubic centimeters of liquid. To graduate a test tube with a pipette, the test tube is placed upright and successive portions of distilled water delivered into the tube with the pipette, the height to which each portion fills the tube being carefully marked with a sharp file. When the tube is graduated the file marks can be enlarged, or the tube can be etched with hydrofluoric acid as described in the article on glass working in the March issue of THE EXPERIMENTER.

Excellent large graduates can be made from storage battery acid jars which are obtainable at small cost. In this case a shellacked cardboard strip can be pasted on the outside of the jar to mark the graduations. Other vessels can be graduated in this manner which is accurate enough to serve most purposes.

Spoons and Spatulas. For handling small portions of dry chemicals it is usual to employ spoons made from porcelain or horn. For many of these uses ordinary table spoons serve just as well. For handling corrosive chemicals suitable ones can be cut from fibre or celluloid sheet. Spatulas or flat spoons which are often used in weighing can be cut from sheet brass or fibre. Ordinary table knives can be made to serve this purpose. The painter's knife is excellent.

Ring Stands, Clamps and Funnel Sup-

forts. These very necessary pieces of apparatus can be nearly all made by the experimenter. A ring stand or universal support can be made by fastening a three-eighths iron rod standard into a flat oak base board, which may be finished in a suitable manner. Rings for this support are best purchased, but with the exercise of a little ingenuity these as well as clamps can be made. Wooden filtering supports are easily made and a great number of varieties of these can be devised. Test tube racks are also articles easy to manufacture. These wooden objects should always be coated with several layers of spar varnish to prevent warping when they are moistened by laboratory solutions. Holders for hot test tubes and beakers can be made from heavy wire and are very satisfactory.

Thistle Tubes. For generating gases thistle tubes are necessary. The usual form however is very easily broken. A home-made one is pictured that possesses the advantage of being made of ordinary materials and which can be made over again when broken. It is simply made by putting together a discarded funnel, some glass tubing and a rubber connector.

Apparatus from Old Bottles. Discarded glass bottles are a great source of apparatus for the experimenter's laboratory, especially if the experimenter has knowledge of the proper method of cutting such heavy glass. Discarded glass bottles that acids come in, or large bottles that distilled water is sold in, make excellent containers for distilled water. A large bottle of this nature fastened near the ceiling of the laboratory and equipped with suitable glass tubes is a most convenient appliance to distribute distilled water for use in the laboratory.

Smaller narrow-necked bottles are suitable for holding solutions of various chemical salts. Discarded glass stoppers can be ground into the mouths of ordinary bottles by using emery dust and water, and such bottles make suitable containers for holding corrosive liquids. Wide-mouthed bottles are used for holding dry chemicals. Excellent specimen bottles can be made from empty olive bottles and other containers of this kind.

In addition, as remarked above, much can be done by cutting off the tops or bottoms of bottles. Many devices have been resorted to in order to accomplish this in a satisfactory manner such as using a hot iron, strings soaked in turpentine, etc. The best way of all, however, is to use a hot chisel-shaped glass rod. This is made by heating a piece of glass rod in a burner flame for a few minutes and then flattening the end with a piece of wood.

Care must be exercised in selecting the bottle to work on. No success will be obtained with bottles having sides of marked uneven thickness or bubbles or other defects. Having taken a good bottle to work on, the glass tool is heated nearly red hot and pressed on the bottle at the point where the crack is to begin. The glass must be hot enough to flatten a little. Usually the bottle will crack. If not a drop of cold water will cause the needed starting crack. The crack is then led around by keeping the heated tool pressed on the glass a little ahead of the crack. In this way a straight crack completely severing the bottle into two parts can be easily made. Good crystallizing dishes can be made in this way.

Large bottles with the bottoms cracked off are excellent bell jars. To make a neat finished job in this manner it is necessary to grind down the sharp edges left by the cracking. A flat piece of sandstone and plenty of water will serve the purpose. The grinding must be done by giving the vessel a rotary motion, never a back and forth motion as this will cause cracking. An excellent way is to use a piece of double thick window glass with a lot of sand and water to rub the bottle on. With practice the work is quickly done and the edge is very true. With practice much excellent apparatus can be made from otherwise discarded bottles.

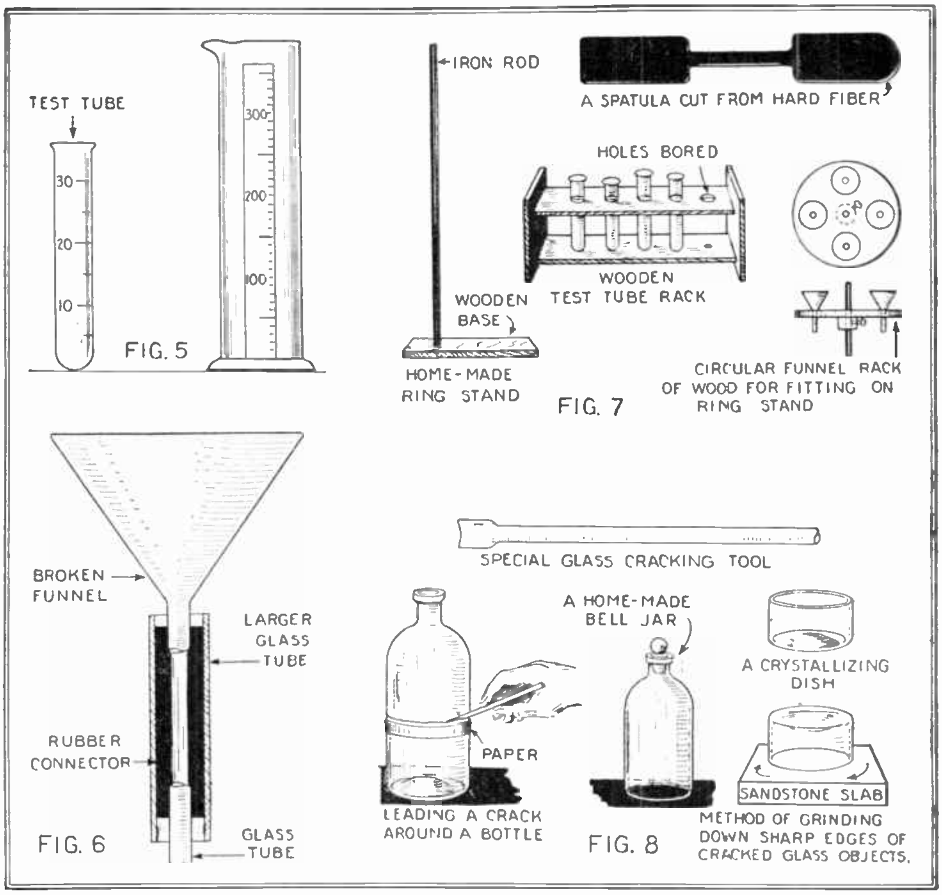


Fig. 5 shows how test tubes or measuring cylinders can be divided off into cubic centimeters and Fig. 6 shows a funnel with broken stem which is restored to usefulness by a rubber tube and a larger glass tube to surround the rubber tube. Fig. 7 shows more laboratory appliances which are so clearly shown and named that a description is not needed. Fig. 8 shows the cutting of bottles. To get a straight cut a piece of paper may be pasted around the bottle or a rubber band may be sprung around it as guides. A cut is started and led around the bottle with a hot rod, which may be of glass or may be the stem of a clay pipe.

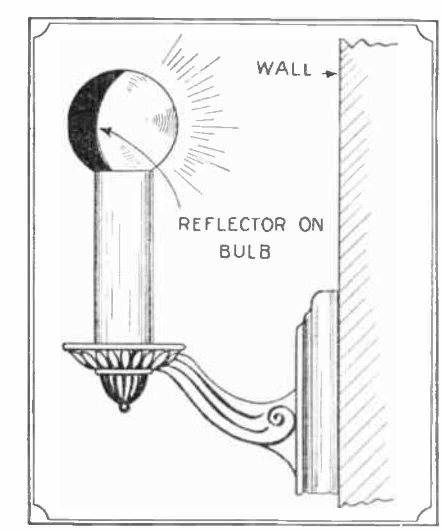
Better Lighting System

A WAY to overcome the disagreeable glare from an electric light and to obtain a better distribution of the light is plainly shown in Fig. 1. Here an ordinary electric bulb is silvered on one side: the unsilvered side faces the wall. Thus, instead of the light shining straight out, it is reflected first to the wall, and thence through the room giving a more even distribution.

A good formula for silvering the electric bulbs is:

(a) Reducing solution: In 12 oz. of distilled water dissolve 12 gr. of Rochelle salts, and boil; while boiling, add 16 gr. of nitrate of silver dissolved in 1 oz. of water and continue the boiling for 10 minutes more; then add water to make 12 oz.

(b) Silvering solution: Dissolve 1 oz. of nitrate of silver in 10 oz. of *distilled* water, then add liquid ammonia until the brown precipitate is nearly, but not quite, all dissolved; then add 1 oz. alcohol and sufficient water to make 12 oz.



An incandescent lamp bulb is silver-plated over half its surface and is placed in a bracket so that the silvered side is away from the wall. This gives indirect illumination, the silver reflecting the light to the wall and the latter reflecting it into the room.

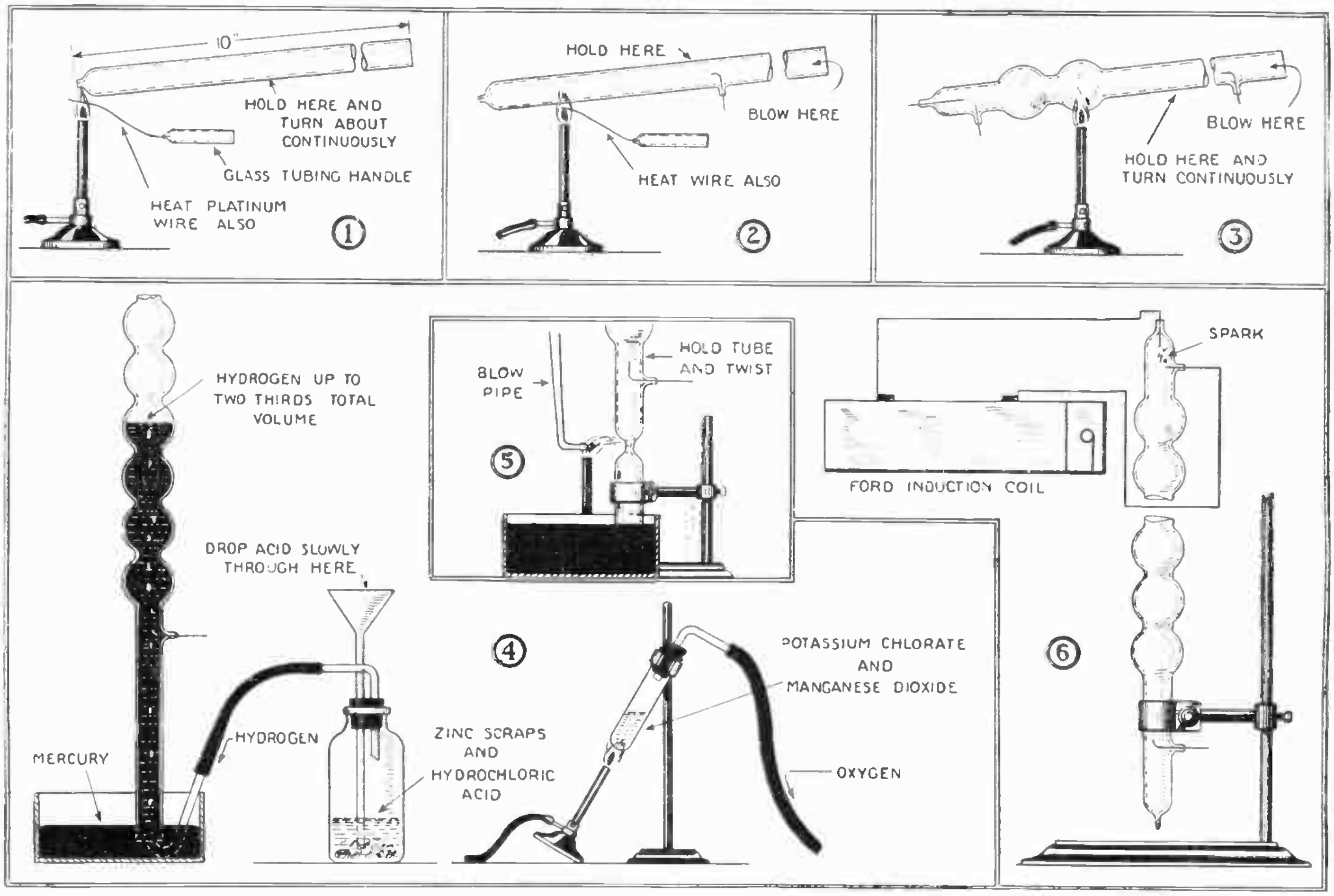
To silver: Take equal parts of (a) and (b), mix thoroughly, and lay the glass bulb face down on top of the mixture while wet, after it has been carefully cleaned with "caustic soda," and well rinsed with clean water. About 2 dr. of each solution will silver a surface of two square inches. The solution should stand and settle two or three days before being used and will keep good for a long time.

For a quick frosted finish the bulb may be daubed with a lump of glazier's putty, carefully and uniformly, until the surface is equally covered. This is an excellent imitation of ground glass and is not disturbed by rain or dampness.

Contributed by George E. Johnson.

Home-Made Geissler Tubes

By F. Castro



Figs. 1, 2, and 3 show consecutive steps in sealing platinum wire electrodes permanently into a Geissler tube and the blowing bulbs thereon to give it a distinctive shape. In Fig. 4 hydrogen is being introduced and the oxygen generating tube is ready for giving it oxygen. Fig. 5 shows the sealing off process and Fig. 6 shows its connection to a Ford induction coil for the explosion of the mixed gases, to get the vacuum.

A NOVEL and simple method for constructing at home and at small cost some of these beautiful tubes is illustrated. The apparatus required is that owned by any amateur chemist, and the materials reduce to thick glass tubing, some common and cheap chemicals, and about three cubic inches of mercury. The platinum wires required can be easily made out of the plate and grid of a discarded radio tube.

Figs. 1 and 2 show how to seal the platinum wires through the glass; in both cases the heating should continue until it is firmly sealed thereto. In Fig. 3 a simple and effective form which can be given to the tube is depicted; the bulbs are easily made by blowing and turning the tube about, while heat is being applied. Other forms can be easily given, if only a little care and ingenuity is exercised. All depends on the manipulator.

The next step (Fig. 4) is to fill the tube with mercury and note the volume required to completely fill it. To do this take the capacity of a small bottle or beaker as unit and calibrate the mercury dish by pouring that known volume of water in it, and making a scratch with a file where the level of the water reaches each time. Then displace exactly two-thirds of the mercury with hydrogen, and the rest with oxygen. Both of these gases can be generated as shown.

Now the tube is sealed as shown in Fig. 5; the flame is directed with a blowpipe or a piece of narrow glass tubing, connecting with the large tube; while applying heat it is slowly twisted until the sealing is complete.

Last, clamp the completed tube as shown in Fig. 6 and connect the two upper platinum wires to the secondary terminals of a spark coil; get at a safe distance (as the slight explosion may break the tube), and close the primary circuit. The spark will cause the rapid combination of the two gases, leaving only a very small quantity of one of them (it is never a mixture of both) and a tiny speck of water. This produces the high rarification necessary in the Geissler tubes. If now one of the upper wires and the lower one are connected to the secondary of an induction coil or to an influence machine, beautiful rings of light will appear in the tube.

If the tube is of sufficiently thick glass to stand a rather violent explosion, a better plan is to fill it completely with mercury, invert it open end downward in a cistern of mercury and introduce electrolytic gas evolved by the decomposition of water by a battery until the mercury is all displaced. The electrolytic gas should be dried before being introduced, which is readily done by passing it over soda lime or other drying agent. When the tube is full and sealed off the gas may be exploded, as described in the preceding.

There is some slight danger that the hot glass may bring about a premature explosion, so as much moderation as possible is to be exercised in the application of the blow-pipe flame.

Other gases were experimented with but the above seem most satisfactory.

Acid, Alkali and Litmus

A rather clever way of remembering the respective action of acids and alkali upon litmus paper and of course upon the litmus solution tests is shown in the illustration. No. 1 indicates the action of an acid which gives a red color. Now the word "acid" and the word "red" both end in the letter "d", so as a *memoria technica*, the fact that acid and red both end in "d" will fix the coloration in the mind. The same applies to the base which is the alkali referred to.

Here the word "base" and the word "blue" both ending with the same letter "e" will fix in one's mind that the two go together.

I = ACI / RE D	II = BAS / BLU E

How to impress upon the mind the respective actions of acid and base upon litmus paper. The acid giving the red and the alkali the blue color. The last letters tell the connections.

The action of litmus of an acid under the ionization theory is the following:

When mixed with water in solution an acid is ionized to a greater or less degree and the ionized hydrogen is supposed to be the thing which affects the litmus paper changing its color to red if it is originally blue. In the alkali, which is also hydrolyzed in solution in water, the hydroxide ion is what affects the color of litmus, turning red litmus blue.

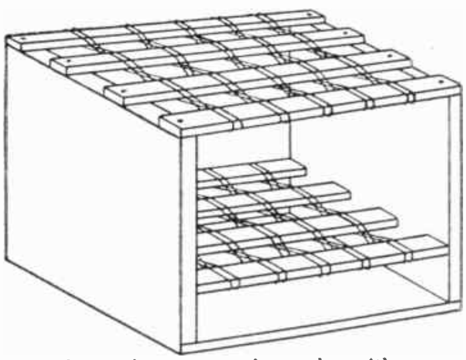
Simple Test Tube Stand

THE following design of test tube stand is easy to construct and is practically costless. The necessary material is a wooden "Kraft cheese" box, some copper wire, and a few nails. The tools required are a pocketknife, sandpaper and a ruler.

The end pieces of the test tube stand are taken directly from the box and are used without any further cutting. These end pieces are wide enough to allow three rows of ¾-inch test tubes when separated by sticks ⅜-inch wide.

The base of the test tube stand is made from one side of the box and the eight sticks from another side. The sticks are cut into the proper lengths and shaped by means of a ruler and a pocketknife. These parts after being sandpapered are ready to be assembled.

The novel feature of this test tube stand is that the difficult process of boring many large-sized holes through thin wood is done



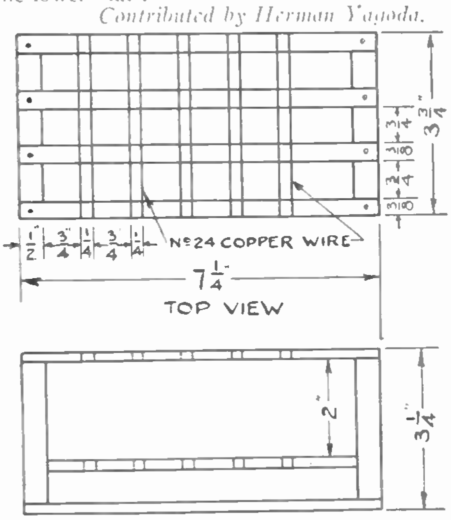
A cheese box test tube rack; with some strips of wood and wire and a "Kraft" cheese box; a very efficient stand is produced. One obvious advantage is that it cannot upset, which is more than can be said for the regular narrow racks.

away with. This is effected by twisting copper wires between the sticks at proper spacings.

The assemblage is apparent from the figures. All that need be said about it is that the bottom row of sticks need not be nailed to the ends, but are inserted tightly between them, the pressure of the sides being sufficient to keep the sticks in place. A test tube stand 7¼ inches long, constructed in accordance with this design, will conveniently hold eighteen test tubes. Glue may be used to hold the sticks in place.

Glue is softened by moisture and this is present in and about test tubes, especially after washing. So it is well to drive brads through the sides of the box into the ends of the lower slats.

Contributed by Herman Yagoda.

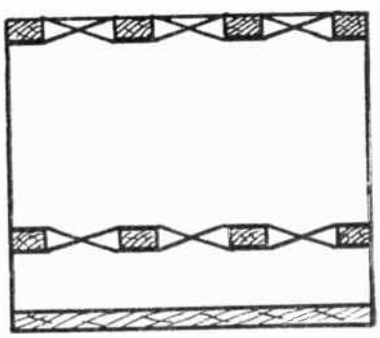


The top and front views shown here with dimensions make the construction of the box clear. The dimensions are given in detail.

A Chemical Cross-Word Puzzle

Solution to November Chemical Cross-Word Puzzle

Here we have the solution of the chemical cross-word puzzle which was given in the November issue. Looking at it, very familiar letters are seen, although as no small letters can well be used, it is not quite correct chemically. Also, there is one mistake which we have found in it; we wonder if any of our readers can detect it.



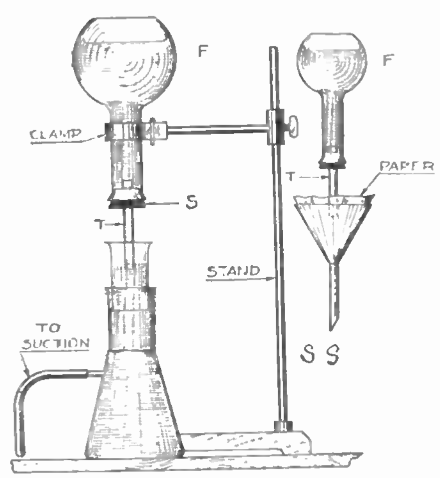
The section above shows how the wires and strips of wood are woven together to make the top and bottom sections of the test tube rack. The sections may be kept in place by very small brads or may be glued.

Constant Filter

IN filtering such things as Fehling's alkaline tartrate solution or aluminum hydroxide suspensions through Gooch crucibles, it requires much time and patience to watch the filter and add a small bit of the mixture from time to time. Therefore, a constant filtering device comes in very handy.

The one-hole stopper (S) is inserted in the mouth of the flask (F) and a piece of glass tubing beveled on the outside end is pushed through the stopper and the flask is quickly inverted, so that the end of the glass tubing (T) is about one-half way down the Gooch crucible. A clamp and stand is used to hold the flask in position over the crucible. By this arrangement the vacuum can be turned on, the filter started and the atmospheric pressure will keep the level of the liquid in the Gooch crucible at exactly the end of the glass tubing. This enables the operation to be carried on without attention from the operator until the last few drops are poured in. It can also be used for filtering with ordinary filter paper.

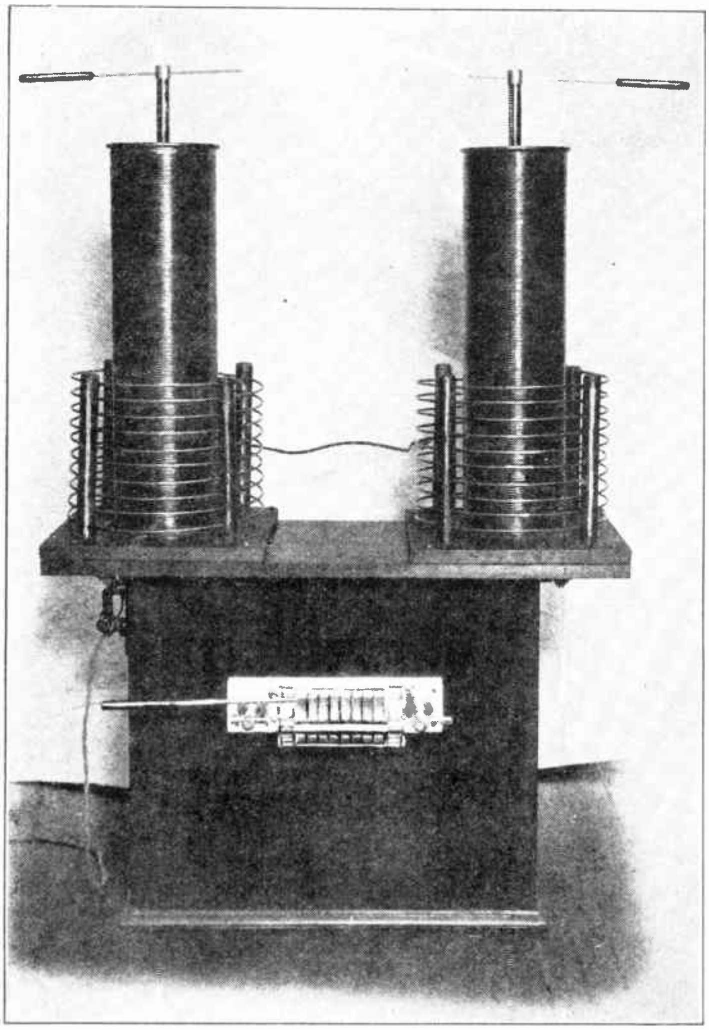
Contributed by Harry L. Elder.



A constant filtering arrangement. Air enters bubble by bubble into the upper vessels so as to give a practically constant delivery of the fluid to be filtered. It is applicable also to supplying water baths with water.

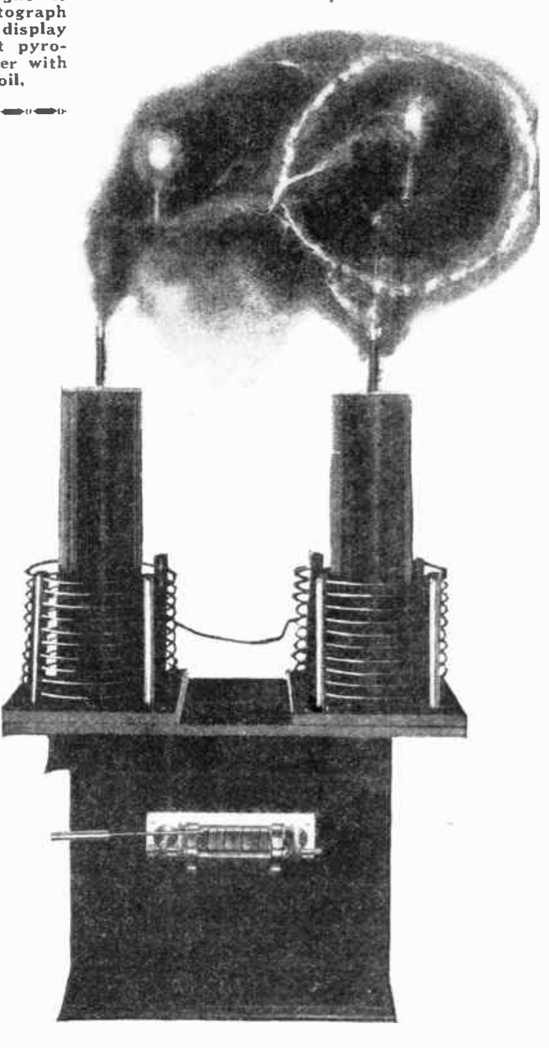
Seeing The Unseen

By Joseph G. Branch*



An interesting high frequency coil claimed to embody the features of the Tesla and Oudin coils is shown on the left. The very neat arrangement of parts will be observed. On the front of the cabinet is a multiple spark gap with its usual adjustment, and a special condenser is contained within the cabinet. It must be remembered that the condenser in a sense is the soul of the high frequency coil. With this coil a 20-inch spark has been produced.

On the right is shown a photograph of a brilliant display of an almost pyrotechnical order with the Branch coil.



IN designing the apparatus illustrated in this article, it was not my purpose to secure the usual spectacular display obtained from the ordinary Tesla high frequency coil, but I did it entirely with the view of experimenting in the greatest and most fascinating field of all science, that of seeking to discover one of the many rays of light that are far beyond our range of vision, that is, to see the unseen—the invisible rays of light.

For many years it was thought that light consisted of a swarm of flying corpuscles which emanated or were discharged from luminous bodies, and, stimulated the sense of sight when they struck the retina of the eye.

While this was a very simple and plausible theory, it was found that it was probably not correct, and while no definite conclusion has been reached as to how light is transmitted, what is now known as the ether theory, that is, that ether fills all space, and that ether waves transmit light, is most generally accepted.

It was found from experiments that the speed of light is independent of whether the source whence it emanates is at rest or in motion, and, which fact disproves entirely the theory of a swarm of corpuscles as being the source of light.

We all know that the different wave-lengths determine the various colors, and, if we compare in this way red, yellow, green, blue and violet lights, we find that the wave-lengths are all different, red being the longest, yellow next, green next, blue next and violet the shortest. The wave-lengths of all these lights have been accurately measured, and the numbers representing several wave-lengths always represent unmistakable colors.

However, it has now been found that there are many million other rays, so that in describing the electro-magnetic spectrum, if we represent visible light by a space of one foot on the spectrum, the entire spectrum would be many times this length. This space of one foot is the visible light that constitutes the colors visible to the naked eye, and, which were thought for many years to constitute the entire spectrum.

In order to understand more clearly what is meant by this, remember that visible light as perceived by the human eye, consists of one octave, and below this there are nine known octaves of infra-red or dark heat rays, then comes a gap of four octaves of unknown rays, then twelve octaves of Hertzian waves, then another twelve octaves of such waves as used in wireless telegraphy. On the other end of the spectrum, beyond the violet rays of light, there are three octaves of ultra-violet and some twenty-four octaves of X-ray and radium rays.

The hidden ray to be discovered by some scientist, or, perhaps by a youthful amateur may be the "death ray," which means death to armies and all life within its range; or, it may give us the means of communicating with the spheres which surround our earth, thus realizing the dream of the great Tesla of communicating with our nearest neighbor, Mars; or, again, it may mean the transmission of enormous power hundreds and thousands of miles at an infinitesimal cost.

A discovery of one of the rays may be made by you, however unknown or limited may be your means. It has been found in

* *President Joseph G. Branch Institute of Engineering, Chicago.*

the course of human events that some of the world's greatest discoveries have been made most unexpectedly and by those unknown to fame. If you possess patience and determination, the great discoveries to be made in this science, are open to you.

In order to better understand the Tesla-Oudin apparatus designed by me, and described in this article, you must first understand the difference between the D'Arsonval coil, the Tesla coil and the Oudin coil, all of which coils produce entirely different currents.

The D'Arsonval discharge is one of high frequency, high voltage and high amperage; the discharge produced by what is known as the Tesla coil, is one of very high tension and frequency, but the amperage is much less than that produced by the D'Arsonval coil; while the discharge produced by the Oudin coil, is of enormous frequency and very little amperage.

In experimental work, as also in other kinds of work, especially therapeutical, it has been found that the high amperage of the D'Arsonval current produced excessive heat and for that reason is not available, especially for experimental work. It was further found that while the Tesla coil produces a very high frequency and voltage, that the amperage is also objectionable. The third current, or that of the Oudin coil, while producing an enormously high frequency, possesses very low amperage, and is, therefore, especially useful in the seeking of these hidden rays.

Owing to the high voltage of the Oudin current, which practically knows no insulation, and, to the fact that very little amperage is present, the spark produced from this current has been termed, "cold heat," which is especially desirable in your experiments.

In beginning my investigation, I saw the necessity of combining the Tesla and the Oudin coils, in conjunction with a condenser of a capacity far beyond that of any manufactured, so as to produce an enormous frequency with practically no amperage, thus producing no heat and capable of having all inductances accurately tuned, or placed in resonance.

It has been found that the frequencies which can be transmitted by the ether, have been explored from the zero frequencies, consisting of the longest wave-lengths, up to frequencies of the highest pitched X-rays, and that within this range there are only two narrow gaps that have not been determined. The above range extends between the wireless waves and the heat waves to the ultra-violet rays and the longest X-rays. Beyond the two extremities of our present spectrum, are to be found countless additional waves or rays.

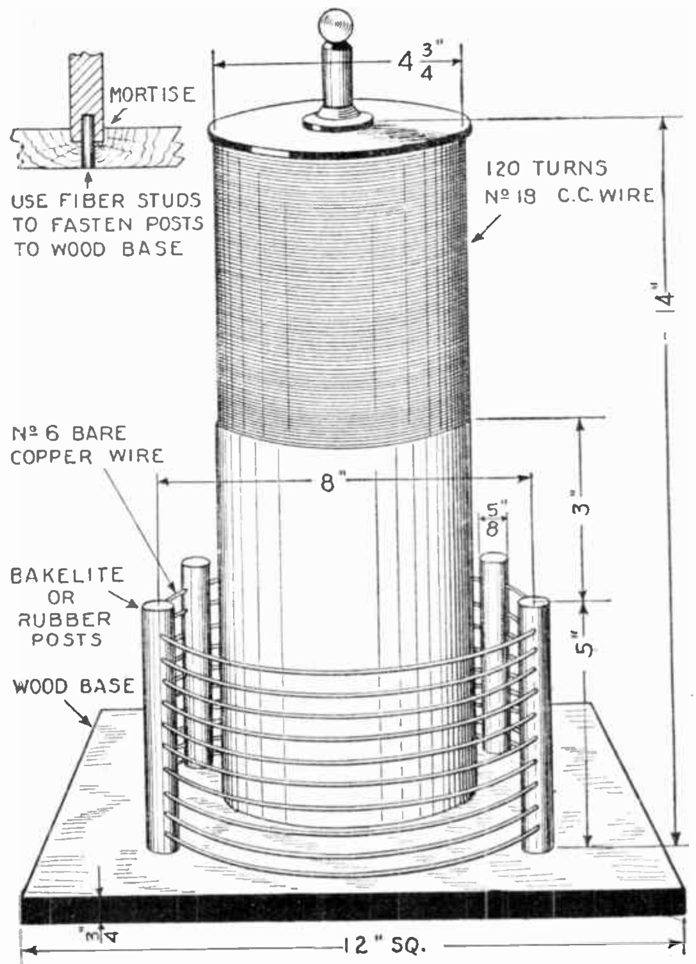


Diagram of the construction of one member of the coil shown on the preceding page, giving dimensions and details of parts. The author distinguishes between the qualities of the Oudin and of the Tesla discharges, and he maintains that this apparatus in a sense combines the qualities of the two.

While you will have no great difficulty in constructing the apparatus necessary for your work, you will find your greatest difficulty in obtaining a condenser of sufficiently high capacity that will not puncture.

The Tesla-Oudin apparatus shown in the illustration is a 2 K.W. outfit, consisting primarily of a 2 K.W. high tension transformer with a wax immersed plate condenser and an 8-section multiple spark gap.

The two secondary coils are Oudin coils, consisting of 600 turns of No. 24 cotton enameled wire; the primary consisting of, ten turns of No. 6 copper wire, the latter coils being placed about four inches distant from each secondary.

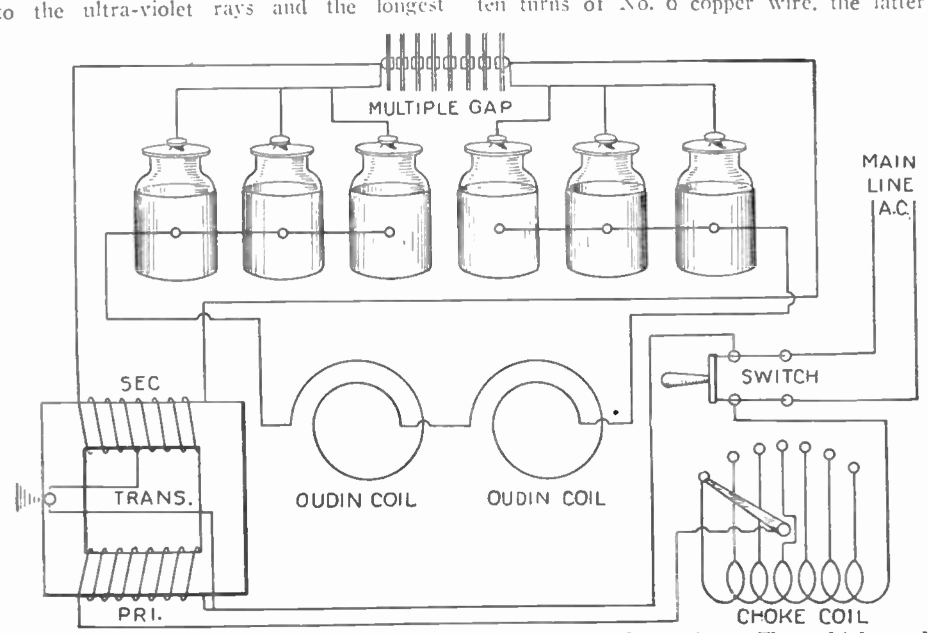
The outfit has a control on the primary circuit and there is also a rheostat mounted on the outside of the cabinet, the apparatus being operated from any 115 volt, 60-cycle circuit. The number of primary turns permit the adjustment of the inductances so that a resonant condition can be easily obtained. The four posts which support the primary windings should be of rubber or Bakelite, the primary wire being inserted in holes drilled through the center of the posts. The posts themselves should be attached to a wooden board, using fibre or rubber stubs. No metal whatever should be used, as it will cause arcing and burning.

The success of your experiments depends almost entirely upon the accuracy of the tuning of the apparatus. It is useless to have either excessive voltage, or excessive capacity, unless you have your coils in perfect resonance.

Instead of using the apparatus shown in the illustration with a primary voltage of 40,000 and a plate condenser with a capacity equal to 24 Leyden jars, the experimenter will find that by using a 1 K.W. transformer and six 1-quart Leyden jars, connected in series-multiple as shown in the diagram, he can secure a frequency that will permit him to make his investigation with probably as much success as obtained from far more powerful and expensive apparatus. The telescope that disclosed the wonders of the planetary system was constructed by a penniless boy from discarded material.

With this 1 K.W. outfit, as shown in the outline drawing, using the above number of Leyden jars, with a primary voltage of 25,000 volts, the experimenter can obtain good results, permitting him to make investigations far beyond what is possible with the most powerful Tesla coil. However, should he wish to obtain a more powerful outfit, it will be necessary for him to discard the Leyden jars, using a condenser construct-

(*Continued on page* 109)



The hook-up of the high frequency coil all clearly explained in the captions. The multiple spark gap is one of the features and although six Leyden jars are shown, they are only an alternative for the condenser.

Variable Speed Motors

By H. Winfield Secor

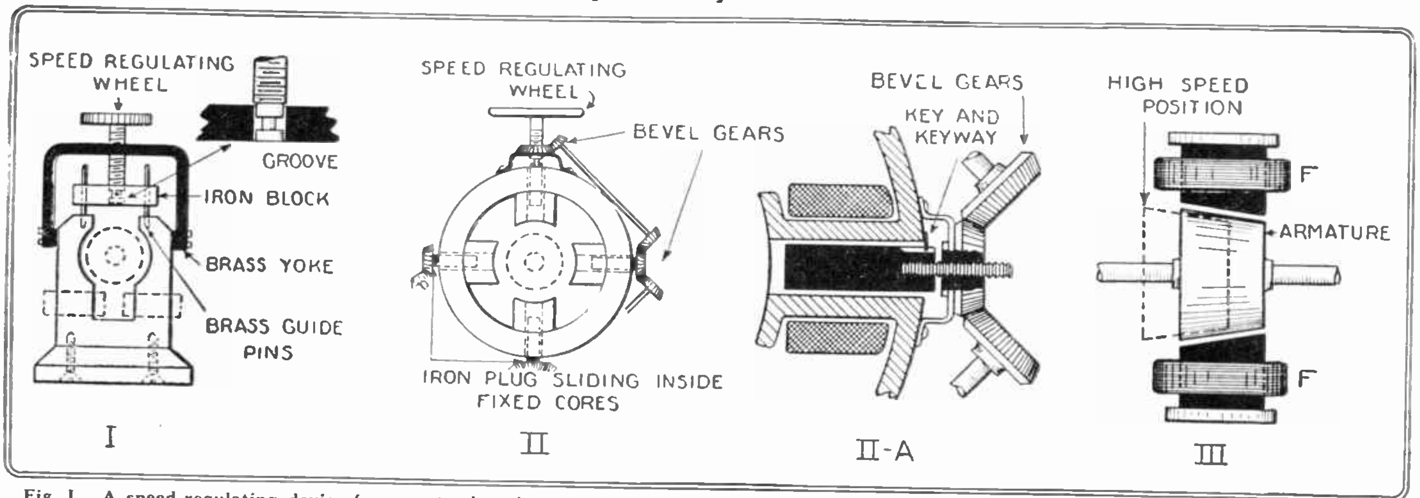


Fig. I. A speed-regulating device for a motor based on bridging across between the pole pieces with a block of iron so as to weaken or strengthen the field by moving it up or down. Fig. II and II-A show another method by which soft iron plungers are moved in and out of a hole through the fields so as to change the distribution of lines of force. Fig. III shows a conical armature which is shifted back and forth to regulate the speed.

THERE are a number of approved methods for varying the speed of electric motors, and some of the more unusual methods will be considered here. In most cases the speed of an electric motor is controlled by connecting a variable resistance, either in the armature circuit or in the field circuit, the effect being to control the amount of electric current passing through the windings of the motor, and thus in turn decrease or increase the magnetic field from the current through the windings.

The experimenter will no doubt find the control scheme outlined in Fig. 1 the most interesting, due to its simplicity. A piece of gray iron casting or wrought iron bar of approximately the same cross-sectional area as the field poles, is arranged to slide up and down on substantial brass guide rods. Control of the position of this shunting bar is vested in a heavy threaded brass rod, which passes through a threaded hole in the brass yoke secured to the motor frame, as Fig. 1 clearly shows. The end of the threaded brass rod turns in the iron block, as the detail drawing shows, the rod being held within the opening in the block by means of a pin resting in a groove on the brass rod. Any other mechanical arrangement for firmly and accurately controlling the position of this iron shunt can be used, of course, as the builder may elect.

As the iron block is moved toward the pole-pieces, more and more of the field magnetic flux is shunted through the iron block, and the speed of the motor armature increases in proportion inversely with the separating space. There is a limit of course to the speed regulation which can be effected by this method, as a point is reached ultimately when further weakening of the field flux passing through the armature, *via* the shunt, will cause undesirable sparking at the brushes and commutator. The reason why the motor speed increases as the main field flux through the armature is weakened, is because the armature will have to rotate faster in order to generate sufficient counter electro-motive-force (E.M.F.) to balance the other electrical quantities involved in the operation of all motors. The exact mathematical relations governing this condition are given herewith.

We have learned that when a conductor moves across lines of magnetic force, an E. M. F. is generated in the wire, and this is the fundamental principle of the dynamo. Now, when the armature of a motor is caused to rotate, by passing a current through it, the very act of moving across the field of the motor causes the generation of an E. M. F. This E. M. F. is opposed to that applied to the motor and is known as the counter E. M. F. The greater the speed of the armature, the greater will be this counter E. M. F., as a larger number of lines of force are cut in a given time. Also the greater the counter E.M.F. the less will be the drop of potential in the armature, for the effective E. M. F. is reduced as the counter E. M. F. increases. The strength of the armature current will therefore depend upon the speed. When the armature is forcibly restrained from rotating, the current is at its maximum, being equal to the E. M. F. applied at the brushes, divided by the resistance. On releasing the armature, the strength of the current gradually decreases as the motor comes up to speed.

The drop of potential in a motor armature is equal to the applied E. M. F. minus the counter E. M. F. Hence from Ohm's law, we have,

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

where I is the armature current, E the E. M. F. applied at the brushes, e the counter E. M. F., and r the armature resistance. This is the fundamental motor equation.

From this equation it is evident that when e is small, that is, before the motor is up to speed, the armature current will be large. As the speed increases the counter E. M. F., e, is increased, causing the current to become less and less until at full speed the current is normal.

To arrive at a general expression which will show upon what factors the speed of a motor depends, we shall make use of the same equation.

Let s represent the speed of rotation, a the number of conductors on the surface of the armature, f the field strength, and k a constant. As the E. M. F. generated by an armature moving in a field depends upon the speed, number of conductors, and strength of field, the counter E. M. F. of a motor will be equal to

$$e = s\,a\,f\,k$$

Substituting this value in the motor equation, we have therefore

$$s\,a\,f\,k = E - I\,r, \text{ and } s = \frac{E - Ir}{a\,f\,k}$$

The armature resistance of a motor is usually very small, hence the product I r would be small and may be neglected.

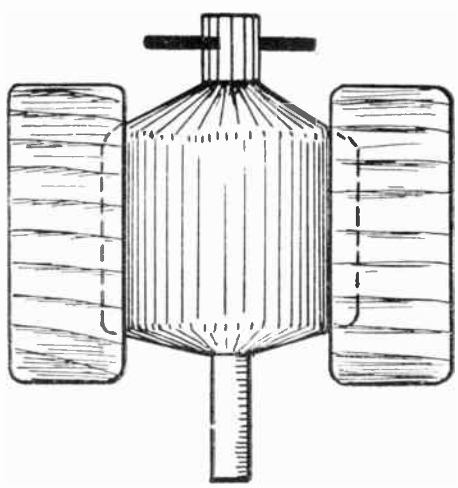
Therefore the expression for speed may be written

$$s = \frac{E}{a\,f\,k}$$

From this expression it is evident that the speed varies directly as the E. M. F. applied at the brushes, if the number of armature conductors and the field strength are constant. An increase in E causes a greater current to pass through the armature, which, acting upon the same field strength, causes an increase of speed, provided the torque exerted is kept constant.

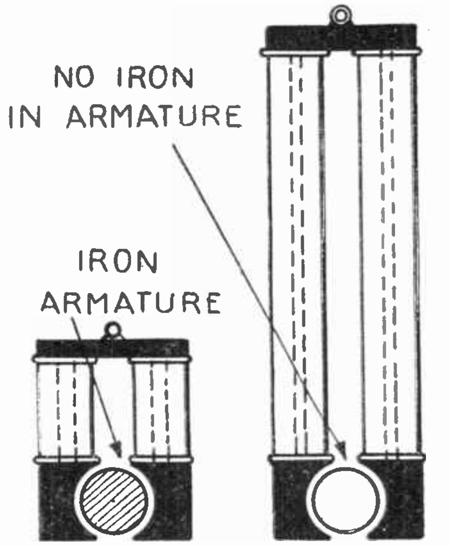
If the number of armature conductors and the applied E. M. F. are constant, the above expression shows that the speed varies inversely as the field strength, that is, if the field is weakened the speed is increased or if the field is strengthened the speed is decreased. This is true, for if the field is weakened the counter E. M. F. generated by the motor will be less, allowing a greater current to pass in the armature. This will tend to increase the torque but if that is kept constant, the speed will increase, a higher speed being now required to generate the same counter E. M. F. as when the field was stronger.

If the field strength and applied E. M. F. are constant, the speed varies inversely as the number of armature conductors, that is, a decrease in the number of armature conductors increases the speed. If a reduction is made in the number of conductors, the



IV

Fig. IV shows the armature and the field coil used in the watt-hour meter. Neither armature nor field have iron cores, but only air cores. This simple form of motor is more accurate than one containing iron, with relation to the speed at varying current strengths in the field.



V

Fig. V illustrates the enormously greater field strength required for a given size dynamo or motor, the armature of which contains no iron core. The field has to force its flux across the very large air gap in the second case and is spread over a greater cross-area so as to be of reduced intensity.

motor must evidently run at a higher speed in order to generate the same counter E. M. F. as before, the torque being kept constant.

In Fig. 2 is shown one form of commercial variable speed D.C. motor operating under the Stow patents. This motor, which is frequently built in the four pole field design, as shown here, operates in the following manner, which will be of extreme interest to all students of motor action. The field poles are made hollow and inside of each field pole there is a closely fitted iron cylinder, as shown by the dotted lines, these cylinders being simultaneously moved in or out by a set of bevel gears and shafts, all of which are controlled by a single speed regulating wheel at the top of the motor. As will be seen, the field flux passing from the pole faces or tips into and through the armature is increased or decreased, smoothly and accurately, as these movable field cores are propelled in and out by means of the gearing. Remembering that weakening the field increases the speed and *vice versa*, the speed of the Stow motor is increased as the cores are propelled outward and decreased as they are propelled inward. Fig. 2 A shows a detail of one of these cores and one manner of arranging for their movement.

Most interesting indeed is the clever speed regulating feature of a motor manufactured by the Reliance Electric & Engineering Co. Here the variation in the field flux passing through the armature is varied by shifting the position of the armature axially. When the armature (together with its commutator and brush gear) is adjusted by means of a hand wheel and levers to the position where it is directly in line with the field poles, a normal speed is obtained. As the field flux through the armature is weakened by shifting the armature away from the pole-pieces, the speed of the armature increases.

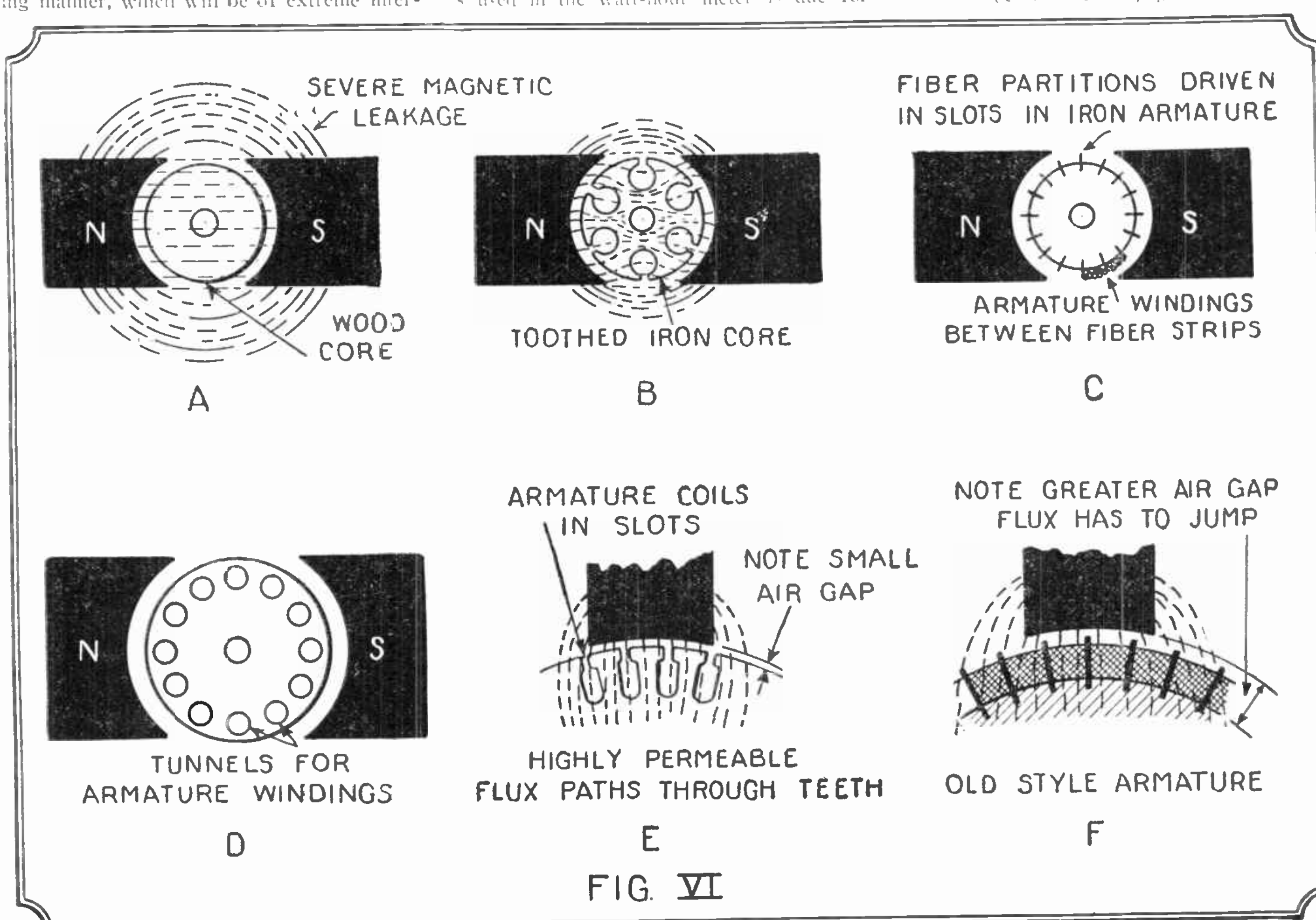
Many electrical students think that every motor or dynamo must have an iron core, both in field and armature. It is interesting to note that integrating watt-hour meter motors are of the air core type and have no iron in them at all, as Fig. 4 shows. The point of interest to electricians in this connection is of course that such a motor is of very low efficiency, but the reason why it is used in the watt-hour meter is due for one thing to its true response to variations in the electric current passing through its field and armature, which current is that passing into the house mains and the one which is to be measured. Also the motor can be used on A.C. or D.C. without interfering iron losses, which would complicate matters.

In the average watt-hour meter, the armature is connected across the line through a resistance and measures the voltage or potential component of the wattage; while the current supplying the lamps or motors in the house or factory passes through the heavy wire field coils, and these we may say do their part in the motor action to measure the current component of the wattage. The motor shaft rests on a jewel bearing, and brushes and commutator bars of silver are used. It will be seen that this motor, while very weak, has sufficient power to operate a train of integrating gears, which in turn carry dials from which the meter-reader will eventually take his readings in order to make out the monthly bill. The current passing through the armature is of course practically constant, and variation in the load, or electrical energy consumed, is taken care of in the composite motor action by the increased current passing through the field coils.

Many experimenters are of course familiar with the small toy motors made from corks and what not, and in which the armature windings are simply placed on the cork or wooden core. Such motors without any iron in their make-up are naturally very weak. If the dynamo of Fig. V had no iron in the armature, but had its armature coils wound on a wooden or any other core except iron, the field magnetizing force required would be enormous, as shown graphically by the drawing with the tall field poles.

Interesting practical considerations with

(*Continued on page* 108)



These illustrations show sectional views of different types of armatures; they are explained adequately by the captions under each one. While the arrangement shown in D may be taken as a perfect method from the standpoint of strength, it is so difficult to wind that it may be considered impractical except for special cases. Fig. B shows a sort of modification of it, as does also Fig. E. These two types are easily wound. Figs. C and F show what may be considered discarded systems of winding. Fig. A is only applicable to watt-meters and the like.

Analogy of the Transformer

By Sydney M. Dows

EVERY student of electrical engineering has, no doubt, wondered what might possibly be the relation between the familiar devices for multiplying force in mechanics

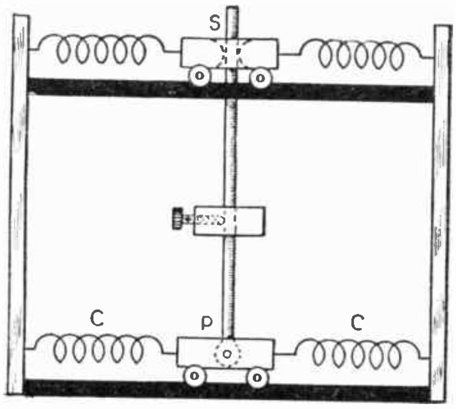


FIG. I

A very interesting analogy for the electric transformer is based on the use of the springs (C C) shown above and two weights (S P) mounted on rollers, in addition to the central weight adjustable for position. Notice the shape of the opening at S; at P there is a journal.

and the devices for multiplying electromotive force. A steady force of 110 pounds is easily "transformed" into a steady force of 1,100 or 11,000 pounds by means of a lever, but a steady electromotive force of 110 volts cannot be converted into a steady electromotive force of 1,100 or 11,000 volts by a transformer. Therefore, it would seem that the lever and the transformer are wholly unrelated. However, a lever with a heavy weight instead of a fixed fulcrum is entirely analogous to a transformer, and the equations of motion of such a lever can be reduced to forms identical with the equations of a transformer, including such complications as magnetizing current and magnetic leakage.

An ideal lever consisting of a weightless bar with an indefinitely large mass as a fulcrum is the exact equivalent of the ideal simple transformer. The to-and-fro velocities of the ends of the lever correspond to primary and secondary currents: the force (alternating) applied to one end of the lever corresponds to the alternating voltage applied to the primary of a transformer, and the force (alternating) exerted by the other end of the lever corresponds to the secondary terminal alternating voltage of a transformer. The velocity values are directly as the lengths of the two arms of the lever (this corresponds to the fact that the primary and secondary voltages of an ideal transformer vary directly with respective numbers of turns of wire), and the two forces are inversely as the lengths of the two arms of the lever (this corresponds to the fact that the primary and secondary voltages of an ideal transformer are directly as the respective numbers of turns of wire).

When the working end of the lever is rigidly fixed, we have a condition corresponding to open-circuited secondary. In this case, the hand-end of the lever will not move perceptibly if the fulcrum mass is very great; but if the fulcrum mass is moderate, the hand-end of the lever will move as the fulcrum mass is accelerated and decelerated. This motion of the hand-end of the lever corresponds exactly to the magnetized current of a transformer.

If the beam of the lever were without mass the forces at the end of the lever would be in exact inverse proportion to the lengths of the arms of the lever; but if the mass of the lever beam is considerable, or if there are weights attached to the ends of the lever, then the lever acts like a transformer with magnetic leakage. Part of the force exerted by the hand is used to accelerate and decelerate the weight at the hand end, the remainder of the force exerted by the hand is transmitted to the other end of the lever (being multiplied in exact inverse proportion to the lengths of arms or lever); a portion of the force so developed at the working end of the lever is used to accelerate and decelerate the weight at the working end, and the remainder is exerted on the receiving device.

In all of the above, the lever is supposed to be frictionless and the transformer coils are assumed to have zero resistance. There is no need to trace out the analogies between mechanical friction and electrical resistance. because, to make the analogy complete, one has to assume that the force of friction is proportional to the velocity of the moving body.

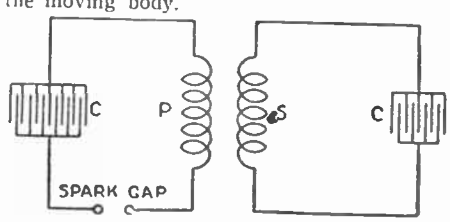


FIG. 2

Diagram of a transformer with inductances (C C) and primary and secondary (P and S). Referring back to Fig. 1, the letters correspond in the two cuts, the springs (C C) representing the condensers (C C) and the weights (P and S) representing the inductances (P and S) of the diagram.

Mysterious Electro-Magnet

FIRST procure a piece of ½-inch iron pipe 2½ inches long, also a 6-inch spike with a head large enough to drive tightly into the pipe. It may be necessary to file it before it will go in. Cut it to the same length as the pipe.

Next drill two 3/32-inch holes in the pipe about ¼-inch from each end; file off the burr and rough edges on the inside and outside left by the drill. Now drive the spike head into the pipe (see Fig. 1) as illustrated: be sure to have the spike centered in the pipe, its end even with the open end of the pipe.

Obtain a bar of iron the diameter of the spike: it may be the left-over end of the same; and a piece of tough paper 2 inches square. Put one turn of the paper around the spike and glue or shellac the rest of it; roll on to form a tube. Do not put the mucilage too close to the ends or it will run out and stick the tube fast. Have the tubes loose enough to pull off the spike.

Wind the tube with cotton magnet wire about 1/100th-inch diameter, always in the same direction. As you wind the wire on, keep trying the coil to see if it will slip inside the pipe over the spike core; when you have all the winding done that you can get in, secure the protruding ends of the wire and shellac them. Leave about three inches free for each end of the coil and have the free ends in line with the holes in the pipe. Assemble the coil in the pipe as shown and pass the free ends of the wire through the holes in the pipe, and shove in the coil over the core, pulling slack wire at the same time through the holes. When the coil is in, pour melted sealing wax in the

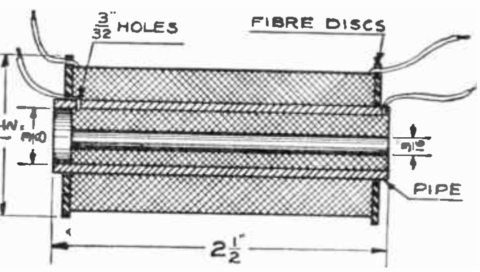


Fig. 1. Section showing the winding of the mysterious magnet with an inside and outside coil, so as to produce the puzzling relation of poles described in the article.

holes to prevent the wire making contact with the core and short-circuiting.

Get two cardboard or fibre washers 1½ inches in diameter and two discs of firm. thin cardboard, just large enough to cover the end of the pipe, also two pieces of tough paper 1½ inches square. Assemble as shown in Fig. 1; put a cardboard disc on one end of the pipe, put the paper over the disc and pull back firmly over the pipe and tie with thread. Now shove the big washers over the paper, back about ⅛-inch from each end of the pipe. Have two holes in the one washer for the free ends of the wire from the outside coil (next to be described): insulate the wires from the pipe with paper.

Now wind the space between the washers full of No. 18 bell wire. Fasten the end in line with thread and cover the wire outside with tape or paper; shellac the magnet all over to improve the appearance and keep the washers in place.

Now, if a battery of four or two dry cells is connected to the wire leading to the inside coil, the core will be magnetized on the open end only. Connect the battery to the outer winding and the core will be magnetized on both ends! Ask somebody to explain why. You will receive some queer explanations. The mystery is good to try on a know-it-all fellow who imagines he knows considerable about electricity. The ends of the core are covered to conceal the construction.

Contributed by Garry Runions.

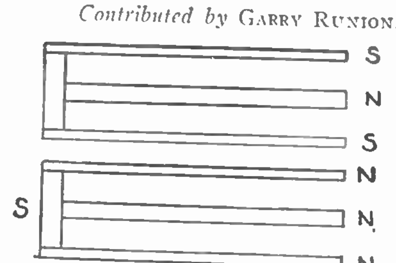


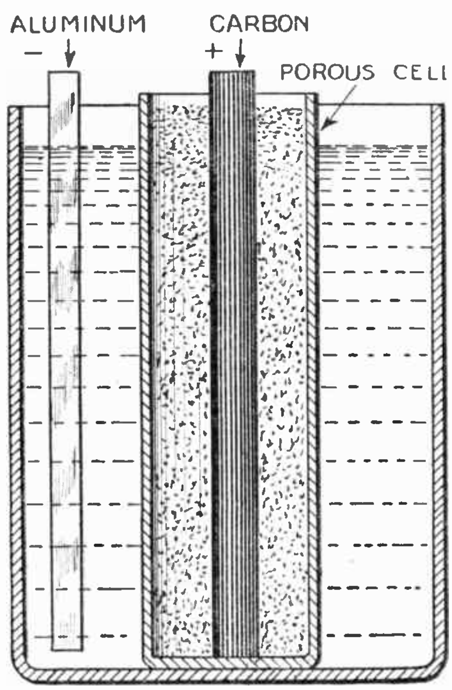
Fig. 2. The diagrams show the poles developed in the mysterious magnet by exciting the coils in different ways. In one case we get north and south poles at one end; in the other case they are all north at one end, with a south pole at the other.

Carbon Consuming Cell

A CARBON consuming cell, which works without external application of heat, is constructed as shown in the figure. It has the regular outer containing vessel, a central porous cup (which may be a small flower pot with the hole stopped up), a rod of carbon (hard gas carbon), and a negative electrode of aluminum sheet or rod.

The carbon rod in the porous cell is packed tightly around with granular carbon previously soaked in oil of vitriol. The containing vessel is three-quarters filled with one part pure sulphuric acid to three parts of water. In this condition no galvanic action takes place.

If powdered potassium chlorate is gradually added to the sulphuric acid in the outer vessel (and this had better be done in a darkened room as sunlight may cause an explosion of the peroxide of chlorine evolved), the liquid becomes red, owing to the separation of this compound.



A very curious cell which is supposed to oxidize carbon, which normally is the negative electrode, but in this battery is the positive one. Potassium chlorate is the characteristic and essential excitant.

The peroxide of chlorine thus liberated permeates the porous cell, and reaching the crushed carbon therein contained is deoxidized by it, yielding up its oxygen and giving rise to carbon dioxide and chlorine gas. This may be conducted into potassium hydrate solution when potassium chlorate is regenerated.

As the fluid in the outer vessel becomes decolorized, more potassium chlorate should be added.

The E. M. F. is about 1.25 volts.

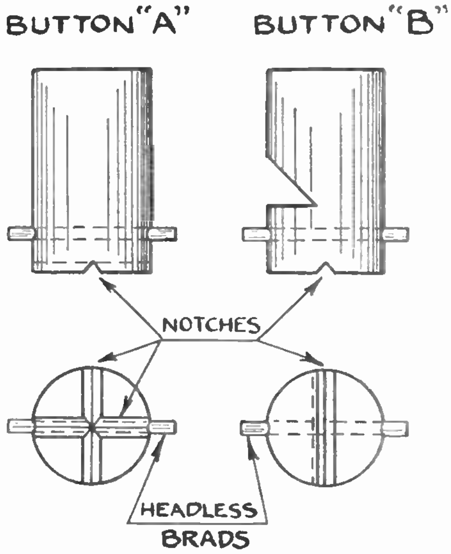
Contributed by D. TERRIERE.

Push Button Switch

A SIMPLE push button switch, which will cost practically nothing and can easily be constructed is shown here. It will give very good service.

First procure a piece of wood, any size desired, for the base. Drill two holes at each end of the base as shown in the illustration and after you have the holes drilled, sandpaper the wood with a fine grade of sandpaper.

After finishing the base, start making the buttons. They are made from a round piece of wood whittled down so that they will fit the holes perfectly, not too loose and not too tight. Dowelling may be used for them. After you have them fixed, make the small notches in the top of both and a slot in one as shown in the illustration. Cut them to the desired length and then sandpaper them. When the sandpapering is done, get two brads with their heads cut off and hammer them into the buttons as shown in the illustration.

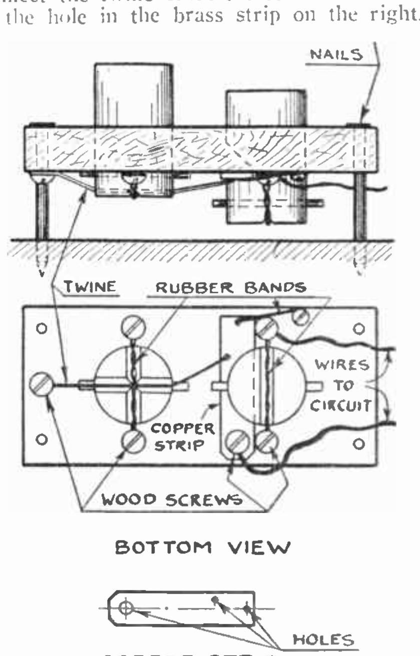


SWITCH BUTTONS

A push-button switch made of household material and which operates like the double push-button switch used in house wiring; pushing one button opens the circuit, and pushing the other closes it. One button releases the other.

Now get a strip of copper about one-inch in length and about one-fourth of an inch in width. Drill holes as shown in the illustration.

Procure seven round head screws, a piece of twine, and three rubber bands. First put in the buttons through the bottom side. Then fasten the strip to the bottom of the base with one of the screws. Do no have the screw too tight or the switch will not operate as the strip has to move freely in order to operate. Put in all of the screws as shown. Put them in half way only. When the screws are in, connect the twine from the left-hand screw to the hole in the brass strip on the right.



Elevation and plan view of the home-made push-button switch. By following out the description it will be seen how the buttons act reciprocally, one upon the other, by means of strings fitting in the notches. Brads driven through the plugs operate as stops.

Then spring the three rubber bands into place, so as to pull the plugs upward. The wires are connected as shown. When the right-hand button is depressed the pivoted brass strip will be drawn into the notch in the right-hand plug by the rubber band at the strip's upper end. This closes the circuit. When the other button is pressed the string withdraws the pivoted strip and the right-hand button springs up and opens the circuit.

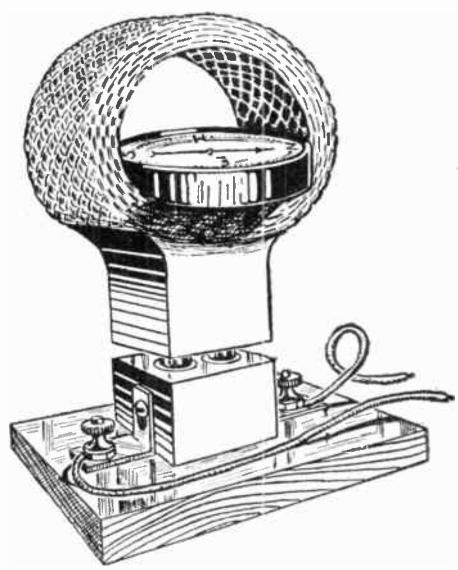
This switch was made by a friend and after he had shown me how to make it. I was so pleased with its results that I am passing this on to you readers.

Contributed by GEORGE KRIVISKEY.

Improvised Galvanometer

A GALVANOMETER is an instrument which can readily be contrived by anyone possessing an ordinary small pocket compass and a few old plug-in or honeycomb coils. The arrangement is shown in the illustration.

A small stand fitted with a pair of binding posts and a plug-in connecting block, made from scraps, with a coil plugged into the stand and a pocket compass laid inside, are the parts. The stand is turned until the needle lies north and south. The needle must lie in the plane of the coil.



A galvanometer improvised from a radio coil and one or two other accessories of a set. A pocket compass within the coil completes the collection and if small enough will give an approximate tangent galvanometer effect.

The coil is connected in series with a dry battery and any line or coil of wire whose continuity is to be tested. A No. 75 coil requires a much larger current than a No. 300 coil (which gives a deflection of compass needle with a current as small as two milliamperes) for an appreciable deflection.

It is a good plan to substitute a marked scale for the compass dial. The scale may be drawn on paper and secured with shellac upon the face of the original dial.

An interesting feature of this galvanometer is that by using a very small compass and supporting it in the center of the circle of the coil an approximately correct tangent compass can be improvised. The principle of this instrument is that the compass needle shall be of negligible length compared to the diameter of the circle of the wire.

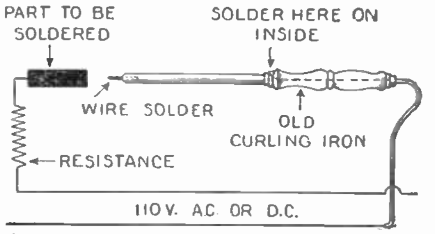
The tangent compass whose relative readings vary with the tangents of the angles of deflection of the compass needle is a very interesting instrument. Its work to an extent is basic and not based on standardization. This, in a sense, makes it a direct reading instrument, where it is a question of getting comparative values.

Contributed by HYMEN BUSHLOWITZ.

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

First Prize, $25	Second Prize, $15	Third Prize, $10	Honorable Mention
Lawrence Brennan 519 East 7th St., Anaconda, Montana	Tomas R. Santos 63 Buenos Aires, Sampaloc, Manila, P. I.	Ralph Stewart W. 811 Providence Ave., Spokane, Wash.	No Name 565 12th Ave., Salt Lake City, Utah

First Prize
Electric Soldering Iron



A soldering iron is made from a lady's curling iron; this opens and closes and the pincer-like action makes it possible for it to hold a bit of solder. By the incandescence of the solder touching the piece of metal to be treated, and possibly by a minute arc, the solder is melted.

AN old electric curling iron can readily be converted into an electric soldering iron by means of a few changes.

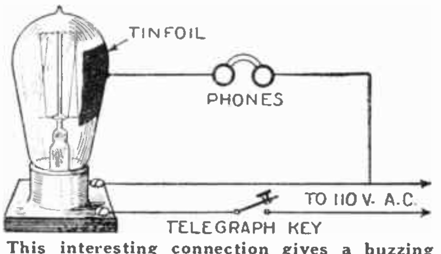
The side clip of the implement and the resistance wire are removed and a small hole ⅛-inch in diameter is bored in the end of the iron to hold the solder, which is the usual solder wire.

One end of a connection from a 110 volt circuit, either A.C. or D.C., is soldered or better brazed to the iron on the inside at the end of the handle. A resistance suitable for the iron is the next thing required, which may be the heating coil taken from the curling iron, or any other available resistance, such as the unit from a flat-iron.

When the solder is touched to the work the incandescence will melt it, and by delicate treatment more or less of an arc action can be produced. This will increase the heating effect. In this case, as in other soldering, the great point is to get the work itself heated. If it is a heavy piece of metal it should be pre-heated with a Bunsen burner or alcohol lamp.

The arc effect can be favored by the manipulation of the iron, withdrawing it and touching the work again with the solder.

Second Prize
Code Practising Apparatus



This interesting connection gives a buzzing sound for practising the code, the source of the same being the cycles of the A.C. called upon for the purpose.

A UNIQUE code practising apparatus which will eliminate the cost of buzzer and batteries, can be constructed easily in the following manner:

First, get an old electric lamp socket—one with a base is preferable. Insert in it a bulb, a 32-watt lamp will do for the purpose, and wire it in series with a telegraph key, as shown in the diagram. Now take a piece of tin foil, enough to cover half the bulb, and glue or cement it with shellac to the bulb, as in the diagram. Connect one terminal of a telephone receiver to the tin foil and the other terminal to one line of the lighting circuit. The apparatus is now ready for use.

One advantage of this home-made code practising apparatus is that one does not only learn the code easily—because the sound produced is high pitched—but it also aids the student in comprehending how to communicate by heliograph, in which the dot and dash code is employed.

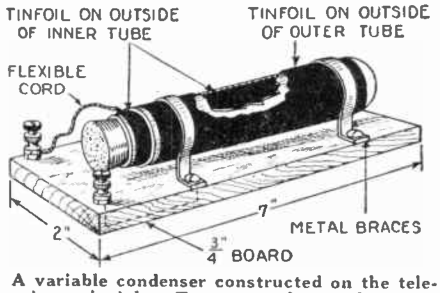
Third Prize
Variable Condenser

THE illustration shows an idea which I have been using in an inefficient static trap, but its other uses are many.

This variable condenser consists of one test tube 1¼-inches in diameter, and a similar round substance of a size as regards diameter to slide freely inside of the test tube and still have a piece of tin foil almost its full length wrapped around it once, corresponding to a similar piece of foil wrapped around the test tube on its outside. If a test tube is used for the inside it will be found advisable to put a cork in its open end to act as a convenient handle.

The one good method for fastening the foil to a wire is to get a flexible wire and spread it, wrapping the foil tightly around it. The outside tube is then fastened by padded metal strips to a base-board of almost any size that is available. By pulling or pushing the inside tube various small capacities may be obtained which are always handy in the experimenter's laboratory.

The binding posts are capped, burned or rivetted at the top only to keep the battery nuts from being lost, if the experimenter wishes to use the condenser inverted, as more convenient in some cases.



A variable condenser constructed on the telescoping principle. Two test tubes each coated with tin foil on the outside, or a test tube and a round stick of wood, supply the requisite material. By pushing the one into and drawing it out of the other, the capacity is varied.

$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.

There are dozens of valuable little stunts and ideas that we young men run across every month, and we mean to publish these for the benefit of all electrical experimenters.

Honorable Mention
Sheep Wool Trimmer

To prepare a sheep for exhibition the rough ends of the fibres of the fleece may be singed off. The idea is not to go too deeply, but merely to secure an even surface, so as to make the animal as presentable as possible.

ANOTHER useful application of electricity is shown in an electrical sheep wool trimmer. It consists of a porcelain tube 10 inches by ¾ inch, which is wound with No. 18 climax heating wire about 30 feet in length. The wire should come to within about four inches of the head of the tube so as to give room for a handle.

To this is attached a cord with attachment plug. One wire of the cord is drawn halfway through the tube, to which is fastened the heating wire. The other wire is fixed on the outside to the other end of the resistance wire. The porcelain tube has the advantage of giving a cool handle and confers a degree of simplicity to the apparatus.

The apparatus is very cheaply made and has proved efficient and satisfactory for trimming sheep for exhibitions and stock shows. It must be understood that the device is intended only for trimming the superfluous or ragged hair so as to produce a perfectly level fleece and in general a good appearance.

It will, of course, be understood that there is no idea of using this appliance for shearing. Its sole object is to remove the rough outer wool, and it can be readily seen that, in preparing the sheep for exhibition at an agricultural show or the like, this treatment might count for a great deal. It reminds one a little of the singeing process which barbers apply to the hair of their victims.

What Our Readers Think

Loss of the Historical Edison Relics

(*A Letter from Mr. Meadowcroft*)
From the Laboratory of Thomas A. Edison.
Orange, N. J.
Sept. 26, 1925.

Dr. T. O'Conor Sloane Managing Editor,
THE EXPERIMENTER,
53 Park Place, New York City.

My dear Dr. Sloane:

Mr. Edison has kept me busy on some special work for the last few days, which will account for a little delay in answering yours of September 21.

It is greatly to be regretted that we have no examples of the old Edison effect bulbs. These and many other old relics that were valuable for historical purposes were destroyed in our great fire of 1914.

I am sorry that we shall be unable to contribute what would be a valuable addition to your illustrations.

Yours sincerely,
WM. H. MEADOWCROFT.
Assistant to Mr. Edison.

(*We had hoped to illustrate in our columns the original bulbs on which Mr. Edison had based his investigations of the Edison effect. Needless to say, these would have been most interesting and valuable. Their loss in the fire coincident with the beginning of the World War is a disaster comparable to the destruction by fire of the Volta relics at Como, Italy, in the Exposition held there in celebration of the centennial of the voltaic battery.*—EDITOR.)

Contributions From Readers

Editor, EXPERIMENTER:

I am writing this to say that I think the EXPERIMENTER is a fine magazine. I like the editorials very much.

May I ask a question? Is the Chemistry department of the EXPERIMENTER open to contribution by anyone, and if so, do you pay anything for articles in this department?

Yours truly,
GERALD WELLS.

Niagara Falls, Ontario.

(*All departments of the* EXPERIMENTER *are open to contributions by everyone, and if such contributions are accepted by us we pay at the rate of 1c a word therefor. The essential thing is that the contributions shall have merit, that they shall be new, and that they are clearly written or typed on one side of the paper with plenty of space between lines; they should be accompanied by photos or diagrams; unillustrated matter is of little value to us.*—EDITOR.)

Chemistry Section

Editor, EXPERIMENTER:

I am not a subscriber to the "EXPERIMENTER" Magazine, but I buy it every month. I think it the most interesting magazine I've ever set hands on. It's the Chemistry "department" that "gets" me. You publish some real handy kinks in it, and I'm hoping you will continue the good work.

Your interested reader,
ROBERT G. DUNLOP.

Saskatoon, Canada.

(*We feel that our Chemistry Department is unique, owing to the adequate illustrations and to the full treatment which each subject receives. We should be very glad to make the section longer, but we have only so many pages and there are many radio experimenters who perhaps never look at the chemistry pages, so we have to take care of them also. We hope we are giving enough chemistry to keep you as a friend and reader.*—EDITOR.)

Kodak Printing Box

Editor, THE EXPERIMENTER:

As a reader of THE EXPERIMENTER I would like a little article put in on building a Kodak printing box for 2½ x 4¼ in. film with electric bulb on the inside and the printing frame on hinges on top, to take the film and paper, like the Eastman printing box.

As an experimenter and photographer I would like to build one.

A. J. DAVIES.

Scranton, Pa.

(*This subject has already been treated in our columns.*—EDITOR.)

Electric Tank Heater

Editor, EXPERIMENTER:

Would you please tell me how much the cost would be to operate the Electric Water Tank Heater described on page 830 of the October issue of THE EXPERIMENTER, provided the heater would be required to heat a tank with a capacity of 80 gallons. The heater of course would be operated on the standard 110 volt circuit. That is how much would the heater cost an hour to run on the above conditions, or how much a killowatt-hour?

Also would you please furnish me with more definite explanations and drawings, or if you cannot furnish me with these would you be kind enough to tell me where I could obtain them.

Very cordially yours,
ROBERT E. METZGER.

(*The expense of running a water tank heater depends on how well it is lagged or insulated against loss of heat and on how much water is taken from it. The thing for you to do is to coat it with asbestos sheet or composition; then, once the water is heated, it will stay hot for a long time. The theoretical figure would be of little use. The only detail that amounts to anything is how to insulate the wire as it enters the metal tank, and this is very easily done by a fibre bushing, or even if you have a metal coupling, by using an insulating bushing or washer therein. No drawings are needed as practically everything was contained in the article.*—EDITOR.)

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

EXPERIMENTERS and amateurs, we want your ideas. Tell us about that new electrical stunt you have meant to write up right along, but never got to. Perhaps you have a new idea, perhaps you have seen some new electrically arranged "do-funny"—we want these ideas, all of them. For all such contributed articles that are accepted we will pay one cent a word upon publication. The shorter the article, and the better the illustration—whether it is a sketch or photograph—the better we like it. Why not get busy at once? Write legibly, in ink, and on one side of the paper only.
EDITOR.

Experiments as a Topic

Editor, EXPERIMENTER:

It gives me much pleasure to write a few words for your fine magazine, THE EXPERIMENTER.

I like the new name because it gives it a much wider scope. I like to read the experiments of other fellow experimenters as I get many novel ideas while doing so. Also, your magazine stimulates people to experiment by offering prizes and paying space rates for articles, and it forms a connecting link between amateur and professional experimenters. Your magazine deserves every success.

Yours truly,
L. CARPENTER.

Burlington, Vt.

(*The above letter was received along with a number of nice little experiments, each one with its illustration, some of which we hope to give in an early issue. Our correspondents will, of course, understand that we have to discriminate between the old and the new and avoid giving things which are familiar to everybody. Then again, comes the question of how good an experiment is, and this does not mean how complicated. A very simple experiment may be admirably illustrative, just as a simple invention with its claim in the fewest possible words may be worth millions of dollars. The clue to* THE EXPERIMENTER *Magazine is: "Experiments." These are what we want and make every effort to give our readers, and we want our readers to send in contributions.*—EDITOR.)

Connecting a Stop-Light on an Automobile

Editor, EXPERIMENTER:

In the October EXPERIMENTER, in the "How and Why" department, the answer to James P. Noon's query of how to connect up a stop light, is incorrect.

The answers state that he should run a wire from the battery to the stoplight on the rear of the car. This was to go from the ungrounded side of the battery. Then from the other terminal of the battery, he was told to run a wire to a simple contact so placed that it would touch the brake pedal when the latter was pushed down. The other terminal of the lamp was to be grounded.

Unless you wish to use a special switch, you should run a wire from the ungrounded terminal of the battery to one terminal of the stop-light. From the other terminal of the stop-light run a wire to an ungrounded contact so placed that it will touch the brake when the latter is pushed down. Your brake pedal is grounded and so completes the circuit.

A special insulated switch may be bought or designed and with it you can ground one side of your stop-light, but in this case you must run two wires to the switch which is closed by mechanical contact but not electrical contact with the brake.

I would like to see a department of automobile electricity and astronomy added to the EXPERIMENTER.

Yours sincerely,
ROBERT E. WALTERS.

Logan, Ohio.

(*The circuit given is very properly found fault with by you as it would not work on a grounded circuit battery. It would only work upon a double wire circuit such as has been used on the Chalmers and other cars, although now the grounded circuit is pretty generally used.*

In the past we had an automobile section which was headed Motor Electrics, and we still hope to give this section from time to time. Can you not send us some good copy with illustrations for it?—EDITOR.)

A Pamphlet of Short Circuits

Editor, EXPERIMENTER:

The column, "Short Circuits," of your publication, has items that apply to accidents.

We believe that these items will be of great value to our school in presenting the facts in this manner to the students who are taking up the electrical course.

We therefore wish to inquire if you can furnish these items in pamphlet form.

Very truly yours,
W. G. STEPHENS, *Director*.

State Trade School, Stamford, Conn.

(*There is much very valuable matter that appears in our column and which we would be only too glad to put into book form for permanent preservation. Your suggestion apropos of the Short-Circuits is an excellent one and the writer can truthfully say that he would be delighted to see it carried out, but it will have to wait. We thank you very much for your interesting suggestion.*—EDITOR.)

Condensers with Vacuum as Dielectric

Editor, THE EXPERIMENTER:

Mr. Lagerquist, in his article on condensers in the September issue of THE EXPERIMENTER, brings forward the idea of using a vacuum as the insulator in a condenser. This sounds all very good, but the charge in a condenser is supposed to be stored in the dielectric, and a vacuum is supposed to be nothing, so it seems to me that Mr. Lagerquist's condensers won't take a charge. When calculating the capacity of a condenser, the constant of the dielectric is designated by K. If air is used at ordinary pressures, the constant, K, will be 1.00. The more you reduce the pressure the less K becomes; hence, by the time you have a vacuum K will be pretty small and so will the condenser.

Yours for better condensers,
ADAM J. KINKALT.

Detroit, Mich.

(*We refer you to the note in the vacuum insulated condenser on page 43 of the November* EXPERIMENTER. *Boltzman found that taking the specific inductive capacity of vacuum as 1, that of air is 1.00050, a very slight difference.*—EDITOR.)

Suggestions from an Appreciative Reader

Editor, THE EXPERIMENTER:

I have just received the August number of THE EXPERIMENTER and thought I would tell you how I like it. At first I was sorry to hear that *Practical Electrics* had ceased, but I soon changed my mind. I think THE EXPERIMENTER is the best magazine Mr. Gernsback has ever produced.

I have only one objection to it; it has too much radio. My principal experimenting is in electricity, though lately I've begun to dabble in chemistry. Radio takes too much money for me.

I think that if you would print the lives of some great experimenter, such as Edison or Faraday, it would interest your readers more than fiction. Well, that's just my opinion, but I'm sure some of the others think the same.

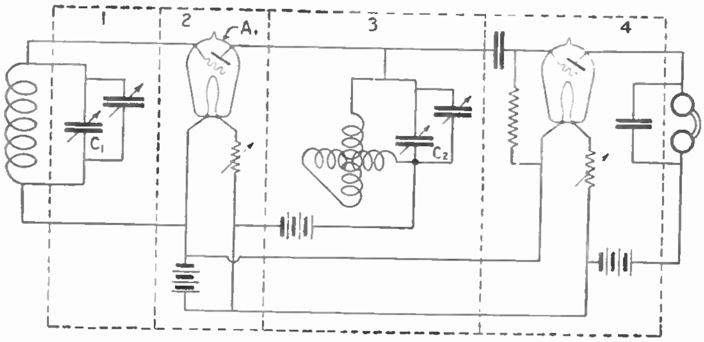
Yours truly,
HOWARD JAMES.

Olney Springs, Colo.

(*We are always glad to receive criticism of practical value.* RADIO NEWS *has been publishing biographies, but* THE EXPERIMENTER *covers so much ground that space is the great desideratum. We certainly welcome your kind words. Remember there are a great many radio experimenters among our readers, and we must take care of them.*—EDITOR.)

Latest Electrical Patents

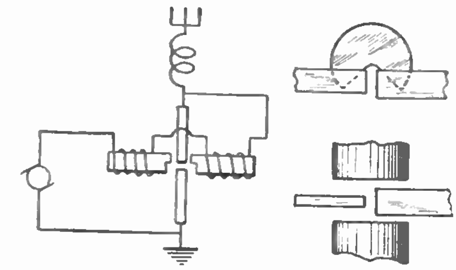
Radio Receiver



A new circuit incorporating multi-stage tuning with single control and a vernier condenser adjustment for each stage is depicted in the above circuit diagram. It is claimed by the inventor that the feature of tuned impedance coupling gives greater amplification per stage, and control of self-oscillation is simplified by effective shielding denoted by 1, 2, 3 and 4.

Patent No. 1,545,940 issued to Sewall Cabot, Brookline, Mass.

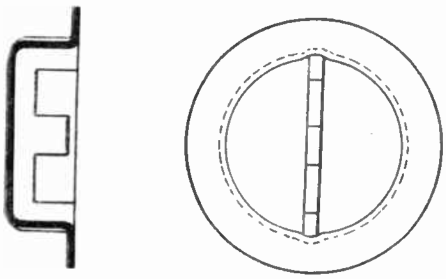
Arc Oscillator



By a peculiar shaping of the blow-out magnet poles, the inventor claims to increase the efficiency of the arc generator. It is supposed that in this type the arc will be maintained at a low voltage during the major part of the cycle, at the end of which the voltage rapidly increases.

Patent No. 1,545.599 issued to P. O. Pedersen, Fredericksberg, Denmark.

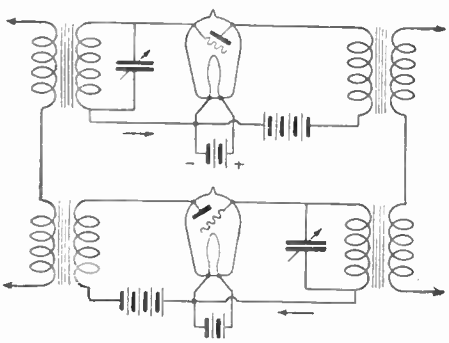
Telephone Receiver



This receiver comprises a diaphragm and a magnet contained in a case as usual. The magnet is "E" shaped in contour and is forced into the case with the back of the "E" against the back of the case and the diaphragm in front as shown clearly in the drawings. In this way, the use of screws and other attaching parts is effectively avoided as the case is made a little too small for the magnet so that it has to be driven in by force.

Patent No. 1,545,920 issued to O. Oelze, Kiel, Germany.

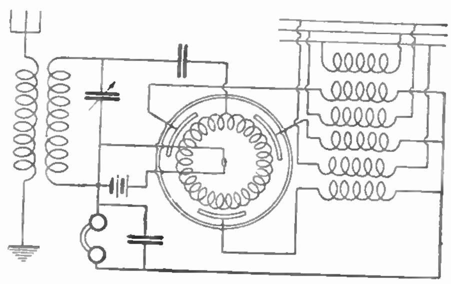
Two-Way Telephone Repeaters



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.

Polyphase Vacuum Tube

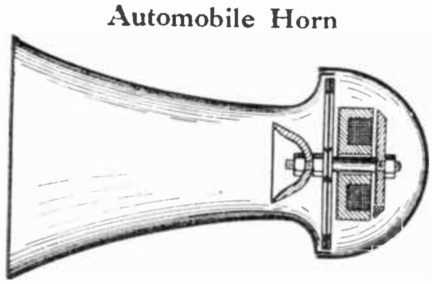


Dr. Slepian of the Westinghouse Company has designed this vacuum tube provided with a plurality of plates and with a polyphase plate excitation. The resulting potential of the polyphase system being constant in amplitude, the effect produced is equivalent to direct current excitation.

Patent No. 1,533,278 issued to Joseph Slepian, Swissvale, Pa.

(Corrected from November Issue)

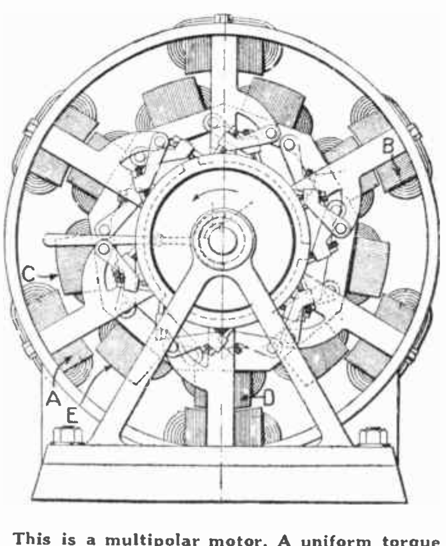
Automobile Horn



The inventor of this device claims that the fullness of the tone and the sounding distance are materially improved if at the horn side of the diaphragm at the place of its greatest oscillation some vibratory body is so affixed that it is in contact with the diaphragm at only that one point.

Patent No. 1,533,964 issued to H. Horig, of Stuttgart, Germany.

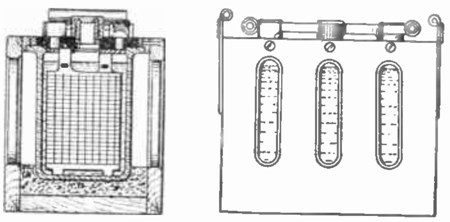
Magnetic Motor



This is a multipolar motor. A uniform torque on the shaft is produced by a special excitation of the various magnets. In some constructions single magnets of the armature are excited at one time, and at other times compound excitation of some of the armature magnets along with the field magnet occurs. The connections, which are quite complicated, have to be studied in the patent.

Patent No. 1,546,720 issued to R. H. Davis, Dow, Okla.

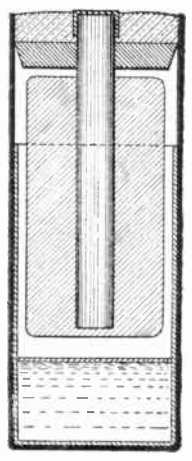
Novel Battery Jars



Many storage battery troubles arise from poor condition of the battery plates, large quantity of sediment or low level of the electrolyte. This invention provides a window for each cell through which the condition of its contents may be observed.

Patent No. 1,545,753 issued to C. F. Gilchrist, Toledo. Ohio.

Telescoping Battery



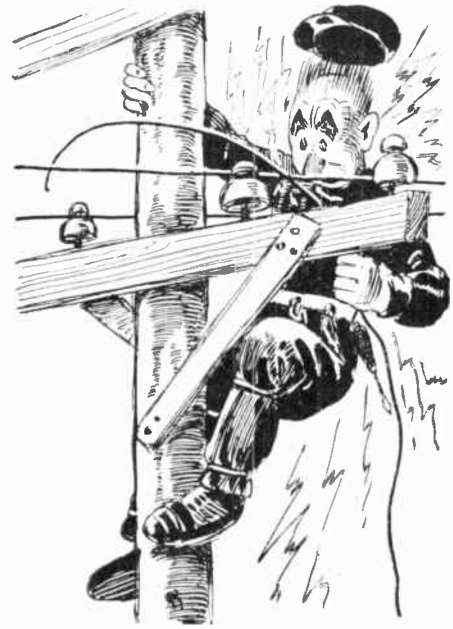
This battery consists of two sections, one telescoping into the other. To make it active the inner member is pushed down, to make it inactive it is drawn up. Thus it can be made inactive for transportation and when received can be made active by pushing down the interior division.

Patent No. 1,533,012 issued to Harry M. Koretzky, et al., Brooklyn, New York.

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!

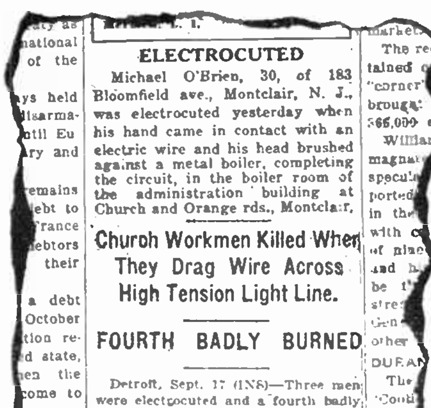
Deep under this sod
  Lies Jimmy McGuire,
He threw his antenna
  Across the trolley wire.
—*R. C. Hawkins.*

Quick was the demise
  Of Jenny Van Stare.
A lightning stroke jumped
  From a socket to her chair.
—*O. P. Dickinson, Jr.*



'Neath this stone
  Lies the late Bob McDoves.
He ridiculed the thought
  Of wearing rubber gloves.
—*Glen F. Stillwell.*

Here lie the remains of
  Chinaman Wun Lung Lee.
He turned on the current
  While doing his "washee."
—*John L. Staunton.*



ELECTROCUTED

Michael O'Brien, 30, of 183 Bloomfield ave., Montclair, N. J., was electrocuted yesterday when his hand came in contact with an electric wire and his head brushed against a metal boiler, completing the circuit, in the boiler room of the administration building at Church and Orange rds., Montclair.

Church Workmen Killed When They Drag Wire Across High Tension Light Line.

FOURTH BADLY BURNED

Detroit, Sept. 17 (INS)—Three men were electrocuted and a fourth badly burned today when workmen on the new St. Thomas Catholic Church and school dragged an elevator guy wire across a high-tension street light wire.

The accident occurred shortly before noon when the streets were crowded with school children.

The sudden electrical flash and cries of the men as they dropped to the ground resulted in a near panic.

Several children became hysterical.

The four men had been instructed to aid in moving the guy wires of the construction elevator, which was being used to hoist stone, wood, concrete and other building materials. While walking with the wire, it came in contact with the street arc light wire, and the men were killed instantly.

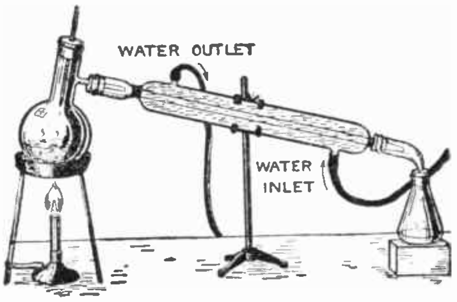
An investigation of the accident will be made immediately, the Coroner said.

Shocking was the end
  For Mineralava Roth.
The switchboard she cleaned
  With a soaking wet cloth.
—*Paul Markarian.*

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.

Liebig's Condenser



How to set up a Liebig's condenser; the water enters at the lowest point and leaves at the highest, taking exactly the opposite course to that of the distillate.

(546) A. Lerner, Pittsburgh, Pa., asks:

Q. 1. In a Liebig's condenser, should the cold water for condensing enter at the top or at the lower end? I understand that it is set in an inclined position.

A. 1. It should enter at the lower end and on the bottom of the condenser. The effect of this is two-fold; if you will study the illustration you will see that the effect will be to keep the interior of the condenser completely filled with water so that the central tube is surrounded therewith. The cold water gets heated as it passes through the condenser so that the gas or vapor to be condensed first meets the warm water and leaves the tube subjected to the water at its full degree of coldness.

Motor Specifications

(547) Edmund Harris, Antigo, Wis., asks:

Q. 1. Could you put a diagram of a motor in the EXPERIMENTER according to the following specifications: Taking a 110 volt motor, 5 amperes more or less of 1/8 horse power, and changing the windings for a 6 volt battery which would run on a storage battery.

Q. 2. I am experimenting with a biplane glider. Would you let me know where I could get a 1/2 to 1 horse power gasoline motor? I'll be waiting for the next issue of THE EXPERIMENTER.

A. 1. Your electrical arithmetic is faulty as your motor is about two-thirds of a horse-power. A rough way to calculate the wire is to take the same weight of wire but of twenty times the cross-sectional area for the winding.

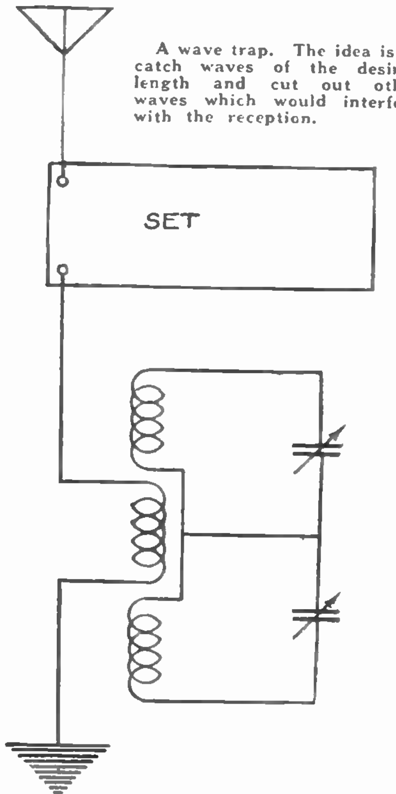
A. 2. It may be hard to find so small an explosion motor. Do you not think that a motor from a motor cycle might meet your requirements even if the horse power were a little high?

Duplex Wave Trap

(548) James P. Madison, Spokane, Wash., inquires:

Q. 1. Is it possible to construct a wave trap which will readily eliminate interfering frequencies, both above and below the frequency it is desired to receive?

A. 1. The accompanying diagram shows how simple it is to install such a device as you have in mind. In series with the ground connection is a 10-turn coil. Closely coupled to both sides of this coil are two larger coils, one containing 55 turns and the other 62 turns. Both coils are tuned by means of separate .0005 variable condensers, and they can be independently adjusted to eliminate any interfering frequency. The system is capable of completely absorbing powerful local signals and allowing the reception of distant ones.



A wave trap. The idea is to catch waves of the desired length and cut out other waves which would interfere with the reception.

Static Eliminator

(549) Donald Atwell, Columbia, S. C., writes as follows:

I read THE EXPERIMENTER and have done so for a number of years. I am coming to you with a question which I think will interest you and the radio world.

Q. 1. What would the Government or a radio corporation pay for a device that would eliminate static and all noise from radio?

A. 1. If you could discover a way of doing what you specify, and could protect it by patent, and if no one else got up an opposition way of doing it, you would have a very valuable invention. What any specific corporation or concern would pay for it, we do not know. The Government probably would not buy it.

But do not imagine that you have discovered any such thing.

Gas Filament Lamp.

(550) O. J. Huge, St. Louis, Mo., writes:

Q. 1. Referring to the gas filament lamp described in the July issue of THE EXPERIMENTER, what kind of gas is used? How can the tube be incandescent if gas is in it?

A. 1. Various gases can be used in the tube; neon would seem to be particularly available; the tube itself does not become incandescent, it is the gas within it which gives the light. You can see this action in the numerous neon tubes now used for advertising purposes in the shape of letters, and also in the mercury vapor lamps used by photographers and by moving picture producers.

Audio Amplifiers

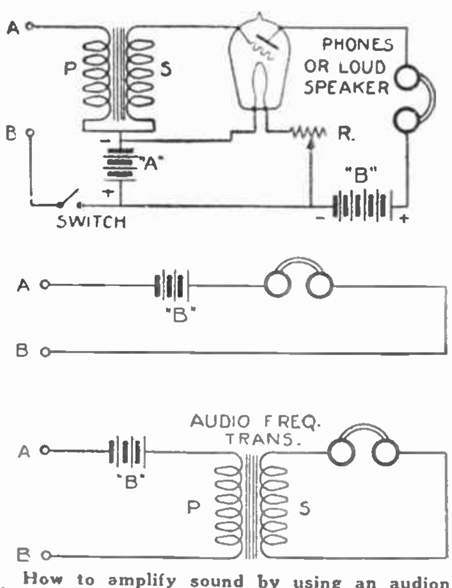
(551) Marcus Ducane, Pittsburgh, Pa., states:

Q. 1. I have a carbon type microphone and would like to learn of the various ways in which I can amplify the voice sufficiently to be loud enough for a moderately deaf person to hear. Can you give me the information?

A. 1. If reference is made to the diagrams, it will be noticed that the first system employs a set-up audio frequency transformer which can be of 4 to 1 ratio, and an ordinary type 201A vacuum tube. The battery which lights the filament of the tube also acts in the capacity of supplying the microphone current. This system is by far the best, although a bit more expensive than the others. The voltage of the "B" battery can be from 20 to 50 volts.

The second diagram shows the simplest method, which consists merely of a small battery giving 4 to 6 volts and a pair of telephone receivers.

In the third diagram, the use of a simple step-up transformer is depicted. This latter system is more generally used because of its ruggedness and it furnishes sufficient amplification—depending upon the ratio of the windings of the transformer—for all average purposes.



How to amplify sound by using an audion bulb so that a moderately deaf person can hear what is said; it can also be used with a detectaphone.

Three Brush Generator

(552) James A. Cooper, Batavia, N. Y., asks:

Q. 1. Why does an automobile generator having 3 brushes run harder with no battery connected than when it is connected?

Q. 2. Why is it that a spark coil giving a ¾" spark on 8 volts of battery will not give any spark to speak of when the vibrator is screwed down tight, and 5 amperes at 110 volts 25 cycles pass through it? It seems as though it ought to give at least 4- or 5-inch spark, using so much more primary current and voltage.

Q. 3. What is ultra-violet light? Can you recommend a good book on this subject telling how to build apparatus to produce it?

Q. 4. Is there any available data on building apparatus to produce ultra-high frequency currents such as were used by some scientist. I don't know his name, who rendered the plate of a vacuum tube transparent giving the effect of cold light?

Q. 5. Please refer me to some good books on rare gases of the air, including laboratory technique for producing them.

Q. 6. Is it legal to make ethyl alcohol for chemical laboratory use without violating the law?

A. 1. It all depends on how it is connected, whether the battery is connected so as to drive it, or whether it is driven so hard as to charge the battery. When charging a battery it is working against the electro-motive force of it and this cuts down the current it produces so that it runs easier than if it were generating current through a simple resistance equal to that of the battery. If the battery were running it as a motor then it would run easiest of all.

A. 2. 25 cycles gives a very slow make-and-break for a spark coil. The great displays given by the Tesla coil are due to the rapid make-and-break incident to a spark discharge.

A. 3. Ultra-violet light gives ether waves of frequency exceeding that of violet light, and therefore not affecting the eye, it is merely a question of frequency of vibration. We have had several articles on the subject. An arc lamp with metal electrodes gives these rays and a mercury arc lamp in a quartz tube does the same. Glass will not pass them while fused quartz does. There is no book that we know of devoted to this subject; both the arc lamps are described in several issues of our magazine.

A. 4. Ultra high frequency currents which you speak of might designate the Tesla coil experiments; but we do not know what you allude to.

A. 5. These gases are produced by liquefaction of air; the most recent authority on the subject is a work by Georges Claude on the liquefaction of air, which you can procure at the scientific bookstores.

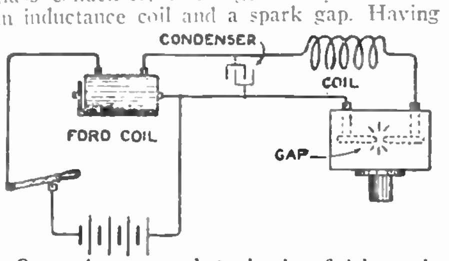
A. 6. You should not attempt to distill an alcoholic liquid unless fully protected by permit from the Internal Revenue Department of the Federal Government.

Ozonator

(553) John O'Mara, Mt. Vernon, N. Y., asks:

Q. 1. Kindly give details of construction of an ozone generator.

A. 1. You will need a small spark coil, a glass condenser, a storage battery, a switch, an inductance coil and a spark gap. Having



Ozone is supposed to be beneficial to the blood. Above is shown a simple ozonator which can be cheaply constructed.

procured these materials, the spark gap is enclosed in a wooden box and an opening made in one side to which is fitted a short length of large sized rubber hose. The construction of the condenser is as follows: 8 photographic 5 x 7 plates are used to separate sheets of tin foil, 4 x 6. This condenser is connected in parallel across the secondary of the spark coil and in series with the spark gap is connected the inductance coil. The coil is comprised of 10 turns of No. 8 bare wire placed in an insulating framework, six inches in diameter. Zinc terminals are used in the construction of the spark gap.

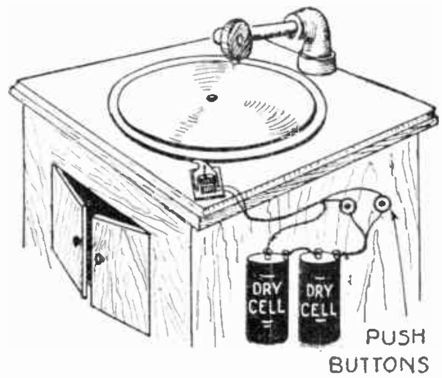
In the operation of the ozone generator, care must be taken not to touch any of the high voltage wires or else a discomforting, but not serious, shock will result. As a precaution, do not inhale too much ozone since it will be detrimental in its effect upon the body tissues.

Electrically Operated Phonograph

(554) W. Classon, Detroit, Mich., wants to know:

Q. 1. Can a phonograph be stopped and started by electricity?

A. 1. As you stand in front of the phonograph you will see a little to the right the brake or stopping piece. By providing this with a spring to pull it open, so that the phonograph will go, and attaching to it an armature with an electro-magnet to attract it so as to put on the brake and stop the phonograph, when current passes, you will have an arrangement by which a battery will stop and start it. It will start it by releasing the brake and stop it by putting on the brake. The driving force of course will be the spring. As shown in the illustration push-buttons are mounted on the side of the case for stopping and starting it, but these push-buttons of course can be placed in any desired part of the room.



Showing how to start and stop a phonograph electrically.

Gravity and Density

(555) John Timberlake, Shadyside, Ohio, writes:

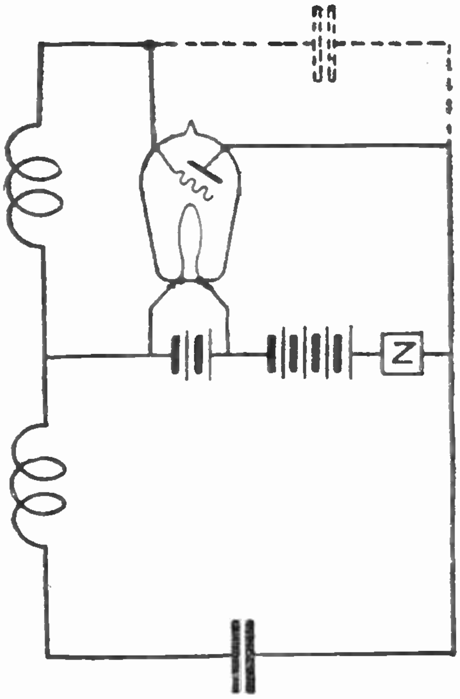
Q. 1. We have been arguing in our high school physics class as to whether a piece of steel that was dropped in the ocean would sink to the bottom at an unlimited depth. Would like to have your opinion on this matter.

A. 1. The steel would sink until it reached a point where the gravity of the water above it would pull it up hard enough to compensate the down pull of the water below it, or of the water and earth below it, as the case might be. In the center of the earth an object would have no attraction or rather pull in any direction; but for all obtainable depths of water on the earth the piece of steel would sink to the bottom.

A Constant Frequency Oscillator

(556) Jerry Stoner, Oshkosh, Wisconsin, asks:

Q. 1. Kindly give me data for a radio frequency oscillator which will operate at a frequency of approximately 500 kc.



Circuit showing how to wire a constant frequency oscillator.

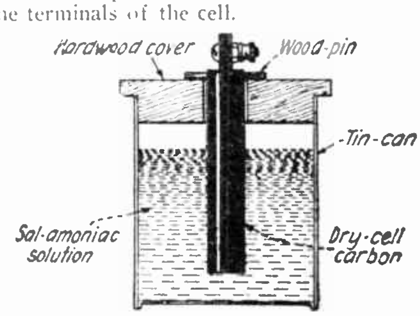
A. 1. We are giving you herewith the details concerning the oscillator you mention. The grid coil is wound on a 3½ inch diameter form and consists of 75 turns of No. 18 D.C.C. wire. The plate coil utilizes 50 turns of the same size wire wound on a similar form. The plate feed-back condenser is of .002 mfd. capacity while the auxiliary shunt condenser across the grid and plate may be of .0001 mfd. At Z, may be placed a pair of phones and if the oscillator is coupled to an antenna, C.W. signals of a 600 meter wave-length can readily be heard. The use of a grid leak and grid condenser is optional and depends upon the type of tube being used. To make the oscillator cover a large band of frequencies it is necessary to shunt only the grid inductance with a .0005 variable condenser.

A Le Clanché Type Cell

(557) David Reynolds, Jamaica, West Indies, asks:

Q. 1. Will you please publish all the necessary information concerning the construction of an open circuit wet cell, preferably using a tin can container?

A. 1. First, clean the tin can thoroughly and fit a hard wood cover boiled in paraffin to it. In the center of the cover, drill a hole large enough to accommodate a dry-cell carbon. Next, fill the tin can about five-sixths full of sal-ammoniac solution. The solution can readily be made by adding a few ounces of the salt to clear cold water. In the original LeClanché cell, a cylindrical carbon electrode encloses a zinc rod which passes through its center and is insulated from it. The use of the tin instead of zinc slightly lowers the potential difference available at the terminals of the cell.

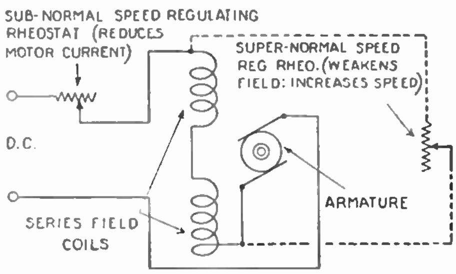


A simple wet cell of the Le Clanche type.

Variable Speed Motors

(Continued from page 99)

regard to the path of the magnetic flux between the field poles and across the armature gap, are shown in Fig. 6. At Fig. 6-A we see that a wooden armature core would result in an excessive magnetic leakage, which firstly, of course, is wasteful; and sec-



VII

The use of rheostats in the armature and field circuit of a series wound motor for regulating the speed is shown here. It is all a question of weakening or strengthening the field.

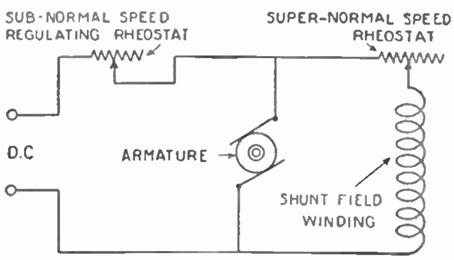
ondly, the amount of magnetic flux passing across the polar gap in which the armature rotates would be very small. Fig. 6-B shows the reduction in magnetic leakage and also how the magnetic flux between the field pole faces is carried through a toothed iron armature of the modern type. This type of armature is as nearly perfect as possible, the armature windings or wires being carried in the slots shown. The chief advantage of the toothed armature is that its outer periphery can be very close to the field pole faces, as close as 1/32d inch in some small motors. This results in a very high efficiency for the flux path through the field frame and in a minimum requirement of magnetizing force for the field. The more electrical energy we have to waste in the field excitation, the lower is the efficiency of the complete machine, of course.

Fig. 6-C shows the old type of surface wound armature, where the iron core has slots cut longitudinally along its surface at equal intervals, corresponding to the width of the coils. In these slots, fibre partitions the length of the armature are driven and the armature coils are then wound on between them, over the proper core insulation of course. This makes a hand winding job. After all of the coils have been wound and shellacked, they are bound in place by several bands of steel piano wire or phosphor bronze wire, soldered and held in place by copper clips, these bands being wound over mica. The great defect in this old design of electrical machine, which was the principal type found twenty-five years ago, is that there is a large air gap between the field poles and the iron core of the armature. This means a lower efficiency for the whole machine, as a greater magnetizing force has to be provided in the field coils to force the flux across these relatively large air gaps.

The surface wound armature of this type is among the most undesirable of the designs brought out, from an electrical point of view: while mechanically it is also one of the poorest. The mechanical trouble lies in the fact that the armature wires are not held rigidly enough in place, and at high speeds or under sudden over-load conditions, etc., the armature conductors were sometimes torn from their positions, the wires being jammed between the armature and field poles. In one case a ten horse-power armature of the surface wound type, which the writer had rewound, and which did not have any fibre or other partitions between the coils, except those at the ends of the armature, split in two halves shortly after being put in place in the machine, and the wires did everything but jam the air gap between the armature and field. Nothing could be done with the armature winding and it had to be rewound again, which required several days' work. The trouble in this case, the explanation of which may prove of value to electricians called upon to rewind such an armature, was due to the fact that the varnish used on the armature windings had not been sufficiently baked and dried for one thing; and secondly, there were not a sufficient number of piano wire bands on the armature to hold the conductors firmly to the core. It should be noted at this point that two very important things happen when an armature rotates between the field poles of a motor or dynamo.

The first thing that happens is that in any surface wound armature particularly, the centrifugal force due to the rapid rotation of the armature tends to force the conductors away from the core. This mechanical stress is frequently exceeded by the electrical stress occurring, which is created by the magnetic pull of the field poles on the current carrying armature conductors. If you don't think there is much of a pull between a magnet pole and a conductor carrying anywhere from five to several hundred amperes perhaps, just try it out in your laboratory. This magnetic stress has to be taken into consideration by electrical designers, even for switchboards, owing to the heavy currents passing through the bus-bars and the resultant powerful magnetic fields surrounding these bars, tending to dislocate them or cause short-circuits.

Fig. 6-D shows the most perfect magnetic design for an armature that the writer ever came in contact with. This armature, built up of annealed steel laminations, had tunnels provided for the armature wires. Of course, this armature is impractical from the winding point of view, as each coil had to be tediously threaded and wound into place by means of small shuttles or bobbins. It



VIII

This is an analogous system to that shown in Fig. 7, but applied to a shunt wound motor. Both diagrams are practically self-explanatory.

stands at the head perhaps for magnetic efficiency, but the slotted toothed armature used universally today is the acme in general electrical and mechanical design. Figs. 6-E and F show the paths of the field flux in the modern toothed armature design as contrasted with the old surface wound armature with its proportionately larger air gap.

Fig. 7 shows the use of rheostats in the armature and field circuits of a series motor for regulating the speed above and below normal; while Fig. 8 shows the use of rheostats for varying the speed of a shunt or compound wound motor above and below the normal speed value. These methods are more of the well-known and obvious types than the ones described in the body of this article.

QRM [I am being interfered with]

(Continued from page 89)

why amateurs are not concerned.

Not so long ago and particularly before the Third Radio Conference held in Washington, D. C., last October, it was the rule rather than the exception for one service to interfere with the adjacent service. Those who live near the coast or lakes have vivid memories of code interference that once made broadcast reception unenjoyable. This commercial interference has been almost entirely done away with so far as American stations are concerned. On numerous occasions articles have appeared regarding the accomplishments of these annual Radio Conferences. Particularly, do I again desire to mention the discontinuance of the 300 meter and 450 meter wave bands for the use of the commercial stations as having done more toward relieving broadcast reception from being interfered with, than any other official act since broadcasting stations were granted other waves than 360 meters. In addition to the discontinuance of the above mentioned waves, the old International wave of 600 meters has been changed so that now it may only be used for calling and distress signals and at the present writing it is possible that this is to be discontinued. This moves commercial code interference caused by American stations to the use of waves sufficiently in excees of the average B. C. L. tuner, so that it is almost impossible these days to hear a commercial at all.

The Navy, Army and Post Office stations are causing but little interference at present—and what few harmonics, mush and the like that do happen down on the lower bands, is being eliminated as promptly as circumstances will permit.

The waves now granted to amateurs and the ones most favorable to meet the amateur's needs are those under 85.7 meters. True, he is still licensed for operation in a band between 150 meters and 199.9 meters which band merges into the Class "A" broadcasting band. However, few of them are using this wave at the present time and it is my opinion that little complaint would be made if half or all of it were given up to broadcasting stations. Some persist in clinging to the old waves and to the old obsolete types of transmitters such as the spark transmitter, ACCW sets or even ICW and 'fone sets. Some also use coupling that serves to defeat the purpose of the law requiring coupling that is not conductive or even approaching it. I now have reference to certain capacity coupled transmitters that pass harmonics with less reactance than the natural wave and what is worse, keyclicks in abundance, also coupling that is inductive in design but far removed from it in practice, coupling that is more jammed than a commercial sending out distress signals. As in the old spark days, there is a proper adjustment that is most efficient and honestly, it is *not* the closest coupling possible betwe primary and secondary circuits.

Defective appa atus in these days is not a great cause for troublesome noises and for that reason is only to be briefly mentioned. Occasionally it happens that we permit our "B" batteries to become practically discharged and to develop a "noisy cell" before we realize it. This is often the case when a l rge number of tubes or exceedingly high plate voltages are used. Also, storage "B" batteries are a source of annoyance providing they are of a type that allows the acid to creep or spray. This, likewise, applies to storage "A" batteries although the greatest cause of their being responsible for irritating noises is due to electrical breakdown or leakage internally. It has even been found that storage cells when charged too rapidly or when given a long overcharge and when placed in service immediately will cause noisy and fluctuating reception. This may be due to excessive gassing or bubbling. It is advisable to refrain from excessive charging or overcharging. If not possible, either permit the battery to stand an hour or so before placing it in service, or else possibly suffer unsatisfactory reception.

It does not seem necessary to discuss in detail the subject of connections. Everyone knows that each and every joint, connection and what not, are to be electrically and mechanically perfect. Do not worry so much about your low-loss apparatus and then overlook your connections. Remember, the chain is only as strong as its weakest link; analogous to this proverb and a later version is, no radio is more perfect than its poorest contact.

Almost everyone knows that such tubes as use thoriated filaments, *i.e.*, type UV-201-A or C-299, etc., are subject to vibrations and jars and set up microphonic disturbances, especially when amplifiers are used. The logical method of alleviating this trouble is naturally to damp out these vibrations before they are transmitted to the tube elements. Spring sockets, sockets mounted on soft sponge rubber and suspended sockets are some of the arrangements being used.

Faulty cords to radio receivers or speakers are, and always will be, a common cause for noises. Whenever your cords become worn or frayed, replace them as a safeguard—they may often cause trouble even though not worn.

Variable grid leaks give an unusually large amount of trouble, occasionally and in my mind I do not believe average conditions warrant their use. It is safest to have a number of fixed leaks to use in a clip mounting.

In helping the lighting company to clear up trouble with power leaks, it is a good plan to mount a loop antenna and a small receiving set on the hood of the inspector's car.

It is not necessary to go into more detail regarding the other pieces of apparatus as sockets-contacts, rheostats, poor jacks, sprung condenser plates, etc., that can and do ruin many an excellent program and try a good man's patience. Suffice to say, do not expect more out of radio than you put into it. Like everything else you will find the Golden Rule must be lived up to. If you want someone to see about that inductive interference go out and get it yourself. The next time a neighbor's receiver chirps or howls at you, ask yourself if you are doing the same thing to him by improper operation of your set. When some other service encroaches upon your pleasure and interferes, take the matter up with the offender and ninety-nine times out of a hundred you will find the guilty party is ignorant of the interference he is causing and is very grateful to you for your report. This other party who is resentful and unwilling to act the part of a gentleman *should be reported* to the Radio Supervisor.

Now, to be concise and to put in a few words what has previously been said in many, for after all this radio game is not for the individual but rather for the whole of us—"Do unto others as you would have others do unto you." *(Only do it first."*—Ed.)

A Circuit Tester DeLuxe

(Continued from page 86)

pass condenser, especially if the needle is unsteady. Zero reading will denote open circuit.

Detector Plate Circuits

These should read 18 to 35 volts, depending on use of 22½-or 45-volt detector potential. Higher reading shows shorted or grounded primary of the first audio transformer. Lower reading shows a bad connection, or, if unsteady, a bad detector bypass condenser. Zero reading will denote an open primary or a broken or disconnected wire in circuit.

Audio Frequency Plate Circuits

65 to 75 volts is a correct reading. Higher reading indicates shorted or grounded primary of A.F. transformer, lower, bad connections or poorly soldered ones. If unsteady there is a leaking by-pass, and zero reading indicates an open primary.

It will now be seen that we have tested almost all the parts in the set, the wiring and the connections. Best of all, we have done so without disconnecting the batteries or removing the set from the cabinet, and in about one-hundredth of the usual time. Test the variable condensers for touching plates, the detector grid circuit for continuity and the antenna coil for open, and we are reasonably sure that the set is in perfect shape.

For sets of the "can" type, such as the Radiola Super Heterodyne and the Music Master-Ware type No. 250, the tester is invaluable. It is the only quick way to check up this type of set and was originally designed for this purpose.

Improvements will readily suggest themselves to the operator for the particular work to be done. The red wire or plate lead may be broken and a 0 to 5 milliameter inserted enabling the plate current on each socket to be checked. This connection will catch many high resistance leaks.

Point 1 is used to determine actual filament voltage only. It will prove valuable in the determination of proper rheostat setting. Due to plate and grid connections, a set will not work well while the tester is in one of the sockets.

If difficulty is encountered in obtaining the specified meter, another make may be substituted. The one used by the writer is extremely satisfactory in every respect and superior to any he has tested for this purpose. If the filament voltage feature is not desired, the instrument can be made using the plate, grid and negative "A" connections to any of the two scale meters now on the market. Connect same to an old tube base, and provide a suitable handle for ease in use.

Seeing the Unseen

(Continued from page 97)

ed of the best crystal glass of double thickness, immersed in wax, the plates being at least 8" x 10" of No. 32 soft brass. It was found by me that the best crystal glass produced less heat than mica, and for this reason was less liable to puncture.

In using the apparatus as shown in the illustration, I found that the primary coils were of only secondary importance to the tuning of the apparatus as above described. With this apparatus in complete resonance, the results obtained far surpassed my anticipation. The ordinary snarling and snapping of high frequency currents passed entirely away, and as the inductances became more and more in perfect accord, such static displays ceased altogether and the apparatus stood before me glowing with a strange light, silent with the exception of a hissing sound such as from steam escaping at a high pressure. The brush discharge extended not only around the apparatus, but around the condenser also.

In reference to the danger from such an apparatus, I found the effect entirely different from that produced by coming in contact with the ordinary 110 or 220 volt current. It is sufficient to state that there is no shock whatever, but caught within its embrace, the contraction of the muscles slowly paralyzes a person, and when pulled loose from the apparatus there were no ill effects, no burning of the flesh or rupture of the blood vessels of the heart, or brain, as found in the ordinary electrocution.

As almost everyone is interested in the transmission of wireless telegraphy and telephony, the effect of this apparatus upon wireless reception and transmission may be of special interest. When in operation all such transmission and reception within a certain range is absolutely impossible. It was found that receivers within our neighborhood, extending several blocks, howled and shrieked, while those in the immediate vicinity of the apparatus were entirely useless.

In any event, you cannot experiment in a field which promises more than in this field, that is, seeking the unseen and communicating with the unknown.

The Experimenter's Bookshelf

College Chemistry

ELEMENTS OF CHEMISTRY. By William Foster, A.M., Ph.D. xviii. 576 pages including index. D. Van Nostrand Co., New York, 1925.

Nearly 600 pages of print are devoted in this book to the elements of chemistry for the use of students in colleges and universities. As we turn over the pages, we are impressed by two features. One is the brief treatment given to each subject, but when in addition to this we realize the great number of subjects which are treated, the necessity for condensation becomes very obvious.

The book impresses us as being an admirable compendium of chemistry. Intended for students' use, each chapter is followed by a summary of its contents and a number of questions covering what is treated in its pages. It is emphatically up to date, and the exactness of the sub-divisions will be realized when we find that there are 47 chapters indicating great systematization.

The only criticism possible to offer on this book is that if three or four volumes were devoted to its topics it would be an improvement and this rather obvious remark is the greatest compliment we can give it, because nothing seems to have been missed, and we take pleasure in warmly recommending it to our readers. A condensed manual as good as this is very valuable. The division is somewhat peculiar in some places, being very much up to date; for when we find bismuth and antimony put into the nitrogen family we might almost say that the book is a victim to chemical modernism.

The work is characterized by a very full presentation of the experimental side of chemistry, and recent developments in manufacturing various compounds are given well up to date. We note the Atcheson furnace for manufacturing graphite, which originally was used principally or nearly entirely for carborundum products. But when the proper place is reached, carborundum is very adequately treated with illustrations of the furnace, although the first suggestion of Atcheson's work under graphite might make one apprehensive that carborundum is omitted. But it is not.

A quantity of interesting portraits are shown in the book, of living men as well as of the old scientists; Baekeland, the inventor of bakelite; Atcheson, the inventor of carborundum and the developments which followed it, are among the modern scientists whose portraits are given.

How Atoms Are Constituted

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

This is an attractive little contribution in very elemental style to the study of the theory of the structure of atoms. It comes from the Oxford University Press and the author is a lecturer in the University of Sheffield. It is a picturesquely written little book; the first chapter entitled "Mainly Historical" is an excellent starting point, recalling to our mind almost forgotten old time experiments. But not only that, coming down to date, it treats of J. J. Thompson's work and the name of Rutherford also appears in this chapter.

The author writes in rather a light vein, and at first sight the book appears too elementary; but the writer of this review has so long advocated starting at the bottom with the usual run of books of this type, that he cannot with any consistency criticize it for this feature. Coming from England, we do not find American scientists overlooked. There is an excellent picture and description of the Coolidge tube, and Millikan's work is appreciatively referred to, and when we get to radio the Hertzian experiments are treated as the germ of wireless telegraphy. In connection with the description of the audion or thermionic valve, as the English author of the book calls it, we would have liked to see the Edison effect noted. It was in 1884 that Edison made the discovery which makes modern radio what it is. A few pages are devoted to atomic structure as investigated by X-ray examination of crystals.

A curious little two page glossary of terms and a select list of books close the text of the work, which is followed by a quite adequate index.

It is evident that 128 pages of a duo-decimo book are hardly sufficient to cover the range of science expressed in the title, but the fact that the work comes from the Oxford University Press lends it rightly or wrongly an authoritative aspect.

Elsewhere in our columns the Edison invention is fully treated. Without it we should have had but a very inferior radio, and the rapidly extending application of the audion links the names of Edison and DeForest with some of the most interesting developments of recent days, and it is a prudent prophecy to say that more is to come.

Lighting with Neon Lamps

(Continued from page 72)

bility, consider a 15-foot letter "N." A single 15 mm. (6/10 inch) neon tube set along the center line of the 12-inch to 16-inch channels has sufficient power to give a brilliant illumination of the letter for its entire width. The resulting illumination will be far superior to that obtained with electric bulbs, and will not only be four times cheaper in cost, but have greater visibility and attractiveness.

The larger the installation, the greater is the difference in operation costs between the neon tubes and incandescent lamps. This is a point worthy of the consideration of those using or contemplating the erection of a large roof sign. Many have held up or rejected the idea of putting up a large sign, due to the large cost of operation, but with neon tubes, such a sign becomes a possibility within means and will permit longer daily use at a moderate operating cost.

The construction of the tubes is such that the letters which they compose are safe for operation at high potentials. However, when the letters or words are too long and would thus necessitate extremely high voltage, the tubes are made up in short lengths of two or three feet. Inasmuch as 200 volts are required for every foot of tubing, the sections are wired in series-parallel. As an example, the words "THE EXPERIMENTER" in a forty-foot sign would require a potential of 8,000 volts for successful operation which is about the maximum voltage used.

There are two constructions of letters shown. In one a single tube in the center or axis of the trough-like letter gives a single lighting effect. In others there are two parallel tubes following along the edge of the letters giving a double effect.

The Ark of the Covenant

(Continued from page 77)

"That's it. It won't combine with anything."

"And that's why our shells did not fire the gas in the envelope?" Milliken insisted.

"Exactly. The aithon would not make the necessary combination with oxygen," Dan said patiently. "Now think of it. We know hydrogen, unsatisfied with its one external electron, has a valence of one. Helium, the element next to hydrogen in weight, satisfied with its two electrons external to the nucleus, has no valence whatever. Here's a thing lighter than either, also with no valence. What makes up its system? We imagine hydrogen to have a positive nucleus round which is whirling a negative electron—or that they're going round each other like the knobs on a twirled dumbell. That's the simplest system we know. But this aitherium—I mean this *aithon*—is much lighter in mass than the hydrogen, and a simpler system is argued. I'm putting it very crudely and in painfully unscientific terms, but I want you to understand——"

"We get you so far, Dan," said I. "What follows exactly?"

"One mustn't say what follows—exactly," he replied. "The thing must be determined by experiment before one begins to talk in set terms. I leave it so, and get along to the next point.

"But it is a curious thing about scientific discovery," he went on, half to himself, "that each new step, at first thought revolutionary, serves but to illumine older ideas. We can say that much about the discovery of radio-activity. A few years before the discovery of radium by the Curies in 1897, anyone postulating the now established facts about radium would have been laughed at; but it was only by applying to the new facts of radium the then established principles of science that the full significance of these new facts was realized. This may well prove to be the case with aithon, when new instruments are made to examine it more delicately than is now possible."

We were now getting a taste of Dan Lamont, the university lecturer, and I dare say Milliken and I were gaping at him, for he turned suddenly with a grin and said as if mocking his own seriousness: "This is deep stuff, Jimmy!"

"You bet it is, Danny," I said. "But go on."

"I'm going to," he declared. "I've got to make you see, if I can, what has been going on in this cavern—aye, and for years before in the brain of the Chief. You know what happens when you ionize a gas?"

"You turn it into a conductor of electricity," I suggested.

"Crude, crude," said Dan, "and I wish for the sake of brevity your description would serve. You make it, as a matter of fact, an electrolyte, bringing it into a dissociated condition of oppositely charged positive and negative ions. These little fellows, the ions, hop over to the opposite poles, making what's called an electric current. Well, you can ionize this aithon. I've seen it done tonight. I've also seen its quite distinctive spectrum. It ionizes comparatively easily. That would make you think aithon had some atomic system as we understand it now."

He broke off again to pace up and down the cave for a moment or two in silence.

"Let us imagine," he went on—"imagine the sun to be the positively charged nucleus of the hydrogen atom, and say—leaving out the remainder of the solar planets for the sake of convenience—that the earth is the single electron. Never mind the failure of the comparison as regards relative mass. Bring the mass of the sun down to the size of the nucleus of the hydrogen atom, and say that we could see its electron, the earth. Do you get me?"

"I get you, Dan," said I.

"Well? Have you nothing to ask me?"

"No," I said slowly. "Not a thing."

Dan looked at me with great pity.

"I embark on entirely unscientific anologies to meet the deficiencies of your education, and you reward me so," said he. "What about you, Milliken?"

"I'd ask you if the moon came into it at all," Milliken said with a grin at me.

"There is balm in Gilead!" said Dan. "That's the notion. On the principle of 'little fleas with lesser fleas'—how do we know that the electron, so called, is not like the earth, a minute system in itself?—held, it is true, by the nucleus? It has been proved beyond cavil in the laboratory next door that this new gas has mass—yet its atomic weight is demonstrably lighter than hydrogen—seven times less. Are we not brought to the conclusion, then, that beyond and within the present known system of the atom there is another, infinitely more minute in unit, and that that which we now know as the electron is to those units merely what the atom is to its electrons?"

Dan is Excited After a Lot of Lecturing; He Has Become Scientific

Dan was still walking up and down the cave, but now he was shaking his loose change in his cupped hands, the old trick when excited. He turned to us with his eyes agleam.

"For the last year or two," he went on, "much of my experimenting has been to discover why electrons varied in behaviour. The electrons of different radio-active substances, though nominally of the same mass and character, often failed to behave similarly in like experiments. I wondered why—why? I begin to think that with the discovery of this aithon we fringe on the cause. We may be on the point of solving that phenomenon which, for lack of a better name, we have called these many years the *ether*—that mysterious, supposedly intangible medium to which, through its conduction of the sun's energy, we owe our very life!"

II

"The ether!" cried Danny. "There's a thought to fire the imagination! What if it should arrive that we find the ether to be our standard for measuring matter? What if it should prove that the ether is composed of particles of matter in-

The Ark of the Covenant

(*Continued from page* 110)

finitely smaller than the electron as we now understand it? Proof of that would go far to upset our present ideas with regard to radiation, energy, light—eh, Jimmy?—eh, Milliken? Upset them—or else illumine them still further!"

It would be unfair to Dan if I attempted to record his development of the theme as if in his own words. Looking back on what I've already written from memory of what Dan said, it doesn't seem at all up to the standard of his talk. I couldn't better it if I rewrote it, so it must stand. The subject is one on which I have but the slightest knowledge, and much that Dan said that night was completely over my head and Milliken's.

When I ask Dan, a very busy man nowadays, even to read what I have written of our conversation that night in the cave, he laughs and says that what I imagine he said will do well enough. If anyone wants accuracy there are plenty of text-books. So I have to give what garbled and hazy version of theory and discovery I must.

It appears that the discovery of the new gas by the Chief of the League came only as additional evidence of facts he had proved in years of secret experiment. The finding of the aithon—except in so far as the secretion and amount of it is concerned—surprised the Master very little. He had proved long before to his own satisfaction a fact that Dan had faint glimmerings of: that the atom with its system of nucleus and attendant electrons was *not* the smallest unit of matter.

Isaac Newton, more than two centuries ago, put forward the hypothesis that light was simply the radiation of minute particles of matter from a glowing body—an idea, according to Dan, which modern scientists still valued as a startling suggestion from the old boy which anticipated later discovery. The scientists valued it, though they discarded it in favour of the wave or transverse vibration of the ether theory.

Light and energy, as far as I follow the reasoning, were inseparable. The light from the sun may come in waves, but waves cannot occur in a void. Matter of some sort is needed for the transmission of vibrations. The medium lying in space between the earth and the sun would therefore be matter. When the shipwrecked mariner put two watch glasses together with water between them, and focussed the sun's rays on his tinder, setting it alight—what did he concentrate? Light or energy? Newton would have said particles of matter. Maxwell or Hertz may have explained it on the electro-magnetic theory. But that, as Doc Peets of Wolfville would say, "is however."

When hydrogen is bombarded by *alpha* particles, as shown by Rutherford in 1919, the heavier helium atom (minus its two electrons) sometimes has a head-on collision with a lighter hydrogen atom. The latter is repelled in the same direction as that travelled by the *alpha* particle, but, having smaller mass and greater velocity than its repellent, travels further through the hydrogen gas than the particle that banged it could. These H-particles might possibly collide with other hydrogen atoms and so keep the ball rolling, as it were.

From similar phenomena in his own observation, the Chief was led to discard in part the later theory of light, and to go back to the Newton idea. He worked on the assumption that the heat of the sun, and its light, was transmitted through the material ether as varying forces of kinetic energy by a progression on the same principle as the H-particles were pellated through the hydrogen. Light came, not so much in waves as in particles at varying speeds, and the spectroscope registered not so much waves or vibrations but these particles at varying speeds. Beyond the power of the spectroscope's register lay the greatest force of all—or almost the greatest—the ultra-violet rays of the modern scientist.

The tangibility, so to word it, of the ether, and its constant interposition of its atoms in the path of the high velocity particles thrown off by the sun, gradually diminished the force of these particles and probably changed their character, thus saving the earth from the destruction inevitable if this mighty energy had reached it unhindered and unchanged. The ether, roughly speaking, acted on the majority of the particles like the plant that reduces the voltage of electricity for domestic uses. Though in the course of the long journey from the sun, through such a dense atomic blanket, more particles had collision than was the case with the *alpha* particles in hydrogen (since *alpha* particles travel only at from 5,000 to 10,000 miles a second, while the *u-v* particles, with an infinitely greater range and greater voyage, started off with an immeasurably greater speed than the old conception of light speed: 185,000 miles per second) a countless number of the *u-v* particles won through. The cases of the *alpha* particles in hydrogen and the *u-v* particles in the ether were analogous in so far as both were heavier than the atoms on which they impinged, the *u-v* particles, however, being infinitely smaller than *alpha* particles.

The Neutral Tint Ray, a New Development in Radiant Energy

As with all the series of rays thrown off by radio-active minerals, which can be deflected in their flight by electric or magnetic fields, so it was discovered that these unseen rays from the sun could be shepherded—and not only shepherded, but *concentrated*. But as in the first experiments with the rays from radium, where the highly important *alpha* particles were neglected for the more showy and more penetrating *beta* and *gamma* rays, beyond the ultra-violet rays in the new science was a varying ray less showy, but infinitely more astonishing in its effects—the Neutral-tint ray.

In trying to explain the source of the energy contained in radium, the scientists of the early twenties pinned their belief to the more demonstrable and feasible theory that the energy was inherent—thus discarding the apparently merely romantic notion that the source of its energy was cosmical. It was said, since it could not be proved otherwise by any known experiment, that the rate or progress of radiation from these new elements could not be speeded up, and that radio-activity could not be created, though it could be induced for a short period of life in certain compounds and elements brought into proximity with radio-active substances.

In experimenting, however, on radium bromide with the concentrated Neutral-tint rays from the sun, the Chief discovered that the salts became supercharged with energy, and threw off not only the previously known rays of the *alpha*, *beta* and *gamma* type at increased speeds, but other rays of a different nature, still unnamed at the time of writing.

Uranium—supposed by the experimenters of the early 'twenties to be the parent of radium—also was subjected to the new rays, and in a day or two had thrown off an appreciable Uranium X emanation, which crystallized into pure ionium, apparently missing two transition periods. The ionium threw off all the new rays seen in the treated radium bromide, and in a few hours it also deposited a film on its container. That film reacted chemically as pure radium! Thus, into a few poor days of human life, the Chief packed the work which normally occupies nature over eight thousand million years!

The ultimate result of his treatment of the radium was its reduction through the various known stages to polonium and lead. The uranium and other radio-active elements were, in relation to the intense radio-activity of the sun, just what elements capable of induced radio-activity were to radium. The radio-active elements were only substances peculiarly adapted for storing and throwing off the energy of the Neutral-tint and other radiations of the sun.

The decision of the earlier experimenters, neither that the rate of radiation from active substances, nor that radio-activity could be produced artificially, was upset by these discoveries of the Chief and by his later experiments on non-active substances. With a weak concentration of the N-t ray on Boron, which was of the normal atomic weight 11, he succeeded in producing a Boron which was isotropic at 10. In the process, a zinc-sulphide screen, carefully insulated from the N-t ray, scintillated to the passage of electrons thrown from the Boron. With other elements, non-active normally, he found on subjecting them to the N-t rays that he could produce sub-rays very little different from the ordinary rays of radium.

So far, the experiments of the Chief had been made with the selection and concentration of the actual rays from the sun, and he set himself, since the new rays were demonstrably electrical in character, to the production of an artificial ray with the same powers. He succeeded. And in succeeding he discovered that the power of the ray was controllable in a way not possible when he had been reflecting the natural rays through the regularly spaced molecules of crystals. Here he came on an element of danger, for with his cathode of a special and still secret substance, he developed a power far beyond that of the natural rays. He found towards the highest power of his projector that he could energize the atoms of different elements to such an extent that he feared to exert the full power of the rays. But with middle variations of the power he was able to alter the atomic structure of any element, and bring an actual chemical change.

He Had, In Fact, Discovered the Secret of Transmutation!

Here was a mighty power! He subjected both actinium and thorium to a carefully calculated degree of his ray, making them, when they reached the state D, expel *alpha* instead of *beta* particles—and the result was *gold!* It was an isotrope of gold, no doubt, but it was perfectly stable, and to the ordinary reactions a gold that would pass in the markets of the world.

With this power in his hand, the Chief of the League of the Covenant was practically omnipotent. He had fathomed the deepest secret of nature and science. If he could make gold of that which was gradually resolving into lead by the slow process of nature, he was also able by the touching of a screw to turn gold into lead. So far from upsetting the basic principles of radio-activity as understood by his scientific confrères, his work in the main went to support and

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See what Doubleday, Page & Co., through Mr. Arthur H. Lynch, Editor of their magazine, "Radio Broadcast," say about the Radio Broadcast's sensational 4-Tube Knock-Out Set developed by Walter Van B. Roberts:

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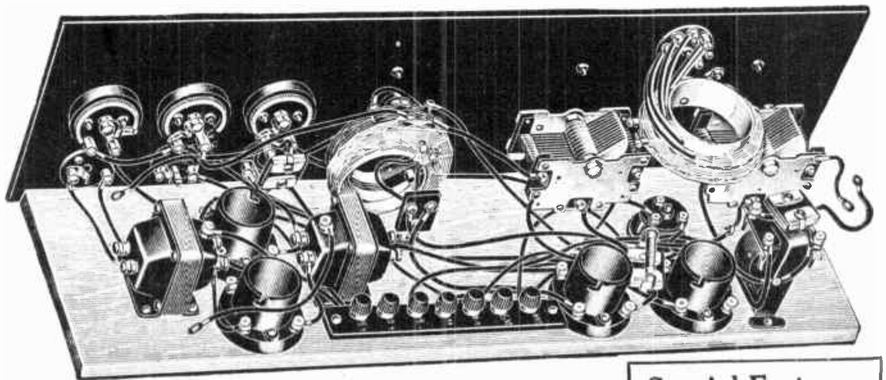

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CUSTOMERS PRAISE IT!

Receives Calif. from N. Y. on Two Tubes!

"I have followed the development of the Roberts circuit with results far beyond all expectations. I find it to be EXACTLY as efficient as described, although I was skeptical as to the unusual operation that it was said to have accomplished. I no longer have any doubts, for in the last week of August and to date in September, I have received KGO at least four times. On one of these occasions I received it on my Dictogrand loud speaker, **using only two tubes!** I have consistently received long distance, such as Dallas, Fort Worth, Auburn, La., Hastings, and Kansas City, in all about 65 stations, while just "fishing." Locals, such as Pittsburgh, Schenectady, New York City, Chicago, Boston, etc., it need not be mentioned, are perfect, **even on occasions when I have used neither aerial nor ground.** I am sure it was a lucky day when this set came to my attention." L. L. Clifford, 190 Second Street, Fulton, NEW YORK.

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By one of the editors of "Radio News"

WJZ	72	65	N. Y. City
WEAF	86	77	N. Y. City
WFBH	65	21	N. Y. City
WFAM	55	18	St. Cloud, Minn.
WQAO	73	40	N. Y. City
WEBH	75	43	Chicago
WJY	72	52	N. Y. City
KDKA	70	32	E. Pittsburgh, Pa.
WTAS	67	25	Elgin, Ill.
WGBS	67	30	N. Y. City
WHN	72	39	N. Y. City
WJAX	88	48	Cleveland
WIT	75	83	Philadelphia, Pa.
KYW	78	93	Chicago
WOC	83	74	Davenport, Iowa

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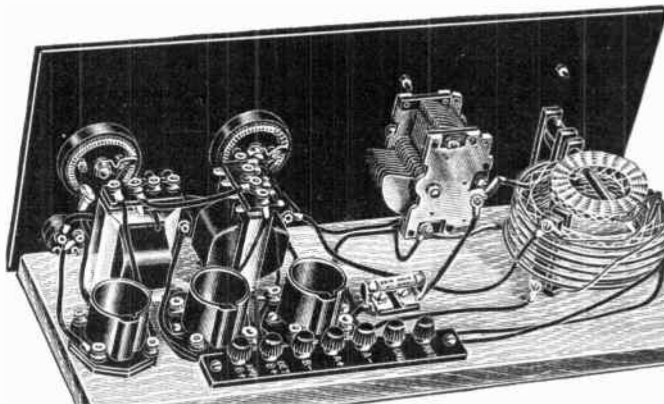

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confirm all their theories and generalizations—except that none had believed the power to effect the changes was attainable. But the apex of his power was that he could unshackle the energy of the atom—yet even he dreaded the full exertion of this power, lest once begun he could not stop the process. The consequence of unloosing that power might readily mean the destruction of the earth or even of the universe.

III

Long into the night Danny talked to us, enfolding mystery on mystery, and the further he went the deeper grew the amazement of Milliken and myself. Our little comrade held us enthralled. He seemed at times to grow in stature, and his voice, normally slight and a trifle stammering, became almost sonorous. He never faltered.

Thread on thread he gathered the various scientific issues that had bewildered us, and he wove them into a close pattern. The power that was in the hand of the Chief was capable of the most astounding variation. The anaesthetizing gas, for example, the real composition of which is still a secret, though it is something akin to nitrogen, if infinitely more stable, was controlled, as we had believed. A ray of the *N-t* series was directed at it, and the atoms of the gas thrown into magnetic sworls, tractating one after the other to a central nodality. Where this nodality moved, the atoms followed in a state of high activity, always struggling to reach the magnetic centre. The explanation of the tarnishing of the gold, as far as I can remember, was something after this fashion: That the *N-t* ray controlling the gas was of such a character that it was inclined to rob the gold atom of something over a hundred positive charges, turning a slight outer skin to an isotope of copper, which was then affectable by the anaesthetic gas.

Another of the *N-t* rays, properly graded, had an effect on the electric current of internal-combustion engines—or indeed on any electrical current—which so changed the character of the current used for firing the gasoline vapour that a spark could not be produced between the points of the plugs. The intermittent recovery of the *Merlin* engines when we were sent down that day off Madeira was due, we were told, to the difficulty of keeping the ray on the engine as we hovered down, but for later use the ray was given a wider scatter so to speak, and the trouble of aiming was obviated. Danny's cage would have been of little value, as the ray was intended primarily for the electrons passing through the engine's electrical circuit. Even the passing of a high-tension current through the cage would not have arrested the ray. It had enough power to pass beyond the cage.

"There it is, Jimmy," Danny concluded an explanation that had thoroughly absorbed both Milliken and myself till the break of day.

"That's the power that is behind the League of the Covenant. If the Chief chooses, he can upset the currency values right through the world. He can wipe out the stocks of gold and silver, or by reversal of the process he can produce the metals so cheaply that they would become valueless. Think of the chaos he could create! He could melt warships, destroy guns, reduce machinery to powder—the power beyond! Thank God the knowledge came to one of a spirit so benign!"

What the Master Dreaded With His Terrible Powers; How Will Others Use Them?

"Thank God, indeed," I echoed with a queer feeling of reverence. "Any man smaller of mind than he would have used his power for his own enrichment. It's a terrible power!"

"A terrible power," Dan agreed, ablaze with enthusiasm, "but properly used, what a power for good! The fall of Man, Jimmy, came from his use of the knowledge he had, not to think upwards and to ennoble himself, but to gratify the beast in him. That's what the Master dreads. Through all the history of science, each new discovery has been prostituted for the support of material, and even evil, purposes. Take radium. It was immediately pinned on for the creation of an industry—and what did they do with it when they got it? In the European War the price of radium went up a hundredfold, and the people who discovered it and might have turned it to helping humanity could not get enough of it for their experiments.

"The Chief will give his knowledge to the world—but he must have a guarantee that it won't be used for war. The power he will give, properly developed, can lead to the manumission of mankind. So far, Jimmy, man has been struggling along on the grudging supply of energy that nature allowed him—and his greatest need has been for energy. The Chief points the way to unlimited, boundless energy—but it must be used for man's ennoblement, and for that only. Before the secret shall be prostituted to mean ends, the Chief will destroy the earth—aye, and world beyond. And he is right!"

Dan stopped his pacing about to throw out a hand with an impressive gesture.

"I'm not given to emotional utterance," he said slowly, "or to religious allusions, either—you know that, Jimmy Boon. But I will say that the airship of the League is justly and aptly named. It is truly the *Ark of the Covenant*—the ark of that new Covenant which will free man from the hard struggle for existence, for because of that it is the very casket of arcana essentially holy."

Here was a different Dan Lamont. Our little comrade, although I never doubted the depths in him—even when I fooled with him in an ordinary childish rough and tumble—thrilled me in a way of which I never could have imagined him capable. Milliken, too, was affected. He sat on his bed, stockstill, and watched Dan open-eyed.

"I don't know how you feel, Jimmy—or you, old Milliken," Danny went on, "but I'm bound to tell you that I'm with the Master and the League of the Covenant heart and soul. He has trusted me. He has laid bare the innermost secrets of his power such secrets that none else will hear—and I swear here and now that the Chief has not trusted me in vain! I'm with him. And if he were to die tomorrow, before the accomplishment of his task, the realization of his big dream—I'm here to say that it would be my great honor to carry out his idea to the very end—God helping me. So there it is, Jimmy—there it is, Milliken. I'm turning my coat, if you like—deserting. I'm crossing to the other side!"

For a moment or two Milliken and I sat in silence, and we both looked on the ground. Then Dan came over to us, suddenly the dear, lovable boy again—almost a kid.

"Do you blame me, fellows?" he pleaded. "Do you, Jimmy?—you Milliken?"

Well—for an answer I did what I've never done before or since—hugged a man. I got up to my feet and squeezed the little fellow in my arms.

Milliken, less emotional, perhaps, just wrung Danny's hand. But my mechanic was black in the face—so I gauge that if his method of expression was different, his feelings were very similar to my own.

CHAPTER THREE
THE WORLD AT BAY

I

From the day, in the middle of June, of our capture by the League, until that night when Dan Lamont partially revealed the secret power of the organization, and declared his adherence to the cause of the raiders, a month had elapsed. Throughout that period the League had been very active. We saw the great airships depart and return successfully several times, and we heard that Madrid, Lisbon, Rome, Berne, and some of the manufacturing cities of France and Britain had been raided.

From newspapers picked up in several of these towns it became apparent that the whole world was in a turmoil. None of the plans made for the destruction of the airships showed the slightest sign of success. Hordes of aeroplanes had been sent up against the airships, only to be sent down before they could approach within attacking distance. Nor were anti-aircraft guns of any value. The ship had such power of stealthy approach and swift descent, that she was nestling over the buildings of the cities before the artillery could come into action, and the get-away was made so quickly that she was out of sight by the time the guns opened fire.

A Systematic War on Commerce by the Raiders to Repress War

In each raid the ledgers and account books of banks and bond-houses were destroyed, together with heaps of securities representing millions of dollars, and the chaos that ensued in business was terrible. Public confidence was completely undermined, and business all over the world was at a standstill. Now there was no abstraction of gold from the banks and treasuries. The only object, apparently, was the destruction of the mechanism of commerce.

Each day the note of the journals we saw grew more and more hysterical, and there was a rising demand that if the raiders could not be discovered and destroyed, they should be asked on what terms they would cease operations. It now was accepted in the more staid sections of the press that the League of the Covenant was not out for gain. Several of the big English newspapers joined to broadcast a radio to the League, asking what its purpose was against the world. The answer came again from mid-Atlantic, the same laconic: "To stop war!"

Right on the heels of this message, several of the American cities on the Great Lakes, and a few on the Atlantic seaboard, were visited by the airships. The American journals then began asking on their own behalf what purpose lay behind the raids, and they were answered in the same cryptic fashion. Immediately the American journals asked a further question: "Will the League of the Covenant enter into a parley?"

The reply to this was that as soon as the governments were ready to parley, the League would make itself heard.

The journals on both sides of the Atlantic instantly began campaigns for urging their governments to meet the League. The answer of both British and American authorities was to redouble the efforts for the destruction of the League. Of planes and airships scouring the face of the earth for the hiding place of the League the number was legion, and, in fact, air machines were passing over or within sight of the plateau almost every day.

The disappearance of the *Merlin* and of my party was a matter for comment and speculation not only in America, but in England, for we were supposed to be the first victims of the raiders. The pilot of the airplane which had passed us that

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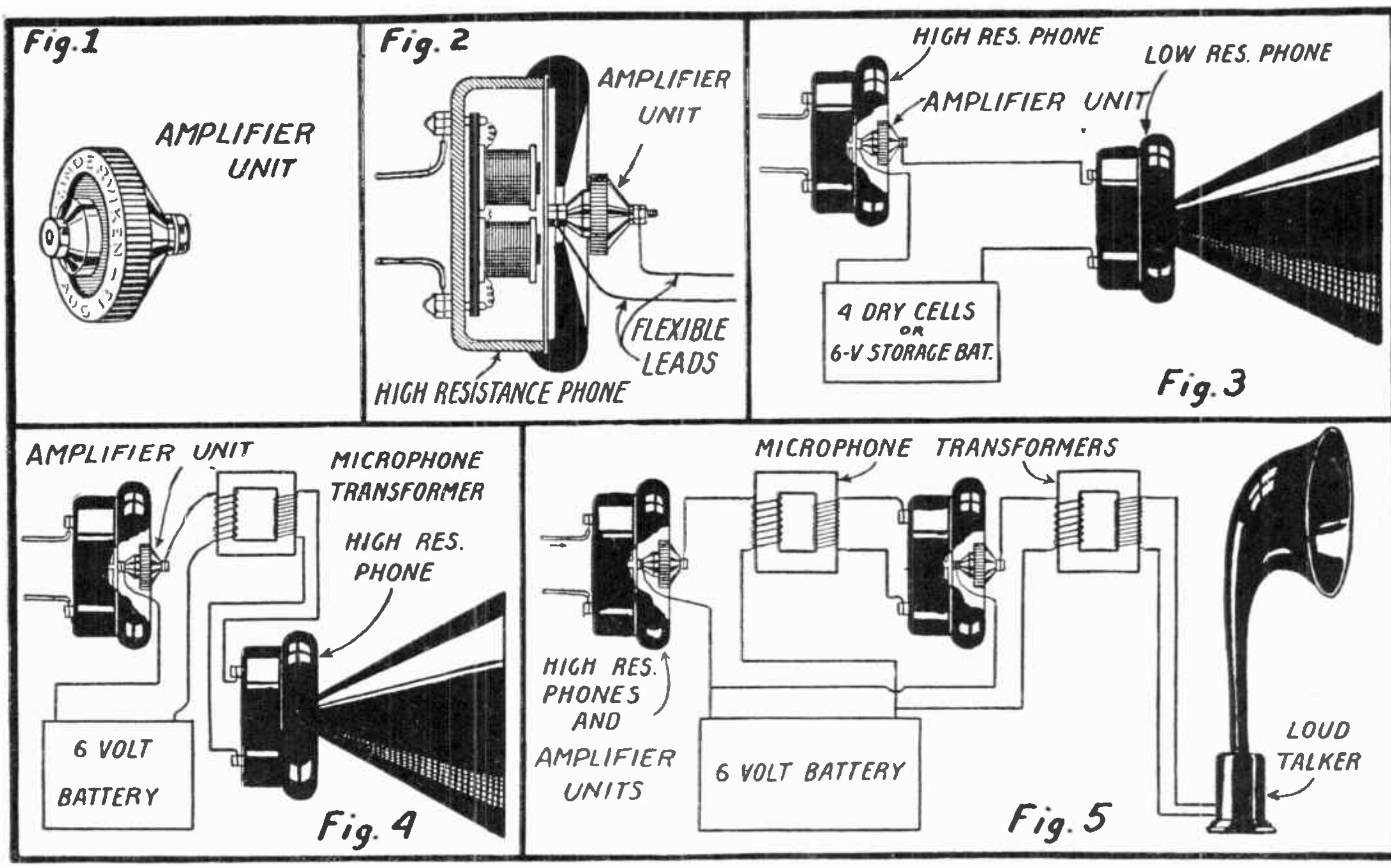

FIG. 1 shows the amplifier unit, actual size.

FIG. 2 shows how the unit is attached to a telephone receiver. The first procedure is to mount the unit on the diaphragm of a telephone receiver, which usually is a high resistance telephone, either 1,000 or 1,500 ohms.

Next we select the loud speaking telephone. If a low resistance telephone is available, it should have for maximum efficiency an impedance equal to the resistance of the amplifier unit, or about 10 ohms; it is connected up as shown in Figure 3. A 5 ohm telephone receiver is used in this circuit with a 6-volt storage battery.

Two telephones taken from a good double head-set of 2,000 to 3,000 ohms which do not rattle on strong currents, are employed in Fig. 4, one at the receiving end, the other as loud talker. In this hook-up there is one instrument which must absolutely be used with this combination, the transformer. As stated before in connection with Fig. 3, the impedance of the telephone, if used in direct connection, should equal the resistance of the unit. But as the impedance of the telephone in Fig. 4 is much higher than the resistance of the unit, it may be 200 times as great, a transformer having a step-up ratio is used to match up the resistance of the unit with the impedance of the loud speaking telephone. In other words, the primary coil of the transformer should have an impedance (which is sometimes called "A. C. resistance") equal to the resistance of the unit, or about 10 ohms, and the secondary coil should have an impedance equal to the impedance of the high resistance telephone. This transformer may be purchased in any Radio Store and is called a microphone transformer or modulation transformer, designed primarily to use in radio transmitting sets. A 6-volt battery gives the best results. The current passing through the unit will vary from .1 to .25 ampere.

FIG. 5 shows a circuit for further increasing the volume of sound. This is simply two of the circuits, such as shown in Fig. 4, linked together. This arrangement is highly sensitive and the telephones on which the units are mounted should be packed in a box of cotton, as the slightest vibration or sound in the room will be picked up and heard in the loud talker. Any sensitive radio loud talker may be used in this particular circuit.

These and innumerable other interesting experiments are possible with these amplifiers. Every amateur should have at least one or two in his "Lab" or workshop. A four-page instruction pamphlet is sent with every unit.

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E1

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.

Manufacturing a Set

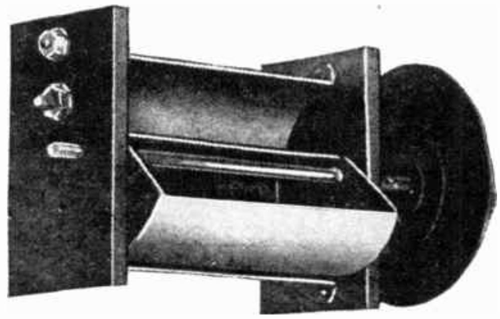
(23) S. J. Morrissey, Huron, South Dakota, asks what steps he should take in order to secure the right to manufacture a radio set of the ordinary five tube tuned radio frequency variety after having first secured the right from the manufacturers of parts to incorporate such parts in the make-up of the set. He also desires to know whether or not the tuned five tube radio circuit of which we see so many sets on the market is patented, and who holds such a patent, and whether the Government requires the individual or company carrying on the manufacturing of radio articles to be specially licensed.

A. The ordinary type of five tube tuned radio frequency circuit is not protected by any patent rights and any manufacturer can build that set. If the five tube tuned radio frequency set is neutralized by neutralizing condensers, or if a potentiometer is employed to effect such neutralization, the right to manufacture this set should be secured from the companies who hold the patent rights to the particular form of neutralization. The Government makes no manufacturer pay for license rights on any radio outfits and the United States is one of the very few countries in the world where such freedom is enjoyed by its citizens.

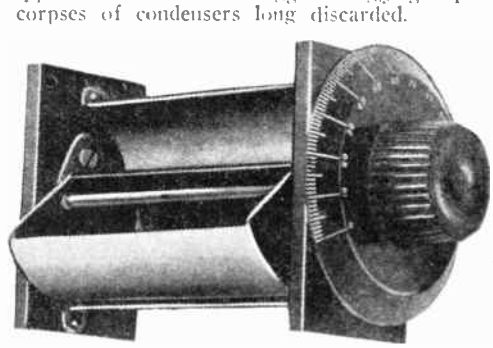
Variable Condenser

(24) Lester Kibler, Luray, Va., submits a photograph of a variable condenser which he has built in which the rotor and stator plates are of cylindrical semi-circular contour, one semi-circle rotating within the other. He wants our frank opinion as to the value of this idea and would like to know whether he can patent the same.

A. We would not advise your applying for a patent on this suggestion by reason of the fact that it is extremely old. In one of the very first editions of the "Wireless Course" this same style of condenser was illustrated. Consequently you will immediately note that the suggestion is not by any means new, as it appeared in publication as early as 1911. Both the single and the multiple plate designs were there shown.


View of the proposed rotary variable condenser showing the rear plates thereof. The dial is seen also from the rear.

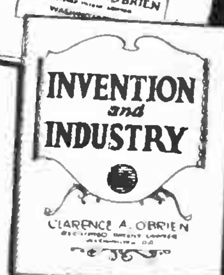
Unless you can greatly improve upon the system so as to prevent buckling or bending of the plates, we doubt if you will be able to find any manufacturer willing to consider the idea. It is difficult to make plates in the particular style you have designed; it is more difficult to prevent shorts, and the only advantage which such a condenser possesses is that it has a straight line wavelength curve. Inasmuch as nearly all condensers are gradually going over to the straight line frequency style, and may even evolve from that to a still more improved type, we would not suggest digging up corpses of condensers long discarded.


This shows a front view in part of the rotary condenser where the graduated dial is seen with its handle. These two views are from photographs sent us by our correspondent to illustrate his device.

PATENTS

INVENTORS Write for these FREE BOOKS!

At the left is a view of my drafting and specification offices where a large staff of experienced experts are in my constant employ. All drawings and specifications are prepared under my personal supervision.



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day after our capture had reported sighting us, and that we were heading in good shape for Caracas. The conclusion was ultimately arrived at that we had either met with an accident, or had been sent down by the raiders and sunk in the sea. We were given up for lost, and Dan and I had the doubtful pleasure of reading our own obituary notices. The anxiety of my father and his sorrow for my supposed demise gave me a great deal of concern, a feeling shared by Dan and Milliken on account of their relations and friends. But we were forbidden to attempt any communication with the outside world, nor would the Chief permit the sending of any message that might have allayed the doubts of our friends, since it would perhaps have been obvious that we were captured somewhere on our journey from Guayaquil, a revelation that might have brought greater numbers of searchers on our trail. We knew, from the American papers, that both Didcot and Dick Schuyler, on new Merlins, were searching the Caribbean and the Antilles for some trace of us.

Our days in the cavern were full of interest. At first, Milliken and myself had been content to go about looking round us, but as week after week passed, we found our hands could no longer keep still, and we began to help the company in small ways that did not offend our consciences. With Lord Devonridge and Haynes, and with one Moggs, an ex-gamekeeper of the former, we went out hunting, and we found the three Englishmen excellent companions. Our hunting expeditions had to be worked in between raids, for both Devonridge and Haynes had special duties on the ships.

The raids were always made in pairs. The first ship would go out with 25 men or so on board, and on its return the second ship would depart immediately with a fresh crew, except for the Chief, Seton, and a few of the officers, who seemed capable of sustaining the most prolonged strains. At the end of the second voyage a period of rest would ensue, and then the process would be started all over again.

Lamont Adheres to the League, and a Friendly Tone Obtains

Dan Lamont was now installed definitely as scientific helper to the Chief, and, save that he did not accompany the leader on the raids, he worked untiringly. His adherence to the cause of the League did not bring any estrangement between him and Milliken and myself. Our views with regard to the members of the League had taken on a complete change of color, for the sincerity actuating these men was unmistakable, and I truly think that both Milliken and I secretly envied our comrade his courage in openly taking the course his conscience dictated.

However that may be, Milliken and I could not find it in our hearts to take the same step, and I dare say the thought of Kirsteen Torrance was in the mind of Milliken as much as in my own. If we could have declared our purpose to her, and could have put the ideal that underlay the operations of the League before her, the step might have been possible. For myself, as an additional factor, I still had the President's commission in my pocket, and until I could hand it back to him in honesty, I could not depart from its terms. But I am certain that the opinion of Kirsteen counted most with me.

Yet, with this enforced aloofness to the purpose of the League, it was not possible for either Milliken or myself to regard its operations without something of a thrill. That the struggle between those selfless men and the world at large was nearing its climax could not be doubted. Each new demonstration of the power of the League was more amazing than its precursor. Towns were attacked—if that word may be used regarding raids so careful of human life—with more open methods each time. No longer was the approach made in the dead of night. The airship would come down on a city in broad day, and the business of creating chaos in commerce would be gone about as coolly as in the night. The best efforts of the authorities against the raiders were completely useless. Each day it became more certain that the world was at the mercy of the League of the Covenant. The marvel was that the several governments remained so stubborn.

Of the feats performed by the *Ark of the Covenant,* its flight across the Pacific to Japan—where Tokio and Yokohama were subjected to similar treatment to that suffered by New York in the first raid of all—was in some ways the most amazing. The Japanese, who were perhaps the most deserving of a lesson from the League by reason of their everlasting itch for power through the agency of war, had obviously regarded the problem affecting the Western Hemisphere with a degree of complacency. The raid on the capital and chief seaport of the Eastern empire went far to destroy this Japanese smugness and sense of security. Here, by the very unexpectedness of the raid as a result of that complacency, the panic caused was greater than anywhere else, and the Pacific radio stations simply hummed in the next days with the frantic messages that emanated from Japan to the other powers.

This was the most daring of raids. On a Sunday night in August, the *Ark of the Covenant* set out on its long flight over the Pacific. Sixty hours' leisurely cruising—leisurely for the Ark—brought the ship over Tokio just after midnight. Two hours were occupied in a very thorough demonstration, in which the gold chests of the Japanese war fund were sadly depleted, and after a casual replenishing of the airship's gasoline tanks from a handy oil-ship, Yokohama was descended upon in the first grey of dawn. Here the second chapter of a smart lesson was read Nippon, and the *Ark of the Covenant* immediately set out on the return voyage. In spite of the throwing out of cordons of air scouts along the Pacific coast of America, on request of those frantic cables from Japan, the airship was berthing in her hangar-cave at dusk on the Friday night.

Japan Receives Her Lesson and Enters Into the Fray.

II

The raid on Japan brought matters to a head. The Powers of the Western Hemisphere had been working together for a long time, pooling their ideas, as far as international jealousies would permit, for the scotching of the raiders. Now Japan made a tardy entrance into the fray, and for the

$5000 Contest!

Prizes totaling $5000 will be awarded in the new contest announced in this issue. The rules are simple and the contest is of such a nature that anyone and everyone can participate in it.

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Radio Wrinkles.
Oracle—General Science Problems Solved and Queries Answered.
Radio Oracle—Radio Questions Answered.

first time since the beginning of the raids all the Powers were in something of an agreement for a single purpose. But to enter into a parley with the League formed no part of their mutual understanding.

It seemed as if the several governments considered it beneath their dignity to discuss terms with mere pirates. All they decided was to adopt further measures for forcibly removing the menace to their happy pursuit of trade-snatching, scabbard-rattling, truculent schemes; but that they were at a loss for further methods to accomplish this aim the reports by radio left no room for doubt.

This was the moment chosen by the Chief of the League for issuing his ultimatum to the world in general. The ultimatum was addressed through the President of the United States:

"From the League of the Covenant to Bring Peace on Earth (it ran) to the President of the United States of America.

"Sir: The object of the League of the Covenant has been put before you heretofore in brief. It is now set out in full for the first and last time.

"The League of the Covenant is composed of men who have suffered in the past from the horror of war, and that in the patriotic service of their various countries. They are determined that never again, if they can prevent it, will war be seen on the face of the earth. To this end, for the last five months the League has been demonstrating by humane methods the power it has for enforcing its will on the nations.

"The efforts of all the governments against the operations of the League have been of no avail. The League exists unharmed.

"But time has passed, and the several nations who have felt the power of the League have made no attempt to enter into negotiations with its members.

The time is approaching, therefore, when the

League of the Covenant must lay aside its former humane methods, and exert the terrible powers it truly possesses. It is in the power of the league utterly to destroy Mankind, to bring about the end of this cosmic day, and bring a new dawn in the history of the Universe. This will the League of the Covenant do rather than fail in its object. Let there be no mistake. The League of the Covenant has deliberately brought chaos into the world's commerce, so that its power should be understood. Should its fiat not be obeyed, it will put humanity beyond even the need of commerce.

The Fiat and Ultimatum of the League of the Covenant; All for Peace

"And here is the fiat of the League of the Covenant:

"The armies of all countries throughout the world shall be disbanded, all weapons of war shall be destroyed, all ships and air-vessels of war shall be scrapped, and the materials converted to peaceful uses. Only sufficient men and material of war shall be left for that police work made necessary by the uncivilized state of mankind.

"For the carrying out of this fiat, representatives of the nations of the world shall be gathered in Washington under your championship, sir, with full power to arrive at an international understanding which will make effective a League of the Nations for Peace; and at the conference thus convened there shall be decided once and for all time the forces that are to be left at the disposal of each nation, taking into consideration the population, and the territorial extent and world disposition of the possessions of each nation.

"A month from the date of this ultimatum, the representatives of the nations shall be gathered in Washington to meet the representatives of the League of the Covenant, when a complete scheme of disarmament will be put before the conference for acceptance.

"Your acceptance, Mr. President, of this order for conference shall be broadcast by radio telegraphy for seven nights after your reception of this document.

"No less than the complete fulfillment of these demands will the League of the Covenant accept.

"There remains that which the League of the Covenant will do for the real brotherhood of man.

"In return for the complete disarmament of the nations the League of the Covenant will place in the hands of an International Board the secret of a power that will bring a new day in the history of mankind. Through that power will be opened a road which will lead to the end of man's struggle for existence, which will lead to the complete manumission of humanity from the curse of labor. No longer will man need to eke out a precarious existence with such small leavings of energy as nature so far has allowed him. Into his hands there will be put the means for arriving at energy unlimited, the boundless energy held together in nature itself.

"To put such power, sir, into the hands of men whose thoughts are turned to unworthy pursuits—the pursuit of war, as an example—you will readily understand would be to invite misery and appalling suffering on the head of mankind. The secrets held by the League of the Covenant can only be given to the world under the strictest guarantees. Failing such guarantees, the League of the Covenant will turn its power to the swift destruction of the world, rather than such power, otherwise discovered, should destroy the world in conditions of prolonged misery and suffering.

"The League of the Covenant will hand over to the new League of Nations for Peace, together with the airship already proved invincible, secret weapons which will enable the International Arbitration Board to enforce its ruling on recalcitrant states.

"In the event of your failure to inform us of a movement for convening the conference herein demanded, you are warned that at noon, on the Sixteenth day of September, American time, the capital city of Washington will be the object of a visit by the League of the Covenant, in circumstances where the shedding of blood will be inevitable. You are warned, further, to consider the probable effects of our anaesthetic alone upon the city at the time of full pressure of traffic."

This document was unsigned, but at the suggestion of Dan, who was terribly concerned at the prospect of the ultimatum being ignored, the Chief was persuaded to allow all three of our party to put their names to an addendum. Apart from my own desire that the authorities should treat the demands of the League understandingly, I was all too willing, since my father—and Kirsteen—would be informed that we were alive.

"Dear Mr. President (we wrote),

"In the hands of the League of the Covenant by capture, we have become certain that the power it holds cannot be resisted. In the air, no known craft is capable of carrying out an attack on the airship with the slightest success, and, scientifically, there is no known counter-weapon of defense against the terrible devastating force embodied in the weapons of the League, so far unused in its operation. The purpose of the League has been truly stated.

(signed) James V. Boon,
Daniel Lamont,
W. Milliken."

Mailing the Fiat, and Ensuing Confusion of the Government When it is Received

III

For the purpose of forwarding the ultimatum to the President, a small town in Alabama was gassed one night, and the envelope containing the document was slipped into the box at the little post office. Then the raiders retired to the cavern of the plateau to await developments.

In the week that followed, no answer was forthcoming from the President, but we gathered from the news that was being broadcasted by the agencies that he had received the document. At first the ultimatum was considered to be a hoax —the *Merlin* party was under the sea, it was said, and the signatures were forgeries. Then came the word that my father and several others had identified the signatures, and the fact that Dan and Milliken and I were in the hands of the raiders was made much of.

The genuineness of the signatures being settled, it was then declared that our testimony to the power of the League had been secured under compulsion—a declaration not very flattering to any of my party. The raiders were putting up one big bluff, was the next idea—if the League of the Covenant had such an ideal purpose, why had it made off with so many millions in gold? "Fudge and Fiddle-de-dee!" said one journalist in a paper secured by another mild raid.

In some of the better journals that we saw readers were reminded of the gifts of radium, and it was demanded that the government should meet the members of the League as suggested. At least, said some of the editors, with an eye perhaps on sensational copy, let us have a look at the men who have bamboozled the best brains in Europe and America!—let us meet them and call the bluff, if it is a bluff.

The voice of America, so far as it was echoed by the newssheets, was all for calling the conference.

From the President, however, no direct reply came. He was reported in the newspapers to have taken up a strong attitude, a report that in my conception of Mr. Whitcomb as rather an obstinate and self-willed man I was inclined to believe. No negotiation with these pirates was said to be his pronouncement—let them exhibit their mighty powers if they dared—let them come to Washington on the day appointed, and it would give definite warning of a raid? This too able or not! Was it at all likely that the raiders would give definite warning of a raid? This too was mere bluff and braggadocio!

Altogether, it was difficult to find out what the President's attitude really was. No official interview was published. But by his very silence, the President seemed to assent to the attitude attributed to him. The week of grace elapsed, and no direct reply was received.

The raiders knew, from a question and answer reported from the British House of Commons, that the President had not issued any invitation to the conference demanded.

"In view," the report of the M.P.'s question ran, "of the appalling condition of business in the country, as a result of the continued raids of the so-called League of the Covenant, would the Secretary for Foreign Affairs help to allay the natural concern of the nation by indicating the attitude of the Government towards the conference demanded by the League?

"The Sec. Foreign Affairs: 'The Government is without official information regarding any demand for such a conference.'

"The Hon. Member: 'The honorable gentleman has doubtless seen the demand reported in the press?'

"The Secretary (shortly): 'Yes.'

"The Hon. Member: 'In view of the urgency of the situation, where an apparently invulnerable League with undeniably high ideals' (cries of "Oh!") 'demanded a conference of the Powers, would the Government not discard red-tape for once in a way, and take steps to make that conference an accomplished fact?' (Opposition cheers.)

"The Secretary (with considerable warmth): 'The honorable member is unfortunate in his choice of words. It must be obvious to him that no league of pirates is "invulnerable," and that however "high" of "ideals" as far as lip service is concerned such a League may be, it is in no position to "demand" anything from such a great nation as America—or as Great Britain.' (Loud cheers.) 'The honorable member is mistaken in believing that either of those nations is to be frightened by melodramatic vapourings into unheard-of concessions to a gang of criminals.' (Prolonged cheers.)"

From other European countries came reports suggesting that the various governments were opposed to the idea of conferring with the League. The raids had touched the nations in their most tender spots—their pockets—and resentment was bitter. The official slogan everywhere seemed to be: No negotiations with the pirates!

Knowing as we did the determination and purpose of the Chief, and the appalling power that was in his hand, we in the cavern were amazed at the folly and stubbornness of the President in particular and of the world in general. As the days went past and the date fixed for the raid on Washington approached our apprehension deepened. We knew that the Master would carry out his purpose to the very end, even if indeed it involved the world's destruction. None of us doubted his power.

I have given, I am afraid, but a poor description of the personality of the Chief of the League. Words fail me when I try to tell of the power that emanated from that frail little man. But in the last days in the cavern, when the world seemed to hold him as naught, while the men round him went about with the shadow of death upon them, quietly doing their tasks with no diminution of energy or efficiency, the magnetism of the Master seemed to heighten. He held the men to him, though it seemed he had only death, swift death to offer them—since the world by failing to estimate the real value of his promise was sweeping to its doom.

To say that all the men composing the League of the Covenant accepted the situation nonchalantly would be to exaggerate, but that none of them faltered in allegiance to his Chief and the purpose of the League is simple truth. There was a set look on the faces of all the men. Even that licensed jester of the company, the insuppressible Lord Devonridge, developed an air of gravity, just as in the old days I have seen others of his kind develop that air when on the point of going over the top. That the normal gaiety of men would return in the case of Devonridge and others when once the "zero" hour was past, I was as certain as that the raid on Washington was inevitable. But until the actual moment arrived when the fate of the world and of the League would be decided, anything but real seriousness would have rung false.

I felt, myself, something like an innocent man in the condemned cell of the felon, but I had feelings to spare for experiencing a deep admiration for the courage and conduct of the men who had captured me. I thought it a great pity that such excellent fellows could not act as a leaven to humanity in general, for they made one proud of one's kind.

The two or three days before the sixteenth of September were devoted to conditioning both ships, for the two were to act simultaneously. From a small cave all the gold taken in the raids since March—minus that left in the Banque de France—was brought out and loaded into the ships. Every gas and spirit tank was filled to its utmost capacity, and every instrument thoroughly tested. Such of the ducks and chickens as survived in the cavern were given their freedom, and the personal stores of the men of the League were loaded into the ships. Nosey, the toucan belonging to Smithers, that unloquacious mariner, was given a perch aboard one of the vessels.

The Plateau of the Red Scar and its cavern system was being completely evacuated by the League of the Covenant, for failure could hope for no return. Success would make a return unnecessary.

Impending Exhaustion of the Aithon Gas Supply Just as the Ark is Starting

We learned now that the reservoir of aithon gas was almost exhausted, which means that the *Ark of the Covenant* would soon be without its marvellous lift, by which it had contrived to avoid bloodshed in its operations, and that its future invulnerability could only come from the exercise of its more ruthless powers.

Milliken and I were not excluded from the final meeting of the fifteenth. We were treated as members of the League, for indeed our sympathies were all with its purpose. Thus it came that we heard the Master speak to his followers.

"Gentlemen," he said in that level, clear voice of his, "before I do anything else, I have to thank you. I have to thank you for a devotion to the cause I have offered you, devotion such as has never been paralleled in history. But, gentlemen—my comrades—I am persuaded that our cause is worthy of even such devotion as yours.

"We take an offering of freedom to our brother man. Our gifts to him can be large. On the other hand, we may end by shattering him and the world he has known into fine particles of matter—for I dare not prophesy what the fate of the world will be if we are forced to use the height of our power. This we undoubtedly will use, before we brook that the smallest fraction of the freedom we offer mankind shall be negatived.

"I have had so many examples, such a revealing exeperience, of the high courage that animates every single man of you, that I am certain not one of you will falter in steadfastness to the last—even if that last should mean oblivion. But my faith is that our cause will prosper, that the League of the Covenant will triumph.

"Gentlemen, I salute you! With a deep pride I hail you a band of brothers worthy of their cause! And I tell you with that certainty which often comes to a man whose course is almost run that you cannot fail!"

That was all he said, with no attempt at eloquence or rhetorical effect, in that level, clear, unemotional voice of his. I thought they would have cheered him, but as he finished something like a sob—or half a sigh—went up from the assembled men. I suddenly understood. It was the first time that the little Chif had acknowledged the drain on his vitality from the great wounds on his frail body.

To see him there, so gentle, so still, and so lovable, and with the knowledge that his every minute was one of terrible agony tugged at the heart-strings and brought a lump to the throat. It was easy to see why the men who faced him were ready to follow him to the death.

It came close to nine o'clock. The Master had been going round the men shifting from group to group, talking to them quietly. He rose to his feet.

"Come, gentlemen," he said simply. "We must start on our voyage."

With Milliken, I was close to him when he spoke, and I turned to him on a impulse.

"Sir," I said, "may I follow you on my seaplane? You have my word that I won't betray—"

He stopped me with a gesture of his one hand.

"Please, Boon, please!" he said. "I know you would never betray. It is not that. I know, believe me, that a man can come to love a machine as he might a gallant horse. But the end is not yet, Boon. The League of the Covenant will win—and in that case you will see your *Merlin* again. She may even do a last service to the League of the Covenant. I have in mind a use for your plane. Trust me—will you, James Boon?"

"I'll trust you, sir," I sort of gulped. "And—and if I can say it in honour, sir, I'm hoping—I'm hoping——"

I broke off stammering, and he put his hand under my arm with an infinite kindness.

"Why, that's well," he said. "I am glad that we are not enemies. Come—you shall sail with your friend Dan Lamont and myself on our ship—and Milliken, too."

Good-bye to the Merlin, off in Ark

The men were trooping silently out of the big recreation cave, and Seton and the Master, Dan, Milliken, and I, followed at the rear down to the hangar-caves. The *Merlin*, looking very tiny against the mass of the big ships, lay on a ledge between the two airship caves, and as we passed her, Milliken shook a float strut as in farewell, an example I had to follow.

"Hell!" whispered Milliken. "Isn't she just fine!"

And with a shrug of his big shoulders my mechanic began to climb the ladder to the airship's gangway. I followed him, and in spite of the Chief's assurance, I felt sad to leave my bus.

Seton was in command of one ship with half the men as crew, and the other was in charge of the Chief himself, with Lord Devonridge as navigator. Milliken and Dan and I were with the Chief as he had promised. Seton's ship led the way, and when her hull had passed through the main mouth of the great cavern, our ship got under way. When we were beyond the gates, Seton was ashore with a small party of men to close them. We saw the lights in the cavern go out, and the big flaps of the door swing to. We mounted high, and below us hovered the silver hull of Seton's ship. At the mouth of the cave some one ran by the basin's edge with an electric torch—Seton, I took it to be. Then even that light vanished, and presently in the dim light of dusk and the stars we saw the hull below us come up.

Seton's voice came, casual and familiar, through the Chief's highly sensitive radio phone:

"All aboard, sir!"

"Very well, then, Seton," the Chief said quietly. "Fall astern as we go. Everything as arranged."

"Aye, sir!"

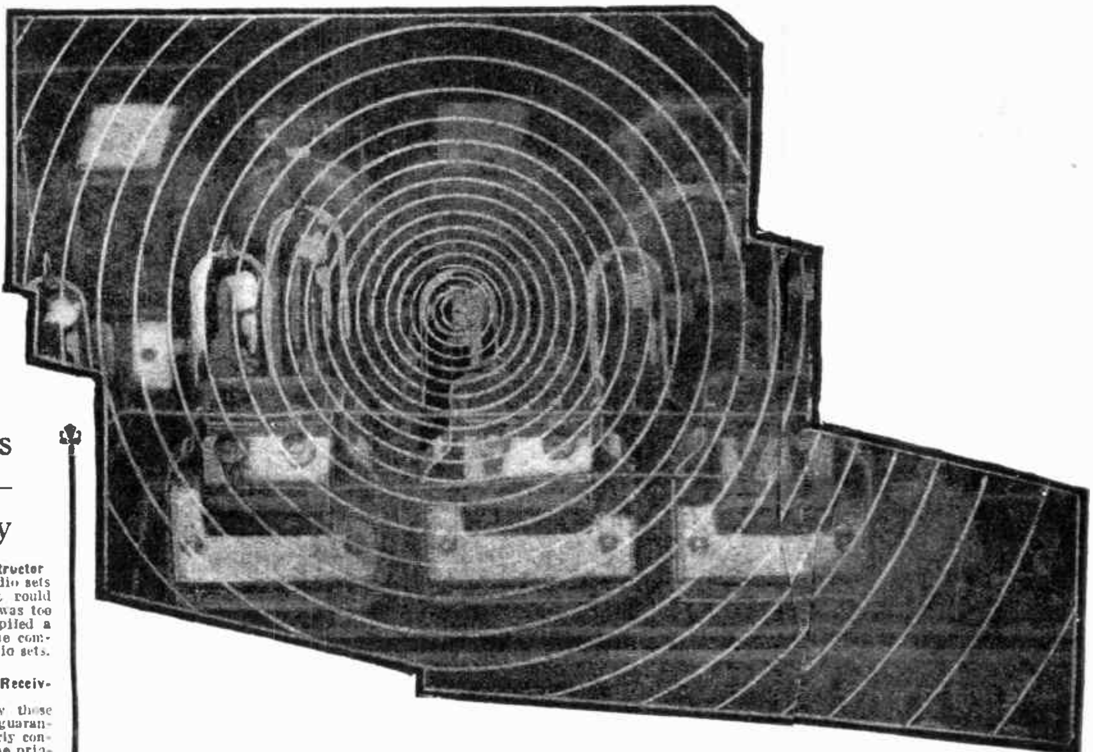
A gesture from the Chief to Devonridge, and the great ship gathered speed. Into the night we sped—on to Washington.

CHAPTER FOUR

The Last Raid

The airships flew at a great height, a height I had never imagined would have been possible for dirigibles of such a low cubic capacity. We were breathing compressed air, all apertures being closed. No sign of earth lay below us and, except for the barely perceptible throb of the engines and the roll of that wonderful navigating globe, nothing indicated the high speed at which we were travelling. No lights were shown externally, but the glow of the stars in the tropical night was enough dimly to illumine the shape of our sister ship

Power Measured in the Millionths!



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astern, a little to the side to escape the backwash of our six propellers.

After a steady progress of about seven hours, the silver hulls were tinted by the first flush of dawn, while the sea of cloud far below us still lay unlit and inky. We were approaching Windward Passage, between Cuba and Haiti. Jamaica, though we could see nothing of it or of the sea, lay on our port bow ahead. Quickly the light grew, and the clouds under us, now paling to delicate green, began to break up into patches and to disperse. Then in a flash of time we saw through a break in the veil of cloud an arc of bright scintillating spots against the dark blue of the sea. The spots were planes, no doubt thrown out to intercept the passage of airships should they approach that way!

At a word from the Chief, one of the men turned a little wheel, and almost at once both ships floated in a thick vapour that soon dispersed in the air behind them, while a mass of it yet seemed to cling about the hulls. From below the effect must have been as of two slight wisps of extremely high cloud.

(To be continued)

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of The EXPERIMENTER, published monthly at New York, N. Y., for Oct. 1, 1925.

STATE OF NEW YORK—
COUNTY OF NEW YORK, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Hugo Gernsback, who, having been duly sworn according to law, deposes and says that he is the editor of THE EXPERIMENTER, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Experimenter Publishing Co., Inc., 53 Park Place, New York City.

Editor, Hugo Gernsback, 53 Park Place, New York City.

Managing Editor, Thomas O'Conor Sloane, 53 Park Place, New York City.

Business Manager, Robert W. De Mott, 53 Park Place, New York City.

2. That the owner is: (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

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H. GERNSBACK.

Sworn to and subscribed before me this 19th day of September, 1925.

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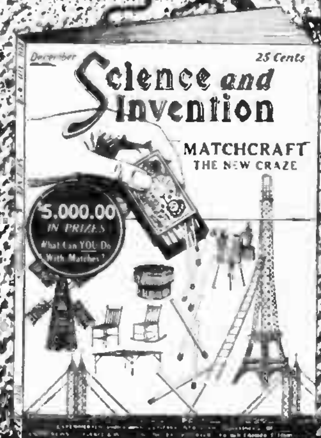

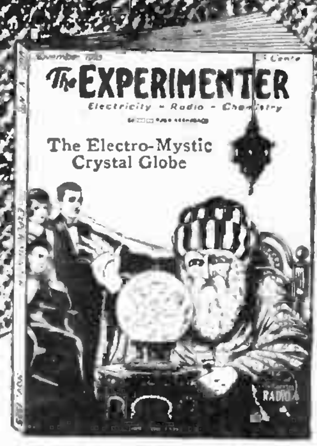

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