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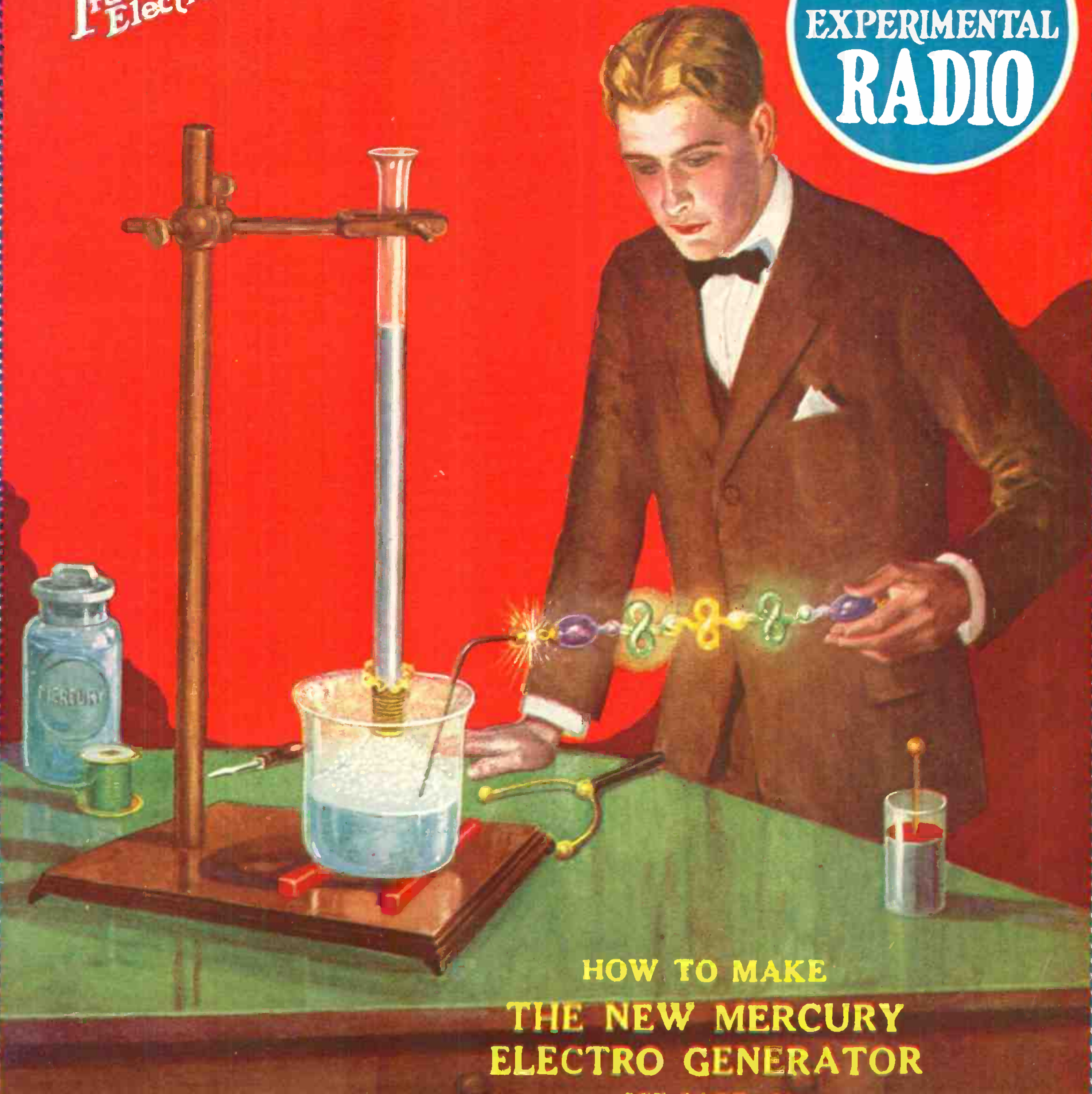
The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

formerly Practical Electrics

12 Pages of EXPERIMENTAL RADIO



HOW TO MAKE

THE NEW MERCURY ELECTRO GENERATOR

SEE PAGE 181

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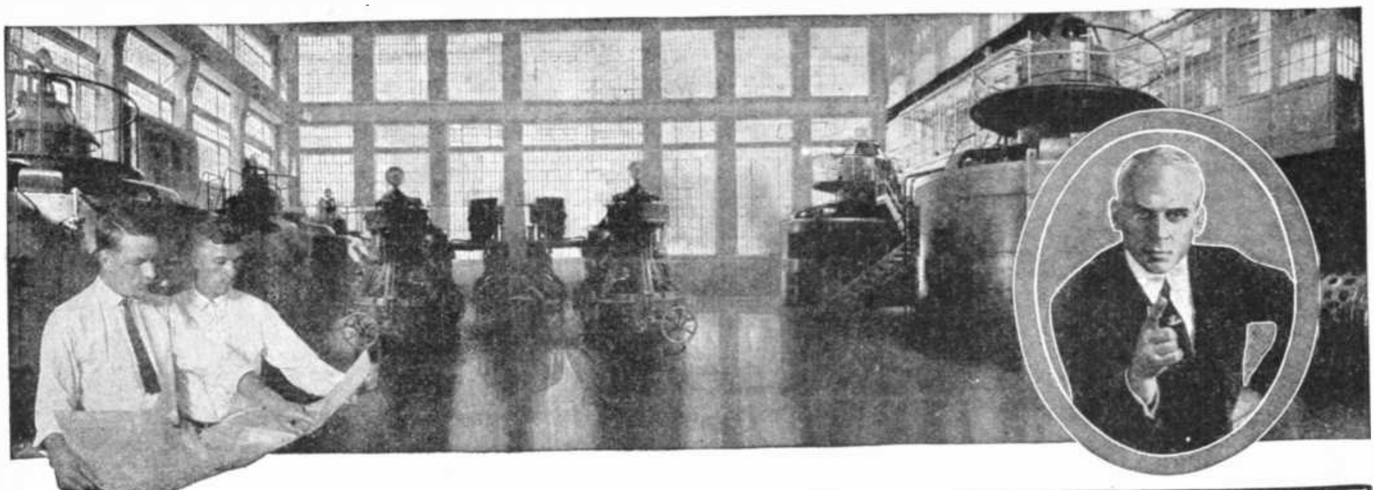

The EXPERIMENTER

Vol. 4 Contents No. 3

FOR JANUARY

FOR FEBRUARY

THE TAULEIGNE MICROPHONE AMPLIFIER. We have received a Tauleigne Amplifier direct from France and the construction with photos, and the results of investigations in our laboratory, wlil be given in detail. Is it to replace the Vacuum Tube?

LESSONS IN ELEMENTARY GLASS BLOWING, by Earle R. Caley, B. Sc. This article will interest all our readers. The successful manipulation of glass, or as it is usually termed, "glass blowing," is of importance in electrical and chemical work.

LISTENING IN FOR THE STARS, by William Grunstein, E. E. If the planets are not addicted to radio, as is our mother earth, the distant stars can be made to tell their story, and Mr. Grunstein tells us how it is done.

HEATING METALS UNDER WATER, by R. A. Goepfrich. This article tells how a bucket of water can be used in bringing heavy iron bars to the welding temperature. The experiment is within the scope of all and is of real use to the experimenter.

BALL LIGHTNING. A resumé with illustrations and descriptions of personal experiences with this strange phenomenon. A clue to its nature has possibly been reached by Dr. Langmuir, and his experiments are given with photographs.

GALVANI AND HIS WORK. This is another collection of illustrations from old time sources showing the very wonderful experiments in animal electricity due to the contemporary of Volta. This falls into our series of Historic Experiments.

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No. 3

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

January
1925

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

Experimenting as a Profession

By Hugo Gernsback

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

MANY of our readers experiment as a sort of hobby, for pleasure or instruction, but comparatively few realize that an experimenter may capitalize his work. Nevertheless, the writer is convinced of this, and he believes that he can readily show you that there is money in independent work of this character.

It is obvious, of course, that if you have a good idea and experiment long enough with it, you may eventually produce something which will be worth while and can be patented. This means, of course, providing the idea is a real good one, that in due time the inventor can sell the patent or else exploit it himself.

But this is not what the writer refers to by "Experimenting as a Profession". There are today numerous concerns and corporations all over the country that are either not big enough to afford an experimental staff, or else are so large that their regular experimental staff is too crowded with routine work to carry out certain investigations and research.

Almost every week letters come to the writer's desk from various concerns somewhat along the following lines:

"Can you furnish us with a man who can do some research and experimental work on this or that apparatus, or machine? We need a man who is a specialist on this sort of thing and would be grateful if you would suggest someone to us."

The writer has even had telegraphic requests for men of this calibre several times in a year. There is not a week that the telephone does not ring to convey a similar request.

If you are an experimenter you may be either working in electricity or in radio, or perhaps in both, or perhaps you are a chemical experimenter. At the present time, and the writer wishes to make this assertion strong, there is an active demand all over the country for men to do experimental and research work. But before you can undertake an order for experimentation from a firm, it is necessary that you should be competent to do the work, because if you fall down once the concern will never give you another chance. In the radio business, particularly, there is today a vast field for experimental work. There is not a radio corporation worth its salt, that could not employ a few more radio investigators to develop a hook-up or a design, or what not.

To make this clear, a large New York manufacturer of radio sets recently called upon the writer to furnish three experimental research men to perfect a certain set. These people had purchased a patent from an inventor who, however, did not know anything about the commercial work, nor could he make the set work where more than one tube was used. The one tube set worked very well, but the company wanted to produce a four tube set. Wouldn't the writer supply or suggest men to do the experimental work to develop such a set?

This is the sort of demand that comes along ever so often, and it would seem that corresponding research work could be carried on very largely in a more business-like manner, than has been done in the past. If those of you who see these lines feel yourselves qualified to do commercial experimental work, the writer would suggest the following course of action:

Print a few thousand circulars on a fairly good grade of paper, not larger than a letterhead. Have a photograph made of yourself and a half-tone of the picture by any photoengraver, so that you can print your portrait on the sheet. The circular can be headed somewhat along these lines: "Professional Experimentation."

Then explain in what particular line you excel. Every one of us is usually more or less expert in one thing or another. State your experience, also what sort of equipment and laboratory work-shop you have in which to do the work, but lay particular stress upon your strong points.

Give any other information that you think would be of interest to the manufacturer. Give your name and address and, above all, remember that the busy executive does not wish to read a long circular. Two or three hundred words at the utmost, and not more, should be used.

Then circularize only the particular trade in which you are interested. For instance, if you excel in radio hook-ups, you will not circularize the radio battery concerns. Pick out from trade directories and magazines the particular concerns, in whose service you know your work would do the most good, and the writer is sure that with this small effort you will get enough work to keep you busy. Most concerns are willing to pay a good price for experimental research, and you should not have much trouble to obtain sufficient occupation to keep you busy during your evening or spare hours.

Work of this kind is usually done on contract. Suppose a concern wishes to have you do a certain amount of experimenting in order to develop, let us say, an electric buzzer. After some correspondence you find out exactly what the company is seeking. You then make your price in a lump sum: $50, $100, $200, or whatever you think it is worth to develop the article. If the company agrees to the amount, you can then go ahead with the work and you will be paid for whatever experimental research you do.

And in closing, the writer recommends particularly that whatever your dealings with any company, *be sure to give them service*. Usually a manufacturer is pressed for time and you will have to work quickly, but also efficiently at the same time. And remember also before you take on a particular job, to be sure that you know in advance that you can go through with it. Taking a company's money and then not producing results, will never get you another chance with that house. Finally, if you get out your circular, send a few to the writer, who will keep them on file for inquiries that come to his desk frequently.

A Great Lightning Stroke

An unprecedented display of the destructive power of a lightning stroke is illustrated above. A 20-inch cast iron gas main had been installed but fortunately was not in service. The lightning struck, tore the pipe to pieces, opened a great cavity in the earth, and had the pipe been in use for conveying gas it is hard to say what the result would have been. The pipe was three feet underground.

A SEVERE storm visited the city of Worcester, Mass., last August and the illustrations show the result of a lightning stroke which occurred during the storm. It was about 10 o'clock at night when the lightning struck the earth at one or more points near the pipe which is shown shattered into pieces.

The pipe was a 20-inch cast iron main, and fortunately had not been put into service for the transmission of gas. One end of the pipe was plugged and the other end was open, waiting for a valve. One of the effects upon the earth was to form a species of crater. The hole in the ground shown in the view is very suggestive of a descent into the crust of the earth and is an indication of the enormous volume, so to speak, of the disturbance.

It was evident, although the pipe was not uncovered, that some damage had been done, so a gang of men were set to work to dig down to the line, which had just been completed. The pipe was found to be literally splintered from one end to the other; five lengths were completely demolished.

There are three surmises as to what may have happened. It is said that the lightning may have created a partial vacuum so that the pipe was ruptured by the air within it expanding, but this theory will not hold water, for the pipe undoubtedly would stand many times the atmospheric pressure, which latter would be the maximum producible under any circumstances.

Another theory is that the lightning struck directly above the pipe and passed through it; the air in the pipe expanded and applied pressure enough to explode the pipe.

The third theory is that water accumulated in the lower end of the pipe, where it was plugged, and the steam which was produced by the lightning burst it. One of these theories is as feasible as the other, and none is plausible. Some leaves on the trees show the trace of the lightning, but the trunks of the trees were untouched. The limbs of the trees showed where stone and mud were blown up against them by the discharge, and were damaged by the stones hitting them.

$100.00 PRIZE CONTEST

THE subject on our cover is "How to Make the New Mercury Electro-Generator." Since we changed our name we have established the policy that *every* cover will give a "How to Make It" or experimental idea, this being more in line with what our readers demand.

We have decided to let our readers earn money by supplying us with some of their ideas, hence this prize contest.

This is what we want:

(1°) First of all a rough illustration of the idea, but understand that this idea must embody some new or unusual experiment, electrical, chemical or radio.

(2°) Commonplace ideas will have little chance of winning a prize. It is the unusual thing that interests our readers.

(3°) If possible you should have tried the experiment and built the apparatus or instrument yourself. Mere suggestions are not greatly favored in this contest.

PRIZES
$100 in Gold

1st Prize	$50.00	in gold
2nd "	20.00	" "
3rd "	15.00	" "
4th "	10.00	" "
5th "	5.00	" "

(4°) Your entry into the contest must be accompanied by a "How to make it" article of not more than 2,000 words, describing the idea in full detail.

(5°) Drawings should be made in pen and ink and if photographs of the design are submitted, such photographs must not be smaller than 5 inches by 7 inches.

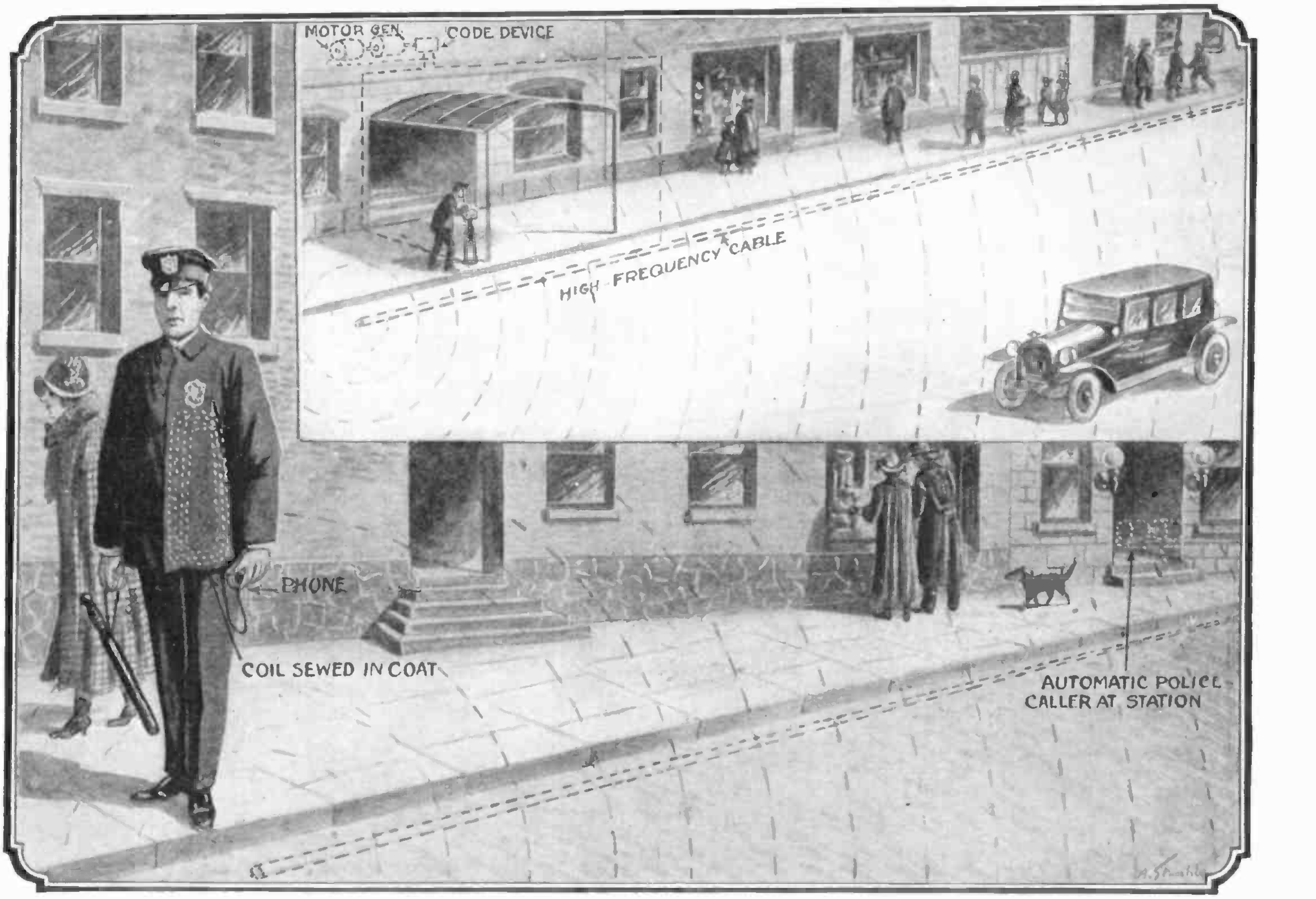
(6°) All manuscripts and photographs must be sent in flat. Rolled manuscripts or photographs are not acceptable. Entries to this contest cannot be returned by this magazine. Ideas not winning a prize may be published in the magazine at our option at regular space rates.

(7°) Should two contestants submit the same idea, then the same prize will be paid to both.

(8°) This contest closes on February 1st, 1925, 12 noon. No contributions postmarked at a later date can be considered.

High Frequency Communication

By Jacques Avon



By means of an underground cable serving as a radiating antenna, signals can be communicated to waiting chauffeurs and policemen, who carry in car or on their person small coils which act as receiving aerials in connection with a small receiving set. This device eliminates the necessity for constant watching of electric signals, at present in use.

THERE is a service which radio more effectively than any other medium, can perform in the field of traffic regulation of police communication. The idea is due to Mr. Earl Hanson.

Out of this system Hanson has developed a new idea which he hopes to have applied to all public institutions such as hotels, theatres, auditoriums and apartment houses where automobiles call for individuals. It is the present practice for the doorman to blow a whistle or to flash a certain number with an electric sign to call forth the driver of any particular automobile. In the hum of a big city these systems have their short-comings and for some years past there has been a need for a more practical method.

From each public institution where automobiles are in the habit of calling, Hanson would bury an electric cable under the curbstone at each side of the street. Connected with this cable there would be a 500 cycle generator which would produce the exciting current, and there would also be a special code-forming device which would interrupt the current a specified number of times and in such a way as to form certain characters that could be easily recognized by the drivers of the cars waiting on each side of the street.

This coding machine would be controlled from the curb by the doorman, who would simply move a lever and a pointer closing the circuit. The cable would at once start sending forth the desired signal and the chauffeur who had that particular call slip with the corresponding dots and dashes on it would immediately call at the door. Each automobile would have a coil of wire connected to a vacuum tube amplifier, and directly back of the driver's ear there would be the ordinary loud speaker which is now used on limousines.

By means of a simple switch this loud speaker could be changed over to operate for this kind of service while the car was in waiting. Thus a great deal of trouble and confusion would be avoided, and at no great expense, for the equipment is simple and practically unfailing in its operation.

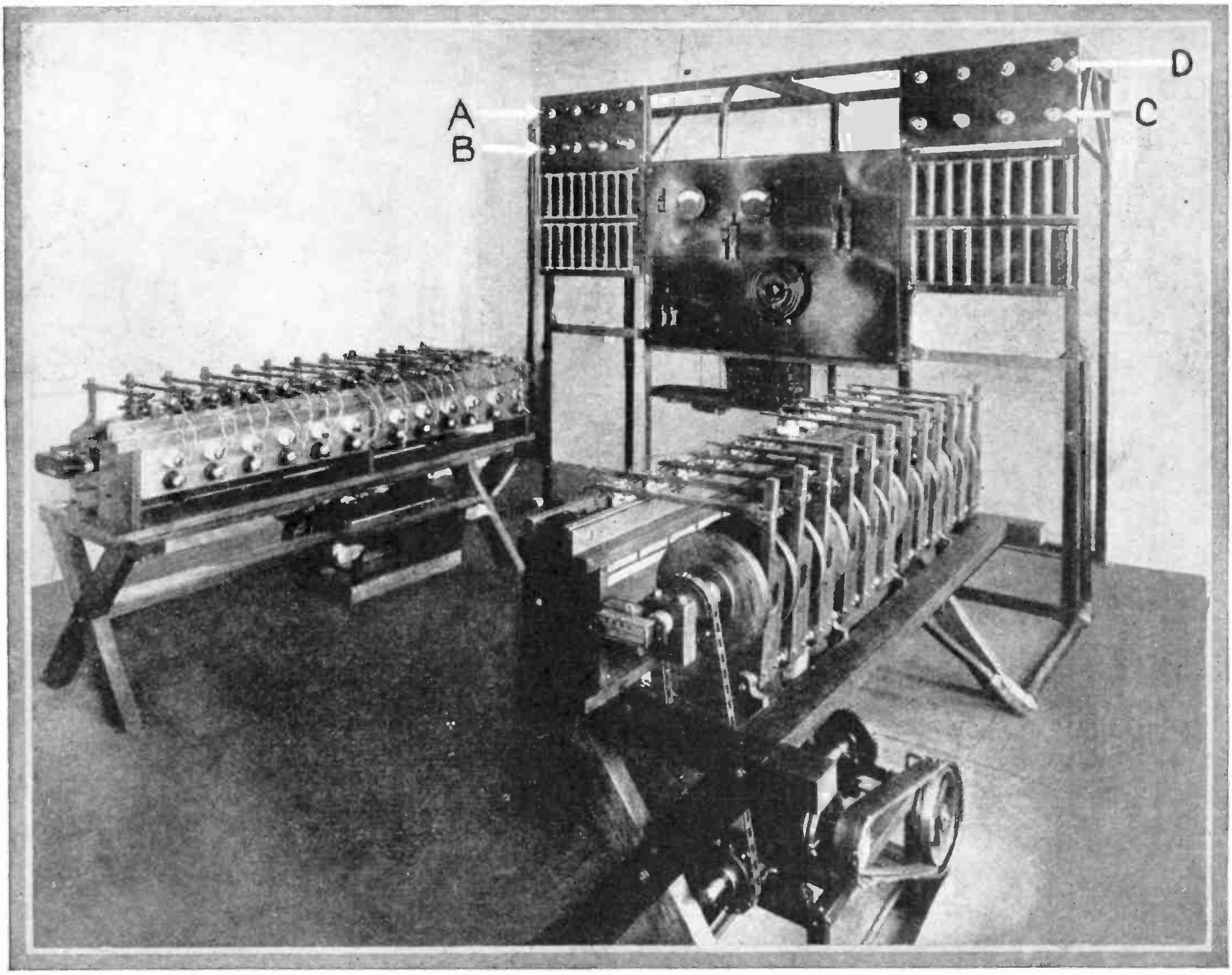
Mr. Hanson has also developed a number of very odd applications of his cable system. One of them has to do with the calling of policemen. At the present time the officer on the beat has to watch the signal lights over the police telephone and when he sees them flashing he at once goes to the communication apparatus. However, he is not always watching the signal, and in many urgent cases he does not arrive in time to be of any service. Mr. Hanson claims that his cable system of calling can overcome all of this trouble if the municipal authorities will bury a small cable either in the center of the road or under the sidewalks.

Each man would then carry a tiny coil of wire in his pocket and a peanut tube amplifier with special light weight batteries. A watch case telephone receiver in his pocket would complete the apparatus and at specified intervals he could with the telephone and receiver receive calls that might be issued to him from headquarters.

A system based on the same principle has actually been tried in the Consolidated Stock Exchange in New York City for communication within the room. The method was found to be well adapted to the requirements of the problem and voice communication was readily carried on.

Looking into the future, we might some day see vessels guided across the Atlantic Ocean by a guiding cable, and like so many other radio devices, it holds out so much promise that one speculates on future happenings with eager anticipation.

Socket and Switch Testing Machine



Apparatus for testing lamp switches, lamp sockets and the like. A number of such can be put on the apparatus and opened and shut in quick succession any desired number of times, to test their durability.

IN recent years practically every large manufacturer of electrical devices has come to realize more and more the growing importance of proper testing equipment for his product.

Every lamp socket, switch or other device operated by means of a spring actuated mechanism for making and breaking the circuit, must be tested on a 250-volt circuit for overload, endurance and heat being being accepted for general use.

During the past thirty or more years many machines have been developed for the testing of operating devices under fixed load.

The testing equipment we illustrate consists of one or more units similar to that shown in Fig. 1. It has a heavy wooden frame, seven feet long, on which is mounted a motor driven shaft carrying twelve side-slotted cams which serve to give twelve extending wooden arms a push-and-pull or reciprocating movement.

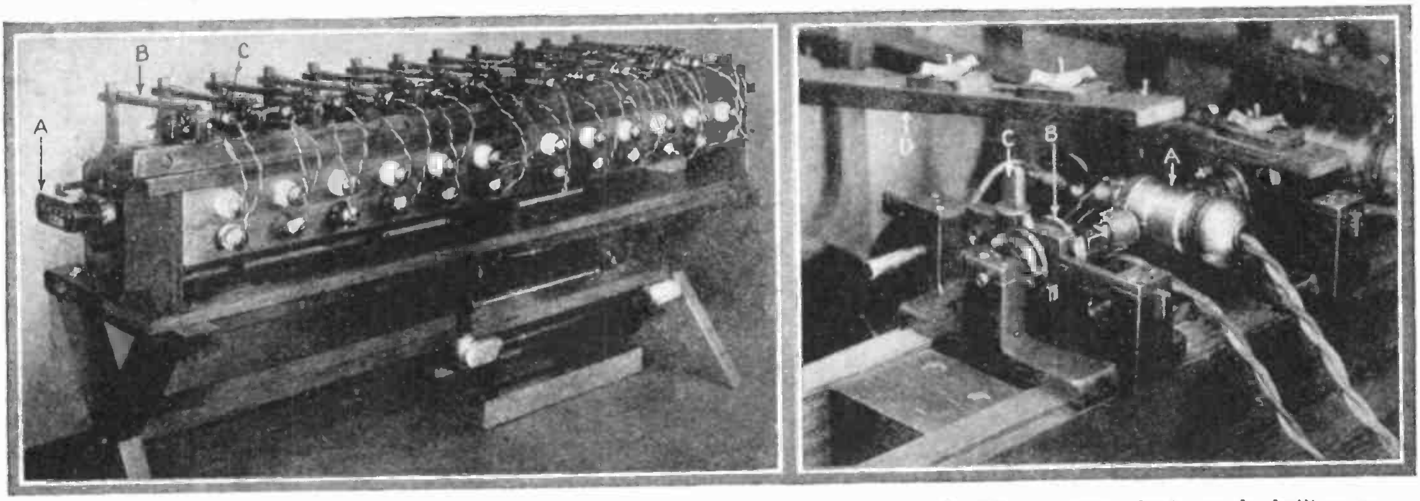
Because of its many advantages for an electrical machine of this type, seasoned hardwood was selected for its frame, and wherever practicable for other parts. Its use eliminates any possibility of short circuiting, and notwithstanding the many moving parts of the machine, assures almost noiseless operation.

The arms, or connecting rods, operate at right angles over a frame, or ladder piece, which extends the length of the machine at the top. This frame, which is readily removeable, has secured to the top surfaces of the side bars, metal straps which are electrically grounded and to which may be attached devices to be tested.

Fig. 2 shows the method of applying the attachment for holding and operating key sockets for testing. These attachments are made in various forms and with their aid, practically every kind of a device can be tested on this one machine. The key socket attachment, for example, transforms the rectilinear movement into a rotory movement, and the attachment for pull sockets revolves a disc on which is fastened a means for holding the chain.

It is understood that this is the first machine to successfully test toggle switches. The flexibility of the extending arm and the method of its operation make the results obtained, nearer to hand operation, than in any other machine so far designed.

Referring again to Fig. 1, it will be noted that on the face of the machine are two half length boards. On the back of these boards are two sets of bus bars, one set connected to the generator, and the other set connected to the Ward-Leonard resistance units mounted on the switchboard (Fig. 3). By means of these units, one-half ampere and one-ampere loads can be built up as required. If finer graduations are wanted, the resistance box as shown below the middle panel of the switchboard in Fig. 3 can be used.



Left—A view of the rear of the socket testing machine, showing resistance units, by which different current loads can be built up as required according to the switches being tested. Right—A socket in place; the wire is seen entering the plug; a comptometer gives the number of openings and shuttings.

To test any given device, it is only necessary to fasten it and the proper attachment to the machine, wire it as it would be in service, plug into the load line and the generator line. Then start the motor of the machine with the small knife switch shown underneath in the center and watch the comptometer at the end.

The machine operates at about ten cycles per minute and is entirely automatic.

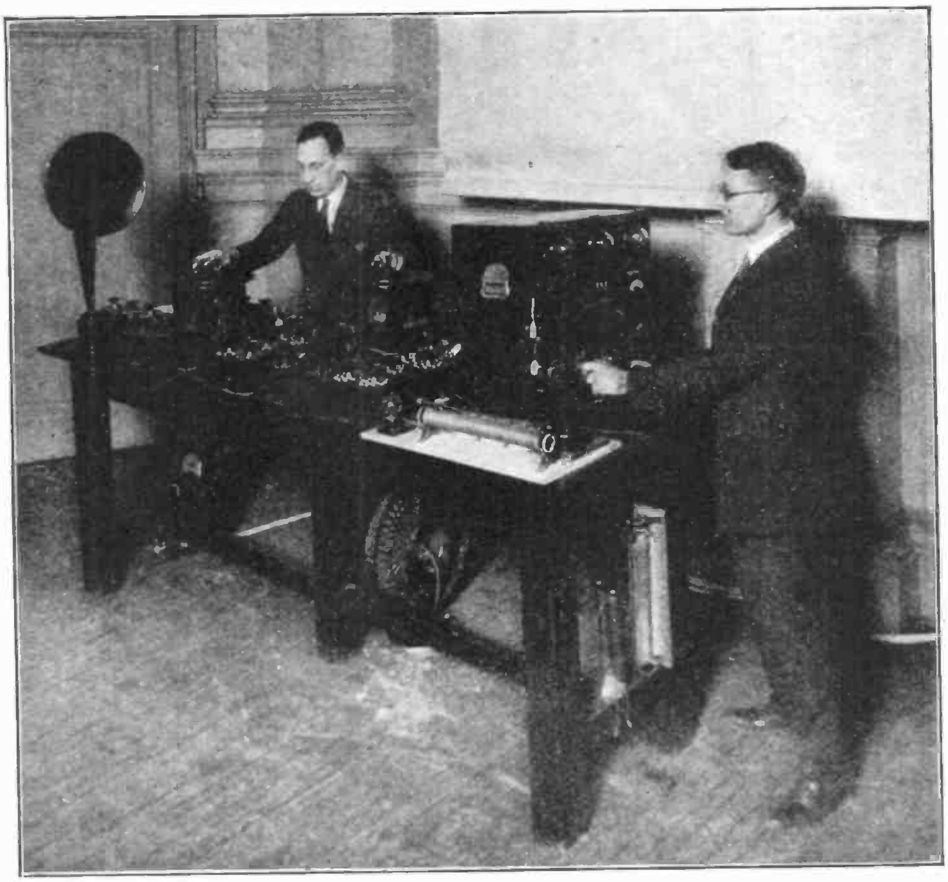
Fig. 3 shows two of these units hooked up to a switchboard. Each unit will accommodate twelve devices in two banks of six each. Units may be added as required.

Electrical Voice Investigation

FOR many years physicists made many attempts to reproduce the human voice mechanically, but never succeeded until the happy inspiration of Edison produced the phonograph, which it is fair to term one of his greatest inventions.

Of recent years electricity has stepped into the field and we have the Poulsen Telegraph phone, which is really a phonograph operating by electricity. The electric current with an electromagnet determines the points of polarity on a long wire, and this wire passing again between the poles of a magnet reproduces the sound.

Recently Dr. Harvey Fletcher of the Western Electric Company of New York, availing himself of the vacuum tube and circuits which could be tuned as desired, gave an interesting demonstration by electric apparatus of the principles of the human voice and of those underlying the reception of sounds by the brain, bringing out many interesting points.



An elaborate apparatus by which the human voice will be electrically produced. This has led to most interesting analyses of sounds and points to the improvement of loud speakers.

The vacuum tube oscillator produced the original sounds; these were fed into an overloaded vacuum tube and the effect of this forcing, as it may be termed, was to produce harmonics of the fundamental tones. An arithmetician would call overtones divisors of the fundamentals.

Those who work at radio know that by adjusting the capacity and inductance of the circuit any desired notes may be obtained. It is therefore possible with this apparatus to try the effect of a production of only a part of the harmonics of a given sound.

The apparatus is connected to a loud speaker and has brought out many reasons for imperfections observabe in loud speaker rendition of voice and music. One of the interesting points evolved is that the ear may be affected by a fundamental note which is not being produced. If pure tones of 500, 600, 700 and 800 cycles are produced there is, of course, an equal difference in tone between all of them, namely, 100 cycles, and this will impress itself upon the ear as an individual note, so that the real notes produced will figure as overtones.

Dr. Fletcher states that organ builders and manufacturers of some radio loud speakers take advantage of this fact, more or less unconsciously. In this way it seems that some loud speakers which cannot produce low tones to give the effect of them in this indirect way.

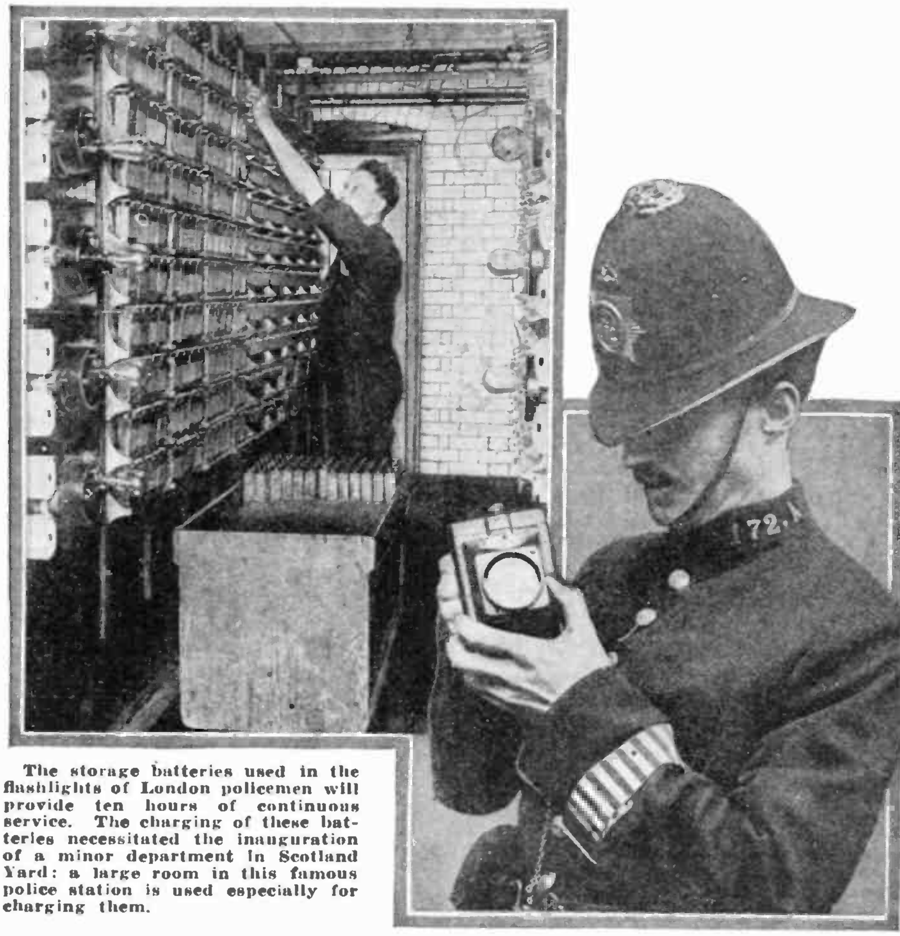
An interesting set of experiments marked the reception of the voice and its transmission to loud speaker through a circuit which, containing coils and condensers, could be arranged to block off all frequencies above a definite cut-off point. The voice without any of the tuning apparatus being in operation would come through clearly, and then the "filter", as it is termed, was adjusted to establish a cut-off point and then to bring it down by steps, from 5,000 toward 100. When this was done sounds began to disappear and such sounds, as si, sh, th were among the first to vanish.

Most commercial loud speakers, it seems, cut off all frequencies above 4,000

(Continued on page 211)

NEW THINGS ELECTRIC

Storage Battery Flashlight Lamp for London Police



The storage batteries used in the flashlights of London policemen will provide ten hours of continuous service. The charging of these batteries necessitated the inauguration of a minor department in Scotland Yard: a large room in this famous police station is used especially for charging them.

The London policemen have recently been provided with powerful flashlights that cast a strong beam over a distance of about 100 yards. The novel feature of these lanterns is the use of small storage batteries instead of the customary dry cells.

THE London police are now supplied with flashlights or spotlights, which are operated by storage batteries. The lantern can cast a strong light for 100 yards and will burn for ten hours on one charge. The charging is done at Scotland Yard, the famous police office of London, in a great room entirely devoted to the recharging of these batteries.

The advantage of the storage battery over the dry battery used so much in flashlights is very great. It lasts longer and gives a much higher power rate, although it is probably considerably heavier.

Self-Turning Bread Toaster

This self-timing electric toaster will be hailed by all housewives as a boon to domestic felicity. When the proper degree of toasting is reached an adjustable timing mechanism drops the wings upon which the slices of bread are carried.

ONE group of popular restaurants have an apparatus for boiling eggs, which is arranged to boil them for a specific time. Here we have a similar principle applied to an electric toaster, but this time for domestic use on the breakfast table.

The slices of bread are carried on racks which are pushed up for toasting and lowered when the operation is to cease, the pushing up being done by hand. On the front of the toaster there is a dial with four finger holes, each one marked for bread, one "extra fresh," another "fresh," another "medium fresh," and another "dry."

The bread is put into the wings of the toaster, pushed up to its vertical position and the dial rotated to the desired position, there being a choice of four indicated grades of heating.

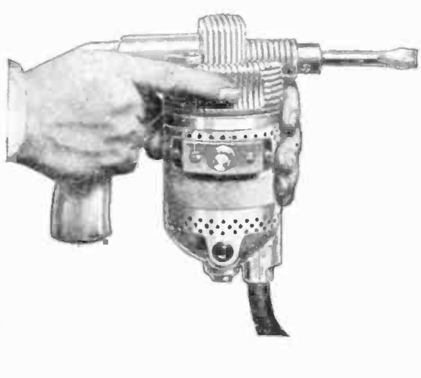
A self-contained timing mechanism drops the wings when toasting is completed, the period varying according to the setting of the dial.

Electric Screw-Driver

OF ALL the operations of carpentry, the driving of screws is one of the most troublesome, although this statement does not seem plausible. Yet the work is exceedingly fatiguing, and when the screws are numerous, the driving of them by hand is hard work.

The appliance we illustrate is an electric screwdriver, which contains within its body a motor running at very high speed, which, of course, it has to do on account of its diminutive size. By worm gears the speed is reduced to a proper one for driving screws.

There are two spindles, or more properly, a double ended spindle, the sockets on the spindle ends receive the bit, and it will be obvious that as both turn in the same direction, one socket will drive a screw and the other will draw it out.



As an instance of its capacity, it is stated that it will drive a three-inch No. 16 screw into a piece of hard-yellow pine without any hole being bored therefor. It is also claimed that it will do the work of three experienced men.

An electric screw driver with remarkable power and which does the work of three men. It will drive a large screw into hard wood without any hole being bored. By reversing the motion it withdraws the screw.

The apparatus is furnished with a pistol grip as shown in the illustration, or without,

(Continued on page 212)

EXPERIMENTAL RADIO

Conducted by Clyde J. Fitch

Experimental Harmonics

By John L. Reinartz, 1QP, 1XAM.

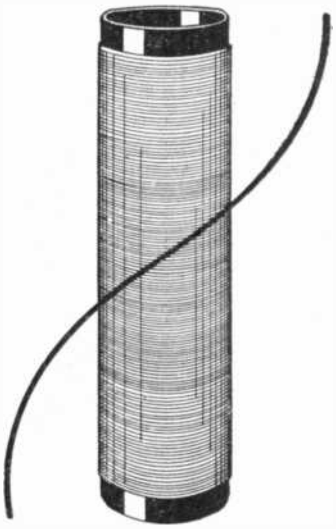


FIG. 1

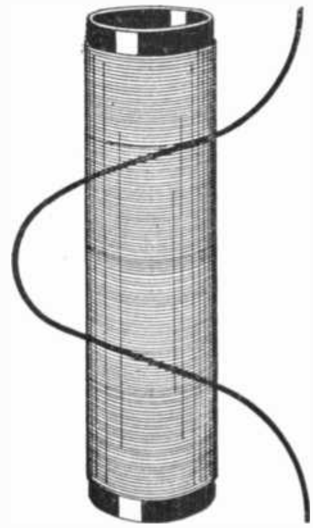


FIG. 2

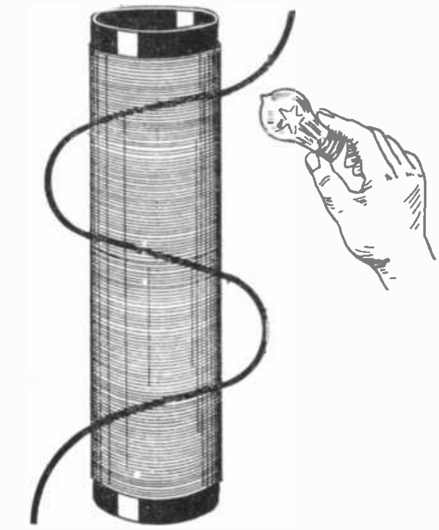


FIG. 3

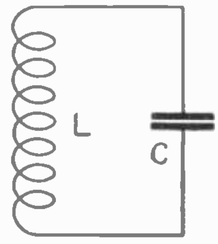


FIG. 4

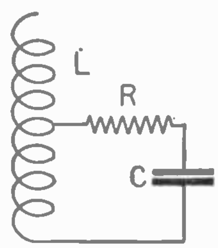


FIG. 5

Fig. 1. Voltage curve of a coil as measured by holding a neon lamp in its vicinity when excited at its fundamental frequency. Fig. 2. Voltage curve of the same coil when excited at a frequency of twice its fundamental. Fig. 3. Voltage curve of a coil when excited at three times its fundamental frequency. This illustration shows how the neon lamp is used for making the tests. Figs. 4 and 5 show circuits used in making the tests.

SINCE good radio weather has made its appearance, together with the removal of the quiet hours and the advent of amateur short waves, it is rather seldom that I can play with the Moduloscope.

For the past year I have been working especially on waves between 10 and 100 meters. Strange to say, it is the short waves which pointed to further use for the Moduloscope. It all occurred in this way.

Mr. Young at the key at station NKF of the navy testing laboratory, Washington, D. C., had repeatedly told me that the signals from my station 1-XAM died down, becoming barely readable (during the tests made early in the year on waves from 50 meters down to 20) whenever I went below 39 meters.

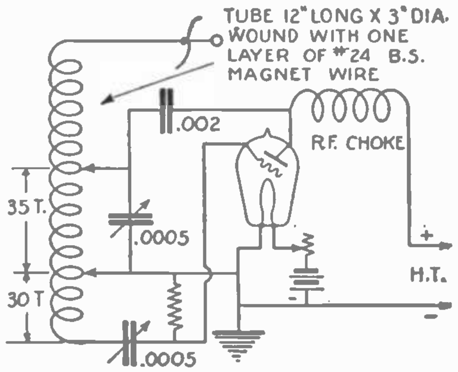
This was so consistent that we decided it was either due to his receiver or surrounding conditions, or to some resonant absorbing influence in the vicinity of my station. I was using a six wire cage antenna with a counterpoise to match. The antenna was of the inverted L type and had a fundamental wave-length of 105 meters. I reasoned that at 35 meters the results should improve rather than become worse, as they had been doing, 35 meters being the third harmonic of the fundamental frequency. At this point of the tests I again went to the Moduloscope for information.

You will recall that the top connection of the Moduloscope emitted corona streamers when properly tuned to the driving circuit. This same high voltage solved my new problem. I had an idea that perhaps when the antenna was operated at a harmonic it could be a wave trap containing considerable resistance, which could be stealing considerable energy from me and which Mr. Young therefore would not receive, hence the weak signals. My method of reasoning was as follows:

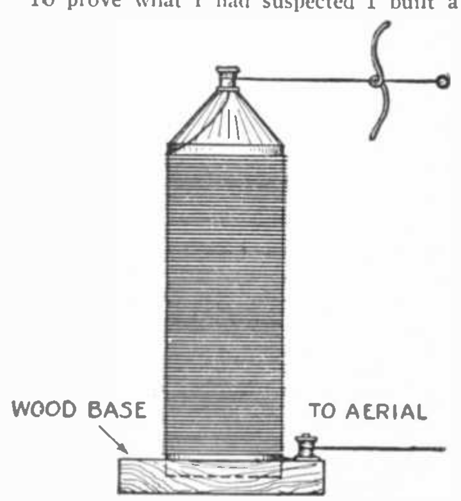
If we take a coil the size of the Moduloscope and excite it at its fundamental frequency, and insert it in the circuit so that it has not ground connection, it will represent a radiating system of the antenna and counterpoise type. Let us assume that its fundamental wave-length is 150 meters; with an energy input to the exciting circuit of 50 watts we will get sufficient power out of the testing coil to give a corona discharge nearly an inch long. This is more than enough for our test.

The voltage curve of the coil can be determined with a neon tube and will look like Fig. 1. This curve also represents a half wave. If we now tune the exciting circuit to 75 meters, we will be operating on the second harmonic, and, due to the higher resistance of the test coil to this higher frequency, we will have less corona discharge at the end of the test coil. The neon tube shows the voltage curve to be as in Fig. 2. Tuning down still farther we come to the third harmonic or 50 meters, and the corona discharge is still less. Evidently the resistance is still higher than before, and we are losing more energy in the test coil. The voltage curve is now as in Fig. 3. We could carry this test still farther and we would lose more and more energy, but the test coil was still giving off a corona discharge and would to the nth harmonic. Bear in mind that it still gave off energy in the form of corona discharges. Therefore, I reasoned that an antenna and its proper counterpoise if of pure inductance would never give trouble in the form of high resistance wave traps.

To prove what I had suspected I built a



An oscillatory circuit suitable for exciting the Moduloscope coil. A Tesla effect is produced at the upper end of the coil causing the small wire to spin around. The ordinary short wave C.W. transmitter may be used for making these interesting experiments.



Constructional details of the moduloscope. This instrument is used as an ordinary Tesla coil except that it is excited by an undamped high frequency current. The voltage glow at the upper end of the coil indicates the degree of modulation when used in connection with a C.W. telephone transmitter.

coil with a condenser connected across it and tuned it to 150 meters. The voltage induced in it by the exciting circuit was high enough to make it break down the air gap between the condenser plates. Evidently I was not losing much energy in the wave trap; leaving the wave trap set for 150 meters and tuning the driving circuit to the second harmonic or 75 meters, occasioned no response from the wave trap, nor did the third harmonic or 50 meters, and so on down. Evidently a coil shunted with a large capacity will not respond to harmonics, but neither does it absorb energy at the harmonics. The wave trap connections are shown in Fig. 4.

By this time I had discovered two facts. A pure inductance would respond to harmonics and have a resistance loss; and an inductance shunted with a capacity would not respond to harmonics, nor would it lose energy. Therefore it must be a combination of both which was giving me so much trouble on the short waves.

I then built a coil with condenser shunted across a portion of its turns, and with one ohm resistance in series with the condenser connection, consisting of some No. 30 German silver resistance wire wound in non-inductive fashion. This is shown in Fig. 5. I again excited this combination at 150 meters as its fundamental. The end turn of the coil was at high voltage but the discharge was not as in the coil of pure inductance; also the resistance got warm. Then I excited the system at the second harmonic or 75 meters with the same result. Then came the surprise.

While tuning the exciter circuit down towards the third harmonic or 50 meters, the resistance wire got hot and started to smoke. Careful testing brought to light the fact that I had unconsciously achieved what I had sought. The condenser portion of the test coil was tuned to 55 meters and was absorbing energy at no mean rate. Also due to the resistance in the circuit the tuning was rather broad and entirely spoiled the Tesla effect at the top of the inductance cage type antenna, especially at the cage lead-in. It was a small matter to replace the good looking antenna system with a single No. 16 copper wire and counterpoise to match. Mr. Young's report on short waves below 30 meters in the tests which followed clinched the matter.

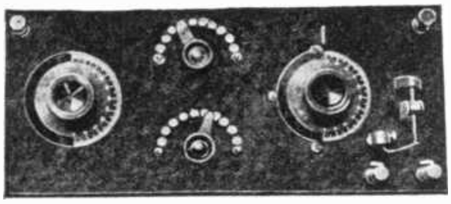
By this time you are no doubt wondering why I did not erect a shorter antenna and operate it at its fundamental frequency to get rid of the high resistance wave trap effects. This was done, but due to the intense field which surrounded the shorter antenna, and to the fact that it was so near the house, more energy was lost than before. At various waves I could in turn light the hall light, the bedroom light or the porch light. This was a worse evil and furthermore, it was my contention that if the wave is radiated at a higher elevation the absorbing influences of the surroundings are reduced. At any rate, the house lights would not light when using the large antenna, so now another mystery was cleared up.

No, we are not yet through with the pure inductance. Remember it responded to all the harmonics, so why not make more use of it? All of us are in need of a wavemeter, but still more in need of a device to check our wavemeters. That is where the inductance comes to our aid. On some 3-inch diameter paper mailing tubes wind three coils with No. 26 D.C.C. wire. Each coil is to contain twice the turns of the next one. This need not be exact, because some of the turns will have to be removed anyway. Let the first coil have 200 turns, the second 100 turns and the third 50 turns. Now boil all three coils in paraffin wax to remove moisture and let cool. Then either borrow a real wavemeter or listen for the standard waves from WWV and determine the fundamental wave of each coil.

Suppose the larger one has a fundamental wave-length of 200 meters; its next resonant point would be 100 meters. Then remove as many turns from the second coil until its fundamental is 100 meters. The next resonant point of this second coil will be 550 meters. Remove as many turns from the third coil as are required to bring its fundamental down to 50 meters. You now have three standards which will not change and which give a great range. The first coil will respond to 200, 100, 66.66, 50, 40, 33.33 meters and so on down. The second will respond to 100, 50, 33.33, 25, 20, 16.66 and so on down. The third responds to 50, 25, 16.66, 12.5, 10 and so on down. They will check each other and constitute an accurate wavemeter. The resonant points can readily be found when holding the coil near the tuner coil. A click in the ear phones will give you the different harmonics like beats in piano tuning.

Receiving Without a Crystal

By Guy Dillon



Front view of the crystal receiver that works without a crystal.

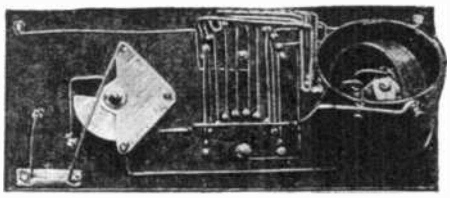
THERE are a great many amateurs who would like to receive long-range stations with a crystal. To do so *without* a crystal or tube is quite a stunt, but I have done it.

Now, to begin with, receiving without a crystal at short range is comparatively easy; to accomplish this at long range is difficult unless a very senstitive set is used, and not one in a thousand is what would be called sensitive. And until you buy or build a set that is efficient, don't try it, but after you have acquired this set you may really start experimenting with the methods I have used to attain my results.

It might be appropriate at this point to investigate the reason why you receive long-range signals. I have proved to my entire satisfaction that there are two different methods of doing this, the first and hardest is directly from the station; the second and most widely used is by reradiation, or in other words, you let your neighbor pick it up on his set, amplify, and relay it by regeneration. In other words, he has a regenerative set, which is really a small relay station working in his vicinity.

A crystal is merely a rectifier that rectifies the high-frequency current; or, in other words, allows only one-half of the wave to pass, and by that method we are able to pick up the necessary amount of current to form the words reproduced in the phones. We know that copper carries electrical energy with less resistance than many other metals; we also know that steel has a drag effect on such currents, so if the two are put together in the same manner in which a crystal contact is made we get the same results; sometimes better results are obtained if the right spot on the steel is used.

I would suggest the use of a razor-blade, one of the safety variety. Lay it on the top of the crystal cup and adjust the catwhisker on it in such a manner that it touches very lightly. Bear in mind the fact that such a blade has sensitive points on it,



Rear view of the crystal receiver showing the tuning condenser and the variocoupler.

as a crystal has, and it is necessary to hunt for them.

The best way to get on to catching distant stations is to set your crystal on the most sensitive point while your local station is broadcasting and leave it there until they finish, then listen in for the long distance stations. It won't be any trouble at all to pick them up. The photos and drawing are plain enough to be understood by anyone.

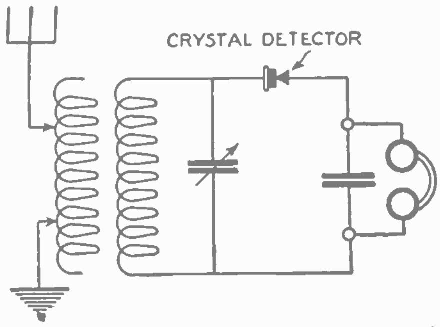


Diagram of the crystal receiver. The crystal detector indicated is merely a metal wire in contact with the metal detector holder.

It happens that I am listening to Atlanta, Ga., while writing this paper. I am using a gold cat whisker and a brass crystal cup for my rectifier. It is one of my latest experiments, in fact, only two hours old.

$50.00 in Prizes

A contest for radio experimenters. There are three monthly prizes:

First prize ....$25.00 in gold
Second prize .....$15.00 in gold
Third prize ....$10.00 in gold

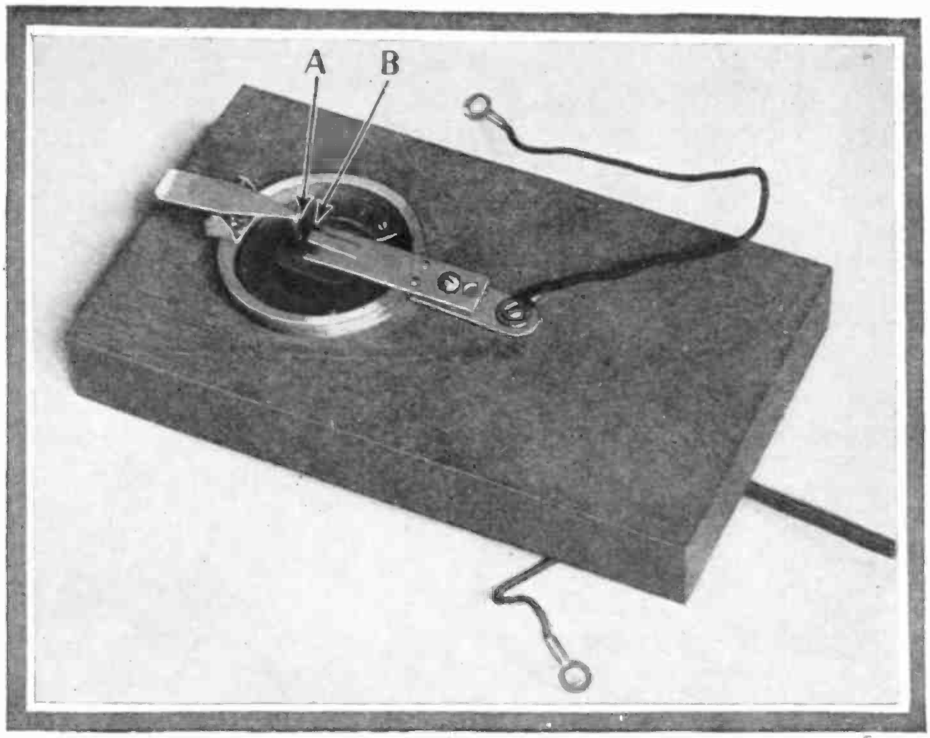
In order to be eligible for a prize the manuscript must deal ONLY with the experimental phase of radio, somewhat along the following lines: Radio *experimental* wrinkles. Short cuts for the *experimenter*. Simple devices to help radio *experimenters* in their work are wanted particularly.

This prize contest is open to all. All prizes are paid upon publication. If two contestants submit the same idea, both will receive the same prize. Address Editor, *Radio Experiments Contest*, c/o this publication. Contest closes on the 15th of each month of issue.

A Crystal Set Loud Speaker

(Continued)

THOSE who built the microphone relays described in the December issue were no doubt disappointed by the results. Very seldom both quality and volume will be obtained from these amplifiers when used with crystal receivers, and the microphone contact must be so delicate that the instrument does not stay in permanent adjustment; but the fact that it does operate gives us something to work upon with the idea of developing it to the final degree of perfection. In Europe there are at least two microphone amplifiers on the market that apparently are successful. We have not tested these instruments, but for the benefit of our readers we are giving below a version of the English "Crystovox" amplifier as it appeared in *Radio Rundschau.*



A microphone amplifier that operates on the Tauleigne principle. A microphone contact is obtained between the two carbon electrodes A and B. The lower one is actuated by the telephone.

"The use of the principle of the microphone for amplifying telephonic transmission is not unknown; many loud speakers avail themselves of the microphonic intensification of the speech-current in order to give a more powerful vibration to the talking membrane.

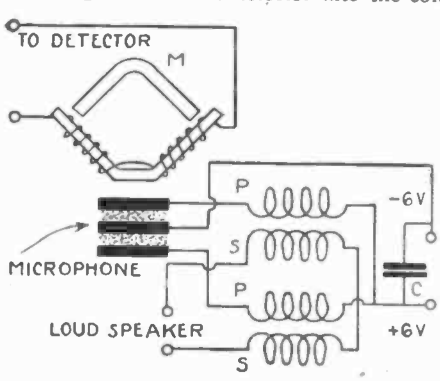
"The English constructor, Brown, has brought out two types of microphone amplifiers. Above all he builds a loud speaker called the Crystovox which, in consequence of the built-in microphone, can be excited by very weak currents. He then developed the apparatus still further and made it independent so that the new Brown microphone amplifier can take up the role of a two-stage audio frequency amplifier.

"A substitute for the vacuum tube amplifier is certainly much to be desired; in the use of vacuum tubes a distortion of the enunciation can hardly be avoided on account of the low frequency transformers. A crystal receiver in the vicinity of the transmitter gives by far best quality of reception, if one listens in without using any amplifier.

"From our own experience with the new microphone amplifier we can give the following particulars:

"Its principle can be derived from the diagram, Fig. 3. The audio frequency talking current goes from the detector into the coils of the electromagnet, whose magnetism is maintained by a permanent magnet (M). This magnet works upon a tongue which, by means of a lever, affects the microphone that is connected through two primary coils (P) of a coreless transformer to the 6-volt battery. A block condenser (C) is connected in parallel between the two transformers; the secondary coils (S) of the two transformers are connected in series with the telephone receivers or loud speaker.

> At the time that this issue went to press, we received direct from France a Tauleigne microphonic amplifier. In the February issue we will give full details of construction and photographs of this instrument together with a report of the results of our tests on the device.



Connections of the amplifier used in the Crystovox. Note that two chambers of carbon granules are used.

"Only 60 milli-amperes of current are used; dry cells are enough for its operation. What sort of reception does it give? On the occasion of a Radi-Hekafon concert the amplifier was connected to a simple crystal receiver with the very excellent 'rusonite' as crystal, with a high antenna 180 feet long. The sound in two ear phones was overpowering. A Seibt loud talker was so strong in its sound that the notes filled a medium sized room.

"Next the crystal detector was connected to a two-wire indoor antenna altogether hardly 130 feet long; without an amplifier the reception was barely audible; with the amplifier connected the sound was very good in the ear-set and sufficiently loud. By comparison it appeared that in these tests the amplification was about equal to that of a low frequency vacuum tube, but the purity of tone and the clear enunciation of the crystal detector was perfectly preserved by the microphone amplifier, which the low frequency amplification by a vacuum tube cannot give in equal degree. The microphone amplifier acts still better when it is connected to a vacuum tube detector. It seems that its amplifying operation noticeably grows with the increase of the input low frequency speaking current.

"By use of a radio frequency amplifier, audion detector, and the microphone amplifier, an unusually powerful reception was produced with a loop antenna. The quality of the sound from the Brown microphone amplifier is higher than in low frequency tube connections, so that its complete operation first develops as an addition to vacuum tube reception.

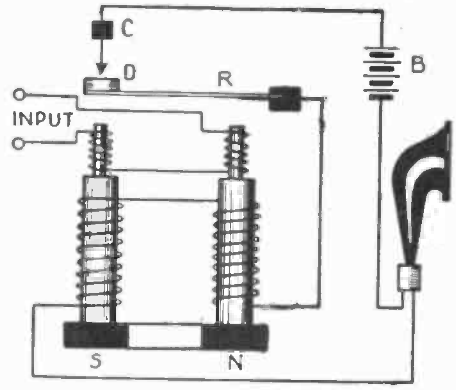
"The setting up of the apparatus is extremely simple; it has a little screw that is turned until reception begins, then for the fine adjustment a small hard rubber plate it turned in which a magnet is embedded, which affects the field of a permanent magnet.

"The high price of this novel loud-speaker, in spite of its good qualities, stands in the way of its extensive use. But undoubtedly the microphonic amplification is a field to which radio experimenters must give their attention.

"PAUL BELLAK, Eng."

Another form of Brown relay developed years ago and used by the Marconi Co. for transatlantic communication in connection with a carborundum crystal is depicted in Fig. 4.

This relay has two electromagnet windings as shown and the core is polarized by the permanent magnet (N-S). The current to be amplified passes through fine winding on the pole tips. This causes vibration of the soft iron armature (R) which is fitted with a carbon button (D). An adjustable contact (C) of an osmium-iridium alloy presses lightly on the button, the contact forming a very sensitive microphone. The microphone current from the battery (B) passes through the contact and also through the coarse magnet-winding on the poles.

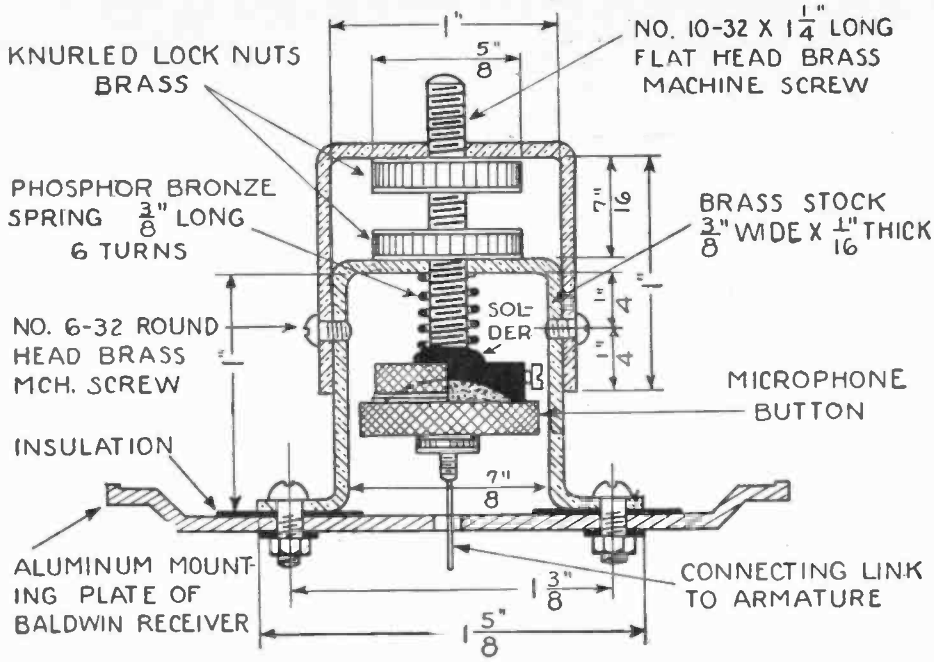


An early form of Brown relay. A regenerative effect is produced by the larger winding in the microphone circuit that encircles the magnetic core.

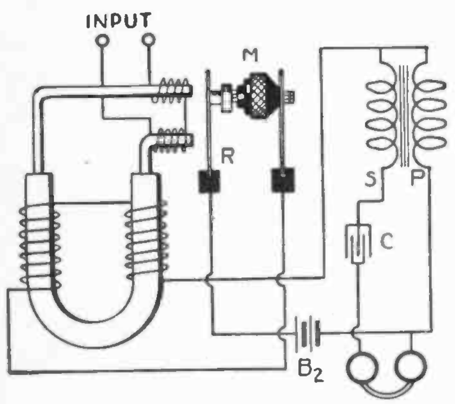
This further changes the magnetism of the pole tips and increases the vibration of the armature, so that a regenerative effect is obtained. Remarkable results are claimed from this relay. It should be used with a low resistance loud speaker.

It is interesting to note that this relay was used with a carborundum crystal, which detector requires a local battery current for its operation. This current of course passes through the fine winding on the pole tips and may have some effect on the operation of the instrument.

Fig. 5 shows another form of relay of simple construction instead of light microphonic contact, a transmitter button (M) is placed against the vibrating armature (R). The step-up transformer is used in conjunction with this relay so that a high resistance radio loud speaker may be used. The battery (B) supplies the microphone current that passes through the transformer



Details of an amplifier employing a transmitter button that may be attached directly to the front mounting plate of a standard type C Baldwin receiver.



An early form of Brown relay employing a microphone button and step-up transformer.

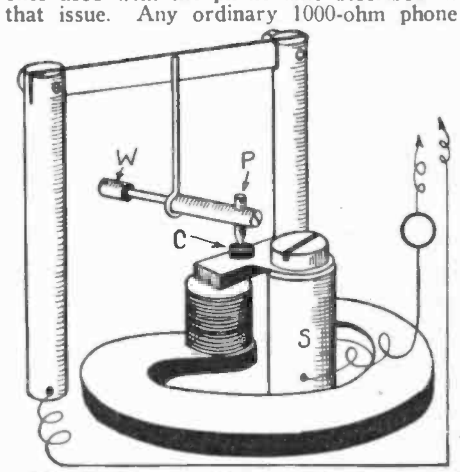
primary (P). The secondary is connected in series with a two mfd. condenser (C) and the loud speaker.

The details of construction of a very good microphone relay for use with a Baldwin phone unit are shown in Fig. 6. The diaphragm of the unit is removed and the connecting link from the vibrating armature is attached directly to the microphone button. The button is made adjustable by soldering a 10/32 threaded brass rod to the back of it. By means of the two lock nuts and the coil spring a very tight adjustment is obtained. The advantage of this form of relay is that the vibrating armature acts directly upon the button, without the use of an intervening diaphragm.

A microphone amplifier that has gained wide popularity in France is shown in Fig. 7. This instrument is now on the market in Europe and appears to be a success for use with galena receiving sets. It was developed by Tauleigne.

Experimenters should have little difficulty in constructing this amplifier by carefully following the illustration. The permanent magnet and the two pole tips may be taken from a standard two pole loud speaker phone unit. They should be securely attached to a wooden base. The standard (S) that supports the vibrating armature is also attached to the base. It should be of the correct height so as to give a very small air gap between the armature and the pole tips. On top of the armature is placed a carbon button (C) and in contact with this a carbon pencil (P), the light contact forming the microphone. A weight (W) is used to counterbalance the weight of the pencil, and by sliding this weight along the rod a very light and adjustable contact is obtained. Experiments with this amplifier indicated that the lighter the contact the greater the amplification.

The photographic view shows a relay of the Tauleigne type built in THE EXPERIMENTER's laboratories. This instrument was not a brilliant success but gave fair results when properly adjusted. The details of the carbon contact point and hinged lever were given in the December issue, as they are the same as the ones used with the phone unit described in that issue. Any ordinary 1000-ohm phone unit may be used. The armature carries a piece of a carbon diaphragm as one electrode. This is clamped in place by a small piece of brass soldered to the iron armature.



The Tauleigne amplifier. This instrument has met with commercial success in France. A microphonic contact is made between the two electrodes C and P.

Experimental Flewelling Receiver

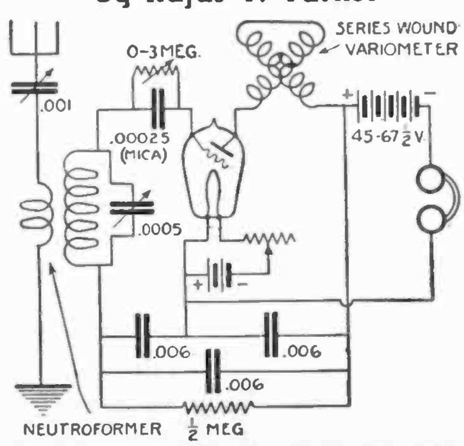
By Rufus T. Turner

ANYONE who has ever used a one-tube Flewelling super-regenerative receiver will seldom want to be without one.

Though it employs only one tube the results are equal to any receiver consisting of a stage of radio frequency, a vacuum tube detector and two stages of audio frequency amplification.

- 1—.001 mfd. variable condenser
- 1—neutroformer
- 1—variable grid leak, 1 to 3 megohms
- 1—.00025 mfd. fixed condenser
- 3—.006 mfd. fixed condensers
- 1—½ megohm grid leak
- 1—variometer
- 1—standard V.T. socket.

Reflex circuits are said to give similar results but the builder is forced often, to experiment a great deal in order to make a reflex receiver work properly. The troubles in using the Flewelling receiver would be relieved if transformers, fussy crystal detector, etc., could be dispensed with and the desired results are obtained more readily.



A super-regenerative circuit of a Flewelling type. This receiver is claimed by the writer to give results equaling those obtained from the ordinary detector and two stage amplifier.

Every circuit, when it makes its initial bow to the fraternity of dial-twisters, is claimed, by its originators, to have numerous advantages and no disadvantages. But as long as I used the Flewelling "super" I found but one disadvantage, namely: radiation when used with an outside aerial.

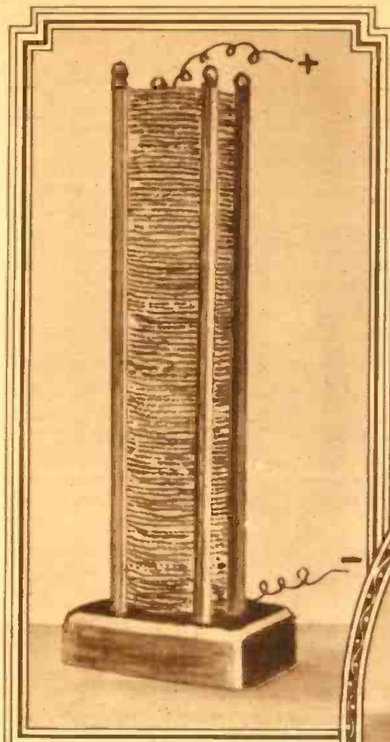
Often, for one or many reasons, use of an outside aerial was desired. I experimented with my "super" until I reduced radiation considerably and still retained the advantages of the super-generator.

By consulting the drawing one may readily see the improvement. All details are given in this diagram. This improved circuit is much more selective than the original Flewelling "super," and equal to any receiver consisting of an audion detector and two stages of audio amplification.

Historic Experiments

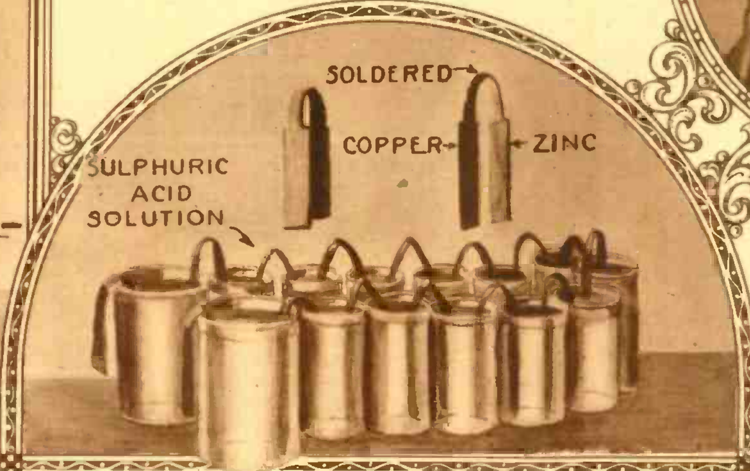
No. 3

Volta and the Primary Battery

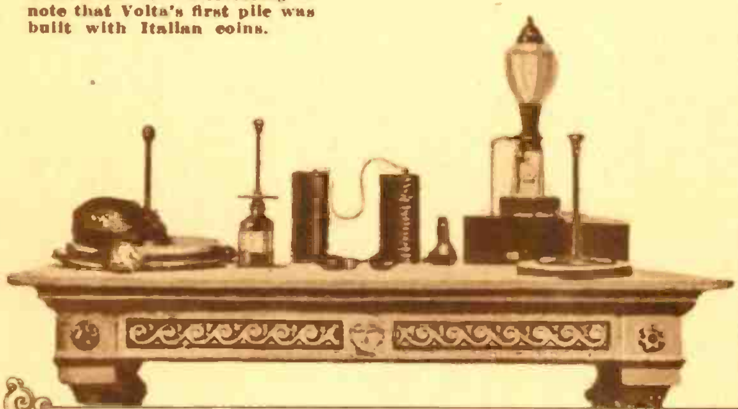


One of the earliest electric piles built by Volta is illustrated here. It consists of pairs of unlike metals in metallic contact and separated from similar pairs by a layer of fabric soaked in brine or weak acid. It is interesting to note that Volta's first pile was built with Italian coins.

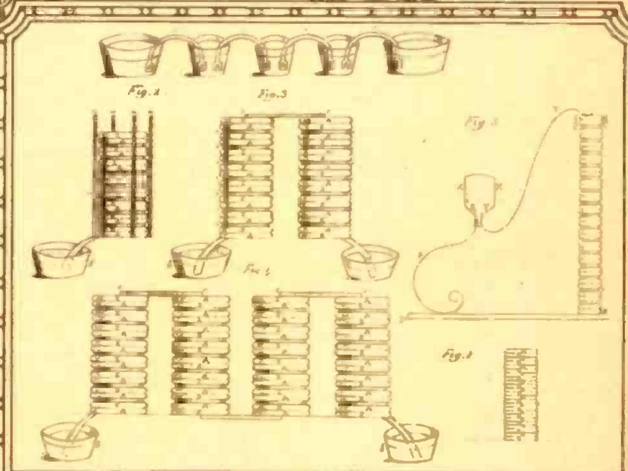
Alessandro Volta, one of the greatest electrical experimenters of the past. Born 1745. Died 1827.



Volta's electric battery shown at left is a development of the Voltaic pile. It was called the crown of cups. From this humble apparatus grew the multitude of our primary batteries.



Volta's laboratory table and apparatus has been preserved in the Instituto Lombardo di Scienze, in Milan. Note the electrophorus at either side and the Voltaic piles in the center.



Above is a reproduction of an illustration of one of Volta's books. The pile supplies current for the explosion of gases, contained in the flask.

A curious physiological application of Voltaic electricity is shown at left. The slight application was thought beneficial.

Alessandro Volta

IN 1759 Alessandro Volta, a slim, pale boy of 14 startled the faculty of the School of Rhetoric at Como, Italy, with the beauty and mature style of his Latin poetry. He showed a keen perception of Nature's moods and expressed a soul awed by her deeper mysteries. Eagerly and with a precocity that gave early signs of genius, he pursued his elementary studies and absorbed so rapidly all his masters could teach him that three years later we find him studying philosophy in the College of the Jesuits. With an enthusiasm that bordered on passion, he devoted his time to the study of the natural sciences and to the writing of poetry. This rare union of the muse of poetry and the sterner genius of science soon gained him a wide reputation and at the early age of eighteen he was already engaged in serious scientific correspondence with the Abbe Nollet, one of whose experiments, our readers will recall, were described in the preceding issue of THE EXPERIMENTER.

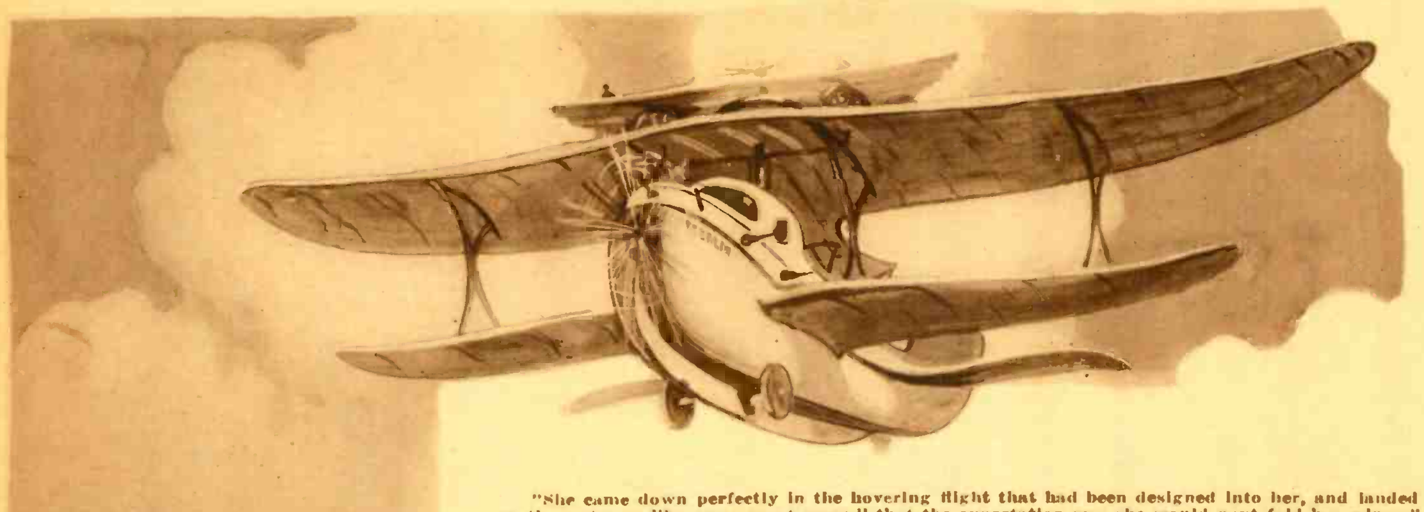
His enthusiasm did not wane with the approach of manhood but found adequate expression in brilliant research and writing. In 1775 he invented the now widely known electrophorus which at the time created a great stir in France and England as well as in Italy. His fame spread rapidly abroad and his scientific interests broadened, extending his research work to chemistry in which he made many important discoveries.

At the age of 34, Volta became professor at the famous University of Pavia where he gave inspiring lectures in physics for 25 years. Years replete with joyous industry! In the quiet retreat of his laboratory that bears all the quaint decorations of his period, we see the matured Volta in deep study of the causes of electrical phenomena

(*Continued on page* 213)

The Ark of the Covenant

By Victor MacClure




"She came down perfectly in the hovering flight that had been designed into her, and landed on the water so like some great seagull that the expectation was she would next fold her wings."

(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 is notified of it and stands by his son's bedside early in the morning and wakes him. Instinctively the son realized that something was wrong, and jumped out of bed, and seeing that his father was in deadly earnest, no questions were asked, but with his roadster and airplane he undertook to rush him to the city.

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

Four banks in all, it seems, had been robbed. Guards and watchmen had been asleep. Some mysterious method was used to burn open the safe, and the oxidation of the watch added to the mystery and brought it into the realm of chemistry.

One of the policemen recovered consciousness and found he had been lying asleep on the sidewalk, and in a doorway he found his own inspector overcome by the same unconsciousness. The mystery is at its height.

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

The son of the banker is active in investigating the occurrence. A friend of his, a chemist, undertakes to examine the tarnish on the gold, and the contents of the lead boxes seem to be a radium compound.

The Boxes in the Post Office and Their Lead Cases

"Have they been opened yet?" I asked.

Mr. Glover looked pained at my lack of finesse.

"Not officially, Mr. Boon—not officially. Special authority is needed for that." He dropped his voice to a whisper more confidential than ever. "But *I* can tell you—quite unofficially, of course—that the square packages contained black boxes of wood, inside which were what at first appeared to be lumps of solid lead. Closer investigation, however, proved these last to be lead cases with extremely thick sides."

"What was in the lead cases?"

Mr. Glover shook his head.

Explosives?

"I cannot say," he said ponderously. "But as I am inclined to think some outrage is contemplated, I should say—explosives! But, as you may know, there is a special department of the Post Office primarily concerned with the handling of such contingencies, and at the moment, Mr. Boon, an investigation is going forward—behind closed doors!"

"You don't know what was in the envelopes?"

Once more Mr. Glover was pained at my bluntness.

"No. That I cannot tell," he said severely. "You now have all the information I can lay at your disposal, Mr. Boon—and that, sir, I beg you to remember, is quite unofficial—and sacrosanct. It must not be bruited abroad!"

I admit that I saw little ground for connecting this mystery with the robberies around Wall Street, nor any need for secrecy. I was inclined to think Mr. Glover's love for the mysterious had led him into a fantastic interpretation of some silly joke on the institutions, but I thanked him with every appearance of being impressed, and took a speedy leave of him. I was not a little annoyed with myself for having wasted my time on the pedantic fool. But subsequent events, since made public, were to show me that Glover, for all his absurd pomposity, had got nearer the truth than I imagined, and that I had underestimated what was to prove one of the most surprising of a chain of happenings that ultimately were to baffle the whole world. Yet, as I say, at the time I thought the thing some ill-conceived joke on the institutions, or perhaps the result of an error on the part of some manufacturer's dispatch clerk, and I took little stock of it. Without pausing to look into the bank, I made for the seaplane jetty and the *Sieve*.

At the Landing Stage Once More

Round the landing stage now, in addition to the bronze-painted machines of the police, a number of privately owned boats were moored. Luxuriously appointed craft, with their closed cabins and the silk or brocade curtains on their windows, they made the old *Sieve* look more disreputable than ever; but when I noticed that one or two of these swell conveyances belonged to bank presidents like my father, I smiled to think that my old tub, like a mongrel pup to a dog-fight, had been first on the scene of action. And as I set the old girl skimming down the Bay, I smiled still more when I thought how ornamental all that swagger effect would look, once I got back in its midst with my lovely silver *Merlin*.

She not only had the whole bunch beaten for sheer good looks, but—in the matter of speed—she was to the best of them what the hawk is to the peacock.

CHAPTER THREE

The Merlin

1

The cluster of buildings close to Gardiner Bay, where we did our construction and experimenting, was beginning to find definition on the white margin of the sea, when there dropped from the clouds in front and above the *Sieve* a beautiful silver shape. It was the *Merlin* which Milliken had out for a trial flight.

Until that moment I had never seen her in the air. She was my design and had been built in the sheds on the beach under my supervision. Her tests had all been carried out at my hands, and she had never been in the air without me. Milliken had often landed her, but always with myself at his elbow. Until now he had not taken her up on a solo spin.

To see her so, as an outsider would, was a queer experience for me. I felt pretty much as a dramatist might if he saw a play of his acted for the first time. The clean look of the *Merlin* gave me a thrill. I wanted to fly her myself and be able, at the same time, to watch her from a distance.

It was something of a surprise to me to see her up in the hands of Milliken, though I couldn't say that he had exceeded his privilege. It was quite a natural thing for him to do, considering the way I trusted him. But even while I was admitting that he handled her splendidly, a sort of jealousy had hold of me for a minute or two. He passed me, and I signaled half angrily that I would land first.

The New Airplane, the "*Merlin*"

The graceful silver shape swept dizzily over my bows, turned banking into a sideways loop round me, and righted again to come about after the clumsy old *Sieve* like a great, slim-winged bird. No, I'm wrong. There isn't a bird that could repeat the manœuvre, and I had thought, until I saw Milliken do it, that only the *Merlin* and myself had the knack, but the mechanic had copied my stunt.

Stupidly annoyed, I planed down for the shore and flattened out to taxi up to the jetty. The mechanics ran out and brought the old seaplane to rest in the shed, and I disembarked to watch Milliken bring in the *Merlin*. She came down perfectly in the hovering flight that had been designed into her, and landed on the water so like some great seagull that the expectation was she would next fold her wings. It was gracefully done and by the time Milliken stepped ashore my jealousy and irritation were swept from me by a feeling of gratitude.

The *Merlin* Is a Dream

"What's she like, Milliken?" I asked.

"Oh, sir! Oh, sir!" he cried, ablaze with delight. "She's a dream! There's nothing to touch her on sea or land—and we made her, sir—we made her!"

Now Milliken, as a rule, is prone neither to call other men "sir," nor to wax enthusiastic, and his excitement surprised me.

"You handled her well," I said casually. "You've got the hang of that side loop all right."

"Oh, that!" said Milliken. "Why, do you know, a baby could handle her. She's a credit to you, Mr. Boon—it's all in the design."

This from Milliken was by way of an *amende honorable*. When I first introduced him to the design for the *Merlin*, and showed him the wing modifications that were meant to achieve the steep hovering which now distinguished her, he had thought the notion impossible. The idea had evolved from stalling, and he then had the old fixed idea that the only safe way of landing was to plane down on a thin angle and flatten. The idea of perfecting a continuous stalling, in which the machine got into neither tail nor nose dive, nor even into a spin, but simply floated to earth as a feather might, seemed mad to him. The principle is now a commonplace in aeronautics, and how Milliken and I arrived at it, very nearly at the cost of our lives, has little to do with the story I have to tell. I mention Milliken's apology to give just what sidelight it may on the man's character, for he wants some explaining.

If I know anything about Milliken, he will never bother to read these pages, even if he is told he comes into them—Shakespeare and real *belles lettres* are more in his way than this sort of production—so I may say what I like about him. In any case, I won't say anything that I wouldn't tell him to his own ugly old face if the need arose.

Milliken, a Character

I have never met a man with as great a passion so carefully hidden as Milliken and his love for air machines, nor anybody with half his practical experience and skill. He has the strongest hands and the gentlest. No fractious nut is too firmly fixed for his spanner, and no adjustment too delicate for his fingers, and I am open to bet that he has never stripped a screw in his life. He looks about as broad as he is long—which, since he is little over five feet in height, is perhaps not saying such a lot—and with the most equitable of tempers the habitual expression of his face is one of untamed ferocity. If Milliken had wanted to, he could have cleared the workshops in quick time, and I have seen him rise under three big men, during a rag, and carry them off like so many feather pillows. Like most good men of their hands, he can control his fists. I take it he knows too well the power in them and behind them to use them unworthily.

Milliken is the sort of mechanic who always has about him a lump of cotton waste, and as we inspected the *Merlin* that day—I suppose for about the thousandth time—he was rubbing the frosted aluminum of the fusilage and of the shuttered wings, or was polishing up the glass of the portholes. It was as if he could not get his darling clean enough, for he fussed about the machine like a mother over a spoiled child.

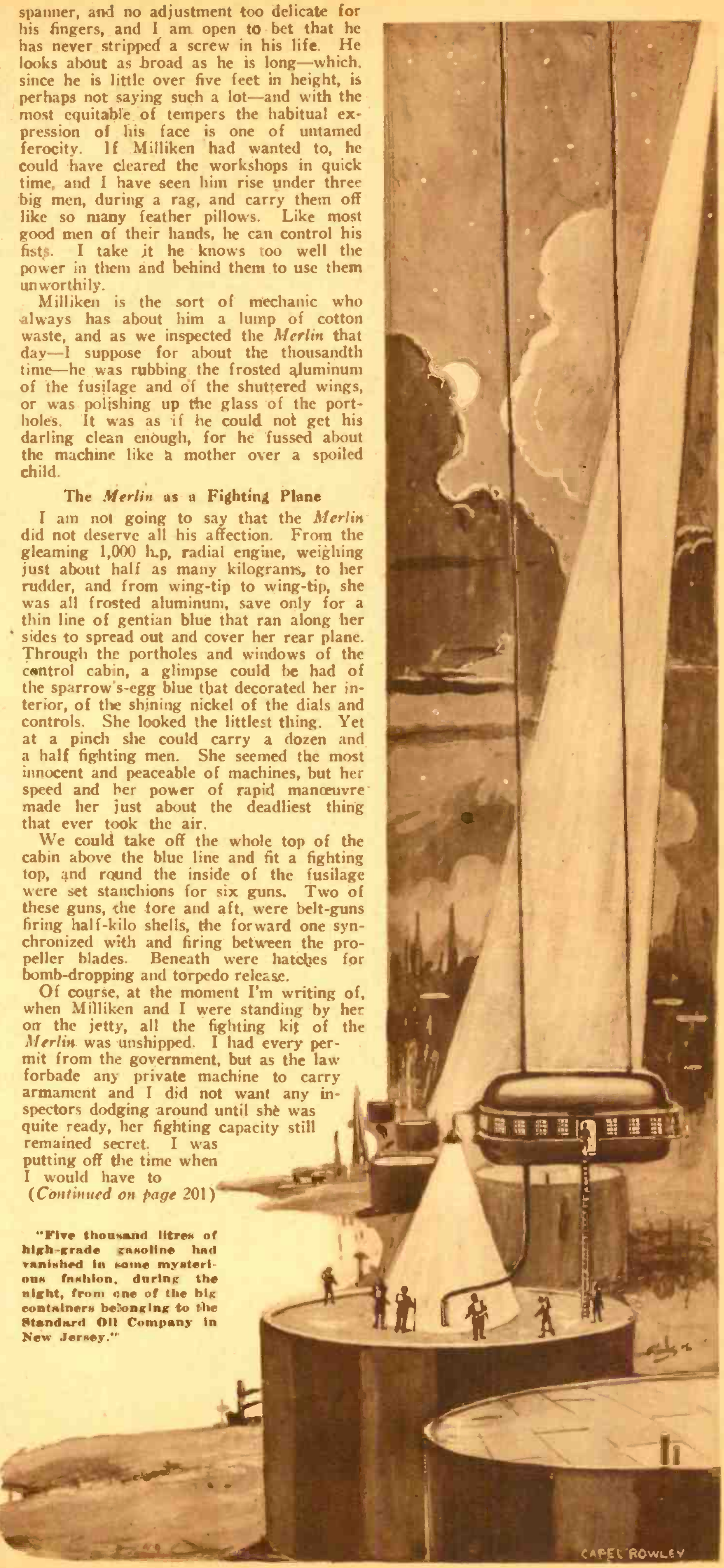
The *Merlin* as a Fighting Plane

I am not going to say that the *Merlin* did not deserve all his affection. From the gleaming 1,000 h.p. radial engine, weighing just about half as many kilograms, to her rudder, and from wing-tip to wing-tip, she was all frosted aluminum, save only for a thin line of gentian blue that ran along her sides to spread out and cover her rear plane. Through the portholes and windows of the control cabin, a glimpse could be had of the sparrow's-egg blue that decorated her interior, of the shining nickel of the dials and controls. She looked the littlest thing. Yet at a pinch she could carry a dozen and a half fighting men. She seemed the most innocent and peaceable of machines, but her speed and her power of rapid manœuvre made her just about the deadliest thing that ever took the air.

We could take off the whole top of the cabin above the blue line and fit a fighting top, and round the inside of the fusilage were set stanchions for six guns. Two of these guns, the fore and aft, were belt-guns firing half-kilo shells, the forward one synchronized with and firing between the propeller blades. Beneath were hatches for bomb-dropping and torpedo release.

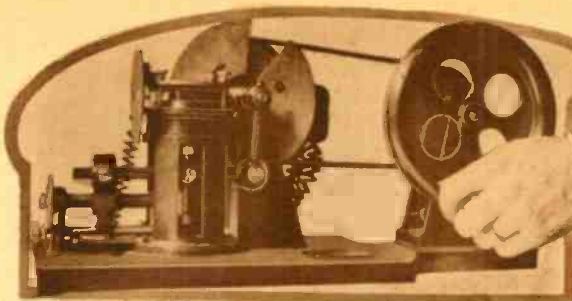
Of course, at the moment I'm writing of, when Milliken and I were standing by her on the jetty, all the fighting kit of the *Merlin* was unshipped. I had every permit from the government, but as the law forbade any private machine to carry armament and I did not want any inspectors dodging around until she was quite ready, her fighting capacity still remained secret. I was putting off the time when I would have to

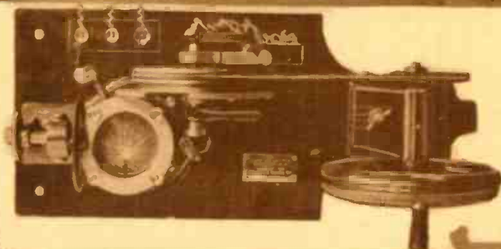
(*Continued on page* 201)

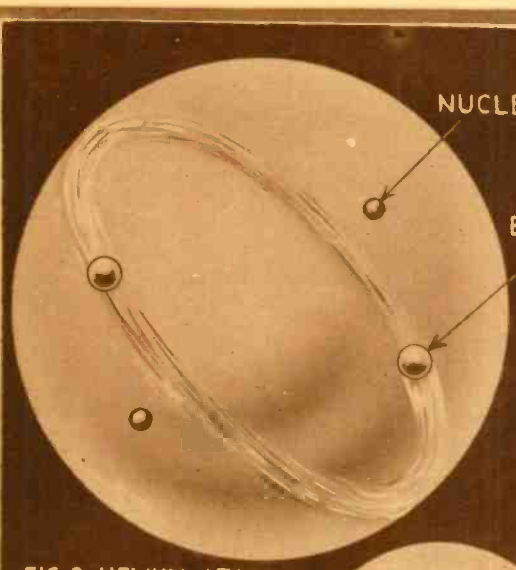


"Five thousand litres of high-grade gasoline had vanished in some mysterious fashion, during the night, from one of the big containers belonging to the Standard Oil Company in New Jersey."

The World of Whirling Electrons







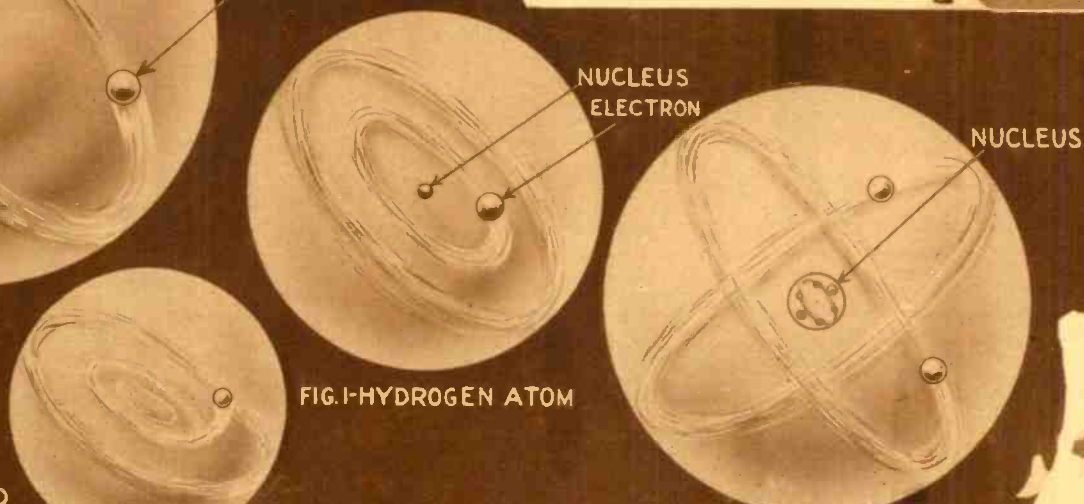


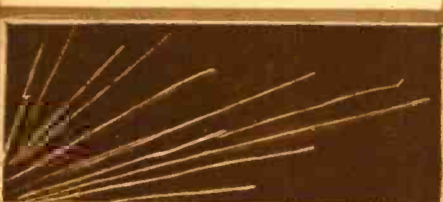
FIG. 2-HELIUM ATOM

FIG. 3-ENERGIZED HYDROGEN ATOM

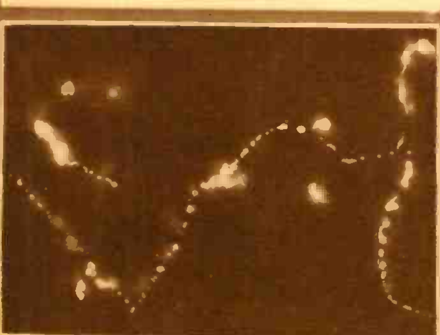
FIG. 1-HYDROGEN ATOM

FIG. 4-HELIUM ATOM

At the root of all natural phenomena are the electrons, in incessant motion. The powerful electric currents that drive our machines, radio waves, light rays, are at bottom but electronic motions.



An enlarged view of the electron paths observed in the Wilson apparatus shown at top of page. Note the deviations due to the repelling force of gas atoms.



The photograph above shows another view of the path of an electron. The sharp turn at the left is caused by the attraction of the electron by the nucleus of an atom.

Our Electro-Atomic Universe

By WILLIAM GRUNSTEIN, E. E.

We are informed that two German scientists have recently succeeded in the transformation of mercury into gold. The event recalls to us earlier efforts in this direction, and in reviewing the work of the alchemists of the Middle Ages, the marvels of modern alchemy become accentuated.

With all the fantastic visions of their unrestrained imagination, the older alchemists never dared dream of the vast prospects of curious research that have opened with the advent of the electron theory. Today we are on the threshold of the most far-reaching discoveries, and we feel a necessity for acquainting our readers with the nature of these impending revolutions of science.

The atom and its components form today the center of interest in the scientific world. A general agreement has been reached in the essential structure of the atom, that is, on the theory that the atom consists of a positively charged nucleus about which negatively charged electrons rotate. To take a simple instance, let us consider the atom of hydrogen represented in Fig. 1. As shown in the figure, the electron in its normal state is in continuous motion about the nucleus. The atom itself may be linked with other atoms to form molecules.

The little apparatus at the top gives the experimenter a momentary glimpse of electrons flying through space. In a small cylinder filled with water vapor, a sudden chilling is caused by expansion due to the motion of the piston. The vapor condenses in the path of the electrons emitted by a minute piece of radioactive substance. The condensed vapor illuminated by a beam of light from the side is viewed through the glass top of the chamber and gives an exact indication of the path of the electrons.

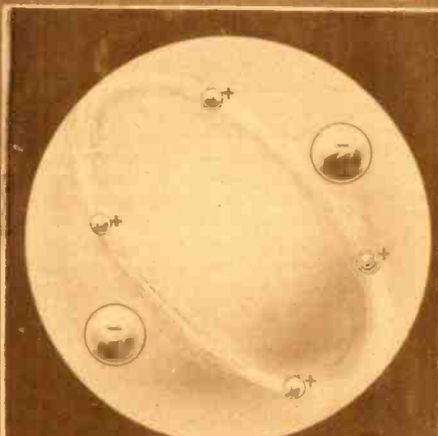
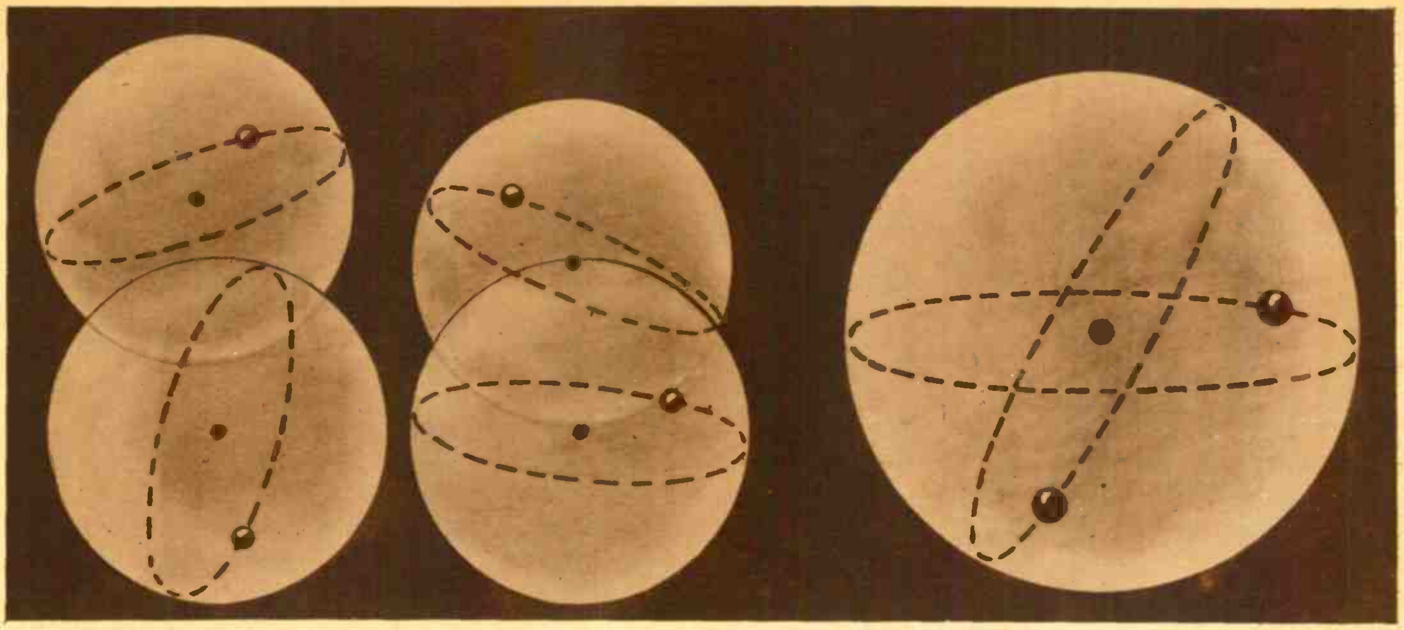


FIG. 5 NUCLEUS OF HELIUM ATOM

The nucleus of an atom of helium enlarged many billion times would appear as shown above.



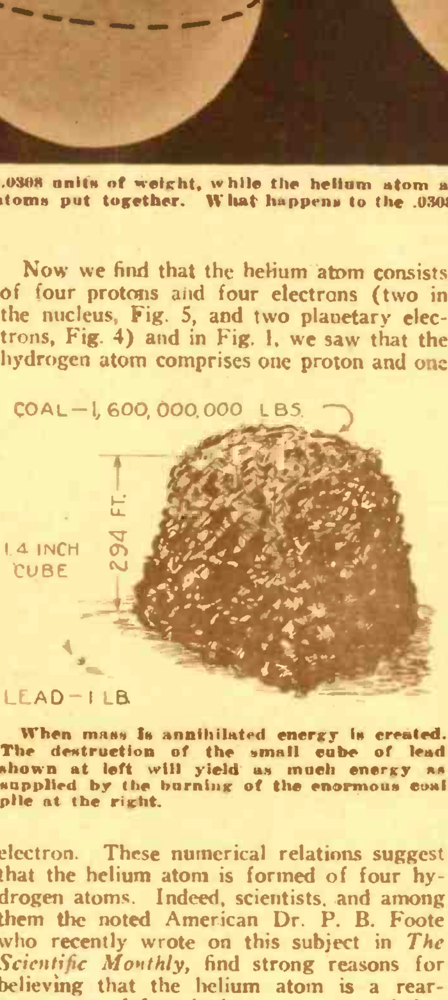
The four hydrogen atoms at the left weigh 4.0308 units of weight, while the helium atom at the right weighs only 4.0000. The helium atom has the same constituents as the four hydrogen atoms put together. What happens to the .0308 units of weight when these four hydrogen atoms are bound together to form a helium atom?

The hydrogen molecule, for instance, is made up of two hydrogen atoms, with their nuclei and electrons rearranged as shown in Fig. 2. The accuracy of the arrangement shown in these figures has, of course, never been verified by direct experiment but are based on purely theoretical considerations which, however, are in accord with experimental facts. To return to the atom, suppose that by some means, say a very high temperature, energy is conveyed to the atom. The atom absorbs this energy and in consequence some change must take place within it. According to one reliable theory, the so-called Bohr theory, when the atom receives energy the electron moves from its normal orbit to a new outer one, (as illustrated in Fig. 3) where, having acquired more energy, it moves with a greater velocity than in its normal orbit. The more energy the electron receives the further it recedes from the nucleus (which is not indicated in Fig. 3). Now, of course, the field of attraction of the nucleus is limited and sufficient energy may be imparted to the atom to lift the electron out of this field and thus allow it to shoot out into space.

The loss of an electron does not appreciably alter the weight of the atom, the mass being concentrated in the nucleus. The nucleus itself is of extremely minute size compared with the orbits of the planetary electrons. In the hydrogen nucleus there is but a single positively charged particle, whose mass compared with its volume is enormous. This particle is called a proton. All matter can be analyzed into some configuration of electrons and protons.

The hydrogen atom we have just examined has the simplest of all atomic structures. It is also the lightest known atom. All heavier atoms have more complex structures. For instance, an atom of the gas helium is depicted in Fig. 4. Note that it has two planetary electrons revolving about the central nucleus. The drawing, for want of space, is made somewhat out of proportion, the nucleus being much too large in proportion to the orbits of the electrons. Besides the two electrons revolving about the nucleus, there are two other electrons within the nucleus itself; held there by the attractive forces of the positively charged protons. If enlarged many billions of times, this nucleus would appear as shown in Fig. 5. Here four protons are arranged in an orbit on whose axis the two nuclear electrons are located. It is found that the attractive and repulsive forces of the protons and electrons so situated maintain the nucleus in equilibrium.

Now we find that the helium atom consists of four protons and four electrons (two in the nucleus, Fig. 5, and two planetary electrons, Fig. 4) and in Fig. 1, we saw that the hydrogen atom comprises one proton and one



When mass is annihilated energy is created. The destruction of the small cube of lead shown at left will yield as much energy as supplied by the burning of the enormous coal pile at the right.

electron. These numerical relations suggest that the helium atom is formed of four hydrogen atoms. Indeed, scientists, and among them the noted American Dr. P. B. Foote who recently wrote on this subject in *The Scientific Monthly*, find strong reasons for believing that the helium atom is a rearrangement of four hydrogen atoms, and that once the proper means are perfected helium could be made by the union of hydrogen atoms.

But there is another and more interesting aspect of the question. We find that if we represent the mass of the hydrogen atom according to any scale of weights as 1.0077, the weight of the helium atom on the same scale will be 4. But we find above that the helium atom is made up of four hydrogen atoms, and therefore should weigh 4x1.0077 or 4.0308! In other words if we take four hydrogen atoms and bind them together to form a helium atom .0308 weight or about 0.75 per cent. of mass are lost in the process! (Fig. 6).

It is difficult at first glance to fully grasp the significance of these facts. If, further we recall that in school we were taught that matter could neither be created nor destroyed, we find this total loss of mass even more incomprehensible. It starts endless trains of speculation on the future of science, suggesting ultimate success in the annihilation of matter, a process hardly conceivable but which, nevertheless, looms with a weird vividness in the fantasms of the speculative scientist. Is such complete destruction of matter a future possibility? Can Man ever achieve this climax of scientific development, this acme of control over his environment?

If we take a long step to Einstein, we find that this oracle of science has touched upon this question in his far-reaching Theory of Relativity. According to this theory mass and energy are associated according to a definite law. It will suffice for our purposes to understand that when mass is destroyed enormous energies are liberated, and that mass is electrical in nature. Or, loosely speaking, mass is just another manifestation of energy.

Now if matter is electrical in nature, that is if it cannot exist without the electrical charges which are always present in the nuclei of its atoms, is it possible that a neutralization of this charge will destroy the mass with which it is inseparably linked? But how is this neutralization to be effected?

The nucleus carries a positive charge. We would expect that it would tend to draw electrons into itself. This, however, does not happen. Its own planetary electrons never approach nearer than the normal orbit allows, and even at its nearest approach they are at comparatively vast distances from their nucleus.

An electron from some external source may enter an atom. In fact this happens very frequently when electrons move in matter. The result usually is a deflection of the electron due either to the repulsion by other electrons or to attraction by the nucleus. However, the latter was never observed to exert enough force to attract the electron within the nucleus itself, and so the atom remains essentially unaltered by the passage of an electron through it.

But suppose we can produce means for the union of the nucleus with enough electrons to neutralize its charge. Will this be accompanied by the destruction of mass? Of this we can say nothing definite, for no experimental evidence of such complete destruction has been advanced. However, if the neutralization of the positive nuclear charge by the negative charges on electrons results in the destruction of mass, a stupendous amount of energy will be liberated. The magnitude of this energy exceeds the limits of human imagination. Dr. Foote has computed that the destruction of one pound of matter would yield 10,000,000,000 kilowatt-hours of energy. To produce this energy through coal burning, 1,600,000,000 pounds of the

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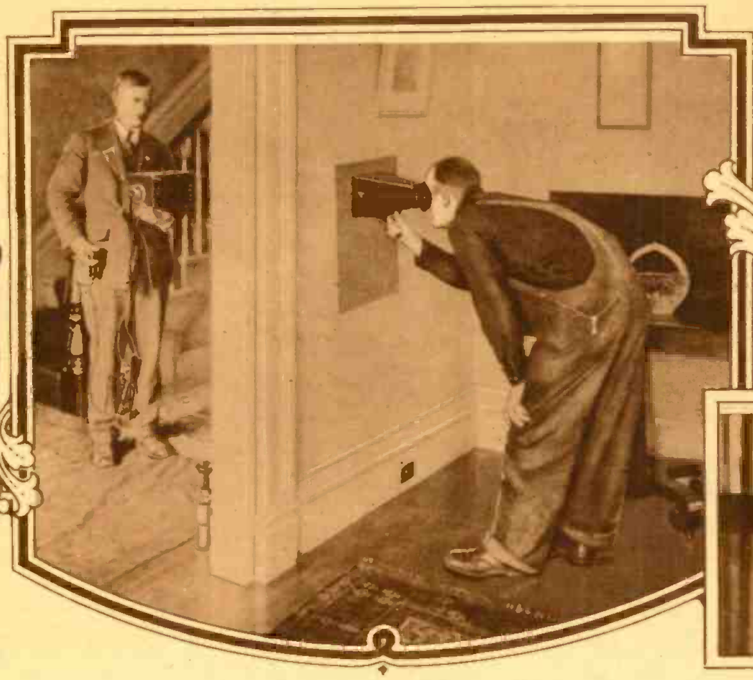
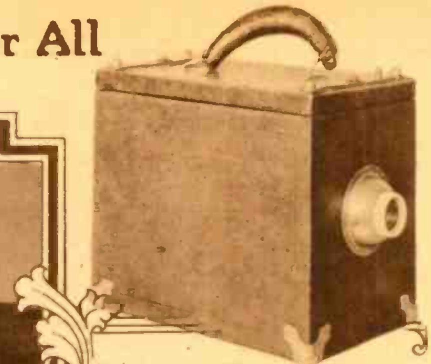
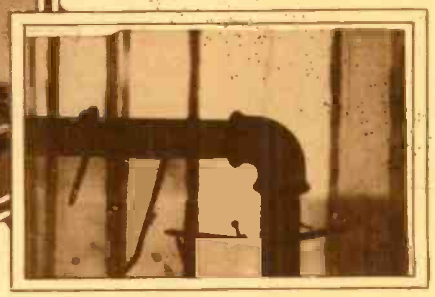
Portable X-Ray Apparatus for All





Portable X-ray apparatus, weighing only 20 pounds, developed by Dr. Coolidge and his associatees for general use. It is plugged into the regular house circuit.



A plumber carrying the outfit to his work has in one hand a fluoroscope and he uses it for looking for pipes behind the plaster and woodwork of a house.

The plumber in the house. The apparatus is held on one side of the partition where pipes are being searched for, this time not by the plumber's helper, however. The plumber on the other side of the partition uses a fluoroscope and on its screen all metal objects are silhouetted. The electrician can use it for tracing wires, and its other uses are innumerable.

This shows what appears on the screen of the fluoroscope. The large pipe is seen, which of course is what the plumber is in search of. The pipe is held in place by wires, which with the nails holding them are also pictured there.

Ultra-Violet Light and Chickens

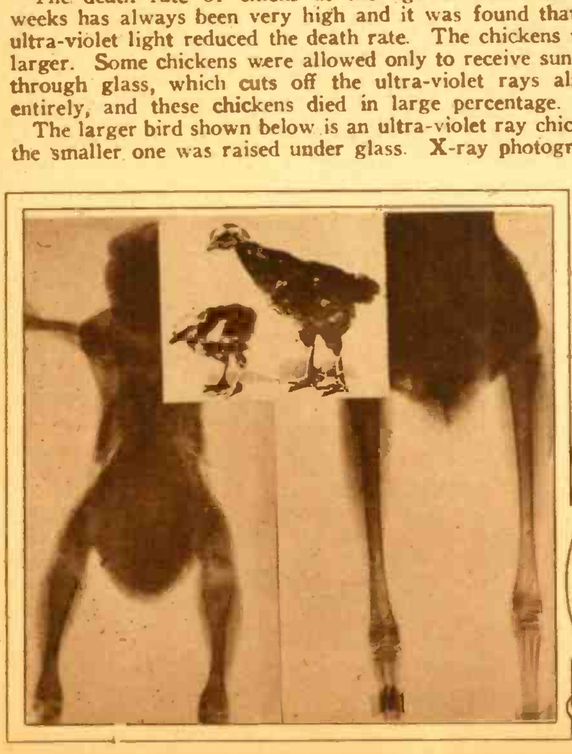
UNDER the auspices of Professor Willima T. Bovie, of Harvard University, and President C. C. Little of the University of Maine, experiments with ultra-violet light in its effects upon chickens have been tried with most interesting results.

The mercury vapor quartz glass electric lamp is used for the production of the ultra-violet rays. Some chickens were raised under ordinary conditions while others under identical conditions were subjected for fifteen minutes a day to the ultra-violet ray.

The death rate of chicks at the age of four and five weeks has always been very high and it was found that the ultra-violet light reduced the death rate. The chickens were larger. Some chickens were allowed only to receive sunlight through glass, which cuts off the ultra-violet rays almost entirely, and these chickens died in large percentage.

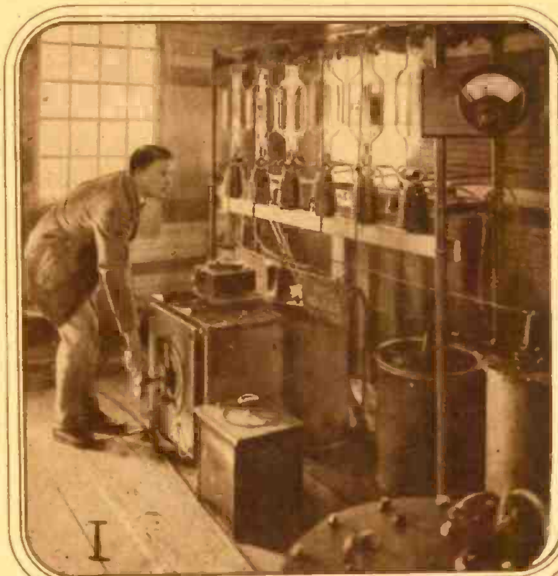
The larger bird shown below is an ultra-violet ray chicken; the smaller one was raised under glass. X-ray photographs show the osseous development of each one. There is a certain amount of danger, however, that an excess ultra-violet ray may bring about too early ossification.

By the ultra-violet rays artificially produced, the development of a chicken can be absolutely controlled, and by the X-rays the development can be watched from day to day.

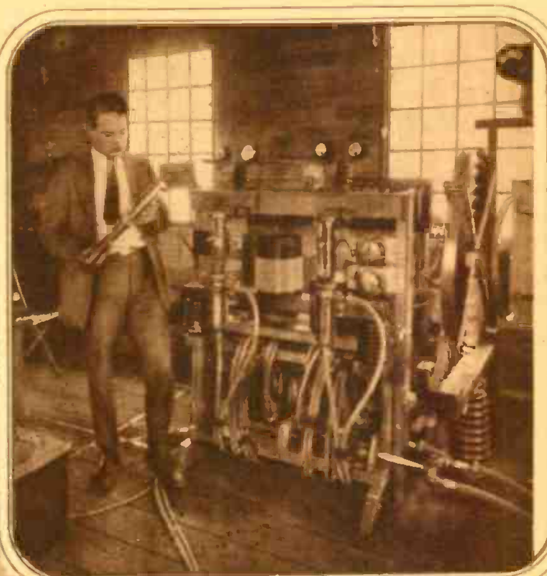


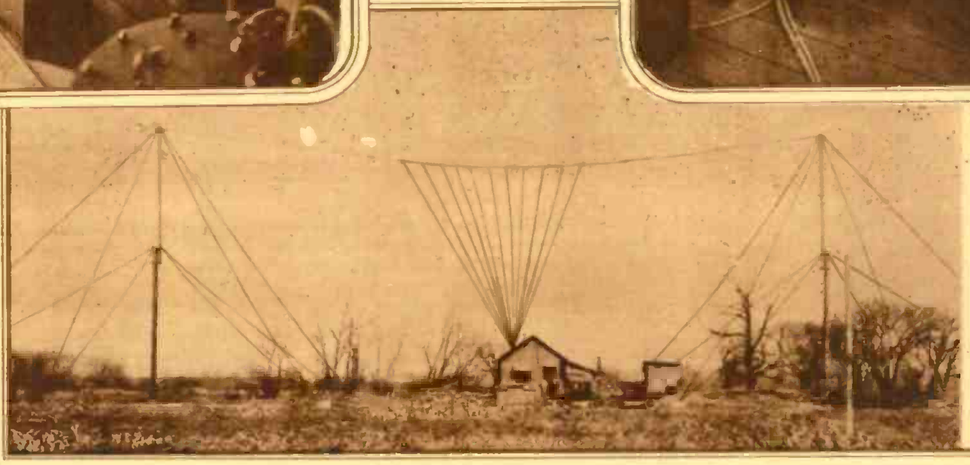
Left: Large chicken affected by ultra-violet light; small chicken cut off therefrom. Right: Holding the chicken under the mercury vapor quartz tube lamp.

Schenectady Short Wave Broadcasting Plant

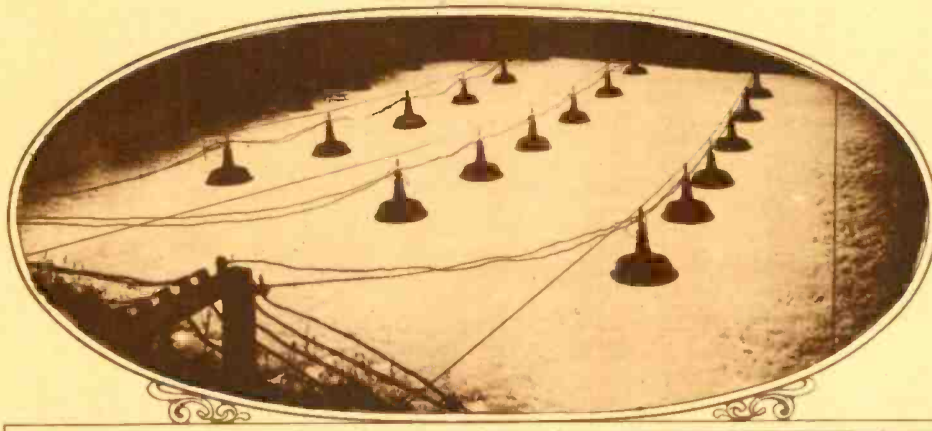


Left: The 30 K.W. 15,000 volt three phase rectifier for 107 meter wave-length. At the General Electric Company's Schenectady Plant.
Right: Oscillator unit for same wave-length, using water cooled tubes, such as in the hand of the operator.
Below: The antenna of the 107 meter Schenectady transmitting station.





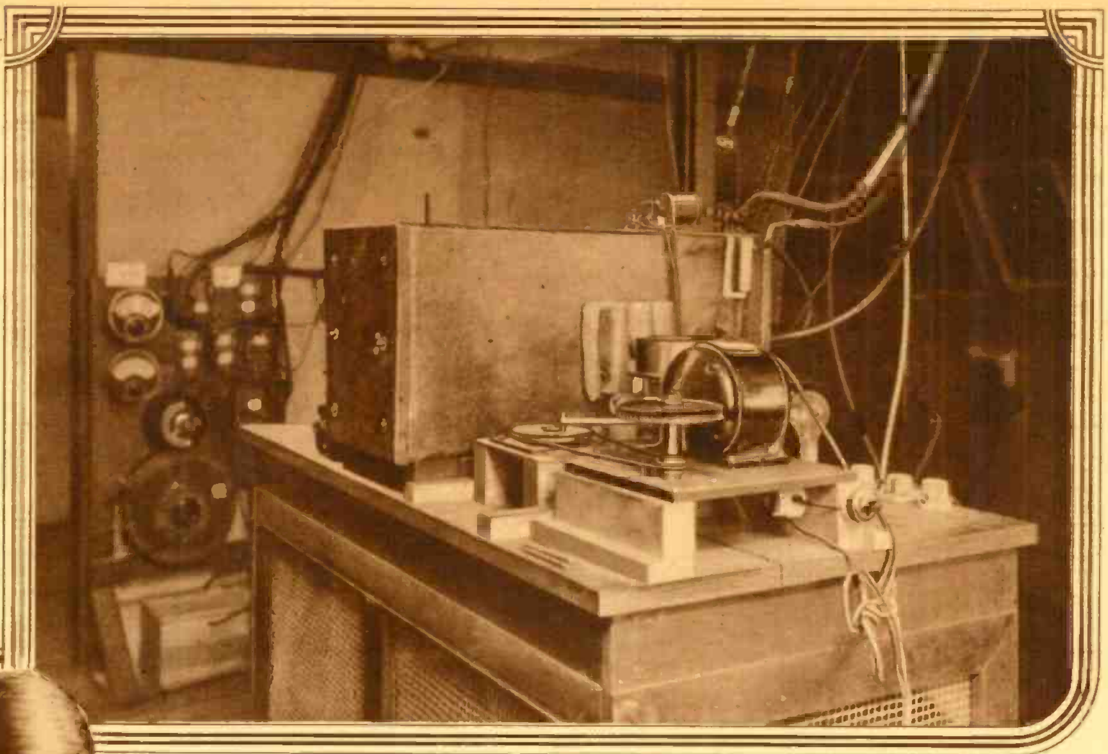
Golf by Electric Light



At Bradley Beach, New Jersey, the golf club has installed twenty-four 1000 watt lamps and kept them in action five hours per night for three weeks. It accelerated the growth of grass upon the green some two months.

The lamps were suspended at about four feet from the ground, with reflectors to give an evenly distributed light. At another one of the great golf links the fairways have been lighted so that night playing is quite practical. The light is so good that the balls in the air can be watched for their entire flight. It is said that the lighting of golf courses at night may revolutionize the game by introducing night playing.

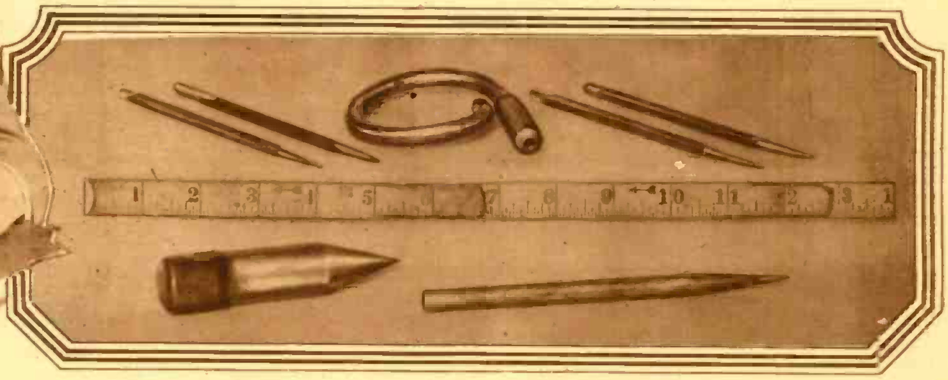
Copper Bends Like Putty



Above: The electric furnace in which copper bars are maintained at a high heat for many hours and are then gradually cooled. Each piece represents a single crystal of copper and can be bent more easily than lead.

Left: Bending the copper. A mere touch of the finger will do it.

Below: The copper crystals; after once bending cannot be straightened except by great effort. The crucible had a pointed end which gave them their shape as shown. The largest crystals ever produced appear in this photograph.



COPPER bars that can be bent double with one finger, but which require strength to straighten again, are expected to lead to a greater understanding of the properties of metals. The bars, which are really single crystals of pure copper, were produced in the Research Laboratory of the General Electric Company at Schenectady, N. Y., and have been subjected to many kinds of examinations, with the revelation of numerous unexpected facts.

The usual piece of metal is a conglomeration of small, closely packed crystals, with the crystalline structure often apparent at a glance. Zinc, for instance, is known as a brittle metal; a rod of it can be bent but slightly without snapping. Yet investigations of small, single zinc crystals show that any one crystal of the metal can be drawn out to six times its length in one direction; in another direction it is extremely brittle. The properties of zinc thus depend upon how the crystal is examined—whether "with the grain" or against it. The usual piece of zinc is really a collection of small crystals pointing in all directions, so that the properties are the combined qualities of the small crystals in the different axial directions. The same holds true for other metals and other substances.

A single crystal of copper seven-eighths of an inch in diameter and six inches long, as well as numerous smaller crystals of the same metal, have been produced by Dr. Wheeler P. Davey of the Research Laboratory. These crystals, obtained by a modification of the method devised by Dr. P. W. Bridgman of Harvard University, are much larger than any previously recorded.

Very gradual heating and cooling of pure copper in an electric furnace is the secret of the success in producing them. The necessary amount of pure copper, in the form of a bar, was placed in a closed, cylindrical carbon crucible, and slowly passed through the electric furnace. If molten metal is cooled quickly, the resultant mass is composed of very small crystals; if the melt is cooled slowly, the crystals are larger. Dr. Davey cooled the melt so slowly that only one crystal was produced, and that included the entire melt. The atoms had plenty of time in which to arrange themselves as they desired—to build up a single crystal rather than a multitude of small ones.

Several interesting results have been obtained with the large crystals. A piece about the size of a lead pencil, if given a jerking motion, bends as easily as does a stick of soft wax; it cannot be bent back, however, any more easily than a similar piece of ordinary copper. When the copper is a single crystal, all of the atoms are arranged in columns, equally spaced. When the bar is bent, the spacing is changed; the atoms on the inside curve are pressed together, and those on the outside are spread apart. Strains are set up and the crystal structure is altered. The bar becomes an ordinary piece of copper, of smaller crystals facing in all directions.

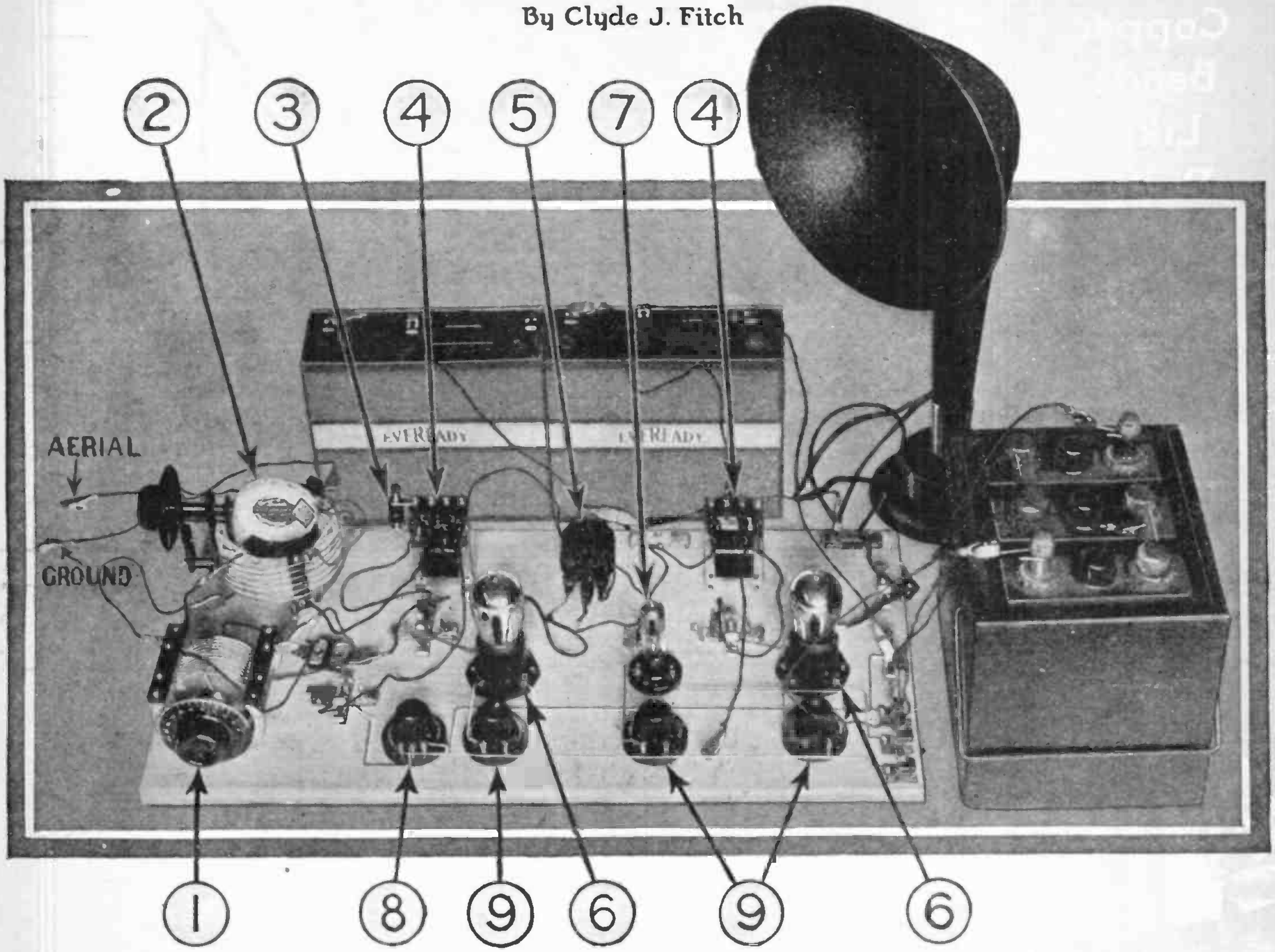
If the surface of the large crystal is nicked or dented, the structure in the neighborhood is changed in the same way. It is similarly affected by filing or polishing. When one of the bars is polished it is necessary to take off a mil or less at a time. Even then the structure of the new surface is altered. The condition is remedied by etching away the surface with an acid bath.

An etched bar of the copper appears to be rough. There seem to be alternate dark and light lines. The appearance of the lines is due to the fact that the acid etches more easily in some directions than in others. The directions in which it etches with the greatest difficulty are parallel to the axes of the crystal.

X-ray analysis furnishes conclusive evidence that such a crystal has been produced.

Two Tube Reflex Experiments

By Clyde J. Fitch



The two tube hook-up board with circuit No. 5 on the opposite page connected. The numbers designate the following instruments: 1. Variable condenser; 2. Low loss tuner; 3. Crystal detector; 4. Audio transformer; 5. Radio transformer; 6. Vacuum tube socket; 7. Diode tube; 8. Potentiometer; 9. Filament rheostats.

ALTHOUGH there are thousands of circuit combinations possible with a single tube and a crystal very few if any of these give real worth while results. What we require is a receiving set that will give loud speaker volume on distant stations when used with either an outdoor aerial or a loop, but in order to do this two or more tubes are usually required.

We all understand of course that in a multi-tube receiving set the first tube receives little of the load, whereas the last tube is usually overloaded. If the first tube could be worked to its full output the other tubes would be unnecessary and we would have a single tube set equal in results to many of the multi-tube sets. By reflexing, the tube is worked at both radio and audio frequency and the load is more evenly distributed. In this way we save in the number of tubes required. But even reflexing does not give us ideal conditions. At least two tubes are required for good results. Of course super-regeneration solves the problem in a different manner, but this comes under a heading by itself and will not be described in this series.

With two tubes and a crystal at our disposal the field of experimenting is practically unlimited. There are all kinds of combinations possible. It is up to the experimenter to try out the various combinations and develop something really useful in the line of an ideal two tube receiver. In order to try the two tube circuits, it is best to build a new experimental hook-up board similar to the one shown in the accompanying illustrations. This board is 12"x24"x5/8" thick. It should be made of soft wood so that instruments can be easily mounted upon it. An ordinary drafting board with rubber feet on the bottom is ideal for this purpose.

Fig. 11 shows the constructional details of the board. On it are mounted two standard vacuum tube sockets and a socket for a two electrode valve. The filament rheostats, potentiometer and binding posts are permanently mounted and wired, as the filament circuits of the tubes will probably be the same regardless of the type of hook-up used.

> The following list of parts will be required for making the two tube reflex experiments:
>
> 2 *Flewelling* 23-plate condensers.
> 1 *Flewelling* 43-plate condenser.
> 1 *Gen-Win* low loss tuner.
> 1 Set of *Gen-Win* reflex coils.
> 2 *National Airphone* calibrated transformers.
> 1 *Rasco* radio frequency transformer.
> 1 *Rasco* Neutroformer.
> 2 Standard V. T. sockets.
> 3 30-ohm rheostats.
> 1 1200-ohm potentiometer.
> 1 *Electrad* diode tube with socket.
> 1 *Erla* reflex crystal.
> 1 Set 50-, 75-, and 100-turn honeycomb coils.

The other instruments shown in the photographic views and those that will be required for making the various hook-ups in the illustrations are given in the list.

By using a crystal detector, we eliminate one tube, but unless a fixed crystal detector is used the circuit will be very noisy when adjusting the crystal. By using a fixed crystal the noise is eliminated but it is very difficult to obtain a sensitive fixed crystal detector and sometimes if the set does not work it is difficult to determine whether the trouble is in the crystal detector or in some other part of the circuit. Therefore, it is well to make use of a two electrode vacuum tube rectifier for detection. Once a circuit is working with this detector it is a simple matter to substitute the crystal.

As almost all two electrode tubes require 1½ volts for the filament it will be necessary to tap on to one cell of the six volt storage battery and consequently three A battery binding posts are required. A 30-ohm rheostat is used for controlling the current through the filament. If a two electrode tube is not available any dry cell tube such as the type WD-12 may be used by connecting the grid and plate together.

We are showing ten illustrations of two-tube hook-ups. The instruments shown in the diagrams are numbered to correspond with the numbers given in the other illustrations of the hook-up board. One of the photographic views shows the hook-up board complete with circuit No. 5 connected.

In our other issues we showed a number

Two Tube Reflex Circuits

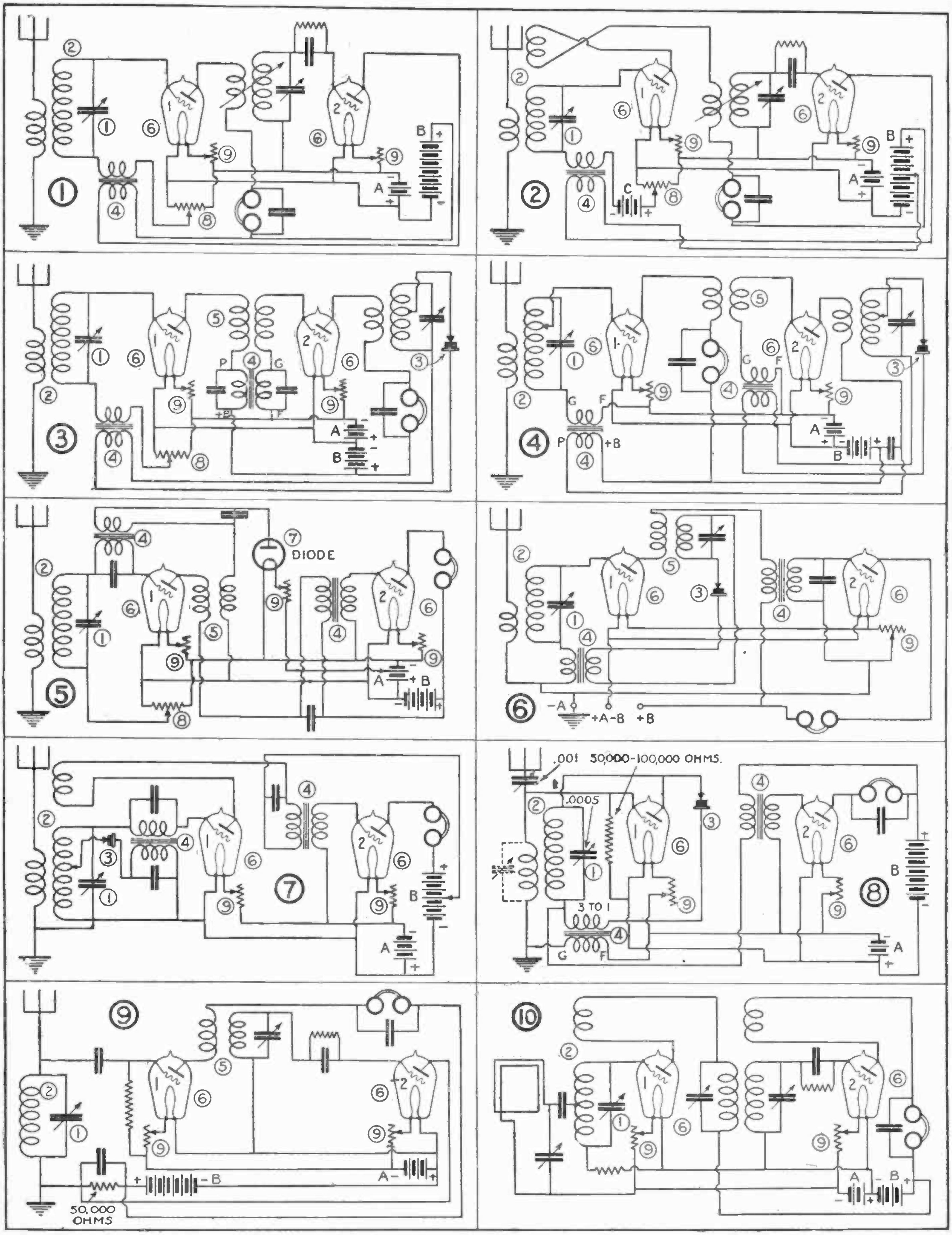


Fig. 1. Standard reflex circuit employing a vacuum tube detector. **Fig. 2.** The same circuit with reverse feed-back added to control oscillations. **Fig. 3.** Standard two tube reflex circuit with crystal detector. **Fig. 4.** The Grimes inverse duplex circuit. **Fig. 5.** A two tube reflex circuit employing a two electrode valve for the detector. **Fig. 6.** The Harkness two tube reflex. **Fig. 7.** A two tube circuit employing regeneration and a crystal detector. **Fig. 8.** The ST 100 two tube circuit. **Fig. 9.** The resistoflex, a reflex circuit employing resistance coupled audio amplification. **Fig. 10.** A two tube super-heterodyne.

of single tube and crystal circuits. The experimenter may try these circuits on the two-tube hook-up board and use the second tube as a one-stage audio frequency amplifier. This will increase the signal strength considerably and in most cases loud speaker volume will result. In making the connections a large number of clip leads and tip leads will be required. It is well to use type UV-201A tubes in all cases although very good results may be obtained with dry cell tubes. After a circuit has been connected that gives good results the instruments used in it and the exact connections should be copied, so that if it desired to build a complete set in a cabinet the same conditions can be duplicated.

Standard Two Tube Reflex

Fig. 1 shows a standard two tube reflex hook-up using a vacuum tube for the detector. In this case tube No. 1 acts as both radio and audio frequency amplifier and tube No. 2 is the detector. This circuit requires a suitable tuner for the aerial in which case a low loss tuner such as the one shown in the photograph is preferable. The tickler winding is not in use in this case. A suitable radio frequency transformer, preferably of the tuned type, should be used in the plate circuit. In order to control oscillations a potentiometer is required. The connections of the detector tube are standard and need no explanation. Only one audio frequency transformer is used. This couples the output of the detector tube to the input of the amplifier tube. The head-set or loud speaker is connected in the plate circuit of tube No. 1.

This circuit is equivalent to a one stage radio frequency amplifier, vacuum tube detector, and practically a one stage audio frequency amplifier. This is due to the fact that in order to prevent oscillations in the radio frequency amplifier it is necessary to place a positive bias on the grid of this tube. This bias is determined by the potentiometer setting and of course prevents the tube from working at its maximum efficiency as an audio amplifier. For best results as an audio amplifier a negative potential is required on the grid; this is usually obtained by the use of a C battery. But in order to use a C battery some other method must be employed for preventing oscillations. The best method so far evolved makes use of a tickler coil with reverse feed-back superdyne principle. We can easily make use of the tickler coil on the tuner for this purpose in which case we will have circuit No. 2.

Superdyned Reflex

The superdyned reflex is clearly shown in Fig. 2. Although this circuit shows one tube used as a detector there is no reason why this tube cannot be used as an audio amplifier by using a crystal for the detector. We are giving this circuit merely to show how well the superdyned principle works out in a reflex receiver, and of course this principle can be made use of in practically all of the following circuits. Any tuner having a primary, secondary, and tickler windings may be used, preferably one of the low loss type in order to gain in sensitivity and selectivity. A low loss condenser is also recommended. The tickler coil is used for obtaining negative feed-back. This coil prevents the circuit from oscillating. A C battery of about three volts is used to increase the amplification of the tube. Incidentally this increases the selectivity of the circuit as it reduces the grid current to zero, and no energy is absorbed from the aerial circuit. Either a tuned radio frequency transformer or an untuned transformer, which covers the broadcast wave-length range, may be used. This circuit was described by R. Washburne in the December issue.

Two Tube and Crystal Reflex

This circuit, Fig. 3, is similar to circuit Fig. 1 except that both tubes are used for reflexing and a crystal is used for detecting. In theory this hook-up is equivalent to a five tube receiver but in practice it seldom reaches this state. The instruments used may be the same as those used in Fig. 1. Either the crystal or the two electrode tube may be used for the detector. The Rasco radio frequency transformer works well in this circuit. Of course the superdyne principle may be used by connecting the first tube as shown in Fig. 2. For tube No. 2 it is best to use a tuned radio frequency transformer. A neutroformer may be used for this purpose. The complete hook-up will then have two tuning controls and one potentiometer or stabilizer control.

Inverse Duplex Hook-Up

It will be noted from Fig. 3 that the output of the crystal detector is fed back through the audio transformer to the input of tube No. 1, and the output of tube No. 1 is fed into the input of tube No. 2. In the Grimes Inverse Duplex Circuit the conditions are reversed; instead of feeding the output of the crystal to the input of tube No. 1, it is fed into the input of tube No. 2. This is clearly shown in Fig. 4. The output of tube No. 2 is fed into the input of tube No. 1, and the head-set or loud speaker is connected in the plate circuit of the first tube. For controlling oscillations the grid of the first tube is connected to a tap on the tuning coil. A number of taps are required as the correct one depends upon the wave length of the circuit.

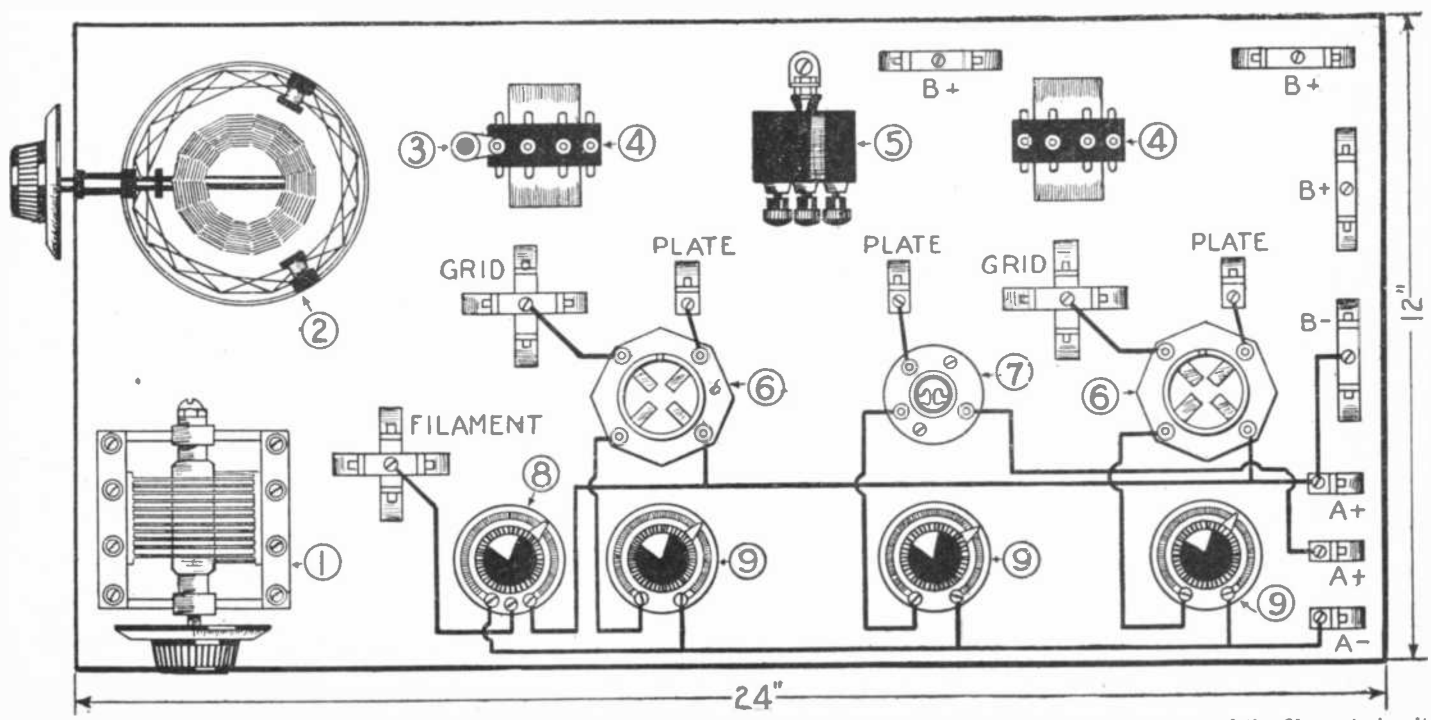
The inverse duplex system is supposed to give a more equal distribution of the load on the tubes. Tube No. 2 receives the greatest radio frequency load, as it is in the second stage of the radio amplifier and it receives the least audio frequency load as it is in the first stage of the audio amplifier. The same conditions hold true with tube No. 1, which operates as the first stage of the radio amplifier and the second stage of the audio amplifier.

Diode Coupled Reflex

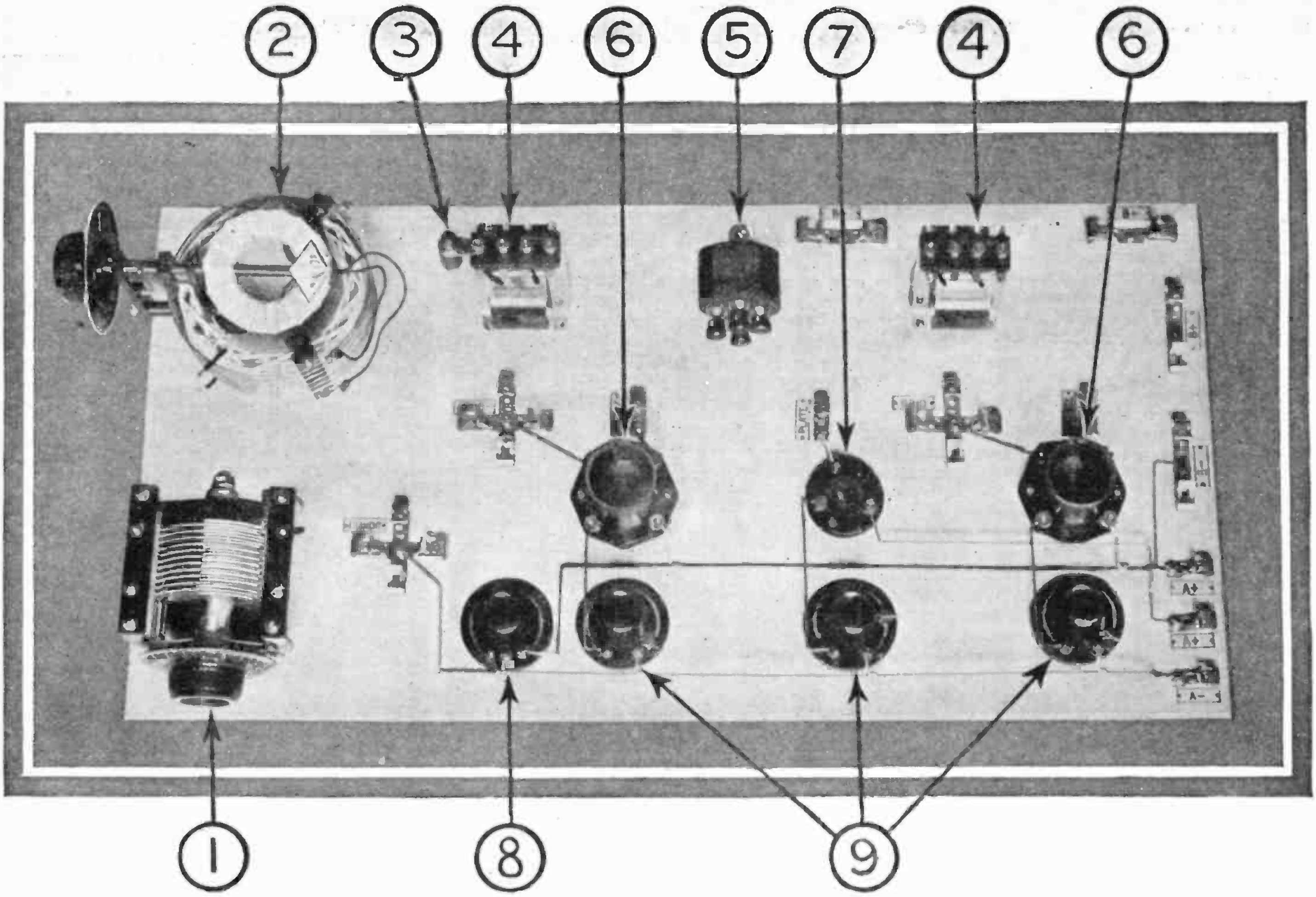
Fig 5 shows a standard reflex circuit with a two electrode tube as the detector. This circuit is given merely to show the connections of the diode tube. Tube No. 1 is used as both a radio and an audio frequency amplifier, and tube No. 2 is used only as an audio amplifier. It is this circuit that is shown in the photograph of the hook-up board A Rasco radio frequency transformer is used. Note that one side of the secondary winding of the radio transformer connects to the positive side of the filament. This gives a slight positive potential on the plate of the diode, and improves its action as a detector.

Harkness Reflex

The Harkness reflex has become very popular among the broadcast enthusiasts. There are no new principles involved in the circuit. The results obtained from it are due mainly to improved design of the parts. It is very difficult to use one stage of tuned radio frequency amplification and a crystal detector and obtain good amplification throughout the entire tuning range without oscillation. But this has been accomplished in the Harkness two tube set by proper design of the coils. The experimenter should obtain a set of Gen-Win reflex coils or wind a set as described in the November issue. Otherwise



Details of the two tube hook-up board showing the location of the instruments and binding posts. The connections of the filament circuit are also clearly shown.



Plan view of the hook-up board showing the instruments mounted in place. The instruments shown are as follows: 1. Condenser; 2. Low loss tuner; 3. Crystal detector; 4. Audio transformer; 5. Radio transformer; 6. Socket; 7. Diode socket; 8. Potentiometer; 9. Rheostat.

the circuit is easily followed and requires no special comment. All the connections are clearly indicated in Fig. 6.

Regenerative Crystal Hook-Up

Fig. 7 shows one of the most simple and stable crystal-tube hook-ups so far evolved. This circuit gives loud speaker volume on distance stations and is comparatively selective. On account of the crystal detector the quality of music received is excellent. In the circuit, tube No. 2 is simply a one-stage audio amplifier. Its connections are standard. If the crystal detector and the audio amplifying transformer were removed from the circuit, tube No. 1 would be connected as a regenerative detector. By adding the crystal and transformer, the coupling between the plate coil and the grid coil may be increased and the extra energy fed back from the plate circuit is rectified by the crystal and applied in the form of audio frequency current to the grid of the same tube through the step-up transformer. In this way the signals are amplified enormously. It will be noted that with the plate coil set at zero inductive relation to the grid coil the circuit acts as a crystal detector and two stage audio frequency amplifier.

By using a low loss tuner and condenser the circuit is made very selective. By connecting the crystal to a tap on the secondary of the tuner the selectivity is further increased. Usually the tap should be about at the center turn. The experimenter should try tapping to several parts of the coil until best results are obtained.

S. T. 100 Circuit

The S. T. 100 circuit was developed by John Scott-Taggart and is very popular in Europe. This circuit is shown in Fig. 8. Honeycomb coils are used for the primary and secondary of the tuner, although any standard variocoupler should give good results. Both the aerial circuit and the secondary circuit are tuned. A .001 mfd. variable condenser is used for tuning the aeiral circuit. A 50-turn honeycomb coil shunted by a .0005 mfd. condenser is sufficient for the secondary circuit as it will cover the broadcast wave-length range. Between the grid and filament is connected a 50,000- to 100,000-ohm variable resistance. A Bradleyohm No. 50 is suitable for this purpose. The remaining connections are clearly indicated in the diagram. Tube No. 2 is connected as a one stage audio frequency amplifier. This circuit gives sufficient amplification to operate a loud speaker. A B battery of 90 to 100 volts should be used.

Resistoflex Circuit

The resistoflex circuit was recently developed in England by John Scott-Taggart. This circuit is shown in Fig. 9. It differs from the usual form of reflex in that it employs resistance coupling for the audio frequency amplifier instead of transformer coupling. As a resistance has no natural period of vibration of its own it will not cause howling so common in transformer coupled reflex circuits. In the circuit shown, tube No. 1 acts as a radio frequency amplifier and tube No. 2 acts as the detector. In the plate circuit of the detector is a resistance of about 50.000 ohms. A by-pass condenser of about .00025 mfd. is connected across the resistance. A Bradleyohm No. 50 is suitable for the resistance. This resistance couples the audio frequency output of the detector tube to the input of the amplifier tube.

A grid condenser and leak is required in the grid circuit of the amplifier tube. The grid condenser is not used for the purpose of operating the tube as a detector but is used merely to block the high voltage of the B battery from the grid of the tube. The grid condenser should have a capacity of about .005 mfd. A ¼-megohm grid leak should be used. The head-set or loud speaker is connected in the plate circuit of the amplifier tube in series with the primary of the radio frequency transformer. This transformer is preferably of the tuned type. It should be designed so that the circuit will not oscillate at any setting. A neutroformer may be used. Of course reverse feed-back such as is used in circuit number 2 may be used for preventing oscillations. In the hook-up of Fig. 9 a single circuit tuner is used. This works very well with a short aerial but if a long aerial is to be used a 43-plate variable condenser should be connected in series.

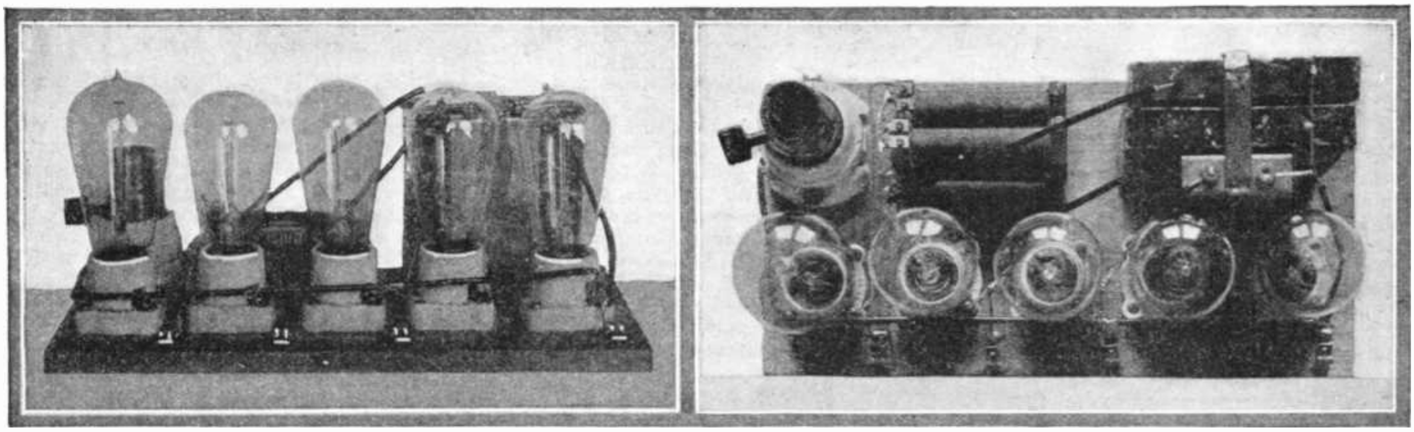
Super-Heterodyne

Although the usual form of super-heterodyne requires 6 or 8 tubes it is not generally known that very good results may be obtained with only two tubes. Fig. 10 shows such a circuit. In this hook-up tube No. 1 acts as both oscillator and first detector by using the tropadyne principle. Coils suitable for this circuit were described in detail in the December issue. The second tube acts as a detector. For the second tube, three 1000-turn honeycomb coils should be used. A triple coil mounting will be found convenient for adjusting the coupling between the coils. This circuit works very well with a head-set and loop aerial. Amplification is obtained both from the heterodyne action of tube No. 1 and from regeneration of tube No. 2.

Corrections.

The following corrections should be made in the circuits given on page 86 of the December issue: In hook-up No. 5 draw a line connecting the +A battery of the filament circuit of the tube to the B terminal on the primary of the audio frequency transformer. In hook-up No. 12 connect a crystal detector between the two condensers in the circuit containing the head-set.

110 V. D. C. Line Replaces "B" Batteries

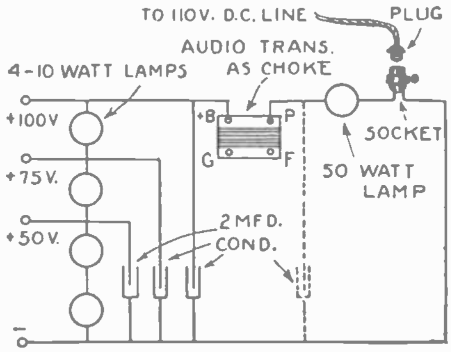


Left, front view of the B battery supply unit showing the five lamps used as resistances. The 50-watt lamp at the left protects the apparatus from accidental short circuits and tube burnouts.
Right, plan view showing the condensers, chokes, and switch base socket. A flexible cord with plug is used to connect the unit to the D.C. line.

THERE is a prevalent tendency in the design of radio circuits to eliminate the "B" battery and to use in its place the 110-volt D. C. source. There are of course important difficulties in the way of such substitution. The D. C. line will produce a pronounced hum in the loud speaker—as the direct current is not constant in intensity but is subject to periodic variations which become quite noticeable in the sensitive radio circuit. A primary requirement of all devices designed to supply plate current from electric power mains is therefore the suppression of these periodic variations in the current, or commutator ripple, as it is often called.

To make the arrangement flexible and readily adaptable to various receiving sets, it must include means for the supply of current at several different voltages. It is, further, preferable to mount all necessary apparatus in a single unit, compact and readily portable. Such units have been constructed by various manufacturers, and placed on the market at prices which a large number of experimenters have found prohibitive. However, these latter need not feel that they are obliged to continue using "B" batteries, for a very simple and economical arrangement enables anyone to eliminate them and use his lighting circuit for plate supply without the disturbing hum.

The device is essentially a potentiometer using the ten-watt bulbs for resistance and provided with four taps. To eliminate the hum due to the low frequency fluctuations in the current a two mfd. condenser is



Hook-up showing the connections of the lamps, condensers, and choke coil in the B battery supply unit. Note that an audio amplifying transformer is used for the choke.

Such arrangement, illustrated diagrammatically in the figure, comprises the following:
1 piece of wood 6x12x½ inches.
4 ten-watt incandescent lamps.
1 fifty-watt incandescent lamp.
1 choke coil (audio frequency transformer primary).
1 lamp socket provided with the usual socket switch.
4 lamp sockets.
3 two mfd. condensers.

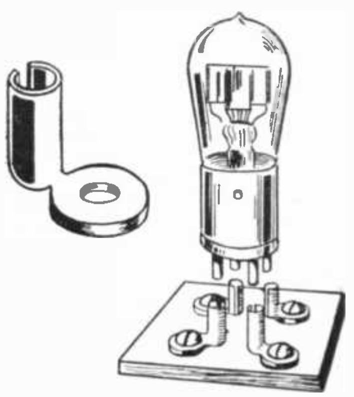
shunted across each tap and a choke coil is placed in series. The primary of an audio frequency amplifying transformer will form a suitable choke coil for sets employing less than four tubes. If a set having more than this number of tubes is used, two audio frequency transformers with their primaries connected in parallel should be used for the choke. Otherwise the high resistance of the primary winding of one transformer will cause a voltage drop and the set will not be operated on the full 100 volts. The unit reproduced herewith employed four "Rasco" one Henry chokes connected in series. This unit was designed primarily for a ten-tube super-heterodyne receiver and gave excellent results. It was silent in operation except for an occasional click due to someone turning on or off a light in the building. To improve the operation if the line noise is still present a two mfd. condenser may be shunted across the system as shown by the dotted lines. In the apparatus shown in the photographs this extra condenser was unnecessary.

To provide for safe operation a fuse is generally placed in the circuit, but since blowouts may cause inconvenient delays and as the fuse will not protect the tubes a fifty-watt incandescent bulb is substituted for the fuse. This lamp limits the current through the system to one-quarter ampere which is a safe value for all vacuum tube filaments except those of the UV-199 type.

Connections to the lighting mains are made through a cord and plug that fits into the switch-base socket.

Simple Tube Sockets

THE experimenter who desires a cheap and effective vacuum tube socket can easily make one by using four copper terminals of the shape shown in the illustration and large enough to fit the prongs of the vacuum tube.



Vacuum tube socket comprising four copper lugs mounted on a hard rubber base. The low capacity and losses make it ideal for short wave experiments.

The lugs may be fastened to a piece of hard rubber and the screws used for binding posts or the lugs may be attached directly to the panel. This not only makes an inexpensive vacuum tube socket, but it is much smaller than the standard type, making it desirable for compact portable receivers and for short-wave receivers where a minimum of electrostatic capacity is desired.

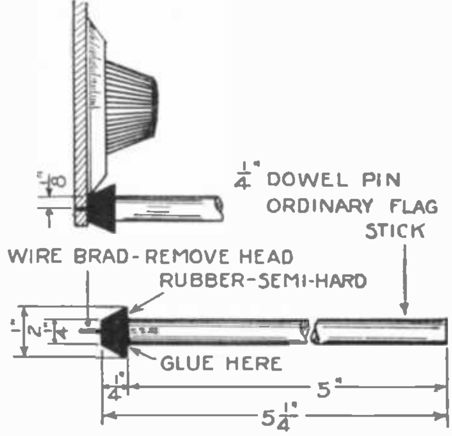
The illustration clearly shows the method of mounting the terminals.

Simple Vernier

THIS device can be built at very little cost and is quite effective, giving a micrometer adjustment, and at the same time helping to reduce body capacity effects.

As the device is no part of the set proper it does away with unnecessary mounting of costly verniers and accomplishes the same effect in a better manner.

Contributed by ERWIN STENTZ.



A vernier that not only gives micrometer adjustment but eliminates body capacity effects is easily made with a dowel pin and rubber tip.

Experiments with Various Voltages on Standard Tubes

By L. W. Hatry

THE thing that the experimenter has to learn, is not to be bound with or by, rules. Just because a patent can-opener and pie-knife is accompanied by directions that limit its use to opening cans and cleaning fish doesn't mean that you can't use it for a quenched gap. Thus, because your vacuum tubes are served to you in nice wrappers with rated voltages and directions, and with names like detector or amplifier you have no good reason to believe that they will not work at different values and in different positions. Refusing to be bound by the accepted knowledge of things has brought forth a receiver that works without any B battery, and what is more, it works very well, as a trial will prove to you.

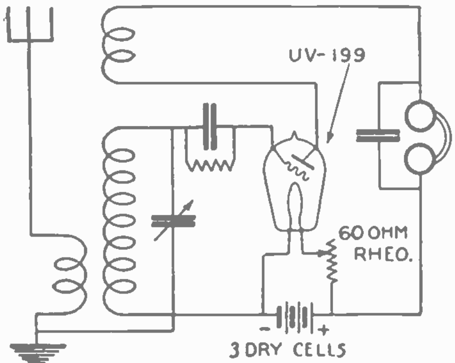


FIG. 1

Hook-up showing how a UV-199 tube may be operated without a "B" battery. In this case the drop across the rheostat is sufficient to produce a current through the headset.

Take the 199 or 299 tubes, for instance, with a rated filament voltage of three and a rated plate voltage of 22½ to 100. Everyone uses a supply source, for the filament, of four or four and one-half volts with regulation provided by a rheostat. On test I have found that the 199 tube works very satisfactorily with only two volts for the filament, a single storage cell, or with three volts as delivered from two dry cells. In neither case was the use of a rheostat needed, and the results were as good or very nearly as good as when the usual methods were employed. This does not hold true except for a regenerative detector as the 199 as an amplifier requires its rated filament voltage, although it will deliver an excellent output at the lower voltages. It is my belief that nothing is gained by using a higher filament voltage for the 199 than that supplied by two dry cells, when the tube is used in the average regenerative set, because by the time the cells drop to so low a voltage that the tube becomes inoperative, the battery is already on its last legs.

I have found some 199's that would work surprisingly well with only one volt on the filament. Of course, it is only occasionally that one will do that. And, as to the B battery, you will be surprised at some of the voltages it is possible to use. I have found 199's, often, that work well with as low as eight volts on the plate and one that worked with the potential drop across the A battery supplying the plate (see Fig. 1.); in other words, a B battery of three volts. As oscillators for heterodyne work of any sort, 199's are usually perfectly satisfactory with only 10 or 12 volts of B battery. It is in regenerative sets that you will find you can use some remarkably low plate and filament voltages and get away with it.

The 201A or 301A tube is often just as satisfactory with 4½ volts on the filament as it is with the higher voltages and rheostat. With only two cells of a storage battery supplying the filament of a 201A, giving a filament voltage of 4.1, I have used it as a detector in a regenerative receiver night after night of C.W. reception, and thereby opened up a dead night, time and time again (see Fig. 2). As an oscillator, solely, you will find that the 201A is often quite satisfactory with only 10 or a little more voltage on the plate, and with three dry cells for the filament supply. Particularly is this handy in an oscillator-wave meter built to include the batteries as it eliminates the rheostat (see Fig. 3). This is also applicable to super-heterodynes if the oscillator coil is well separated from the pickup coil.

There are the 200 or 300 tubes of course, but I can offer no hope for them on reduced voltages. Being critical as to plate voltage, they are relatively limited as far as experimentation in that direction is concerned; and they are even more critical as to the filament current. But when used as oscillators, though not furnishing much of an output, they work with 10 volts on the plate but require the rated five on the filament. In a regenerative set, they are most sensitive on rated voltages and work best a little below the critical hissing point. They will make a very satisfactory amplifier too, being effective only if no more than one step is used, with the plate and filament voltages adjusted to their critical values.

"Experimenter" Radio Data Sheets

MR. SYLVAN HARRIS, the well known radio engineer and technician, has undertaken to write for an indefinite period for THE EXPERIMENTER a series of new Radio Data Sheets. These sheets, of which six will be printed in every issue of THE EXPERIMENTER, will form a book containing a gold mine of radio information that can not be bought anywhere. The first sheets will be found on the opposite page. By the time the book is complete you will have the most up-to-date radio volume in existence.

We have prepared a handy little binder into which these sheets fit, and which we shall be glad to furnish. This binder also contains a number of blank sheets on which to make notes yourself. Price 25c prepaid.

Then there are the Western Electric tubes, the J and the E and the 216A. Every one of them makes an excellent oscillator on comparatively low voltages and all can be used under their rated filament values. In addition, the J will stand up to 200 volts usually as an amplifier or oscillator, but is designed to be a detector. The E does not work very well above 400 as a higher voltage shortens the life terribly, and the 216A will work well as an oscillator with voltages up to 300 but not much higher safely. The 201A, mentioned above, works without much trouble on 550 volts as an oscillator but doesn't last long in service. It does serve well on 200 volts with good life.

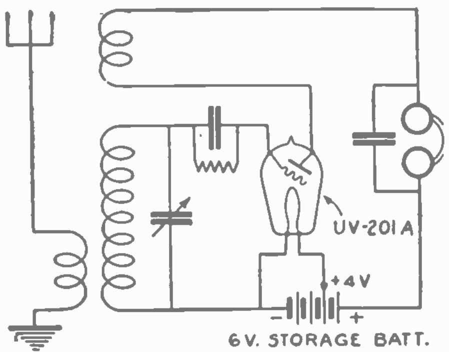


FIG. 2

Circuit showing a type 201-A tube operated with four volts on the filament and two on the plate. Dry cells may be used.

With power tubes the experiments run in the opposite direction, generally, than with the receiving tubes. There the high voltages will be stressed because you want to get the highest possible output from the tubes.

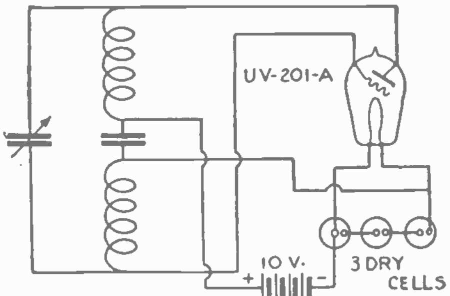


FIG. 3

An oscillator employing a type 201-A tube operated with three dry cells for the filament and ten volts for the plate.

Take the 202 or 302. They are rated 7.5 and 350 volts. Actually they can be used with 800 volts on the plate with enormously increased output. I have used up to 1500 volts but that high a voltage is bothersome, as it had a tendency to spark unexpectedly. You will be surprised at the life of a five watt tube when run with 8 or 9 volts on the filament. This shortens the life noticeably, and should only be used where temporary increased values of output are desired. Actually you should, to obtain long life, run the filament at about 7 volts and the plates with about 800 to 900. This will give excellent power and relatively long life. As a detector or amplifier, the 202 can be operated directly from a six volt battery, and with the usual plate voltages. I have had a 202 oscillating well with only 5 volts on the filament and 10 on the plate. As a detector, it generally works as well as it will with 22½ volts and as an amplifier, anything up to 200 or 300 volts, depending on what output is required.

Then there is the 303 or 203, the 50-watt tube. Its ratings are 10 and 100 volts but, as usual, it can be operated well at many other values. For power the plate voltage can be increased safely to 2000 volts and even 3000 volts can be used but not safely. Overloading the filament does not help as the filament is designed so that its peak is around ten volts, but it can be operated at subnormal values with an appreciable gain in life on heavy plate overloads. The 203 will oscillate with voltages on the plate as low as 22½ and on the filament of 8½, but as no one wants to play with a thirty dollar tube that way, I suppose the inference is relatively unnecessary. As a power amplifier, of course, it is very powerful, but no one wants to use it as a detector, in spite of the fact it works well.

In addition to these things mentioned, the 202 and 203 both make excellent rectifiers for high voltages. They are expensive to use but are available for emergencies or in experiments.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

WAVE LENGTH AND FREQUENCY

It is generally known that the electromagnetic waves such as are used in radio communication travel through space with the same velocity as that with which ordinary light travels, viz., 186,000 miles per second, or 300,000,000 meters per second. When signals are radiated from an antenna, the electromagnetic impulses are transmitted to the "ether" at regular intervals, which ether is supposed to carry the radio waves of a frequency of the current in the oscillation circuits of the transmitter. Thus, if the current in the transmitter is oscillating at the rate of 1,000,000 cycles per second, the time between these impulses will be 1/1,000,000th of a second. In other words an impulse will be imparted to the ether every 1/1,000,000th of a second, and as each impulse is imparted thereto it begins to travel away from the antenna at the velocity of 300,000,000 meters per second.

By the time the second impulse is imparted to the ether, the one preceding it has already traveled a distance equal to

$$300{,}000{,}000 \div 1{,}000{,}000 = 300 \text{ meters}$$

The impulses will maintain this interval as they travel outward into the ether, and this distance is known as the wavelength. The above ideas are very simple, and may be reduced to a convenient form by the algebraic expression

$$\lambda = \frac{300{,}000}{f}$$

in which λ is the wave-length in meters, f is the frequency in kilocycles, and 300,000 is the 300,000,000 above divided by 1,000, since we are now using kilocycles instead of cycles. A kilocycle is equal to 1,000 cycles. It is a more convenient unit to use, since it gives us much small numbers to deal with.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE NATURE OF ELECTRICITY

Electricity was first discovered by the Greeks and because of the fact that amber, when rubbed vigorously, would pick up small bits of straw or pith, the property was called electricity from the Greek name for amber, "elektron."

Many substances can be electrified by rubbing, as for instance glass rods or hard rubber fountain pens. The property is not only imparted by rubbing, but may be transferred from one body to another by mere contact. It has been found that if two similar bodies are charged in the same way, these two bodies, when suspended by strings, will repel each other. If two similar bodies are charged in different ways, they will attract each other.

This leads to the idea of two kinds of electrification, and for convenience these are called *positive* and *negative* electricity. The law that follows from the above described phenomenon is that bodies which are charged alike repel each other, and bodies which are differently charged attract each other.

A positive or negative charge can be placed upon any insulated body, and it will be found that these rules always hold, at least under ordinary circumstances. The rule refers to a property of electricity, not to the bodies which are charged, and may be stated, "like charges repel, and unlike charges attract each other."

This is true in all cases where the electric charge is at rest on the body. It is called *static* electricity. "Electricity in motion," or current electricity, will be explained later in the sheets on the "electron theory." Current is attributed to the motion of the "electrons."

The EXPERIMENTER Radio Data Sheets

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The EXPERIMENTER Radio Data Sheets

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PREFACE

The Radio Data Sheets are to be published each month in The Experimenter, beginning with this issue of January, 1925. Six sheets will be printed each month and the subjects of the sheets will be in accordance with the table of contents.

The list of chapters has been chosen to represent every phase of radio theory and practice that is of value to the radio experimenter. Most of the chapters deal with the apparatus used in radio circuits, but these chapters will be confined to the use and design of the apparatus.

The first chapter covers only the theory of radio, together with whatever information in general electrical matters is required to attain a comprehensive knowledge of radio.

The Radio Data Sheets will be numbered at the bottom, the first number representing the section to which the sheet belongs. The second number shows where the sheet is to be placed in that chapter. Thus 7-15 means that the sheet is to be placed in the section on transformers, and is to be the 15th sheet in that section.

This system of numbering will enable the reader to keep his sheets in the proper order very easily. The sheets will not be numbered consecutively each month, but the reader must not think that because some numbers are missing that he has not the entire collection. This is done to facilitate numbering or arranging the sheets.

It may be necessary at times to use decimals in the numbering. Thus, if 6-10 and 6-11 have already been published, and if a sheet is published later on which, from the nature of its contents should be placed between 6-10 and 6-11, it may be given an intermediate number such as 6-10.5. At any rate, all the reader has to do is to arrange them in the numerical order in each section.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

CURRENT ELECTRICITY

If two bodies are charged with electricity so that one is charged more than the other, and a wire touched to both bodies, some of the charge on the one possessing the greater amount will pass through the wire to the other body which possesses the lesser amount of charge. The passage of electricity through the wire constitutes what is known as a flow of electricity, or an *electric current*.

The flow of current from one body to the other continues until equilibrium between the two electrified bodies is attained. The reason for this flow of current is as follows: If a body of a certain size is charged with a certain amount of electricity, and another body of the same size is charged with a greater amount, it is obvious that there will be a greater *pressure* in the second body than in the first. This is somewhat analogous to pumping different amounts of air into two tanks of the same size.

This electric pressure is called the electric *potential* of the charged body, and it is the difference between the potentials of the two bodies above that causes the flow of current from one to the other. The first body has the higher potential, so the current flows away from it to the body which has the lower potential. The current continues to flow until the potentials of the two charged bodies have become equal; that is, until the electrical pressures have become equal.

The quantity of electricity that a body must hold to have a certain potential depends only upon its size and shape. This will be explained in the sheets on capacity.

Electric current will not flow readily through every kind of material. Some materials *conduct* electricity more easily than others. They are called *conductors*. Those materials which will not readily conduct electric currents are called dielectrics, *non-conductors* or *insulators*. Theoretically no material is either a perfect conductor or a perfect insulator. Insulators can be obtained, however, through which the amount of current flowing is hardly appreciable or measurable.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

KILOCYCLES vs. METERS

After studying Radio Data Sheet 1-50, it becomes evident that the idea of wave-length is a secondray one, the primary idea in connection with radio waves being the frequency. The frequency of oscillation depends upon the constants of the circuits in the transmitting apparatus, and is independent of any characteristics of the ether.

The wave-length, on the other hand is dependent both on its frequency and on the velocity with which the waves are propagated through the ether, which is a constant velocity, viz., 186,000 miles per second. It is therefore evident that when we tune a radio set we are not adjusting the wave-length. We are adjusting for the frequency and the wave-length will have to be what it happens to come to as determined by the above factors.

But there are other important reasons why more stress should be placed on the idea of frequency rather than on the wave-length. The most important of these has to do with the frequencies of the voice sounds which are being broadcast in the radio concerts.

Every sound which is in a musical scale has a definite pitch or frequency. The sounds emitted from various sources, including the vocal cords and the cavities of the mouth and throat, are very complex, and are equivalent to a mixture of sounds of various frequencies. The sound as a whole is equivalent to a certain ***fundamental*** or basic frequency and a number of other frequencies which are integral multiples of this fundamental frequency, called harmonics.

These *harmonics* do not exist separately. The original sound wave is very complex, and it is merely for convenience that this wave is resolved into its fundamental and the harmonics by a special mathematical process.

For good telephonic or radiophone transmission quality it is necessary that all the harmonics up to a frequency of about 5000 cycles, or 5 kilocycles, be present in the transmitted wave. If the lower harmonics are missing the sounds will be squeaky, and if the higher ones are missing the sounds will have a hollow quality.

CUT ALONG PERFORATED LINES

Measuring the Amplification Factor of a Vacuum Tube

By H. Diamond, Dept. of Electrical Engineering, Lehigh University

BY definition, the amplification factor of a vacuum tube is the ratio of plate to grid voltages necessary to produce an identical variation in the current of the plate circuit. It is the purpose of this article to discuss three methods of measuring this factor, using apparatus of the simplest nature, so that the average radio fan may perform the same tests upon his own amplifying tubes.

One of these test methods is fundamental, depending directly upon the definition given above, and makes use of the characteristic curves of the tube. The other two methods consist essentially of balancing the effects of simultaneously applied grid and plate voltages upon the plate current, the values of these voltages being so adjusted that the net change in plate current reduces to zero.

Actual results obtained for a UV-201A amplifier tube by all three methods will be compared and discussed.

1. *Fundamental Method.*

The test circuit diagram for the fundamental method is shown in Fig. 1. Potentiometer control of the grid voltage is effected by connecting a 200 ohm potentiometer P, to an eight volt battery C, through a double-pole, double-throw switch S. With the switch thrown to the right any voltage from zero to +8 volts, and with the switch thrown to the left any voltage from zero to —8 volts, may be obtained. The actual voltage applied

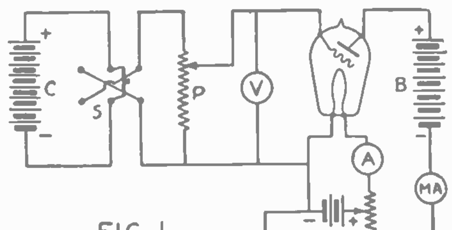


FIG. 1

Hook-up showing how the characteristic curve of a vacuum tube is measured. The curves shown in Figs. 2 and 3 were obtained with these connections.

to the grid circuit is measured by a D.C. voltmeter having a 15 volt scale. An ammeter with a one-half ampere or one-ampere scale is connected in the filament circuit and a milli-ammeter whose scale extends to 15 milli-amperes is placed in the plate circuit. The battery B, consists of five 22½ volt "B" batteries connected in series.

The test procedure is divided into two steps: (a) With the filament current constant at its normal value and the plate voltage adjusted to the value which gives best amplifying action when in actual operation, the plate current is recorded for different values of grid voltage from —8 to +8 volts. (b) With the filament current constant at its normal value and the grid voltage adjusted to a value which, when used with the optimum plate voltage mentioned in (a), gives best amplifying action, the plate current is recorded for different values of plate voltage from 22.5 to 112.5 volts.

For the UV-201A amplifier tube on hand, a positive grid bias of 4 volts and 90 volts on the plate with a normal filament current of 0.25 amperes gave the condition of best amplifying action, as shown from previous use. These values were, therefore, used in (a) and (b), the data obtained being shown in the form of curves in Figs. 2 and 3. The curve of Fig. 2 is known as the grid-voltage plate-current characteristic curve of the tube, and that of Fig. 3 as the plate-voltage plate-current characteristic curve.

From Fig. 2 it is seen that to cause a

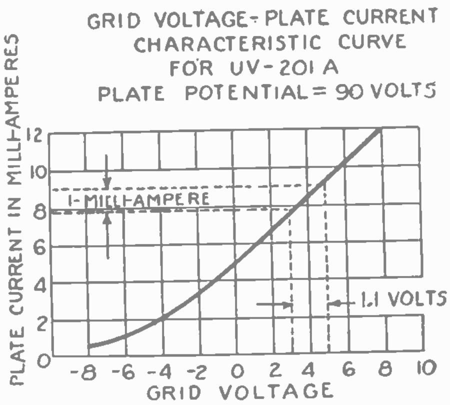


FIG. 2

A characteristic curve of a 201-A tube showing the relation of the plate current with various grid voltages.

variation of one milli-ampere in the plate current requires a change in grid voltage of 1.1 volts. From Fig. 3, to cause a variation of one milli-ampere in the plate current a change in plate voltage of 8.8 volts is seen to be required. By definition then, the amplification factor is equal to

$$\frac{8.8}{1.1} \text{ or } 8.0.$$

It should be noted that the amplification factor is here obtained from the static characteristics of the tube, as distinguished from the dynamic characteristics when the tube is in actual operation. The static and dynamic characteristics differ only when the resistance of the external plate circuit is appreciable. The amplification factor as here determined holds true, therefore, only when the D.C. resistance of the external plate circuit is low, a condition which obtains for transformer or choke-coil amplifiers, but *not* for resistance coupled amplifiers. With a high resistance in the plate circuit, the plate voltage changes with change of grid voltage on account of the voltage drop across the resistance, and this change in plate voltage varies the amplification factor.

2. *Static Method.*

The second method of measuring the amplification factor of a tube is the so-called "static method", which consists of applying a certain positive potential to the plate and the giving sufficient negative potential to the grid to bring the plate current down to zero. The amplification factor is then the ratio of the plate and grid voltages existing at the time this condition of zero plate current obtains. From the procedure it is seen that the same test connections may here be used

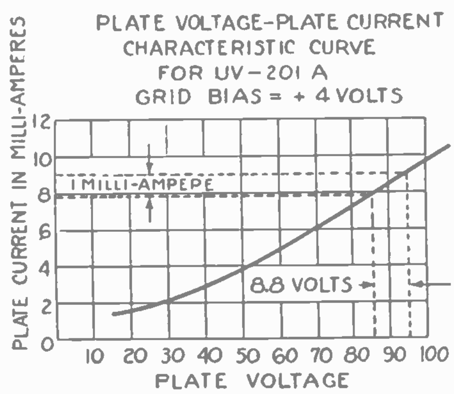


FIG. 3

Curve showing the relation of the plate current with plate voltage. This curve, together with curve Fig. 2, will give the amplification factor of the tube.

as for the fundamental method (see Fig. 1), except that a higher voltage may be necessary for battery C.

The measurement is repeated for various values of plate potential and the average value of the results is usually taken as the correct figure. The results obtained by this method for the UV-201A amplifier tube follow:

Positive Plate Potential	Negative Grid Voltage	Amplification Factor
22.5	2.9	7.75
45	5.9	7.63
67.5	8.9	7.59
90	12.0	7.50
	Average	7.62

This method is the least accurate of the three test methods described here, since it comes the furthest from approximating actual operating conditions. An amplifier tube is never used under conditions which require that the direct current in the plate circuit be equal to zero.

3. *Dynamic Method.*

The circuit diagram used for this method of test is shown in Fig. 4. R_1 is a fixed resistance of 20 ohms and R_2 a variable resistance of from zero to 200 ohms. This may well be the 200-ohm potentiometer. The transformer shown may be an ordinary bell-ringing transformer, having its high-voltage side connected to a 110 volt, 60 cycle A.C.

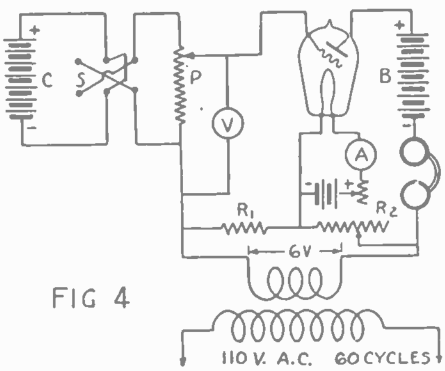


FIG 4

Hook-up showing how the amplification factor of a tube is measured directly by the dynamic method.

lighting circuit. Its low voltage side is impressed across the resistance R_1 and R_2 in series. The hook-up is otherwise the same as for Fig. 1 with the exception that phones are substituted for the plate milli-ammeter.

Before connecting to the A.C. circuit, the filament current, grid voltage and plate voltage are adjusted to their optimum operating values. For the UV-201A we have assumed that these are 0.25 amperes, 4 volts and 90 volts, respectively.

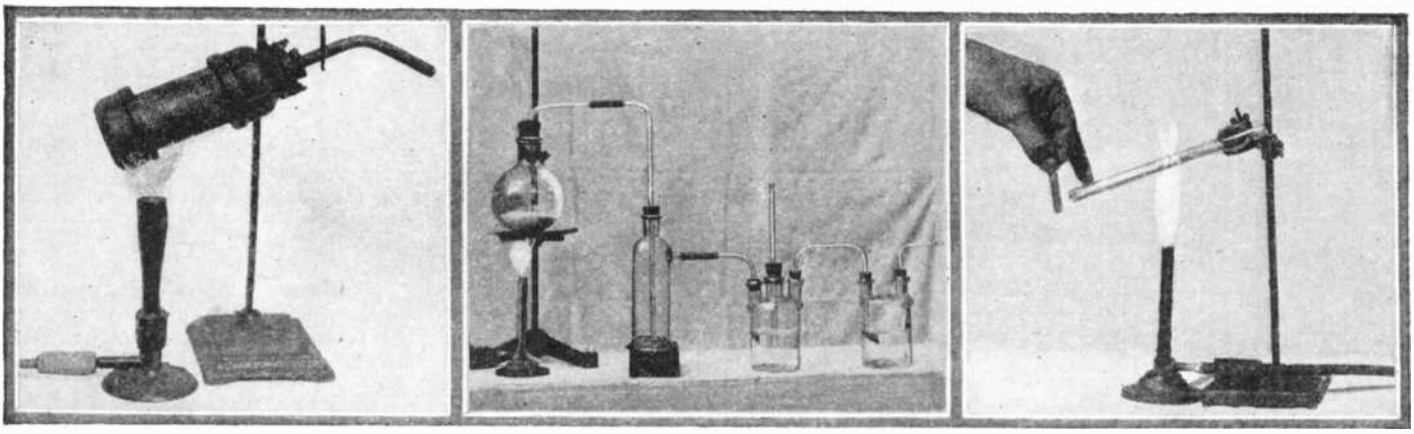
Impressing the alternating e.m.f. across R_1 and R_2 results in a simultaneous application of alternating grid and plate voltages which are in opposite directions when referred to the negative filament terminal. These voltages will, therefore, have opposite effect on the electron flow in the tube. If, now, the value of R_2 is so adjusted that the effect on the electron flow of the drop across R_1 is just equal to the effect of the drop across R_2, the two effects will balance out, and there will be no net change in the plate current This condition obtains when the 60 cycle hum, present in the phones before the two effects are balanced out, is at a minimum or disappears completely.

The test procedure consists, then, of adjusting the value of R_2 for minimum noise in the phones. For this condition, the amplification factor is equal to the ratio of the

(*Continued on page* 212)

Simple Experiments in Chemistry

By Raymond B. Wailes



The evolution of gases, 1, by destructive distillation on the large and small scale, 2, by double decomposition and, 3, by the decomposition of a chemical, by the simple application of heat, are shown in experimental guise above.

AFTER a few pieces of apparatus such as ringstands, test tubes, beakers, glass tubing, etc., have been acquired by the amateur chemist, he is naturally inclined to do a little experimenting, be it for pleasure, for knowledge, or both.

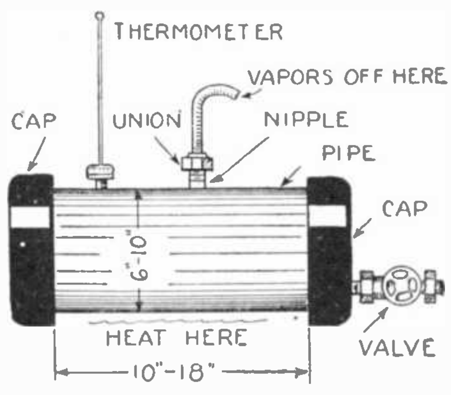
Coal gas is made by heating a suitable grade of coal in a fire clay retort. Ammonia gas and coal gas are two of the substances which are produced from the retort as you can prove for yourself in a miniature iron retort made from pipe fittings. This retort can be made in any size. The writer's had a body of 2½" diameter. A local pipe shop will make this up very cheaply. The ends are pipe caps and are simply screwed on with a little graphite on the threads to make a tight joint.

If the retort is filled half full of soft coal and heated with a Bunsen burner, gas will escape from the nozzle or bent mouth pipe. The gas can be burned at the tip of this pipe. If a moistened strip of red litmus paper is held in the gas, it will turn blue, because there is ammonia gas in the products coming from the distillation of the coal. If the red paper turns blue, ammonia is being made. The retort will be found to contain a lump of coke if it is opened after cooling. The beauty of the gas pipe retort is that it can be used over and over again.

You can also experiment with larger amounts of coal, or even other substances such as tar, in larger retorts shown in Fig. 8. If a liquid is distilled, the tailings or residue can be removed by means of a small valve or pet cock shown.

A supply of ammonium hydroxide or ammonia water will always be needed in the experimenter's chemical laboratory. This liquid is easily made from two common substances, ammonium chloride or sal ammoniac, and calcium oxide, or lime. The apparatus shown in Fig. 2 is used to make fairly pure ammonium hydroxide. It consists of a round bottom flask, preferably of pyrex, an empty wash bottle to catch solid particles which might be accidentally driven over, a three-necked Woulff bottle followed by a two-necked Woulff bottle. Equal parts of the sal ammoniac and lime with water to form a thin paste are heated in the flask.

Ammonia is soon evolved which passes, bubbling, through the water in the first Woulff bottle. The water will dissolve some of this gas, the next bottle dissolving what is left unabsorbed. The upright glass tube in the first Woulff bottle acts as a safety valve, for if the pressure becomes too strong in the generating vessel, the water will be driven up and possibly out through this tube. The water in the two bottles after the experiment will contain moderately strong ammonium hydroxide, and the two can be mixed together and



The dimensions of a simple retort for making coal gas upon a larger scale, as described in the article.

labelled for future use in the "lab." or workshop.

It should not be thought by the experimenter that the ammonia gas is simply absorbed or contained in the two substances used in the last experiment. A real chemical reaction takes place which generates this gas from the two substances, the nitrogen changing from the triad valence to pentad.

Ammonia gas can really be obtained by heating ammonium chloride under suitable conditions. Here is what happens:

$$NH_4Cl = NH_3 + HCl$$

The first symbol is sal ammoniac or ammonium chloride written chemically. When heated it yields, as shown by the equality sign, NH_3, which is ammonia gas, and HCl which is hydrochloric acid, a pure muriatic acid, in other words. But these two substances, if not separated instantly, will turn about and combine with each other, forming by doing so, fresh ammonium chloride. These two gases *can* be separated, however, by using the apparatus shown in Fig. 3.

This consists of a glass tube into which is rammed rather loosely a wad of asbestos shreds and then a little ammonium chloride. By heating the ammonium chloride, the above chemical reaction will take place, and the ammonia will actually pass or diffuse through the asbestos slug and come out at the end of the tube. Wet red litmus paper held here will turn blue, showing the presence of ammonia gas.

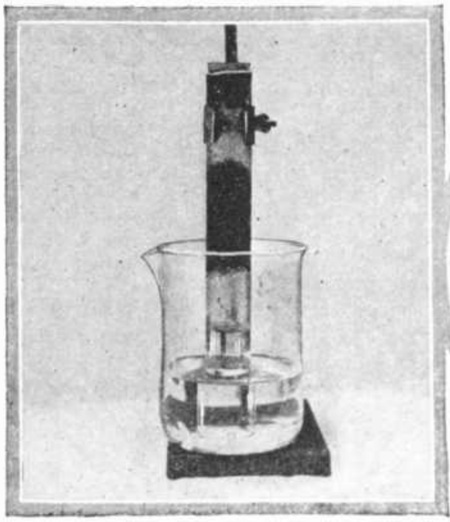
Bright Iron Eats Oxygen

Iron rusts by chemically uniting with the oxygen of the air. This is only true when the air contains moisture. This fact is clearly shown in the extremely simple apparatus set-up shown as Fig. 4.

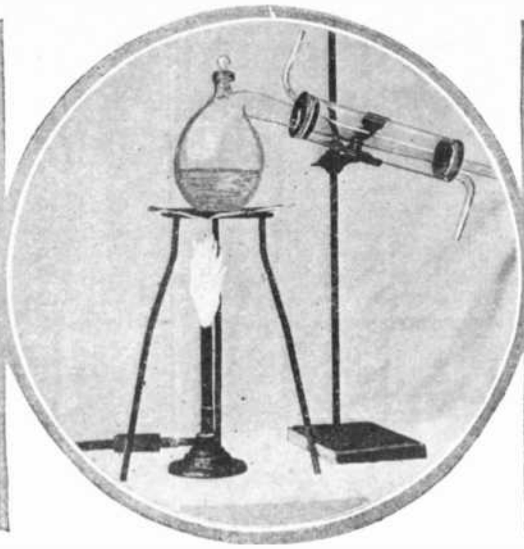
A wad of steel wool is inserted in a glass tube. After moistening the wool the tube is corked and raised so that the water level in and outside of the tube is at the same height. Even after half an hour, the water can be seen to have risen some distance up into the tube. This is because the iron or steel has combined chemically with the oxygen of the air in the tube, the nitrogen of the air remaining. By marking the tube and adjusting the water levels at the end of a day or two, it can be shown that one-fifth of the tube has been occupied by water, or, one-fifth of the air is oxygen.

Making Nitric Acid

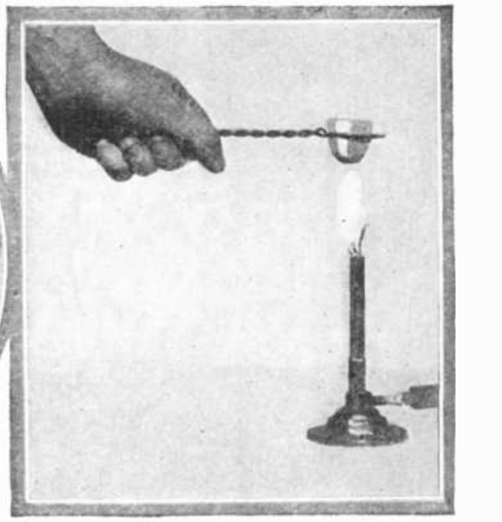
Nitric acid is another substance which you will find use for in your laboratory. This acid can be made by heating a mixture of concentrated sulphuric acid and sodium nitrate in the retort of the apparatus shown in Fig. 5. The retort shown here has fitted to it a home-made condenser which will condense the nitric acid vapor into liquid nitric acid which is caught in a bottle at the end of the retort.



The combination of oxygen with iron, the experimental demonstration of the rusting of the metal.



Making nitric acid from sodium nitrate, the so-called Chile saltpetre. Note the simple condenser.



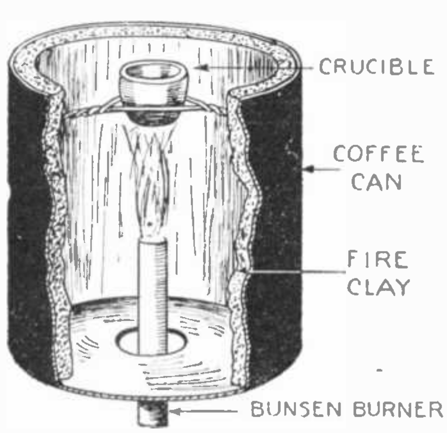
A practical crucible holder made of wire is shown as a substitute for the regular chemist's tongs.

The condenser consists of a glass tube about two inches in diameter fitted with corks and a tube for water to pass through in each cork. The corks are bored and slipped over the neck or spout of the retort, making a self-contained, all-glass distilling system. Water should be led into the bent glass tube near the delivery end. The retort should be laid on a 5" square of wire gauze. This gauze in turn rests upon a tripod or a ring of a laboratory support. The wire gauze will aid in obtaining even heating effects and prevent breakage to some degree. A piece of asbestos board is better than the gauze.

Perhaps your nitric acid will not be as strong as that which you can buy but it should stand this test: Light a match and allow half of the stick to burn away. Quickly extinguish it and while still glowing thrust the tip into a drop of your nitric acid. The nitric acid will be chemically decomposed by the heat and will liberate oxygen gas. This gas will cause the rest of the still-glowing match to glow even brighter, due to the combination of the charcoal or carbon, with the oxygen gas liberated.

The experimenter should not confuse names of chemicals with those of other closely allied chemicals. For instance, in preparing nitric acid from sodium nitrate, sodium nitrite should not be used. Here a difference of one letter means a different result.

It is possible to prepare many different compounds from one substance. Copper nitrate can be made by dissolving copper in nitric acid. Try this with some of your home made nitric acid. Now by heating copper nitrate crystals in a porcelain crucible, the nitric acid radical will be torn from



A coffee can lined with fire clay encloses the flame of a Bunsen burner so as to constitute a species of furnace; a very good home-made appliance for laboratory use.

it and copper oxide, a black powder, will be left in the crucible.

A handy pair of crucible tongs can be made by twisting two heavy gauge iron wires together. One end should be made into a handle, the other forked. The use of this instrument is shown in Fig. 6. The crucible can be heated on an ordinary pipestem triangle if desired, and the crucible simply lifted from this as desired.

A simple "furnace" for heating a porcelain crucible is illustrated here. It is made from a coffee can through the bottom of which is punched a 1½-inch hole. The inside is lined with fireclay mixed to a paste with water and dried. An ordinary pipestem triangle is imbedded into the sides of the fireclay wall and supports the crucible. A Bunsen burner is thrust through the bottom hole, the can being supported in a suitable manner upon a ringstand.

But to return to the black powdery copper oxide. This can be converted into copper sulphate or bluestone by dissolving it in sulphuric acid, or copper chloride can be made from it by dissolving it in hydrochloric acid.

It is interesting to note the deep blue solution which is formed when an excess or a large amount of ammonium hydroxide (you can use the product which you have made), is added to a solution of copper nitrate or sulphate in water.

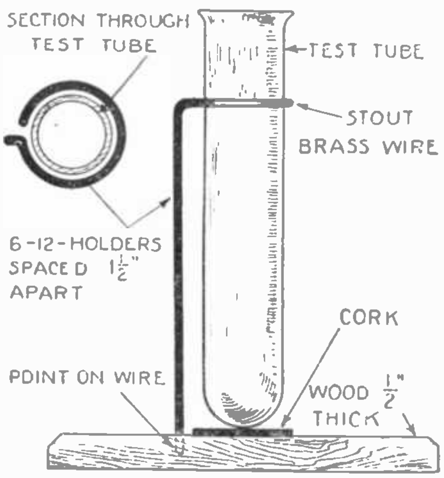
Simple Test Tube Holder

By C. A. Oldroyd

A VERY efficience holder for test tubes for laboratory use can be quickly and easily made from a baseboard and a few lengths of stiff brass wires. The type shown here (see illustration) has the advantage that only the neck of the test tube comes into contact with metal, while the base of the tube rests on wood or a cork strip, so that a tube can be inserted while hot, without fear of cracking it.

One end of the wire is bent into a loop having an inner diameter of about ⅛ to ¼ inch larger than the test tube diameter, then the wire is bent at right angles to the loop and its end cut off to suit the length of the tube. The free end is pointed and driven into a small hole in the wooden baseboard. Any number of these holders can be arranged on a common base side by side, as shown.

Under the rounded end of the test tubes, a strip of cork or lino is tacked to the baseboard to prevent breakages due to careless handling of the test tubes when being placed into the holder. It is a good plan to bore a hole about ¼ inch deep and put in a disc of cork to come directly under the end of the tube and retain it in place.



A simple test tube holder. As shown it holds a single test tube, but by using a long strip of wood for the base and a number of wires it can be made to accommodate any number.

The principle shown here as applied to a holder for a single test tube is so good that it deserves to be carried out for larger numbers of test tubes as described below the illustration. A wooden base 4 inches wide and 8 or 10 inches long could accommodate two rows of test tubes, giving a total of 24, and one set of holders could be made lower and of smaller diameter than the others, so as to take care of the small test tube.

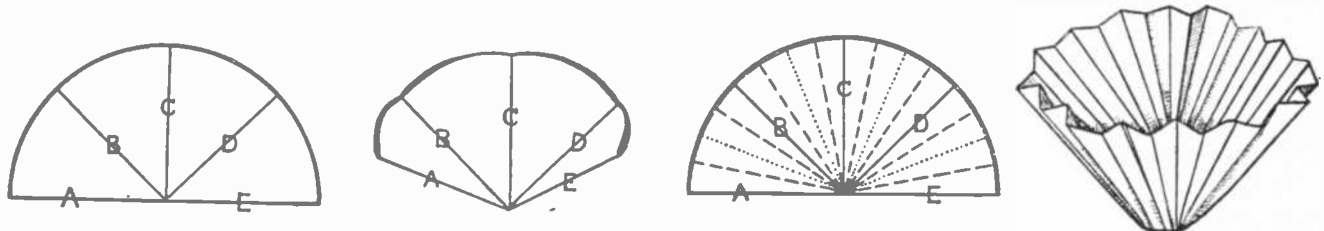
Another way of putting in the cork would be to bore a hole beneath each ring and drop a disc of cork therein, which disc can be cut from an ordinary cork. This has its disadvantages as compared with the method shown in the drawing, because liquid might accumulate in the depression. With the least care, there will be no need of using the cork, as it would only be by absolute clumsiness that the tube would be broken by coming against the wood of the base if dropped into its place.

How to Fold Filter Papers

By T. O'Conor Sloane, Ph. D.

THE way in which a filter paper is folded is a good indication of the quality of the chemist as a manipulator. Laboratory work consists very largely of doing things in the right way and the simple folding of filter paper can be done rightly or wrongly.

There are two general ways of folding a filter paper, giving the ribbed or the smooth folded paper. The first is supposed to filter more rapidly and can be used for such precipitates as ferric hydroxide, but is hardly to be recommended for general use in a laboratory. Yet the folding of it is rather interesting and there are times when a ribbed paper may prove very serviceable.



These four diagrams show how to fold a ribbed filter in the correct way. Thus folded there will always be two narrow flat sections of the paper, which come directly opposite each other in the funnel.

The filter paper, as we suppose is known to our readers, is a circle of porous paper through which a fluid will pass. There are numbers of varieties. For a long time in quantitative work what is known as Swedish filter paper held sway. This was made in Sweden with pure water, so that the finished product contained a very small amount of ash. There are now several kinds of paper on the market with a very small ash content, even acid treated papers may be bought in which the greater part of the ash normally present has been dissolved out by hydrochloric and hydrofluoric acids.

To fold a ribbed paper, proceed as follows: First fold it across the center. This gives a half circle. Then doubling it over until the bent edges meet fold it once more and this divides it into quarters. The illustration shows a paper in which these folds have been made and they are marked respectivelyA, B, C, D and E. Bringing A to coincide with B, a fold is put in as indicated by the dotted line.

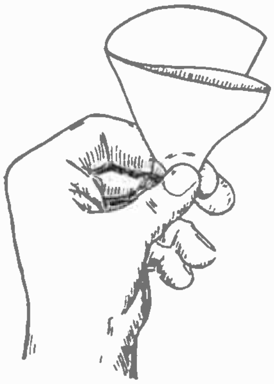
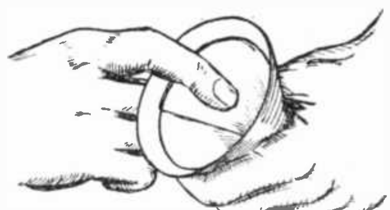
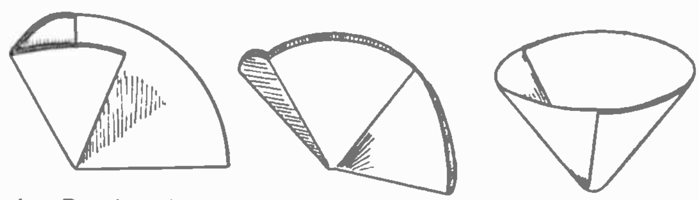
Next, A is placed upon B and the fold made which will come where the dotted line indicates between B and C. Placing E upon D and folding it gives the fold between the two letters as shown, and placing E upon B gives the fold corresponding to the dotted line between C and D. These represent one-half the fold for a small paper and they are all made in the one direction.

Next the paper is folded backward halfway between A and its adjoining dotted line along the line of dashes. Holding the fold firmly, a second fold is made along the next line of dashes, and it will be observed that in doing this the folds will come exactly together, backward or forward. When the reversed folds have all been made the paper is held loosely in the partly closed hand, with the open end projecting, and is blown into. This expands the paper and it comes out into shape in a series of in-and-out bends, and directly opposite each other, 180 degrees apart, are two flat sectors, the general contour being shown in the drawing. This is now placed in the funnel and gently pressed down until it reaches its place, which is unmistakable, as it will come to rest there.

A little water from the wash bottle may be trickled down the sides of the flat portions, which will hold it in place, then all is ready for filtering. The writer once knew a French chemist who after a ribbed paper was folded, used to grasp the pointed end in one hand and twisting it tightly turned the entire paper inside out, so that the twisted end projected into the interior of the paper. This is quite applicable to large papers, but is not used on small ones.

By keeping up the process on the lines described, the number of folds in the paper may be increased until one's patience is exhausted.

We now come to smooth folded papers. The simplest way is to fold a paper in half and then complete the process by putting in the quarter folds. If the funnel is what is known as a 60 degree funnel, a paper thus folded will fit it perfectly. But there is apt to be a considerable variation and to cope with this it is well not to put in the second fold but merely to give a little pinch at the apex so as to fix the location approximately. It is then put into a perfectly dry funnel and gently pushed down. When it reaches its place, and this can be unmistakably told by the feel, the folding is completed with the finger, first on the outside layer and then working it around so as to finish on the inside one, the idea being that the paper will fit the glass perfectly. Holding it in position it is moistened with the wash bottle and if any air bubbles appear between glass and paper they are pressed out with the fingers. When complete the paper should fit the funnel perfectly.

Folding a smooth filter paper. There are three ways of doing this, all of which are described in the article. If the funnel is exactly a 60 degree funnel, so-called, a paper folded as described will fit it exactly. But as this is not always the case, the last fold of the paper can be given inside the funnel, by a sort of rolling motion of the index finger moving toward the place where the fold will come.

In another system the paper is folded in half, and a quarter fold is put in; then the folded edges of the paper are carried up to the quarter mark, forward in one case, backward in the other, so as to give a zigzag effect. It is well in putting in the two folds to put one in complete and to put the other in incomplete, merely pinching it at the point. These are put in a dry funnel, fitted as described, held in place and moistened. It seems to be a nicer way of folding than the first described and is claimed to work more rapidly, although this is an open question. The difference in rapidity is certainly not impressive.

An odd way of folding a paper is after quartering to fold one side only over to give the eighth fold, and to put this in the funnel. Here the majority of the paper will be of single thickness and one-eighth of the surface of the paper will be four layers thick.

There is another way of putting the paper in a funnel which is sometimes adopted, and this is to keep the funnel full of water by placing the finger over the lower end of the stem, and then to introduce the paper into the liquid. It is supposed when the finger is withdrawn that the paper will settle into its place, and final adjustment can be given as described.

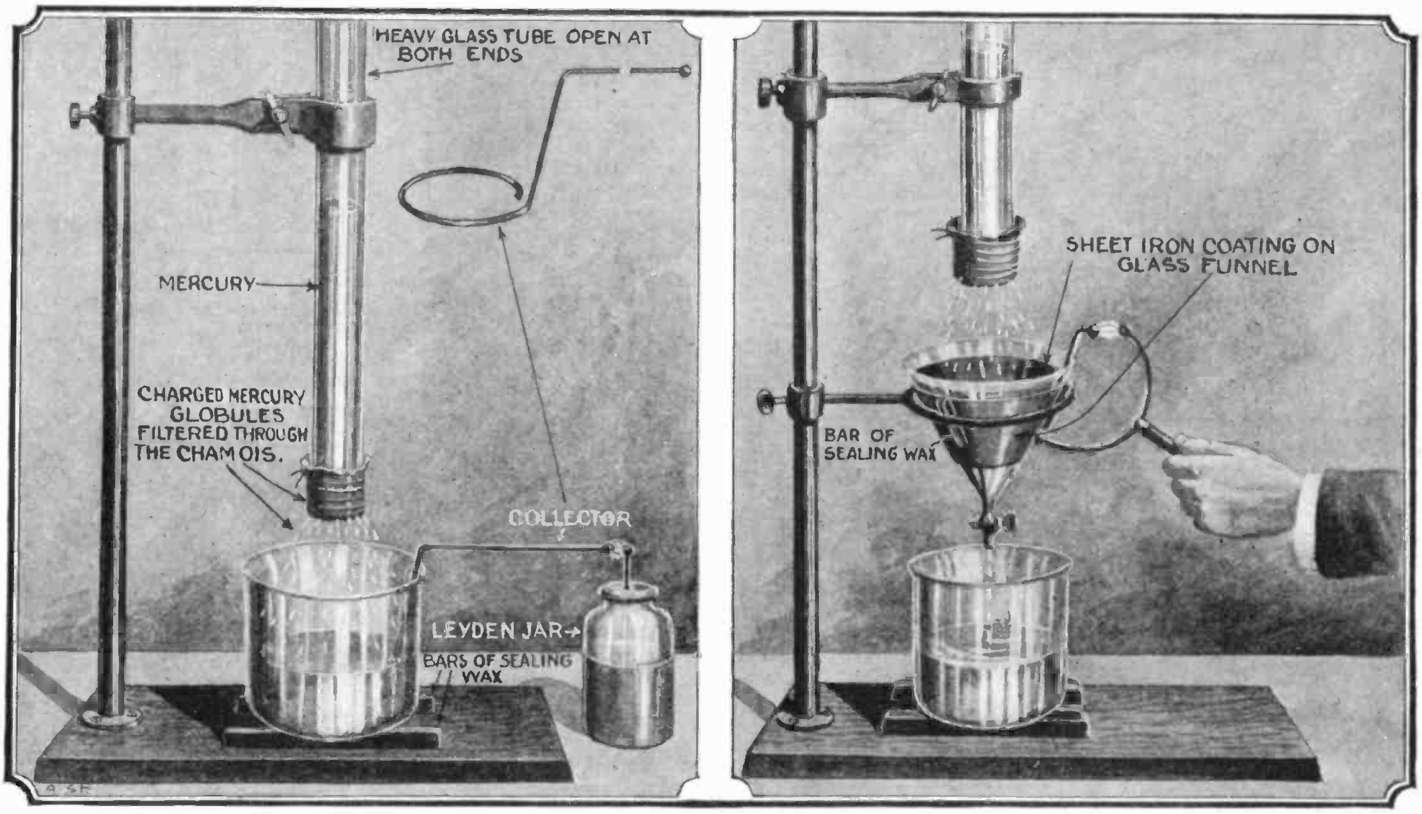
This gives the simple filter paper manipulation which in spite of all the modern advances in the way of asbestos and Gooch filtering will hold its way for many years to come.

In quantitative analysis, the contents of ash of a filter paper for the different sizes is sometimes required. This is easily found by incinerating a definite number of papers and weighing the ash. It should be done for untreated filter papers and for filter papers through which acid has been passed followed by washing, so as to have the ash of untreated filter paper and of filter paper through which an acid solution has been passed. In most routine commercial analysis the high grade paper used leaves so little ash when burned that the weight of such ash can be disregarded.

To a considerable extent, the quality of a chemist's work depends on manipulation, and if one watches the insertion of a filter paper into a funnel, a good clue to the methods of the individual is obtained. A badly folded filter paper, not fitting the funnel, is liable to break. If air bubbles are allowed to remain between it and the glass, it is careless manipulation and should not be permitted. As a criterion, ever so many little things count in the experimenter's laboratory, for the chemist must not only know things correctly, but must do them correctly.

Mercury Filter as Static Machine

By C. A. Oldroud



A static machine of very curious but simple construction was devised by an experimenter who in filtering mercury through a thin piece of chamois noticed an accumulation of electricity on the filtered mercury. Obviously it is the friction of mercury against the fibres of chamois that generates the electricity, which if the receiving vessel is insulated will accumulate in sufficient quantities to charge a large Leyden jar. A modified form of this apparatus illustrated at the right converts the receiving vessel into a Leyden jar by lining both the inner and outer walls with sheet iron. To provide for the removal of the mercury a funnel with stop-cock is employed.

STATIC electricity is often generated in many unexpected ways. A striking instance is the fact that as simple a device as a mercury filter was found to generate electricity to such an extent that sparks ½ inch in length could be obtained.

The filter consists of a long glass tube, having an internal diameter of about ½ inch. The length of the tube should be at least two feet, so as to obtain great pressure at the base of the tube; a longer tube is even better.

The lower end of the tube is fitted with the filter element; this is a piece of chamois leather which is secured to the tube by stretching the leather over it and cementing it to the sides of the tube with fish glue (seccotine) or any other strong adhesive.

Afterwards, the leather is bound to the tube end by a layer or two of strong cord wound on under tension. For the experiment, the tube is held upright in a strong clamp; under the filter a glass jar or beaker is placed. The pressure caused by the high column of mercury forces the lower layers through the filter; the dirt is retained by the chamois leather.

As the drops of mercury issue from the leather, a careful observer will notice that the drops strongly repel each other. For this reason the glass jar under the filter must be high, or the mercury drops might fall outside the jar.

This repelling effect is caused by static electricity, and the latter can be collected if we insulate the glass jar. This is very easily done by placing it on two sticks of sealing wax or any other insulating material.

To lead the electricity out of the lower container, we bend an iron wire to the shape shown. The lower ring-shaped end lies in the bottom of the jar, in contact with the mercury that has filtered through. The other end of the wire ends in a ball or is rounded off, so as not to dissipate the charge. From this ball sparks half an inch long can be drawn; of course not continual sparks as with a spark coil, as sufficient electricity must be accumulated after each spark, before the next spark can be drawn.

The electricity is caused by the friction between the mercury particles and the leather. Although the leather is porous, a great pressure is needed to force the globules of mercury through the pores, and the friction incident thereto produces electricity.

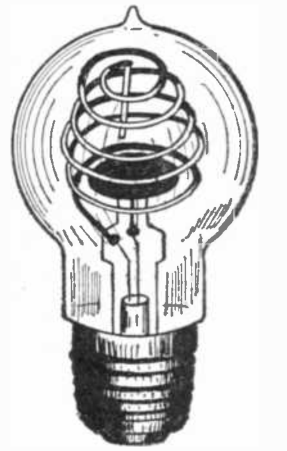
When shown this experiment, a friend remarked to the writer: "At last you have a machine that creates electricity out of nothing."

Unfortunately, the "expert" was wrong, and the perpetual motion machine is as far distant as ever. For energy must be expended here in lifting the mercury up to pour it into the mouth of the tube.

Experimenting With Neon Tubes

By William Grunstein

WHILE most of our readers have seen neon lamps, few are aware of the strange electrical properties of this gas, for, their prevalent use in illumination and advertising has eclipsed the more interesting features of these lamps.



A common type of neon lamp is shown above. It consists essentially of two metallic electrodes located close to each other in a neon filled tube. The application of about 150 volts to the terminals of this lamp will cause the negative electrode to glow.

A number of experimenters, however, have taken up the study of neon tubes and have discovered numerous fascinating peculiarities in their behavior. The field is, by no means exhausted and the enterprising experimenter will find innumerable opportunities in the study of neon lamps.

Neon is one of the inert gases of the terrestrial atmosphere, there being 15 parts by volume, of neon, to one million parts of air. Its electrical conductivity is seventy-five times as good as that of air. In fact, it is so active that even a slight shaking of a tube containing some mercury sealed in pure neon, will cause a brilliant glow. This glow is characteristic of neon and is of a yellowish-red or orange color. The glow is due to an electronic excitation in the gas, and is so readily produced that a form of neon tube has been adapted for the detection of static charges accumulating on machinery in chemical plants.

Another form has been designed for the purpose of testing the ignition system of an auto. In this device a small tube of neon

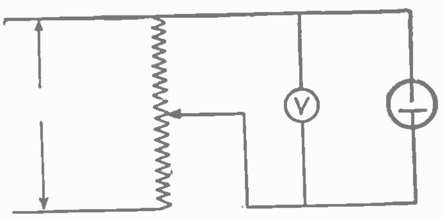


FIG. 2

The illustration shows diagrammatically a circuit for the study of the behavior of the neon lamp under various potentials.

is covered with silver-leaf at both ends. When one of the ends is charged, as by contact with a live ignition plug, an opposite charge is induced in the other end, and the circuit being completed through the capacity of the tube to the ground, a feeble current flows through the tube, resulting in the characteristic bright glow. The failure of this glow to appear indicates that the plug is not operating properly.

In the neon lamps used for advertising purposes, one of which is illustrated in Fig. 1, two iron electrodes at a small distance apart are connected to the supply line. When the voltage is raised to a suitable value a bright orange glow surrounds the negative electrode or cathode. When quite close to the cathode no glow at all appears on the anode. When supplied with alternating current, of course, both electrodes become alternately luminous. These tubes are manufactured by the General Electric Co., and can be obtained at a low price. They are designated by the trade name: "Osglim."

Connect the lamps to the 220 volt lighting main through a potentiometer as shown in Fig. 2 and starting at zero increase the voltage across the lamp. You will find that the lamp remains dark until a certain critical voltage is reached at which point a sudden glow appears. Upon decreasing the voltage you will find that this glow persists until the voltage has dropped considerably below the critical starting potential. On the "Osglim" lamps the critical starting voltage is about 170 volts varying slightly with different lamps and also with the temperature of the surrounding air.

Another peculiarity of the neon lamp is its negative resistance characteristic. That is, an increase in the current passing through the lamp causes a decrease in its resistance. At all voltages below the critical voltage the resistance of the lamp is infinite.

These characteristics of neon tubes adapt it to many diverse uses a few of which will be illustrated in the following experiments. Before proceeding with these, however, it will be necessary to make some alterations on the "Osglim" lamp. As stated above, neon lamps have a negative resistance characteristic and are therefore unstable in an electrical circuit. To stabilize them a resistance is placed in series. This "ballast" resistance is mounted inside the cap of the lamps and should be removed before experimenting with the lamp.

The Neon Tube "Oscillator"

Arrange a resistance of about .5 to 1 megohm, a variable condenser of from .001 to .05 mfd., an "Osglim" neon lamp and a low resistance telephone receiver as shown in Fig. 3 and connect the system to a supply of direct current at 220 volts or over. Despite the fact that the circuit is supplied with direct current the telephone receiver will indicate an intermittent current. By increasing the capacity of the condenser the frequency of these pulsations can be reduced until the neon lamps will noticeably light up and go out at regular intervals. How is the continuous current broken into pulsations?

When electromotive force is applied to a circuit containing capacity and resistance an appreciable time elapses before steady

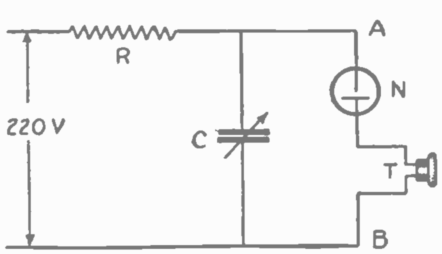


FIG. 3

By varying the capacity of the condenser shunted across the neon tube in the circuit shown above, the frequency of pulsations of the current through the neon tube can be varied. The lower frequencies can be observed by periodic flashing of the neon lamp. The telephone receiver in the circuit enables the operator to listen to the pulsations.

conditions are established. During this time the potential across the condenser grows and a weak current flows through the circuit until the condenser voltage becomes equal to the applied emf. The condenser is now charged. The time elapsing during this charging period depends upon the capacitty and the

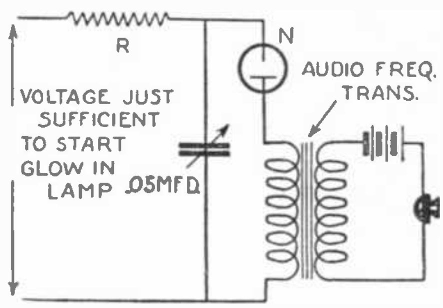


FIG. 4

The diagram shows the connections for the neon tube "oscilloscope". By means of this device the modulations of sound impressed upon the microphone are "rendered visible" by the varying intensities of the glow of the neon tube.

resistance. In the experiment under consideration, the condenser is charging while the neon lamp is dark. During this period the condenser potential increases until it reaches the critical voltage of the neon lamp which then suddenly becomes illuminated. When this happens the lamp resistance suddenly drops and forms a low resistance shunt through which the condenser discharges. During the discharge the condenser voltage drops until it reaches the point at which the neon glow ceases. The lamp resistance is now again infinite and the condenser is once more charged and the cycle is repeated.

The duration of the glow period of the lamp depends upon the resistance of the circuit AB while that of dark period varies with the resistance R. Thus, you can decrease the dark period by decreasing the resistance R. It must be remembered, however, that the best operating resistance in connection with "Osglim" lamp is about a half megohm.

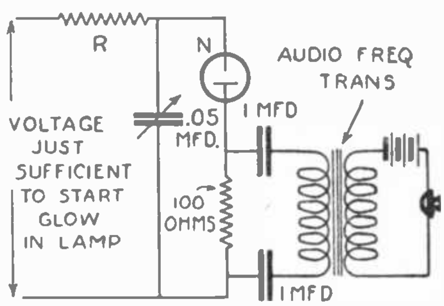


FIG 5

Another form of the "oscilloscope" is shown above. The secondary circuit of the audio frequency transformer is here coupled through a low resistance, to the neon tube oscillator.

The "Oscilloscope"

The neon oscillator offers a novel addition to methods of "rendering sound visible". Couple a microphone and battery to the oscillator circuit by means of an audio frequency transformer. If the resistance of the transformer is too great for the higher frequencies a resistance coupling with two high capacity condensers may be used. These two arrangements are shown respectively in Figs. 4 and 5.

Apply a voltage to the neon tube oscillator just sufficient to start the glow in the lamp. Adjust the frequency of pulsations to a high audio frequency and talk into the microphone. The audio frequency pulsations set up in the microphone circuit will be impressed on the neon lamp and the lamp

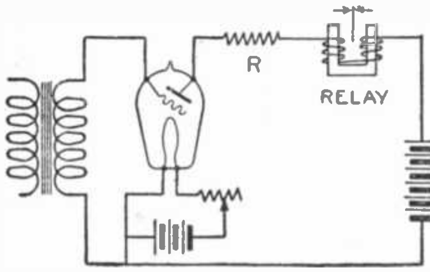


FIG. 6

In recording radio messages through the action of an electro-magnetic relay, the introduction of a resistance R in series with the relay is necessary to accelerate the action of the latter.

intensity will vary in accord with the variations in the sound waves impinging on the microphone diaphragm.

The Neon Tube Rectifier

It has been known for some time that in discharge tubes the flow of current increases when the area of the cathode is increased, provided the electrodes are only a short distance apart. If then, one electrode of a neon discharge tube is made larger than the other, the current through the tube will be greater when the large electrode is the cathode than when it is the anode. Such a tube on alternating current will be asymmetrically conductive.

These conditions obtain in the "Osglim" lamps which are, therefore, fairly efficient rectifiers.

The Neon Tube Resistance

The automatic recorders in wireless communication have not found extensive application because the speed of operation of the relays used with these recorders is not sufficiently high. For it is well known that in a circuit containing inductance and resistance the current does not reach a steady state until considerable time has elapsed after the application of the electromotive force.

To improve the speed of operation of the relay the time constant must be reduced, but if ordinary resistance is inserted in the plate circuit of a vacuum tube in series with this relay, the potential drop across this resistance will increase directly as the current. As the plate current increases, therefore, there will be a consequent drop in potential across the vacuum tube. To obviate this defect neon tubes have been used for resistance. In comparing the current-voltage characteristics of ordinary metallic resistance with that of a neon discharge tube the advantages of the latter will become apparent. It will be noticed that over considerable variations in current the potential across the lamp remains constant. Such resistance introduced in the plate circuit in series with the relay will reduce the time constant,

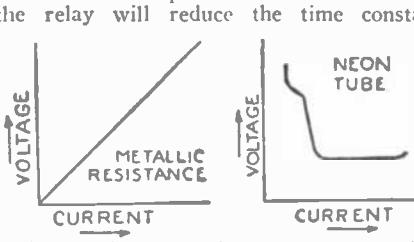


Fig. 7. The illustration shows a comparison of the current-voltage characteristis of a metallic resistance and of a neon tube respectively. In obtaining data for the latter graph a resistance in series with the neon tube was gradually decreased, thus increasing the current through the lamp. The voltage across the lamp was measured for each value of current.

accelerating the action of the relay without impairing the operation of the vacuum tube. This method has proved so successful that it has been embodied in the so-called Anson Relay manufactured in England. Experimenters will find this application of the neon tube interesting and useful.

The "Stroboscope"

By the interrupted illumination of pictures of successive stages of motion presented to our view, an illusion of motion can be created. This is the principle by which the familiar motion picture operates. Simpler representations of motion can be achieved by the amateur experimenter with the aid of an electric motor and a neon oscillator. Cut slots in a large disk of cardboard as shown in Fig. 8 and cover the slots with tracing cloth or other transparent material on which pictures illustrating some action, as for instance a horse and rider jumping a fence, or two boxers, etc., in successive stages have been drawn. Mount a neon lamp as shown and connect it in parallel with a variable condenser. The disk is mounted on a shaft and driven through pulley and belt by a small toy motor. Set the disks in rotation so that about 10 pictures pass the lamp per second. Then vary the "oscillator" condenser until the lamp glows only when a picture is in front of it. When this adjustment is reached, preferably in a darkened room, an illusion of motion of the objects represented in the pictures, will be observed. The advantage of this form of stroboscope is that the speed of rotation can be adjusted to any suitable value and the intermittent illumination of the neon lamp can then be set in synchronism with this rotation.

Another form of the stroboscope offers a baffling demonstration before an uninitiated parlor audience. A disk with four black segments (see Fig. 9) is mounted on a

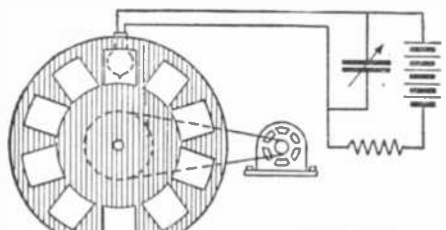


FIG. 8

The diagram illustrates the action of the "stroboscope." The periodic flashing of the neon lamp is set in synchronism with the rotation of the large disc carrying near its periphery a series of pictures depicting the successive stages of some action. The resulting effect will be an illusion of continuous action.

shaft and rotated by an electric motor as in Fig. 8. The room in which the demonstration is made is illuminated only by the lamp of the neon oscillator which is placed in front of the disk. The disk is set in rotation and the neon lamp circuit is closed. The spectators will observe a slow rotation of the disk. The demonstrator by merely adjusting the variable condenser can apparently accelerate, retard or reverse this rotation. He can make the disk go so slowly that it seems almost to stop. He can make it go rapidly in one direction and then suddenly reverses the direction of rotation. And all these changes are made without altering the motor circuit!

The principle back of this "Magic Wheel" is very simple. Referring to Fig. 9, suppose the disk makes 1,800 r.p.m. Then since there are four segments on the disk, 4x1800 or 7,200 segments will pass point A per minute, or 120 per second. Now if the frequency of pulsations of the neon tube oscillator is 120 per second, the neon lamp will glow every time a segment reaches the point A. In other words at every instant that the disk becomes visible a segment is at point A, causing the illusion that the disk is stationary. Under these conditions the interval of time between successive glows of the neon lamp is the same as that required for the wheel to advance one segment.

But suppose the frequency of the neon lamp is greater than 120, say 150 glows per second. Then the motion of the segments

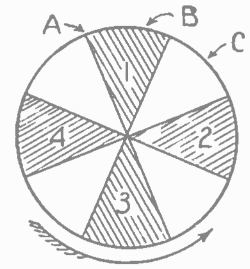


FIG. 9

A rotating disc such as that shown above observed by the light of the neon tube oscillator gives rise to an illusory apparent motion which may differ in speed and even in direction from the actual rotation of the disc.

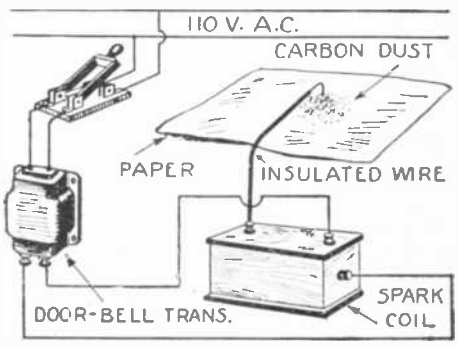
will lag behind the glows. That is if when the lamp is glowing, segment 1 is at point A, at the next glow segment 2 will not have reached A but will be seen at point B. At the next glow again, segment three will be seen at point C, and so on, the successive segments being observed at constantly more and more retarded positions. This effect will create the illusion that the disk is rotating in a clockwise direction (that is, opposite to its actual direction of rotation). By increasing the neon oscillator frequency, that is by decreasing the capacity of the variable condenser, the speed of this apparent rotation can be increased and vice versa.

Now, by reducing the frequency of the neon oscillator below the synchronous frequency, that is, below that at which the disk appears stationary, the apparent rotation can be made clockwise at a rate well below the actual speed of the disk. This requires a considerable increase in the condenser capacity. The arrangement is perfectly flexible and the changes in apparent rotation respond very quickly to the adjustments in condenser capacity, so that the innocent spectators will wonder at the incredible rapidity with which the rapidly rotating disk changes speed and even reverses from high speed in one direction to an equally high speed in the other, without coming to rest!

Carbon Dust Experiment

THIS simple experiment requires a door-bell transformer, an old Ford spark coil, a little pile of carbon dust made from the carbon of an old dry cell battery, and a newspaper. Queer effects may be seen by holding the rubber insulated wire over the top of the dust which is placed upon the newspaper. When the current is turned on the carbon dust moves in wave-like circles in and out, as water does when a stone is thrown into it.

Contributed by F. E. BERRY.



A curious electro-static experiment is illustrated above. The secondary lead from a Ford spark coil is brought near a small pile of carbon dust on a piece of paper. As the primary circuit is closed the electro-static field set up by the secondary potential will cause the carbon particles to assume positions in wave-like circles.

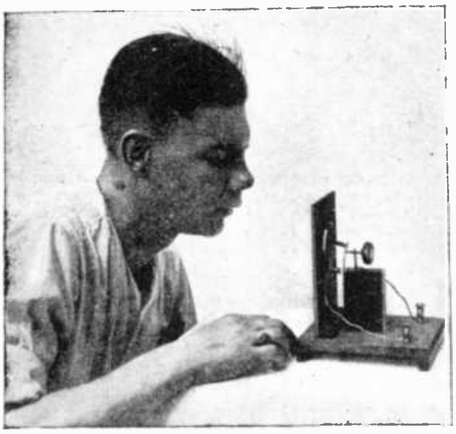
Experimental Microphone and Transmitter

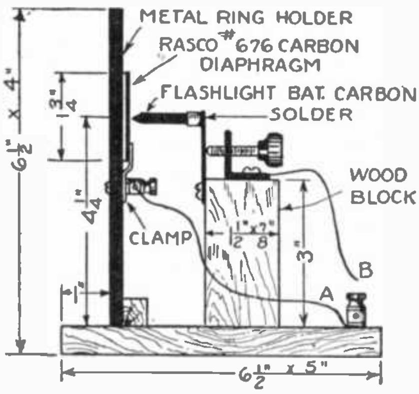
By Raymond B. Wailes

HOME-MADE microphones have always been the bugaboo of electrical experimenters. The writer can well vouch for this when, after laborious filings of battery carbons to pointed ends; snuggling the double pointed carbon a supposedly movable carbon is inserted haphazardly between two carbon electrodes. Small cups are drilled in each carbon.

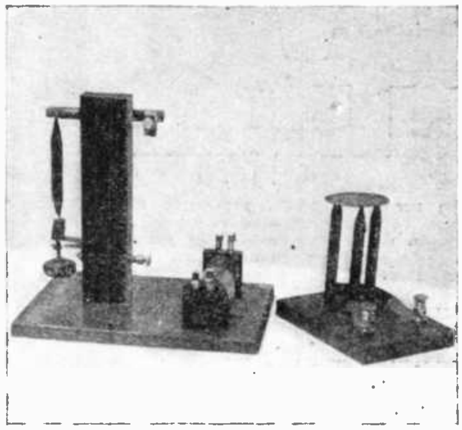
The lower carbon holder can be a half inch of a carbon rod affixed to a flexible L-strip which is moved by the adjusting

3 is the usual two tube amplifier for use with either of the instruments, the microphone or the transmitter described herein. The circuit, Fig. 4 is a method by which one tube can be used to amplify the output of the instruments.





An interesting and novel variation of an old theme is shown in this illustration of an experimental microphone. A sharply pointed carbon rod in contact with a loosely supported carbon diaphragm assures a high degree of sensitivity.



A very delicate microphone can be constructed with a double pointed carbon rod supported between two carbon discs.

into the "sensitive" position between two carbon electrodes connected in series with a receiver and bundle of dry cells discarded from the garages of the then battery-ignition automotive days, the whole compilation of what should be a good microphone, which should amplify a fly's walk, refused to work.

Yes, I shouldn't forget the time when my little brother was told to talk against the bottom of a tin can which was supposed to act as a diaphragm which compressed a pill box of carbon granules and thus send the pulsating current of the worn out discarded batteries of the same old days through the 75 ohm pony receiver which I, on the second floor, held tightly to my ear. The "transmitting" was produced in the cellar. And did I hear him? Well, I guess not!

But here are two little telephonic items about apparatus which will work very well. They are a microphone which is fairly sensitive and a carbon diaphragm transmitter which translates speech into electrical impulses very well, the tone being very clear when the simplicity of the instrument is considered.

Both or rather the three instruments described here can be made from the average experimenter's catch-all box. Perhaps the only item which would not be found there is a carbon diaphragm, but this can be purchased very reasonably from the dealers in electrical supplies.

The Microphone

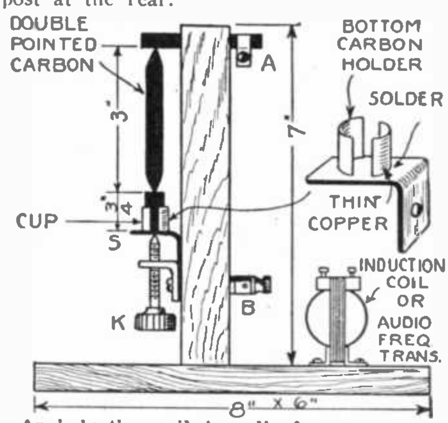
You should not expect too much from a home-made microphone based on a vibrating carbon rod principle. Telephone corporations have spent years of research before the commercial transmitter and super-sensitive "mikes" were perfected. What can be assembled in several hours of constructing and adjusting cannot equal a perfect product which is the development of years. At best, the home-made microphone works fairly well.

Fig. 1 shows how the same is assembled. A 3" length of carbon rod is filed to a point on both ends and inserted between two carbons, one stationary and the other movable and adjustable. This item, that of adjustment, greatly improves the operation of the instrument and eliminates the hit-or-miss product which is formed when

knob operating through a rigid ⅛" L-bracket or strip. The carbon is held on the flexible L by means of a thin copper sheet cup which is soldered to the L and bent with the fingers to make contact with the carbon.

The upper carbon holder is a length of carbon rod thrust through the wooden standard, and has a contact with the circuit at the rear.

The two lower L-strips are fastened to the upright post by a common machine screw, which in turn receives a binding post at the rear.



An induction coil or audio frequency transformer used in connection with the carbon rod microphone forms an excellent large amplitude microphone for experimental work.

A small telephone induction coil or audio frequency transformer can be mounted on the base of the instrument and used to step up the impulses caused by the variation of resistance between the loose carbon rod and the stationary carbon top and bottom contacts or holders.

Connecting the Instrument

The two contacts, or top and bottom carbons (a and b), can be connected in series with a dry cell and telephones and ordinary household vibrations will be heard very loudly. A watch resting near the microphone will sound like a miniature sledge hammer pounding away at your ear.

The diagram of connections shows some methods for procuring greater output strengths from the microphone. Fig. 1 is the simplest. Fig. 2 shows the induction coil or audio-frequency transformer. Fig.

Another Simple Microphone

Our second instrument can be made from three pointed rods mounted in holes in a wooden base and capped with a carbon diaphragm. Two of the carbon rods are connected together and made the A terminal, the other carbon rod being connected with a binding post and made the B terminal.

A Carbon Diaphragm Transmitter

This little instrument will translate electricity, and so transfer the human voice with quite a degree of clearness. In the main, it consists of a carbon diaphragm being made the A electrode or terminal, with a pointed rod of flashlight battery carbon lightly pressing against the middle. This pointed carbon is the B electrode.

The pointed carbon rod is adjusted by means of a knob and screw which feeds through a stiff L bracket. The carbon rod can be very conveniently fastened by soldering to the copper strip which is moved by the adjusting screw. To do this, one should leave intact the little brass cap which is found on the flashlight battery carbon, as this brass cap is soldered to the movable strip.

The carbon diaphragm is held against the sounding board and in front of the circular hole cut in the board, by means of a light clamp of copper or brass strip about half an inch long. It is best to make a cardboard gasket to fit around the edge of the circular hole through which the operator speaks, and allow the carbon diaphragm to rest upon this, the diaphragm being held by the thin metal strip; which in turn is fastened to the board by means of a machine screw carrying a binding post as shown.

As a substitute for the carbon diaphragm, one could possibly use a thin metallic diaphragm with a little button of carbon rod glued to the center. Tinfoil could be then run to the button to make contact with it and the binding post B.

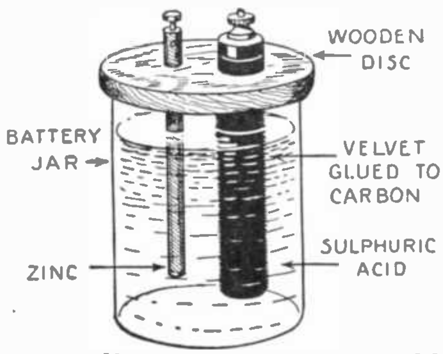
In operating these easily made experimental instruments, the lightness of contact should be varied along with the applied potential — the working battery — which can be one, two or three dry cells in series until best results are secured.

Mechanically Depolarized Primary Cell

By Earle R. Caley, B.Sc.

POLARIZATION, due to the collection of hydrogen gas upon the negative electrode of primary cells, is a common defect of all such batteries.

The usual method of preventing this is to use some oxidizing chemical in the cell to prevent the formation of hydrogen. Nitric and chromic acids have been used. These are quite satisfactory when used in double-fluid cells with a porous cup, except that nitric acid evolves nitric oxide gas. Such batteries, however, are a nuisance to handle and fill.



SIMPLE FORM WITH CARBON ELECTRODE

All experimenters will welcome this novel method of depolarizing a wet cell. A coating of velvet glued to the carbon electrode is carbonized and the fine irregularities so produced prevent the accumulation of hydrogen bubbles on the electrode.

Single fluid cells such as the common bi-chromate cell which have the depolarizer dissolved in the attacking fluid, while simpler and more convenient, rapidly deteriorate in use and fail to give a constant current. As an alternative to chemically depolarized cells, mechanical depolarization has been tried in several forms either by roughening the negative plate, by having a flowing electrolyte or by blowing air through the cell.

The earliest attempt of this kind was a cell devised by Smee in which the negative electrode was a plate of platinum or of platinum-plated silver, the surface of which was roughened by depositing the platinum electrolytically. In this cell, the hydrogen, due to the mass of fine particles on the surface of the platinum plate, did not adhere readily to it and the cell gave a fairly constant current. Such a cell, however, due to the present prohibitive price of platinum, is manifestly impractical. The E. M. F. of the Smee cell was also quite low, being less than half a volt.

The cell whose construction is described in the present article follows the idea of the Smee cell except that instead of using a specially roughened platinum plate a specially prepared surface of carbon is employed, the other elements of the cell being simply dilute sulphuric acid and zinc. This cell can be readily constructed from materials and tools easily obtained by the electrical experimenter. The trick lies in the preparation of the special carbon electrodes. This process is detailed below.

An ordinary cylindrical battery carbon from a discarded dry cell is first obtained and thoroughly cleansed of any adhering matter by the use of sandpaper. A small quantity of ordinary heavy velvet of fine texture is next procured. A piece of this velvet is then cut out whose length is equal to that of the battery carbon, and whose width is such that it will wrap around the carbon once. The velvet is then cemented upon the carbon by using ordinary liquid glue and water-glass, the water-glass being used along a half-inch strip at the top and for a quarter of an inch width where the edges are joined; the glue is used for the remainder. In this way the carbon is surrounded by a layer of velvet.

After the cloth has thoroughly dried it must then be carbonized upon the electrode. This is done by putting the wrapped electrode in a closed metal vessel such as a piece of iron pipe with caps for both ends, or a tight-fitting tin can, burying it in the container by completely embedding it in coal or coke dust, and placing the whole in a good hot coal fire for several hours until carbonization is complete. After cooling, the carbon electrode is removed from the metal box and gently tapped to free it from any adhering coal dust. It will now be found to be completely covered with a coating of carbon taking the form of the velvet. It is this surface that constitutes the active depolarizing medium.

As shown in the illustration, this electrode is fitted in a wooden disc with an ordinary battery zinc as the other electrode, the two electrodes are set in a battery jar containing a 20 per cent. solution of sulphuric acid, and the cell is ready for operation. The E. M. F. of this cell is slightly less than one volt, but the current flowing from it will be found to be quite constant over a long period of time.

The above arrangement can, of course, be modified if cells of greater ampere output are desired. A number of carbons prepared as above can be used with a similar number of zincs in a single cell to obtain a lower resistance. Another modification even more effective than the above one is to do away entirely with carbon electrodes as a base upon which to form the active surface and to form this active surface upon plates of copper.

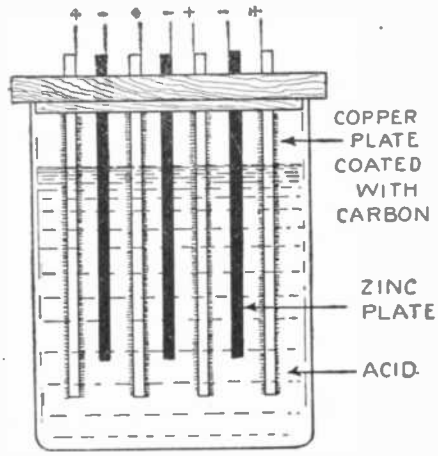


PLATE FORM—ACTIVE MATERIAL ON COPPER — END VIEW

The carbonized velvet depolarizer is applicable to other than carbon electrodes. It has been tried with success on copper electrodes to which the velvet is applied as to the carbon electrode.

Pieces of velvet the same size as the copper plates are fastened on by brushing alternately liquid glue and water-glass in half-inch bands across the surface of the copper and attaching the velvet thereupon. These are then dried and carbonized as before. The exposed edges of the copper plates should be coated with some waterproof varnish. By building up a cell of such plates alternated with plates of zinc of the same size a cell of high ampere output and low resistance can be obtained.

These cells should all be arranged so that the zinc can be slipped out of the solution when not in use, but the carbons should be allowed to remain in the liquid. The simplicity and effectiveness of this type of cell make it a good one for experimental work where a constant and considerable current is desired with a minimum of attention. This cell is far superior to the ordinary bichromate cell, except perhaps when such cells are freshly set up; over longer periods of time it is more reliable and requires less attention. Be sure to amalgamate the zinc.

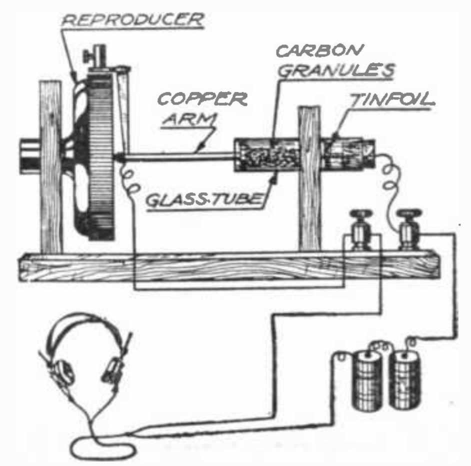
Simple Microphone

A SIMPLE but efficient microphone can be made from odds and ends generally to be found around the experimenter's shop.

Secure an old Victrola reproducer, taking care that the diaphragm is in good condition; then a glass tube about one inch long, a cork, some carbon granules or chips from a dry-cell post, a few feet of copper wire No. 18, a pair of phones, a couple of good dry cells, two binding posts, a wooden base six inches long, three inches wide, one-half inch thick, and two pieces of wood three inches long, three inches wide, one-half inch thick are the requirements.

Drill a hole in one of the small wooden pieces, so that the glass tube slides through tightly; then drill a hole in the other small piece so that the nozzle of the reproducer fits snugly.

Fasten a copper arm to the iron spindle projecting from the diaphragm, so that one end of the copper arm enters the glass tube but does not bind in it. Put some tinfoil in the glass tube close to one end; fasten a wire to the tinfoil and then to one of the binding posts. Put a few pieces of carbon in between the copper arm and the tinfoil, and connect a wire to reproducer spindle and then to the other binding post. The tone and clearness can be regulated by moving the glass tube in or out from the copper arm.



An ordinary Victrola reproducer is here employed for the construction of an effective experimental microphone. The reproducer is supplemented by a tube of carbon granules whose resistance varies in accordance with the diaphragm vibrations.

Then connect the instruments as shown in the figure.

Contributed by SHERWOOD SMITH.

The Electron-Valve Converter

A Vacuum Tube with Filament Currents of 4400 amp. and Plate Voltage of 200,000 Volts

By William Grunstein, E.E.

As our industrial civilization grows in complexity, power generated at a convenient location must be transmitted to more and more distant places. At the present stage of electrical development transmission lines extend over as much as 300 miles and the time is not very distant when centralized generation with concomitant large area of distribution will become general practice in the electrical industry. These requirements will raise new and difficult problems, which the electrical engineer will have to solve before long distance transmission becomes practicable.

Among the foremost of these problems is one involving the voltage of transmission. At high voltages the air between conductors becomes ionized and corona losses result. This loss, over a large range of frequencies, is proportional to the frequency of the current traversing the line, and by making the frequency zero, that is, by using direct current, the corona loss may be made as small as ½ or ¼ of the loss at a frequency of 60 cycles per second.

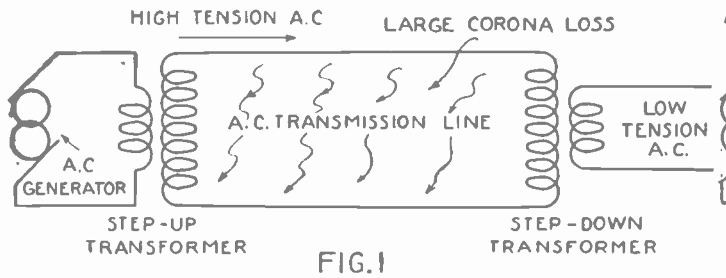


FIG. 1

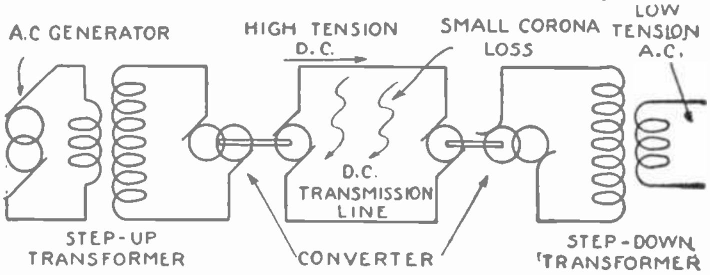


FIG. 2

Corona is a glow appearing on high tension transmission lines as a result of the radiation of energy from these lines, due to the ionization of the surrounding air. The loss of energy through such radiation is greater on alternating current than on direct current transmission systems. The diagrams above give a comparative representation of an A. C. and a D. C. transmission system.

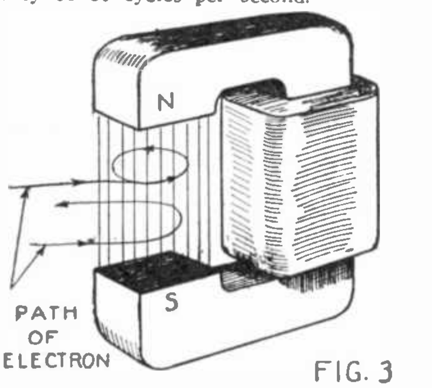


FIG. 3

Charged particles such as electrons moving in a magnetic field are considered to follow a circular path. In fact, in a very strong magnetic field an electron moving with a comparatively small velocity may be forced to move in a circle without leaving the field.

Now long transmission systems require high transmission voltages and these in turn may cause serious corona losses (Fig. 1). It may therefore be of great advantage to transmit power in the form of direct rather than alternating current. However, alternating current machinery has become so prevalent that such current must be available at the receiving end of the transmission system. Further, great difficulty has been experienced in the past with the generation of direct current at high voltages, the alternating current generators being very much better adapted, by virtue of higher insulating capacities, to the generation of high voltages. Besides, the output of such A.C. generator may be directly connected to a transformer and the terminal voltage stepped up to the transmission voltage, at very high efficiency. In other words, while direct current may be of advantage in the transmission line, the use of alternating currents is preferable at both the generating and the receiving ends (Fig. 2).

Such transmission system would have to be provided with converters at both ends of the line, but the rotary converters used almost exclusively on modern power systems could not be employed in the case under consideration. For the rotary converter is open to the same objections raised against the direct current generator, that is, it is not applicable to the conversion of currents at high voltages. For the purpose of direct current transmission at high voltage over great distances, a radically new type of converter will have to be designed.

It is an added tribute to the ultimate utility of disinterested research that this requirement is met by a device which less than a generation ago was of merely academic interest. The electron valve which has found such extensive application in the form of the radio vacuum tube finds here another extended field of usefulness.

The electron valve has already been employed as a converter in the form of a small power rectifier, and when used in an oscillating circuit, it serves essentially as a converter of direct into alternating currents, but it has not been applied to high power high potential conversion. That it is eminently adapted to serve such function has been demonstrated by A. W. Hall of the General Electric Co., who in his recent experiments has developed a vacuum tube converter of very high efficiency.

Most of our readers are acquainted with the fact that the space between a hot filament emitting electrons and a cold electrode by which these electrons are attracted is unilaterally conductive, that is, current can flow only from the latter electrode to the filament. All electron valves operate on this principle, but in those employed in radio circuits the flow of electrons through the tube is modulated. The method of modulation used almost universally today depends on the electrostatic influence of a third element in the tube. That is, the electron flow is varied by altering the electrical charge on this third element, the so-called grid.

Another method, which has not found general application, depends for its operation on the influence of an electro-magnetic field on the electrons emitted by the filament. It is known that when an electron moves through a magnetic field, whose lines of force are at right angles to its direction of motion, the electron is constrained to move in a circular path (Fig. 3). In fact, if the field is made strong enough the electron may be forced to stay in the field and revolve in a circular orbit whose diameter is smaller the stronger the field. In this way if a magnetic field is applied transversely to the motion of the electrons in a vacuum tube the electrons may be deflected to such an extent as to prevent them from reaching the plate and to constrain them to return to the filament (Fig. 4). In a small power tube a separate coil would have to be wound around the tube to supply the magnetic field, but in tubes of very large power employing heavy filament currents the magnetic field set up by this current is sufficient to deflect the electrons. It is of course necessary to make this magnetic field strong enough to overcome the electrostatic field between filament and plate.

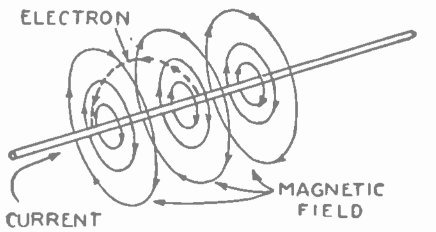


FIG. 4

It is well known that a current passing through a conductor sets up a magnetic field as shown above. An electron emitted by a heated conductor will, if the field is strong enough, be constrained to move in a circular path and be forced to return into the conductor.

In the tube developed by Mr. Hall, which he calls "Magnetron" (Fig. 5), the filament is a straight wire coaxial with a cylindrical plate which forms the anode. The filament has a diameter of 2.0 cm. (.79 in.) while the diameter of the anode cylinder is 8.0 cm. (3.1 in.). A current of 4400 amperes is required to heat the filament, raising it to a temperature of 2500 degrees C. At this temperature the electron emission is intense enough to cause the flow

(Continued on page 201)

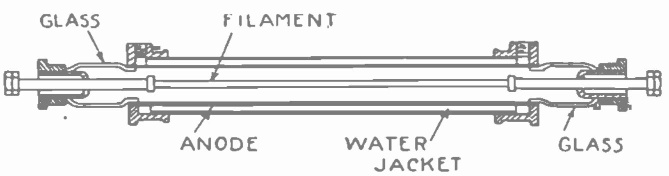


FIG. 5

The illustration shows the two-electrode vacuum tube called Magnetron designed by A. W. Hall of the General Electric. The tube is essentially like the ordinary diode tube used in radio but is built on a larger scale and is of a different form. It has a plate voltage of 200,000 volts and a filament current of 4400 amperes. It has a power output of 10,000 kw.

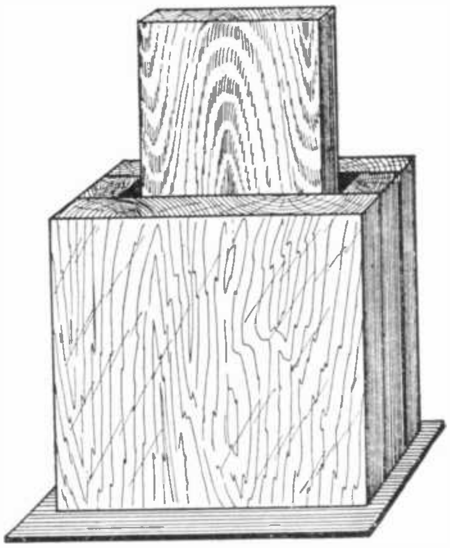
Home-Made Battery Carbons

By Earle R. Caley, B.Sc.

THE usual procedure that the electrical experimenter follows in obtaining carbon electrodes for home-made primary batteries is to break open some old dry cells and to extract therefrom the round or corrugated carbons that are used in this type of battery.

Oftentimes, however, if the amateur does much experimenting with primary cells he may desire to have flat carbon plates, curved carbon plates or hollow tubes of various shapes and sizes. The present article describes in detail a simple process for moulding carbon electrodes of any desired size or shape for use in primary batteries or any use to which such carbon forms may be put. The materials and tools used for this process are cheaply and readily made or obtained, so that the cost of making these carbons is very little, the chief expenditure being in time.

The basic material used for this process is ordinary gas coke. The hard variety that has been thoroughly ignited gives the best results. The coke must be reduced to a very fine powder free from any lumps or foreign matter. A preliminary breaking up of the large coke lumps must first be effected. The best way to do this is to enclose a considerable quantity of the coke in a coarse cloth or burlap sack, lay this upon a stone or cement floor and strike it repeatedly with a heavy hammer or wooden rammer. After this preliminary reduction has removed all large lumps, the contents of the sack are removed to a large iron or porcelain mortar and ground down to a fine powder. This material is then sifted through a fine linen cloth or a fine mesh copper gauze sieve. The fine powder so obtained is used for moulding the electrodes. A considerable quantity of this powdered coke may be prepared at one time and preserved in wide-mouthed bottles or Mason jars for future use.



This simple form made of pieces of board affords a very satisfactory mould for tamping the coke and graphite mixture to be used for battery carbons. The form shown above is used for making carbon plates. Some glucose syrup or other binder is mixed with the pulverized material.

Having now obtained a quantity of coke powder this is placed in a measuring cylinder or graduate and a quantity of ordinary wheat flour added so as to increase its volume about one-sixth. If available, a small quantity of powdered graphite may also be added at this time to increase the conductivity of the finished product. The wheat flour acts as a binding medium The powders are then thoroughly mixed. This intimate mixture is now dampened by cautiously adding a water solution of glucose made by adding a tablespoonful of Karo syrup to a pint of water. It is important that the powdered mixture be made damp throughout and yet not be actually made wet with the glucose solution. The dampened mixture is now allowed to stand several hours in a closed vessel to allow it to become evenly moist and to give time for the flour to swell and become sticky. It is then ready for moulding.

These moulds may be of any convenient shape or size as shown in the illustration, but the simple case of moulding and baking a long cylindrical electrode will be carried through as an example of the working of this process. A tube of seamless brass or steel tubing is selected having an internal diameter equal to the desired diameter of the carbon rod and a length equal to the length of the electrode. A tamping rod for this mould is made from a piece of metal rod of a slightly smaller diameter and about twice as long.

The tube mould is then clamped in an upright position on the surface of the workbench or table. A small quantity of the coke mixture is next introduced into this tube and firmly tamped into place by means of the metal tamper and aided by blows from a light hammer.

This procedure of filling and tamping is then continued until the tube is nearly filled up. The moulded rod must now be discharged from the tube. The tube containing the moulded rod is laid flat upon the table with one end of the tamping rod in one end of the mould and the other end of the tamping rod resting against a wooden block firmly nailed to the table top. By grasping the filled tube and exerting an even, steady pressure against the tamping rod the moulded product will be discharged. The moulded electrode must be, at this point, handled with considerable care, since it is quite easily broken.

If any holes are desired in the finished product for the attachment of binding posts, wire or similar objects these should be put in at this time by means of an awl or twist drill, carefully and lightly applied. The next step in the process is the baking of the moulded objects.

This baking process occurs in two steps. The first step is in reality a simple drying preparatory to the real baking or carbonizing process. In this first step the moulded rod is placed in an ordinary gas oven such as are found in kitchen stoves.

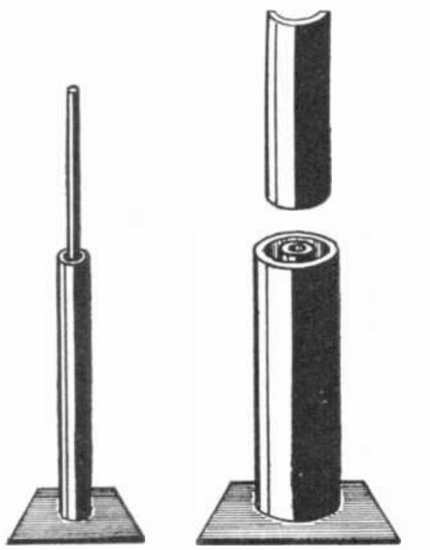
The rod is placed in the oven while cold, upon a flat iron plate, a small fire lit, and the rod is dried for a half an hour at this low temperature. The fire is then slowly increased until the oven reaches its highest temperature. This baking will take two hours or more. Too rapid drying will cause distortion of the moulded electrode. The oven is then allowed to cool down with the rod in it, which is removed when cold.

The next step is the carbonizing process. The rod must be packed in a box of coke dust and subjected to a red heat. A convenient box for the rod whose manufacture we are describing is a section of ordinary iron pipe capped at both ends. The dried rod is packed in this pipe completely surrounded by powdered coke. A small hole must be drilled in one or both caps to allow the escape of gases generated in the carbonizing process. The pipe with the enclosed rod should be placed upon a good coal or coke fire for two or three hours.

If an electric tube furnace or muffle is available this is a more convenient as well as a cleaner source of heat to apply in the carbonizing process. In this case the rod could be packed in a silica tube with coke and allowed to remain two hours at red heat. After heating, the rod and carbonizing box are taken from the fire and allowed to cool. The rod when removed is now finished. The electrode as it comes from this process is firm and strong, although somewhat light and porous.

In case a heavier and denser product is desired, which will also be a better electrical conductor the rod may be further treated as follows: It is boiled in a 50 per cent. solution (by volume) of Karo syrup in water for about 20 minutes and then dried and carbonized again as before. By repeating this latter procedure several times a very dense and heavy product may be obtained.

The entire process as detailed above may be used for any other shape, such as plates, tubes or articles of irregular outline, with but slight modifications. The illustrations suggest forms of moulds for two other shapes. Large, wide carbon plates are excellent for bichromate plunge batteries, when zinc plates are used for the negative electrodes. Such batteries are capable of yielding a heavy current. A mould for such plates is shown. It is constructed from two pieces of one-inch smoothly-planed and sanded hardwood separated at the ends by two half-inch strips of the same material. A tamping plunger is made from a board of the same material that is slightly smaller than the opening. The inside of this mould should be given a slight plating of vaseline or graphite so that the moulded plate can be easily forced out. An alternative method of making a mould for plates is to arrange it with hinges, thus lessening the liability of breaking the plates when removing them from the mould.

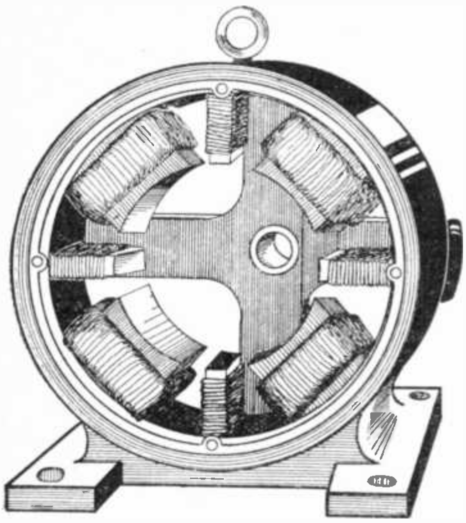


The moulds illustrated above enable the experimenter to make rods or hollow cylinders of carbon. The battery carbons so formed must be dried and baked after removal from the mould.

A mould for hollow carbon cylinders is also shown. This consists of two sections of hollow brass or steel seamless tubing of different diameters. These are placed one inside the other and the powdered coke mixture is tamped between them by means of a plate of brass or steel.

Inter-Poles

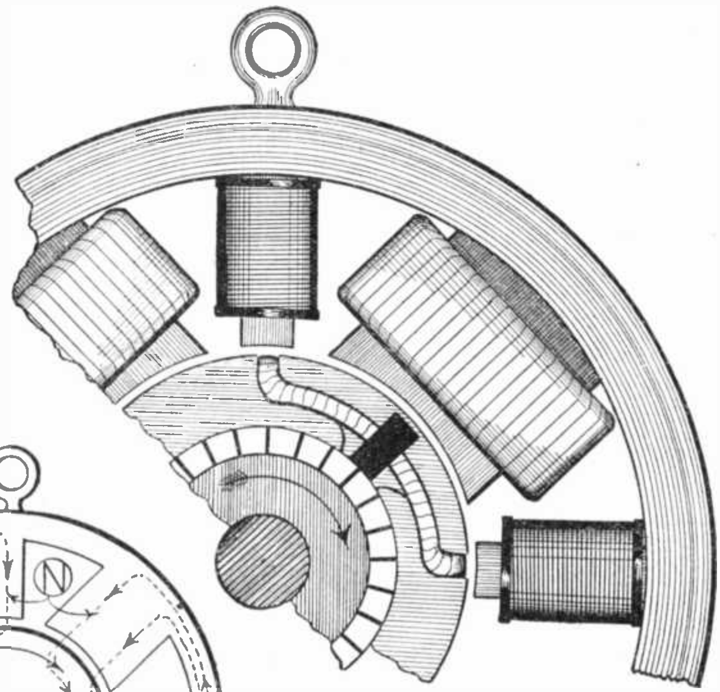
By Harold Jackson

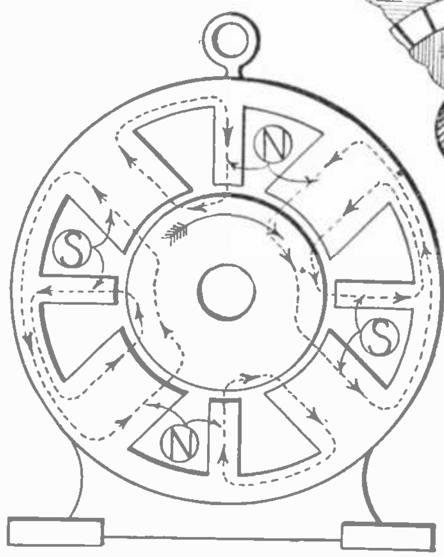


Left. The field of an inter-pole generator. The small coils are wound on the inter-poles.

Right. A portion of the field of an inter-pole machine with a part of the armature showing the loading coil, and one of the brushes bearing on the commutator.

Below. Diagram of field and armature of the inter-pole generator showing the polarity of lines of force and direction of rotation of the armature.





In order to improve commutation and prevent the necessity of shifting the position of the brushes for changes in speed or load of dynamos and motors, small auxiliary poles, called "inter-poles," are sometimes provided in addition to the regular poles of the machine. These inter-poles, as the name implies, are placed between the main poles of the field as shown in Fig. 1.

As shown here these poles are small in comparison to the regular poles. It is the duty of these smaller ones to provide a magnetic flux of such polarity as to reverse the direction of the current in the short-circuited coil during commutation. Sparking at the brushes is due to self-induction and will occur if the coil is thrown into a magnetic field of opposite polarity without the direction of its current being stopped and started in the opposite direction. Inter-poles are wound so that their flux cause this reversal of current, in order that the current in the coil will be flowing in the proper direction when the segments to which the coil is connected leave the brush.

Inter-poles are connected in series with the armature so that either all or a definite part of the armature current flows through them. The density of the inter-pole flux therefore varies with any change in the armature current, which results in their magnetizing effect varying directly as the armature current, just as the effect of the cross-magnetizing ampere-turns varies with the armature current, and if the effects balance at one particular current, they will practically balance at all currents. The strength of these poles is therefore automatically regulated, which tends to provide a rigid magnetic field at all loads and speeds for which the machine is designed. The position of the neutral plane of minimum induction will remain practically constant.

The dotted lines in Fig. 2 show in a general way the magnetic circuit of an inter-pole field wound for clock-wise rotation as indicated by the arrow on the front of the armature. It can be seen here how the inter-poles provide an auxiliary flux through which the armature coils must pass before it enters the flux of the main poles. As shown here the inter-pole that follows the main north pole, in the direction of rotation, is a south pole, and those that follow the main south poles are north poles.

The coil in leaving the main poles passes under the inter-poles, which quickly reverse the direction of the current in the coil; the coil then passes on under the following main pole with its current flowing in the direction in which it would be induced to flow while passing under this pole. Fig. 3 shows this in more detail. Here a single coil is shown on the armature core. This coil is undergoing commutation, that is, it is short-circuited by the brush, while the direction of its current is reversed by the action of the inter-poles.

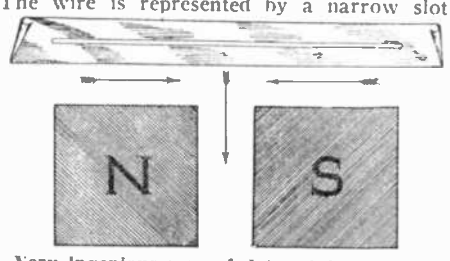
The polarity of the poles in this figure corresponds with those in Fig. 2; the upper part of the coil therefore is passing from a south pole into the influence of an inter-pole of opposite polarity; or under a north pole. Likewise the part of the coil on the right side of the armature is passing from a north pole to an inter-pole of south polarity. The influence of these two inter-poles upon the coil will cause the direction of its current to be reversed during the brief interval of time in which it is short-circuited by the brush; the coil then moves on under the main poles with its current flowing in the proper direction.

Induced Current Direction

By Harold Jackson

The direction of current induced in a wire while passing through a magnetic field depends upon the direction in which the wire is moved and the polarity of the field. The induced current will flow through a wire in one direction while moving in a given direction past a north pole, and in the opposite direction while moving past a south pole.

The illustration shows a method by which the direction of the induced current can easily be determined. In the diagram the two poles (N) and (S) are shaded with diagonal lines, those on the north pole slanting in the same direction as the slanting part of the letter "N," while those on the south pole slant in the opposite direction. The wire is represented by a narrow slot



Very ingenious way of determining or illustrating the direction of currents induced by sweeping a wire through the magnetic field. It should be tried by our readers.

in a strip of paper as shown at the top of the illustration. This strip of paper is moved in a downward direction across the poles as indicated by the vertical arrow. The narrow slot passing over the oblique lines will give the effect of an apparent motion in the direction in which the induced current would actually flow.

The direction of the currents in the wire for downward movement are indicated by the horizontal arrows. The upward movement of the paper will cause the apparent motion to be reversed, which will indicate that the current would flow in the opposite direction with the reversed direction of movement, a condition that obtains in practice.

Electrical Measuring Instruments

By Harold Jackson

THE operation of electrical measuring instruments depends upon some effect produced by the current, such as heating or magnetic effect. Since the magnitude of such effects varies with the value of the

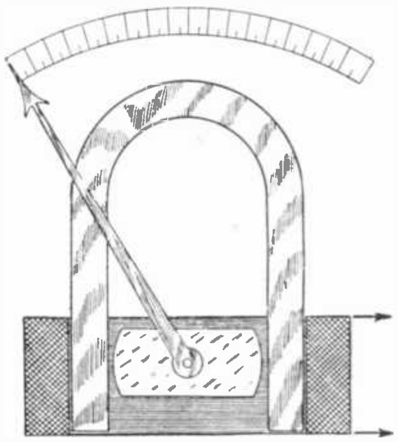


Fig. 1. Diagram of the construction of a moving armature instrument. The coil acts at right angles to the field of the magnet and moves the armature carrying the index.

current it is possible to obtain the value thereof by determining the magnitude of the effect.

The most common type of measuring instruments are those which depend upon the magnetic action of the current for their operation. Only that type will be described in this article. Hot wire and electrostatic instruments, etc., are types sometimes used, and though more bulky than the magnetic type, possess some advantages. Hot wire instruments are not affected by magnetic fields as are those of the magnetic type and operate on A. C. or D. C. Electrostatic instruments are used for measuring high pressures, up to 200,000 volts.

The winding of an ammeter consists of a few turns of heavy copper wire, as it is essential in this instrument that the resistance be kept as low as possible. In automobile ammeters, which show "charge" and "discharge," a single turn of heavy wire is used to supply the magnetic field. Ammeters are always connected to the circuit in series.

Voltmeters, quite oppositely, are wound

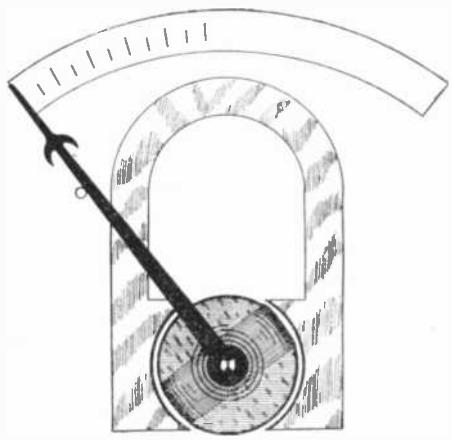


Fig. 2. A moving coil instrument. Here the pivoted core is in the opening of a coil of wire surrounding it, core, coil and index all moving together. The current goes through the coil.

with very fine wire, as it is desirable to have the resistance of these instruments as high as possible. Otherwise the operative principles of voltmeters and ammeters are quite the same.

The moving armature type of instrument is a simple form; the arrangement of the parts is shown in Fig. 1. As seen here, a soft iron armature is pivoted between the poles of a permanent horseshoe magnet. The magnetic attraction of the magnet holds the armature in a horizontal position as shown. A coil of wire is placed around the lower ends of the magnet as indicated.

When a current is passed through the coil a magnetic field is set up which is at right angles to the field of the permanent magnet. This results in the armature being turned from its initial position until equilibrium is established between the two fields. A pointer attached to the armature shaft moves with the armature and travels over a graduated scale placed back of the range end of the pointer. This scale is graduated to read either volts or amperes, according to the winding of the instrument.

Fig. 2 illustrates the construction of the moving coil type of instrument. As in the preceding type, a permanent magnet forms the basis of construction. This magnet is provided with curved pole pieces and a small drum armature. This armature has a single coil, applied as shown, and pivoted between the poles as indicated. The pointer is held

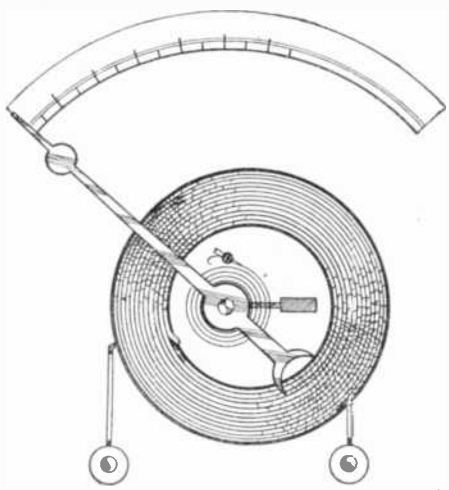


Fig. 3. An eccentric vane instrument in which a hairspring brings the index back to zero and holds it there. When current passes through a coil, an eccentrically pivoted armature is attracted and moves the index.

in the zero position by two spiral springs located at the ends of the armature. These springs also serve as electrical connections for the armature coil. Using the springs in this way makes electrical connection with the armature coil possible without the use of brushes, the friction of which would render the instrument useless.

When a current is passed through the armature coil the armature becomes magnetized. The reaction between its field and the field of the permanent magnet causes the armature to rotate, carrying the pointer across the graduated scale. The greater the value of the current in the armature the greater will be the reaction, which causes a greater deflection of the pointer.

Magnetic vane instruments are also of simple construction. This type is shown in Fig. 3. Here a magnetic vane is secured to the pointer shaft. This shaft is pivoted a little off center in relation to the current-carrying coil, as shown. A spiral hairspring holds the pointer in the zero position.

The principle of operation of this type of instrument is this: if a piece of iron which is free to move be placed in a non-uniform magnetic field it will move so as to conduct the maximum number of lines of force. Therefore, the vane being pivoted eccentrically, will be induced to swing around, for by so doing it will come closer to the inner edge of the coil, where the magnetic flux is more dense. The greater

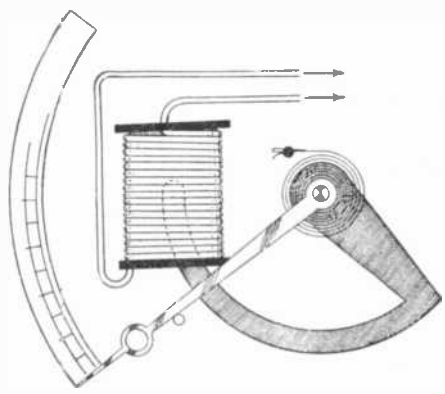


Fig. 4. The solenoid instrument. Here a solenoid is provided with a curved core, which is attracted to a greater or less extent by the current in general proportion to its strength. A very simple and useful instrument.

the value of the current in the coil the greater will be the number of lines of force near the coil, consequently the vane will be attracted further causing a greater deflection of the pointer indicating the increase of current through the instrument.

Plunger or solenoid type instruments depend upon the action of a solenoid for their operation. Fig. 4 shows clearly how this principle is applied. A curved soft iron plunger is arranged so that it will be drawn into the solenoid when the current to be measured excites the solenoid by passing through its winding. The greater the value of the current passing through the winding the further the plunger will be drawn into the solenoid.

The plunger and the pointer are mounted on the same shaft so that the pointer indicates exactly the amount of the plunger movement. A spiral hair-spring swings the movement back to the zero position when the current is disconnected from the instrument. This type of instrument is slightly less accurate than some of the others, due to the residual magnetism of the plunger.

Fig. 5 illustrates the inclined coil type of measuring instrument, a type extensively used in measuring alternating currents. In

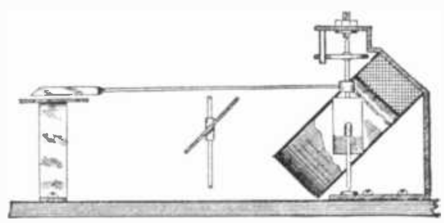
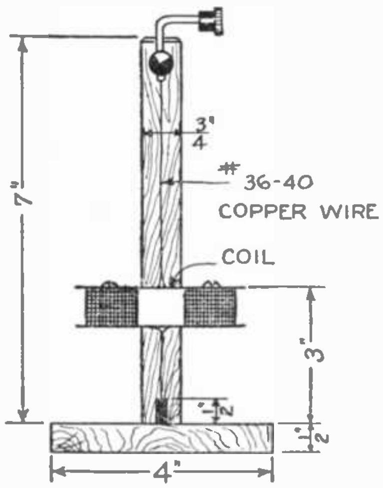


Fig. 5. An inclined coil measuring instrument; when current passes the magnetic vane pivoted within the opening of the coil is, moved more or less, according to the strength of the current.

this instrument the current-carrying coil is mounted at an angle of about 45 degrees to the pointer shaft, as shown. The shaft is fitted with a magnetic vane, which is also mounted at an angle as indicated in the insert. When a current is passed through the coil the vane will turn so that its long sides are more nearly parallel with the lines of force, causing the pointer to move across the scale. The movement is restrained in the usual manner by a spiral hair-spring.

Easily Made Galvanometer

By Raymond B. Wailes



The galvanometer here shown in section is within reach of every experimenter. It is of the moving coil type with wire suspension, one absolute requirement being a strong horseshoe magnet with broad poles.

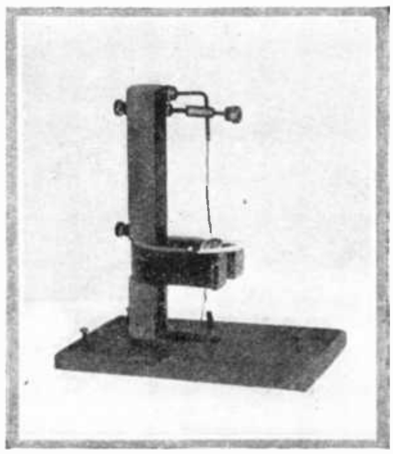
EVERY electrical experimenter has need for a sensitive galvanometer during his periods of "experimentation." Many articles have appeared which have treated on the construction of this instrument, but as you have doubtless found, there was a certain item of the construction which was complicated or required exceedingly fine workmanship. Lathe work alone on some of the instruments described in the literature has been the drawback for many amateurs who would not attempt to construct the article as they had no lathe. The galvanometer described here can be readily made and produced by one with the humblest of shops.

The principal item is the permanent field magnet. The one used by the writer for this particular instrument was taken from a small toy shocking machine. This type of machine should be well remembered by every experimenter. It is the popular one which has the little crank on the side to rotate the armature and a little contact breaker in the shape of a cam on the shaft to interrupt the current. Remember it?

Possession of the red magnet of this type of shocking machine means that the galvanometer is half constructed, and in several hours you should have the whole instrument completed.

The core for the moving coil which is suspended in the circular field poles of the magnet is made of writing paper cut to size and glued together. A strip of paper three-eighths of an inch should be used and bent so that it just fits into the place occupied by the armature of the shocking machine. Just a bit of glue should be used to hold the form together.

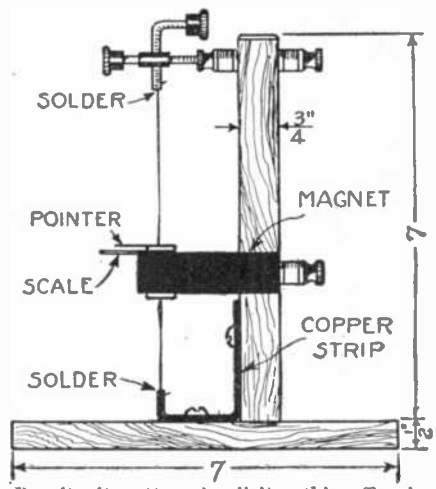
The moving coil is now to be wound. The insulated wire taken from the secondary of a spark coil is very suitable for this, although you can use any size wire smaller than No. 34. Old telephone magnets afford a source of supply for the wire. Wind on as many turns as you see fit, the more the merrier, but at the same time you must remember that your coil may be too heavy. The writer wound on 100 turns. You do not need to wind it evenly, although this is desirable. About eight inches of the wire are left as leads and the wire is fastened in place by a very small amount of shellac. The winding must stop at the mid-



This photograph displays the admirable plainness of an efficient and readily constructed galvanometer of high sensitivity, which will prove a welcome asset to all experimenters.

dle of the top and bottom pieces of the writing paper form. In winding you can make a wood form over which the paper is placed, the wire being wound directly upon the paper.

The magnet is mounted upon the wooden support at a distance of three inches from



Despite its utter simplicity, this efficacious galvanometer can be finely adjusted with respect to coil position and the tension in the suspension wire, by means of the adjustment screws at the top of the apparatus.

the base. In the side view of the instrument shown here the metal strip held by screws (SS) hold the magnet firmly in place. The binding post is soldered to this metal strip, and serves for one terminal of the little coil which you have just wound. The copper strip connecting the lower end or suspension of the coil is connected to this binding post.

The upper suspension of the coil is soldered to a bent L-shaped piece of wire which has a small binding post knob threaded to it. Two binding posts and a length of brass threaded rod serves to make the whole upper suspension and connection.

The wire which is wound upon the little paper frame extends upward and is used for the suspension. The lower or remaining free end of the coil is soldered to the copper strip at the bottom of the instrument, which in turn is connected to the binding post near the base.

A small aluminum or even copper wire pointer can be fastened to the coil by means of a drop of sealing wax. A scale can be mounted on the face of the magnets through the two screw holes, which supported the armature bearing in the original shocking machine instrument.

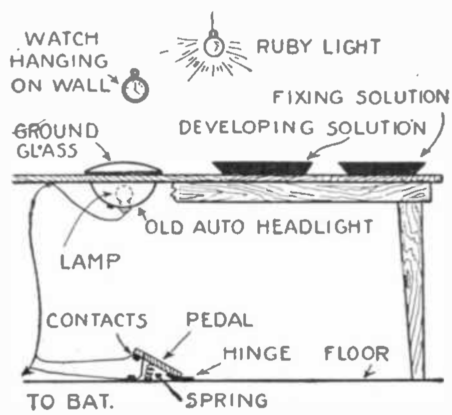
Adjustment of the coil to make it swing in the field and not touch the sides is effected by bending the lower copper strip.

Photographer's Printing Table

By C. H. Ostermeier

THE average amateur photographer cannot afford to buy one of the fancy printing lamps which are offered for sale, and usually manages with some kind of makeshift. This is not conducive to good and regular work and he should fix things in the dark room permanently, so that printing and developing can be quickly and economically done.

The small wooden kitchen tables which can be bought for two dollars or so are ideal for the dark room. The top is covered with plain white oilcloth or treated with some good waterproof varnish to protect it and make it easy to clean. Procure an old automobile headlight (with a good reflector and a plain glass) and mount it face up at the left end of the table. The glass should be removed and coated on both sides with ground glass solution to diffuse



A photographer's working table operated by electric lamps, for developing and printing.

the light evenly. The bulb may also be thrown out of focus by turning the adjusting screw, to help diffuse the light. The printing time is controlled by a pedal of wood and fitted up with a contact device and spring. Pressure with the foot will light the lamp and the time can be measured with a watch hanging in front of the operator in the light of a ruby lamp.

If the photographer finds that the printing time is shorter or longer than about ten seconds, he should change the size of the lamp or change the resistance in the circuit so that the average negative takes about ten seconds. This is long enough to avoid errors and to apply corrections for heavy or light negatives accurately.

To use the light, simply place the negative on the glass with the sensitized paper over it and press on the pedal with the foot.

Night Light

A VERY convenient and economical night light for use in the hall, sick room or nursery, can be made out of an old flashlight case and a small transformer which can be easily constructed with ordinary tools.

The most important part of the night light is the step-down transformer. This is of the open core, auto-transformer type.

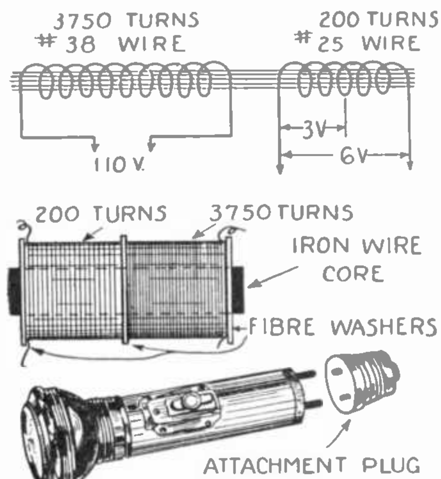
Make a core of iron wire about two inches long and one-half inch in diameter. Form spools on the core by slipping over it three heavy cardboard or fibre washers, one on each end and one in the middle. The core is then wrapped with paper and one section is wound full of No. 38 enameled wire, which should make about 3750 turns.

The other section is wound with No. 25 wire, giving approximately 200 turns, and a tap is brought out at about 100 turns, and then the section is filled as before. Protect the small wire by wrapping with paper and connect the transformer as shown in the diagram. Solder all connections, using resin only as a flux, otherwise the small wire will corrode quickly and an open circuit will result.

The attachment plug is fastened in the bottom end of the flashlight case to make connections with the 110 volt circuit quickly. Connections inside the case for 110 volts should be made with fixture wire.

Two voltages are made available by this arrangement. If the entire secondary winding of 200 turns is used, a six volt bulb should be connected, while if the low step of 100 turns is employed, a three volt lamp should be used.

Contributed by C. H. OSTERMEIER.

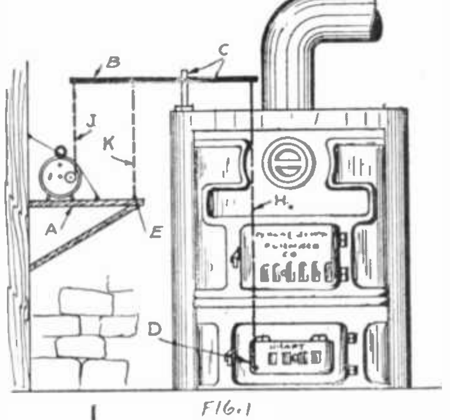


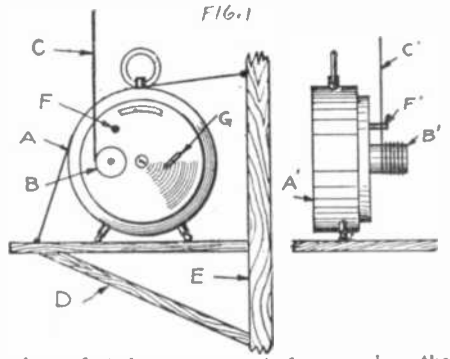
A night light made out of a flashlight case which contains within itself the transformer. It is supposed to be adapted for use on a 110 volt circuit.

A Warm Dressing Room

THE song which says, "It's nice to get up in the mornin', but it's nicer to lie in bed," aptly expresses the idea of a good many of us, especially on a cold winter morning about 5 a. m. Those of us who live in the city merely hang on the pipes beside the bed with good or bad results, but the chap who exists in the country has to answer his own raps by shivering his way to the lower regions and opening up friend furnace.

The writer endeavored last winter to make his head save his feelings and the illustration describes his success. And right here, brother sufferers, let me say that it works and works to perfection, and the entire cost was an old alarm clock and about half an hour's work one evening.

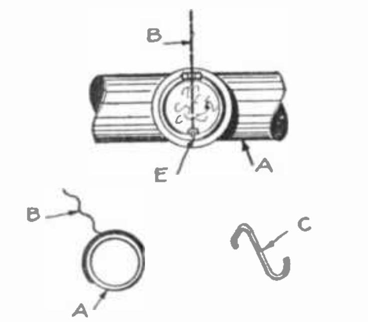




A perfected arrangement for opening the dampers of a furnace by an alarm clock. This is shown as operating a hot air furnace, but of course can be applied to other types of heaters.

First put up a shelf near the furnace as shown. Any kind will do as long as it is strong and rigid. Place the alarm clock on this shelf and wire it down, as shown in Fig. 2 (H). Next purloin, steal, or diplomatically ask your wife for an old spool from her work basket. Slot this just enough so that the key of the clock fits snugly in the slot. Next get some fish line or any strong small cord and rig up as shown. Small rings and hooks as shown in Fig. 5 work admirably. Of course, if you demand precision go to your local hardware store and buy miniature pulleys.

Fig. 1 (A) shows the clock mounted as explained. The cord J is fastened to the bar (B) which in turn swivels on the fulcrum post (C). Be sure at this point to place this post near the end of the horizontal rod in order to enable the spring in the alarm side of the clock to exert all possible pressure and lifting energy. Next run the line down to the bottom door of the furnace, allowing just enough line to permit the door to close without slack in the line, when the spool on the clock is unwound. The line (K) denotes the check control. On hot air furnaces where the check is opened at night this line will hold it open if adjusted to just the right length. When the alarm goes off in the wee sma' hours of the morning the movement of the bar slacks this line, thereby closing the check at the same time as the cord (H) opens the draft. By the use of hooks to fasten the line, the entire apparatus may be disconnected during the day and reconnected just before bed-time at night.



How the chimney damper is operated by the motion of the clock in order to turn on the draft before the occupant rises.

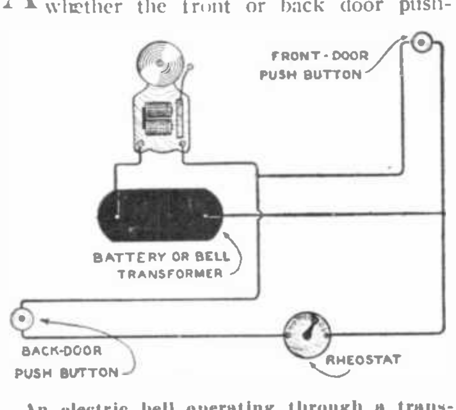
This device must of course be adapted to the particular style of furnace you may have, but will operate equally well on hot air, hot water or steam plants. The line to the check valve or damper is not required on the usual steam plant as you have a bar and diaphragm valve to which your lines from the clock and to the bottom door of the furnace may be attached without requiring the making of any bar or fulcrum post.

The clock I used was of the eight day variety which only required that a button be pushed in F and F', Fig. 2) to reset it for the same time the next morning. When winding the alarm, wind spool and all. This will unwind the cord and leave it in a position to act when ready, at about 4:30. The house was up to its usual daily temperature at 6:30. Try it and start the day right.

Contributed by C. O. IVES.

Two Toned Electric Bell

A SINGLE electric bell will indicate whether the front or back door push-



An electric bell operating through a transformer and made to give two distinctive sounds by having two circuits of different resistances through which it is rung by two push-butttons.

button is pressed if the arrangement of the circuit shown is used.

A rheostat is inserted in series with one of the push-buttons, preferably the one at the rear of the house, and the resistance is set at the point that will cause a noticeable difference in the tone and loudness of the electric bell.

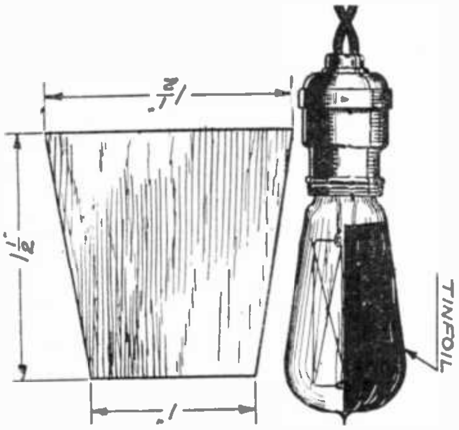
The other push-button circuit is not changed. When this arrangement is in use there is never any doubt as to what door of the house the visitor is at.

Cnotributed by H. P. CLAY.

Simple Reflector

A GOOD reflector for a show-case or work-bench can be made by cutting a piece of tinfoil in accordance with the pattern given and sticking it on an incandescent lamp bulb with shellac.

Contributed by L. I. Dupuy.



A compact reflector is obtained by this ingenious arrangement of tinfoil attached to one side of the glass bulb of an incandescent lamp.

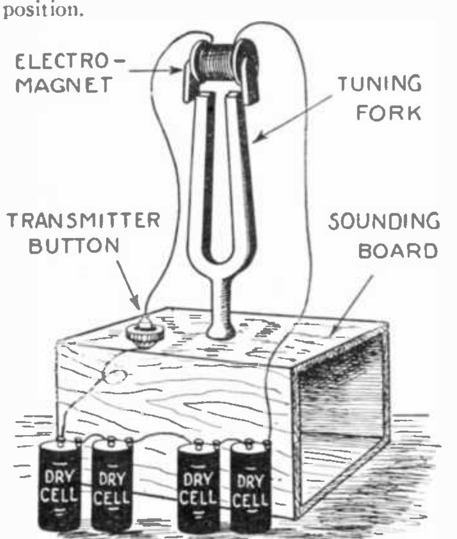
Electric Tuning Forks

By Charles D. Savage

THE electric tuning forks described heretofore have depended either upon the use of vibrating contacts or upon the pulsations of an alternating current. Neither arrangement gives the absolutely synchronized vibrations of the one here illustrated.

As shown in the illustration, a sounding board is used for mounting both the tuning fork and a transmitter button. The latter forms part of a circuit containing, in addition to a six volt battery, an electromagnet wound to a minimum resistance of 15 ohms.

The poles of the magnet enclose the prongs of the fork closely, so that only a short air gap intervenes. Some suitable support is used to hold the magnet in this position.



Complete synchronism between the vibrations of the tuning fork and the interruption of the current through the electromagnet is accomplished by the introduction of a microphone in the electrical circuit.

The operation of the apparatus as described above should now be evident, and is as follows:

The microphone picks up the vibrations of the fork and in turn varies the strength of the electromagnet. An intermittent, though periodic, attraction results, whose effect is to keep the prongs vibrating in exact synchronism. It is easily seen that the frequency of vibration is absolutely dependent upon the natural period of the fork, whatever that happens to be.

In practice the initial vibrations of the fork are almost imperceptible, but gradually increasing in amplitude, they finally give rise to a note of utmost purity and maximum volume.

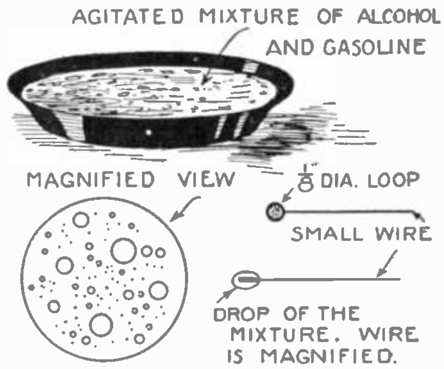
Experiment in Moving Globules

By C. H. Ostermeier

A CURIOUS and interesting experiment may be performed with the aid of a microscope or a powerful magnifying glass and a few odds and ends usually found in the home.

Take a shallow saucer or other dish or pan which will reflect light and pour in gasoline to about one-quarter inch depth, then add a small amount of alcohol and agitate the mixture.

Now if the surface of the liquid is observed through a glass, it will appear as in the illustration. Innumerable small drops of alcohol will be perceived floating around. Each one seems to be headed for some larger drop and each one is deflected from its path half a dozen times or so before it hits and unites with a larger drop. Around the very large drops the smaller ones form "lines of march" and proceed in straight lines to the large particles. Each large drop has from two to seven such lines. In the lines themselves, the larger drops each have their own lines of smaller drops moving toward them. The whole makes a very pretty and interesting spectacle.



The experiment illustrated above affords an interesting study of the movement of minute alcohol globules floating in gasoline.

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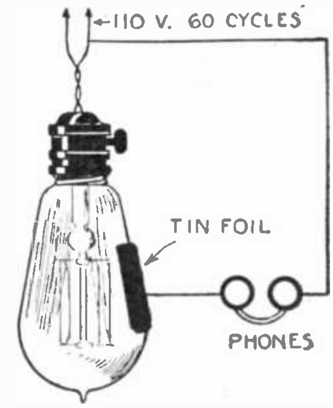
Make a loop one-eighth inch in diameter on the end of a piece of small wire. Dip the loop in the mixture and then look at the drop through the glass. The same picture will be observed as above, on a smaller scale, with the addition that the particles bounce against the wire rim with great speed and "pep." If the drop is observed from below, a strikingly clear image of the surroundings will be seen.

If a drop of the liquid is collected on the end of the wire, the same effects will be seen and the wire inside the drop will be magnified by it. The liquid thus acts as a lens.

Sounds from Incandescent Lamp

AN experiment is described here which may be of interest to experimenters. One wire of a wireless head set was connected to one side of 60-cycle lighting mains, the other to a strip of tinfoil stuck on the lamp bulb as shown.



The arrangement here shown brings the study of the famous Edison effect within reach of all experimenters. The now indispensable radio vacuum tubes are the outgrowth of this simple experiment.

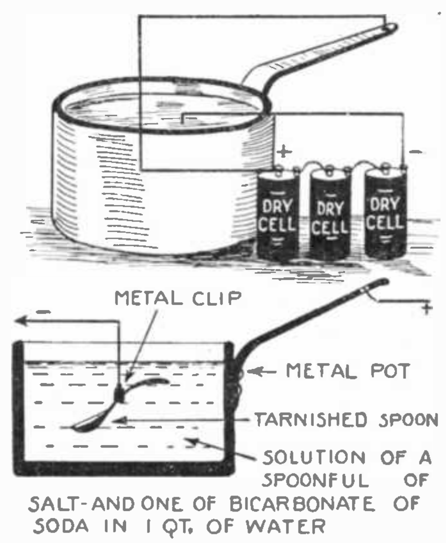
A low pitched note of one-half the pitch of the 60-cycle current, or of thirty waves to the second, was heard; when the lamp was turned out it ceased. If the hand was touched to the tinfoil, thus grounding it, the usual high pitched note was heard. This low note must be caused by negative charges thrown off from the hot filament to the cold tinfoil on the outside of the glass, causing a rectification of the slight current through the phones.

Contributed by Roy Black.

Silver Polishing

By Arthur A. Blumenfeld

SILVER may be cleaned by electricity in the following manner:



A novel application of electrochemistry to a household problem is illustrated in this experiment: Let electricity do your silver cleaning.

Dissolve a teaspoonful each of salt and bicarbonate of soda in a quart of water in an iron or copper pot. Then connect the negative of a battery of dry cells to a tarnished spoon and connect the positive to the metal pot. Place the spoon in the water, taking care that it does not touch the pot, as this will cause a short circuit. In about a minute the silver will be clean.

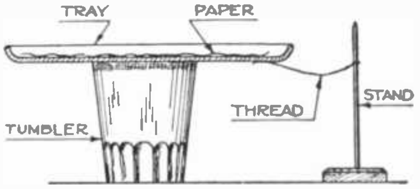
By this method none of the silver is rubbed off and plated silverware may be made to stay bright a long time.

Simple Condenser

SET an ordinary dry tumbler on a table. Next take a metal tray and set it on the tumbler. Now take a piece of heavy drawing paper about the size of the tray and heat it strongly. Then rub the paper briskly with a clothes brush.

Now lay the paper on the tray. Bring your finger near the tray and a spark will jump to your finger. If a thread is attached to a small stand and placed near the charged tray, the thread will cling to the tray. The action is similar to that of the well-known electrophorus.

Contributed by THOMAS PRINGLE, JR.



An improvised electrophorus for after-dinner magicians; a tray, a tumbler and a piece of paper are the materials needed.

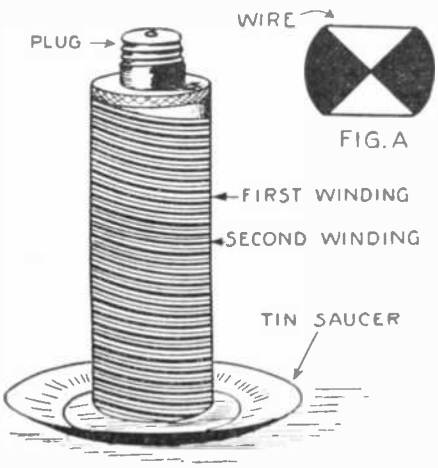
Electric Fly Killer

TAKE two pieces of quarter round moulding and fasten together edge to edge as shown in Fig. A. Ten or twelve feet of bare copper wire, no larger than No. 24 gauge, are wound the full length of the moulding, keeping the turns about one-eighth inch apart. An end about three inches long is left free and the other end is fastened to the moulding.

A second wire is now wound in between each turn of the first, care being taken not to have the two wires touch each other. When this winding is finished three inches are also left free at the same end that the first excess wire was left and the other end fastened in the moulding.

An electric plug is now fastened to the two wires and secured to the top of the moulding. To finish the device, cut a piece of tin in the shape of a saucer and tack on the bottom of the moulding.

The full potential of the circuit is maintained between the two wires. Any fly



A diabolic device for the electrocution of the house-fly; as he alights on it he bridges a gap and closes a circuit.

alighting on the coils inevitably receives his death shock as he bridges the small interval between the windings.

Contributed by H. J. WEBER.

Double Duty Resistances

THE usual form of resistance or rheostat is placed in series with the line or current supply and the load or device to be controlled.

As illustrated in Fig. 1, the resistance (A, C, D) is varied by means of a sliding contact (S). When the contact is at the position shown the current from the terminals (A) and (B) pass in through, say, (A), through part of resistance (AC), out (S), and then to (B). It will be seen here that the length of resistance (CD) is wasted when the slider is in the position indicated. How this objectionable feature can be eliminated and a more sensitive degree of regulation procured can be seen from the figures following.

Fig. 2 shows how two resistances with sliding contacts can be used to regulate any device to a nicety. Merely moving either slider to the left increases the current flowing, and moving the two at different position introduces a fine degree of regulation which could not be obtained if the two variable resistances were connected in series with each other, as would commonly be done.

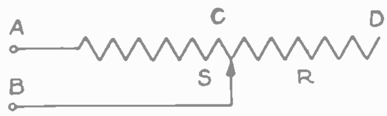


FIG 1

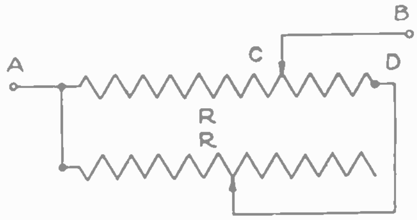


FIG 2

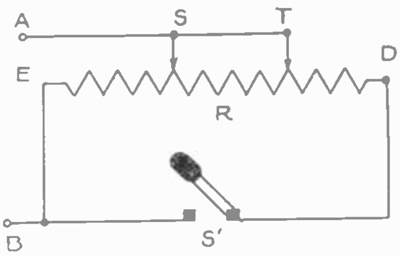


FIG 3

Fig. 3 represents a single resistance designed to accomplish the effects of the two rheostats in Fig. 2; an advance on that and on the single rheostat Fig. 1 used so much by experimenters.

Fig. 3 shows a resistance fitted with two variable contacts or sliders and a switch. This instrument has just been patented and is manufactured by a well known scientific firm.

(S) and (T) are the two sliders. The switch is shown as (S^1). By using these three variable factors the resistance can be made to do double duty. For instance, the objectionable feature of the resistance in Fig. 1 is that when a high current is passed the resistance (A, C) is heated quite perceptibly, while the resistance (C, D) is not being used. By utilizing the scheme in Fig. 3 this unused portion can be brought into use, thereby releasing the overload to which the portion (A, C) is being subjected.

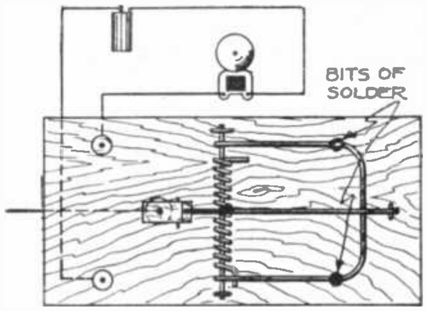
In Fig. 3, with the switch (S^1) closed, the current will enter, say, at (A). It will then go to slider (S), through the left-hand part of the resistance to (E), then to the other terminal of the improved instrument (B). The current will also pass through (T), through the right-handed portion of the resistance, out (D), through switch (S) and then to binding post (B), meeting the other portion of the current and combining with it. Thus a double resistance is secured with one resistance.

Moving (S) to the left or (T) to the right will increase the current flowing through the whole system. With switch (S^1) open, connections can be made by mere variation of the sliders so that the resistance can be used as the ordinary type in series, or two resistances in parallel. With either (S) or (T) in the off position, the ordinary type of laboratory variable resistance will be had, keeping switch (S^1) open.

The double slider and switch can be added to any of the types of variable resistances incorporating sliding contacts which have been described in past issues of PRACTICAL ELECTRICS.

Contributed by RAYMOND B. WAILES.

Rat Trap Burglar Alarm



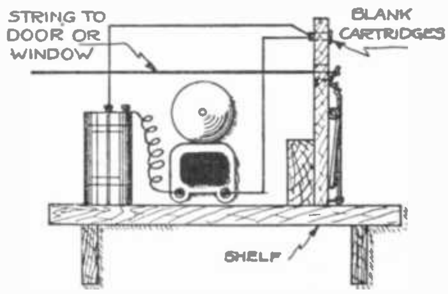
Let your rat-trap protect you against burglars. An ingenius suggestion is indicated above; when the trap is sprung it not only closes an alarm circuit, but discharges two blank cartridges.

WHEN a door or window is opened this alarm will explode two blank cartridges and ring a bell, which may be placed in an adjoining building or room.

First procure a rat trap of the spring type, as illustrated, some wire, string, two blank cartridges, bell, dry cell and some solder.

Then drill holes for the blank cartridges and the string, as shown. Next solder two studs on the corners of the spring-bow to set off the blank cartridges. Then attach the string to release the catch, as illustrated.

After this has been done the wires are put up. These may be run so as to be out of sight and the bell and batteries may be placed wherever desired. Then connect the



The general hook-up and string connections for the rat-trap burglar alarm. Note the cartridges.

bell and battery circuit. Connect the wires for the trap to small strips of brass to be placed so as to fit into the holes for the blank cartridges and be tightly held by them. This is done to secure a good contact.

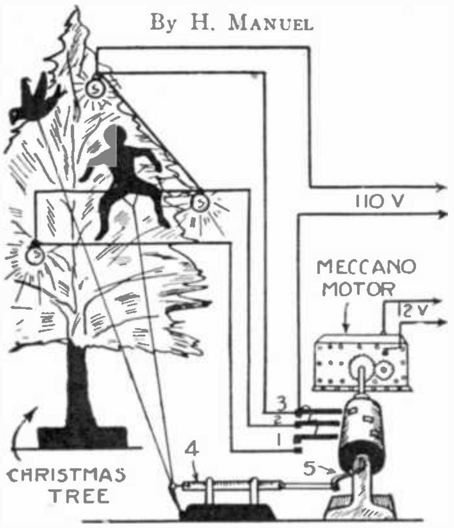
Great care must be taken in putting the blank cartridges in place or they may explode unexpectedly.

When the string is pulled the trap is sprung. The spring-bow flies over and explodes the cartridges. This closes the bell and battery circuit and the bell continues to ring until switched off.

Contributed by ROY HAFNOR.

Electric Christmas Tree

By H. Manuel



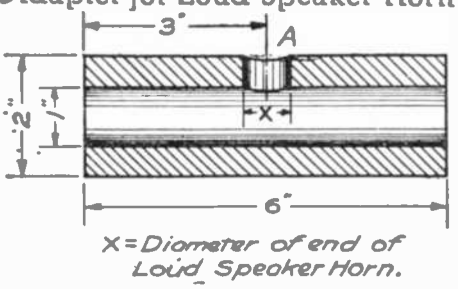
An animated Christmas tree with flashing electric lights can readily be constructed with apparatus assembled in the experimenter's laboratory.

LAST Christmas we greatly enjoyed the Christmas tree which I made at home. It was very wonderful, not only because its branches were weighted down with all kinds of fruits and candies, but because it was operated by electricity.

By means of the Meccano toy motor, the Christmas tree was entirely operated and controlled, flashing with different colors of lights and swinging and trembling with flying birds and dancing dolls. All these movements were operated by the little motor, connected with the A. C. light line stepped down to 12 volts. The motor works as a flasher and as a controlling device for the moving birds and dolls. As a flasher there was attached a wooden roller which controls the switches 1, 2, and 3 and the lights by means of corresponding contacts 1, 2, 3 on the roller. When these projecting contacts pass over the switches they open or break the circuit of the lamps. The projecting contacts are arranged so that they close contacts one at a time. When contact 1 passes over switch 1 the red light will flash, contact 2 when on switch 2 will flash the white light, etc.

As a controlling device of the dancing dolls and flying birds, a small crank was attached to the same roller at the end. The crank 5 is also connected with a horizontal rod 4 which slides back and forth when the motor is in operation. Now all the dancing dolls and flying birds are connected together with this sliding rod by means of strings. And when the motor is in motion the lamps light up flashing in different colors and the dolls and birds are set in motion at the same time.

Adapter for Loud Speaker Horn



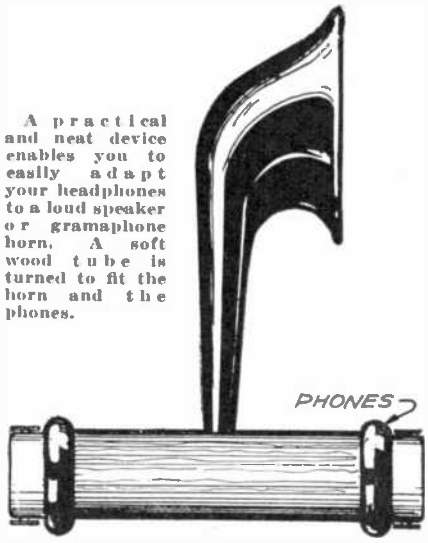
To make a "loud speaker" of your headphones you need merely a gramaphone horn and the readily constructed soft wood tube illustrated above.

A SIMPLE phone adapter for gramophone or loud speaker horn can be constructed in the following way:

A piece of soft wood is turned to a diameter of two inches and is cut off six inches long. A hole one inch in diameter is then drilled from end to end. Next a hole of a diameter to fit the small end of the horn is drilled at (A) in the illustration, through one side only. In this hole the small end of the horn is placed.

The other figure of the illustration shows where the phones and the horn go.

Contributed by O. G. Sangster.



A practical and neat device enables you to easily adapt your headphones to a loud speaker or gramaphone horn. A soft wood tube is turned to fit the horn and the phones.

Sparks Without Wires

THE materials required for this trick are a one-half inch spark coil, three or four dry cells, and some No. 40 enameled copper wire. The wire can be obtained from an old 2,000-ohm telephone receiver.

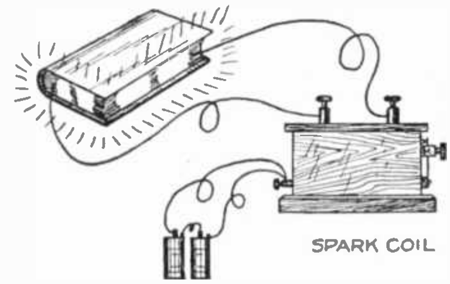
Two lengths of the wire should be tied with a silk thread so that their ends are about one-half inch apart. The wire and thread are stretched across the room, with the break or separation of the wire, in the middle. If this wire is placed in a room illuminated with orange light, the wire will completely disappear.

Mysterious "wireless" sparks are produced before the eyes of wondering spectators who do not suspect that wires, rendered invisible in the orange illumination, are stretched across the room and connected to a remote spark coil.

The wire should be stretched taut across the room and the two lengths should be connected respectively to wires leading to the spark coil in another room. If the spark coil is now operated, sparks will appear in the middle of the room, apparently jumping from nothing to nothing. If the wires are separated at the juncture with the thread to a distance of two inches, a luminous blue glow will appear when the current is turned on.

Contributed by Alden Johnson.

Experiment with Gilt-Edged Book



A shocking but brilliant book, illustrated above, is connected through its gilt-edged pages to a spark coil, causing bright scintillations around its edges.

THE illustration shows a very simple experiment, and one quite effective, in which there is utilized an ordinary gilt-edged book.

The gilt on books, if of good quality, is put on with gold leaf and by connecting such a book to a spark coil very beautiful effects are produced by the scintillations, and the effect can be changed by shifting the pages about a little so as to alter the scintillations.

Contributed by Herbert Traylor, Jr.

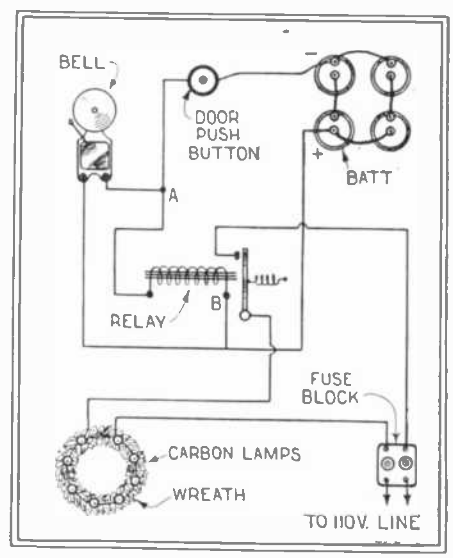
Christmas Door Wrealth

By J. J. Bradley

DURING the Christmas season I worked out a novel idea and rigged up the contrivance. It consisted of a Christmas wreath on the front door decorated with various colored lights.

The diagram shows the connections in detail, and the explanation of its working is as follows: Four dry cells are arranged as shown; two cells are in series and two in parallel. I arranged them thus after much experimenting as I found this to be the best plan. When a person presses the bell push-button the bell rings; current also flows from a point designated as (A), which is beyond the push-button and operates a relay at (B). This relay closes the lighting circuit through the incandescent lamps on the wreath.

The lighting current flows from the fuse block to contact (C) and as the armature of the relay is attracted due to the flow of energizing current from the dry cell battery, the same lighting current flows along the armature through the relay frame and then out through the lamps.



A cheerful welcome is extended to callers by this Christmas wreath mounted on the door and illuminated every time the door-bell is rung. A relay in the bell circuit closes the 110-volt lighting circuit through the lamps on the wreath.

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

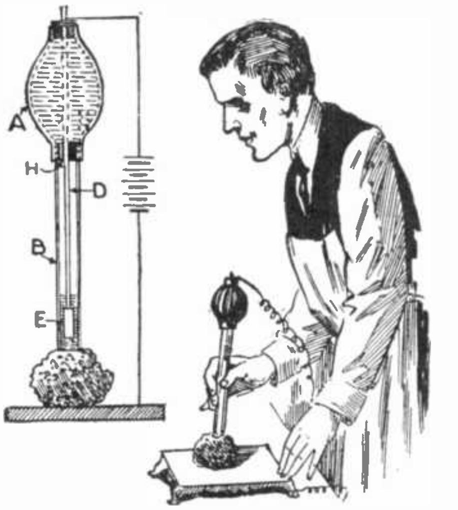
First Prize, $25.00	Second Prize, $15.00	Third Prize, $10.00
Paul Kolbe, 1503 E. 75th Pl., Cleveland, Ohio	H. Bushlowitz, 1636 S. 5th St., Philadelphia, Pa.	Raymond L. Horn, 102 E. Pearl St., Burlington, N. J.

First Prize
Electroplating Without a Tank

By Paul Kolbe

ELECTROPLATING without a tank is rendered possible with the following easily made apparatus.

It consists of a rubber ball, *A* fitted at one end with a glass tube, *B*, which carries



Instead of immersing the object to be plated, in the plating solution, the latter is applied by means of a sponge in the ingenious arrangement illustrated above. The solution is fed to the sponge through a glass tube in which an electrode connected to one terminal of the battery makes contact with the plating solution. The other terminal of the battery is connected to the object to be plated.

at the other end a small sponge. A rod, *D*, passes through the rubber ball, which is tightly corked at both ends, into the glass tube, *B*, and carries at its lower end the anode, *E*.

The connections from the battery to the cathode, *G*, which is the object to be plated, and to the projecting end of the anode rod, *D*, are made as shown. The rubber ball is filled with electrolyte, and is squeezed as needed so as to force the fluid through a hole made in the cork, *H*, into the tube, *B*, filling it and soaking the sponge.

The current is then turned on, and by moving the wet sponge over the cathode, *G*, the latter will be plated.

Not only is this an interesting accessory for the amateur's laboratory but it can be used in the shop.

Second Prize
Opera Hat Electric Sign

By H. Bushlowitz

SOMETHING unusual in advertising will usually attract the crowds.

A French dealer in clothes for theatregoers made an advertising sign in which an opera hat was used for its housing. The sides of the hat were cut so that letters were removed to spell out the words of the sign. These letter holes were covered with a thin, light fabric of the same color as the hat. When unlighted the letters remained invisible; one or more electric lights inside connected, also with batteries inside the hat.

When lighted the hat quickly becomes a conspicuous advertisement. The batteries may be carried in a pocket and secretly wired under the coat to the neck and up to the hat over the hair on the back of the head. The current can then be flashed on and off with a switch concealed in the pocket.

After Jean had hired a man to walk past some theatres at night he soon found that this simple invention had overpaid its weight in gold, for when customers came to ask about his advertisement they always bought something.

$50 IN PRIZES

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

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

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

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

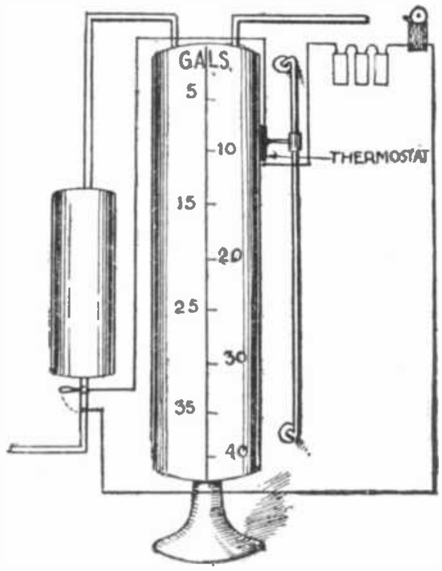
This prize contest is open to everyone. All prizes will be paid upon publication. If two contestants submit the same idea, both will receive the same prize.

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

The customary unsightly advertisement in the form of "sandwich-man" will soon yield to the more fashionable sign illustrated above. Just when the wearer of this outwardly ordinary silk hat has succeeded in deluding the unsuspecting public into taking him for a fashionable theatregoer, the pressure of a button lights a lamp under the hat, and announces to that same public, in glaring letters, that the well-tailored suit worn by him is made by Jeans, tailor.

Third Prize
Hot Water Alarm

By Raymond L. Horn



The simple but effective device shown above will do much to reduce the gas bill in connection with hot water furnaces. An alarm bell actuated by a thermostat will ring when hot water of the required temperature has reached the level to which the rheostat is adjusted; the latter can be shifted along the length of the furnace.

A SHORT time ago, our hot water heater was connected in the cellar. Several times it was lit and forgotten and burned for hours.

I concluded, therefore, that an alarm, which could be set for different amounts of hot water would be very economical in reducing the gas bill.

I took a thermostat, which would close the circuit when heated, and soldered it to a ground clamp which could be slid easily along a pipe and be kept against the side of the boiler.

On the shut-off, on the heater, I rigged a switch to close the circuit when the gas was turned on.

On the side of the boiler I painted a scale to determine the distance down the boiler that the thermostat should be set. An alarm-bell is connected at a convenient location.

When a certain amount of hot water is desired, it is only necessary to turn on the gas, light the heater and adjust the thermostat to the proper marking on the scale.

When the water gets hot, to the proper point, the heat will close the thermostat and complete the circuit, ringing the alarm-bell. The bell will stop ringing when the gas is turned off.

The diagram shows the necessary connections.

IN this department are published various tricks that can be performed by means of the electrical current. Such tricks may be used for entertaining, for window displays, or for any other purpose. This department will pay monthly a first prize of $3.00 for the best electrical trick, and the Editor invites manuscripts from contributors.

To win the first prize, the trick must necessarily be new and original. All other Elec-Tricks published are paid for at regular space rates.

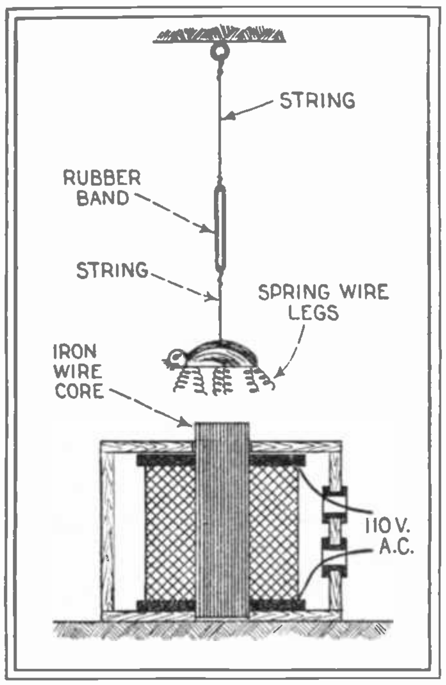
Trick Spider

A VERY simple Elec-Trick, and one which may be very effective, is illustrated here.

A toy spider with the usual vibrating legs made of very delicate springs is suspended by a rubber band, which must be very thin, directly above a coil, which is connected to an alternating circuit.

When the current passes the spider is supposed to jump up and down, its legs, of course, vibrating so that it will altogether present a very funny and attractive exhibition, at least for some people, not only for children and not only for the mere curiosity seekers, as it is an interesting demonstration.

Contributed by PAUL A. SIMPSON.



This curious toy spider is suspended over a hidden electro-magnet supplied with alternating current and will jump up and down in accordance with the frequency of the current. Its legs, made of steel springs, will go through humorously uncanny vibrations.

Mysterious Glass Strip

By C. A. OLDROYD

HERE is a trick involving static electricity which will puzzle your friends who think that they know all about electricity!

You show a strip of glass, and maintain that you can produce both positive and negative electricity from it by rubbing its side with the identical strip of leather. Put to the test, you win every time and pocket the bet.

The secret lies in the glass strip; one side is ground glass, while the others are clear. To obtain such a strip, a narrow piece can be cut from a sufficiently thick sheet of ground glass, as shown in Fig. 1.

One side of the strip will then have a ground surface, while the other three sides will show clear glass. To generate electricity, the glass strip is rubbed with a strip of chamois leather; to facilitate handling and avoid cutting yourself on the sharp edge of the glass, the strip of leather is passed around a cork and secured in position with a rubber band. (See Fig. 2, right hand side.) The least rubbing with a file will take away the cutting edge.

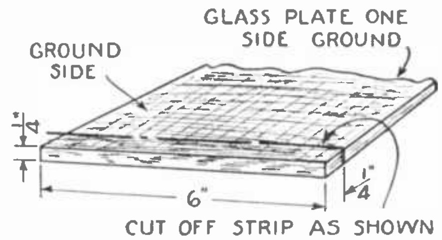


FIG. 1

To make the mysterious glass strip that will yield both positive and negative charges, cut a strip such as indicated in the figure from a plate of glass, one side of which is ground.

If you now rub any of the three clear sides of the glass strip with the rubbing tool described, the electroscope will indicate positive electricity, while negative electricity will be generated when the rough ground side is rubbed.

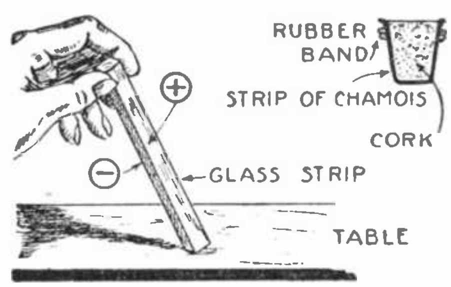


FIG. 2

According to best authorities, rubbing a piece of glass should charge the latter positively. Yet the glass strip shown above will be charged either positively or negatively at the will of the demonstrator. The key to this perplexing anomaly is in the nature of the glass surfaces, one of which is ground while the other is polished.

To change the electricity to be produced from positive to negative, the operator need only give the glass strip an imperceptible turn, so that either the clear glass side or the rough side is uppermost.

If a sheet of ground glass is unobtainable, roughen one side of the glass strip yourself, as shown in Fig. 3. On the table a glass plate slightly larger than the strip is placed, and some fine emery or carborundum powder and a few drops of water are put on the upper surface of the plate.

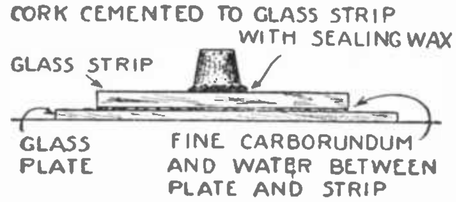


FIG. 3

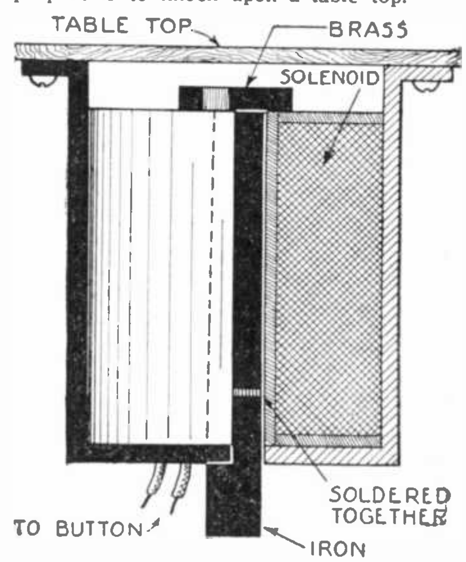
For the purposes of these experiments, one face of a glass plate may be roughened, that is ground, by a method indicated above. Two glass plates with fine carborundum and water between them are rubbed together producing a roughened surface.

For this glass plate, an old photographic plate that has been cleaned in hot water can be used. The glass strip is placed on the emery powder; to handle the strip easily, a cork or wooden handle is cemented to the upper side of the strip with sealing wax. Grasping the handle, the strip is drawn backwards and forwards over the glass plate and the emery powder, as shown by arrow, and in a few minutes the surface in contact with the grinding medium will be sufficiently rough.

Table Knocker

By ROSCOE BETTS

PERHAPS this little device has not been given the proper name, but anyway its purpose is to knock upon a table top.



The amateur magician will find the table knocker illustrated above an effective device in mystifying the credulous and baffling the skeptical members of his audience. The device is merely a solenoid and plunger mounted underneath the table top and through an invisible wiring supplied with current from a dry cell. The knocker is actuated by means of a push button carried by the demonstrator.

But why knock on a table top? Well, the reason is this: It is a method magicians have of answering mystery questions. For instance, say one knock means "yes" and two knocks mean "no." And you asked the magician a question. He would call upon the magic table to aid him and it would respond with one or two knocks, the magician at the same time being several feet away from the table, probably with his hands in his pockets (pushing the button).

The end of the solenoid, battery and button circuit could be conveyed to him through plates under the rug and sharp nails in his shoes and continued through his clothing to his pocket, the knocking then being at his command.

The diagram explains the working principles of the "knocker." The plunger is made partly of brass (upper part) and partly of iron (lower part), the two being soldered together. The object of the combination can readily be seen, to ensure the adequate motion of the solenoid core.

What Some of Our Readers Say

Mr. Lewis, not content with writing, sends us this amusing photo.

What a High School Student Wants

Editor, EXPERIMENTER:

Please allow a new reader to voice his appreciation of your November issue.

I am enclosing one of your voting coupons but am adding these lines so that you might know my opinion as to the kind of magazine many young men are looking for.

We are interested in radio, not only for itself, but because of its application of principles which interest us. Our interests are broader than those of the radio fan. We are interested in all the branches of natural science, not just electricity, so we like your chemistry, particularly electro-chemistry.

Mr. Secor's article on building electro-magnets alone would make this issue worth while; one like that every month and you will sell over 100,000 copies. The article on how to build a high frequency resonator is very welcome. I would like to know more about it, theory and application. I like your "Elec-tricks" and in fact anything that can be made, used or understood by ambitious students of physics in high school.

Very truly yours,

H. H. WALTER.

Peoria, Illinois.

A Big Hit

Editor, EXPERIMENTER:

I have your November copy of THE EXPERIMENTER before me and I like the new sections you have added very much.

I think that this magazine should make a big hit with all experimenters.

Yours for success,

MERLYN P. STEPHENS,

Carbondale, Pa.

Votes for Everything on the Coupon

Editor, EXPERIMENTER:

I have glanced through the magazine and approve of everything listed in the voting coupon.

I especially like the radio section and the timely article by H. Winfield Secor. The chemistry articles are splendid, as is the How and Why Column. I was also pleased to see an improvement in the fiction stories. Those printed several months ago were "applesauce." I would suggest departments for astronomy and physics. I have been waiting for this change ever since *Science & Invention* became a picture book.

Yours truly,

EDWARD EMMERLING.

Norwood, Ohio.

Believes We Have Adopted a Good Course

Editor, EXPERIMENTER:

I noticed in the October issue of *Practical Electrics* that the name would be changed to THE EXPERIMENTER and that the magazine would cover electricity, radio and chemistry. I believe you have adopted a good course as it will give the experimenter a magazine that he can call his. Here is all the good luck to you.

You will find enclosed a description of a wall panel that I use and if suitable you may enter it in any of the new departments in THE EXPERIMENTER.

Yours truly,

R. D. LEWIS,

Minneapolis, Minn.

Better Than "Practical Electrics"

Editor, EXPERIMENTER:

I consider the new EXPERIMENTER a great improvement on *Practical Electrics*, and wish to congratulate you on the improvement.

I had about concluded to cease my subscription to *Practical Electrics*, but now I will renew for the EXPERIMENTER when my subscription expires.

R. A. WORKMAN, M. D.

Woodward, Oklahoma.

The Words, "Experimenter By H. Gernsback"

Editor, EXPERIMENTER:

Just a couple of words to express my appreciation of the restoration of the old *Electrical Experimenter*.

I just happened by accident to spy the words "EXPERIMENTER" by *H. Gernsback* on a newsstand and I'm thanking my guardian angel for keeping my eyes open.

It seems as if I had always bought the *Electrical Experimenter* until the name was changed to *Science & Invention*, and now that you are back to the old policy again—I'm your customer.

I never was interested in chemistry until your articles showed me the interesting points of the experimnts.

There are two articles I wish to especially commend. The first is by Roy C. Hunter on a "Simple Telegraphone." I am constructing one and have two or three ideas for using it.

Another is by Elvin Tilton on a "Loop Aerial." I have just finished it, stand and everything, and it is equal to a $35.00 loop in efficiency and "looks."

With best wishes, I am,

Sincerely,

B. GRANT,

Cambridge, Mass.

A Suggestion for Our Radio Department

Editor, EXPERIMENTER:

It was indeed a pleasure to go through the first issue of THE EXPERIMENTER. It certainly recalls the old *Electrical Experimenter*. I have been a reader since 1918 and I was one who did not like the change to *Science & Invention*, but I readily understood why and did not say anything. I also get *Radio News* and *Practical Electrics* and like them very much. I am interested in all "phases" of experiments and like every article in this issue.

My only hope is that you will find that the majority of readers will like the line of this issue and that it will continue to expand, but still stick to these lines. In regard to the voting coupon, I vote in the affirmative to every question. I save every issue and use them for a set of reference books in my experimental lab and I wish to add that I would *not* sell what I have for any price, as often when I am working on something I will look through them until I get what I want and there is hardly a subject that is not covered in some way by them.

An article I would like to see soon is "Supplying the Plate Potential to Vacuum Tubes in a Receiving Set: From 110 Volts A. C. 60 Cycle."

Very respectfully yours,

CHARLES L. HAUSEL,

Chester, Pa.

From Girard College, Philadelphia

Editor, EXPERIMENTER:

Permit me to congratulate you upon the new issue of the old EXPERIMENTER, which has taken a great stride over the former *Practical Electrics*.

I have been especially interested in the departments in the rear of the magazine. The boys and myself at the college always look forward to your and our magazine.

Yours for success,

RICHARD W. ROSS,

Section E2, Girard College, Philadelphia, Pa.

Old Electrical Experimenter Comes Back

Editor, EXPERIMENTER:

I am enclosing your voting coupon and in addition would like to make a few additional comments and ask a few questions.

I like nearly all the material in your new magazine and am glad to see the old *Electrical Experimenter* come back. Being a student of chemistry, I appreciate your new magazine with its chemical department even more than the old.

However, there is one improvement which might be made, which would aid when referring to back numbers, and that is placing the name of the department at the top of each page. It would also be a great help if the continuation of articles in the back of the book could be avoided.

Now for some questions: In Mr. Gernsback's article, "Radio and Life," he states that sparks may be drawn from an automobile when under the antenna of the navy station NAA. Would this not cause serious trouble in the case of the radio power station? He also states that steel buildings absorb the radio waves. This being the case, it being well known that when radiant energy is absorbed heat is produced, would not the operation of the super radio of the future allow a sufficient amount of energy to be absorbed to produce a dangerous heating effect?

Hoping to learn Mr. Gernsback's opinion on these phases of the subject in a later issue, I remain,

Yours respectfully,

FRANK L. AUGUSTUS,

Hawthorne, Calif.

The Experimenter Is Great

Editor, EXPERIMENTER:

I am sending you the voting coupon and thought that at the same time I might tell you what I think of your magazine, THE EXPERIMENTER.

I think the magazine is great. I have marked a few of the subjects on the coupon; these I like extra well, especially the Chemistry Department. This I would like to see more of in the magazine, as I am exceedingly interested in it. Also the Electrical Department and Electro-Chemistry.

And now for *Science & Invention*. This magazine I would never part with without a struggle, and I always look forward with eagerness to the time for its arrival.

There isn't an article in this paper or, rather, magazine, that I don't read except astronomy. The Readers' Forum I like very well and the fiction stories are fine. As long as these two magazines are as interesting as they now are, I will never say a word against them.

Yours truly,

LEONARD G. YOCUM.

Douglassville, Pa.

Hits the Mark Just Right

Editor, EXPERIMENTER:

I have received the first copy of THE EXPERIMENTER and I must say that you hit the mark just right. It is just the type of magazine I have been waiting for since you discontinued the old *Electrical Experimenter* of which I was a subscriber for a number of years.

Hoping you will make a big success out of your new venture so that we may always have THE EXPERIMENTER with us, I am,

Respectfully,

ELMER F. HOFFMAN.

Dunellen, N. J.

It Supplies a Need

Editor, EXPERIMENTER:

I am very pleased to welcome the *Electrical Experimenter* back. I purchased my first copy just a few days ago and was very pleased to see it. THE EXPERIMENTER supplies a need which your other publications do not do.

Wishing THE EXPERIMENTER a long life, I remain,

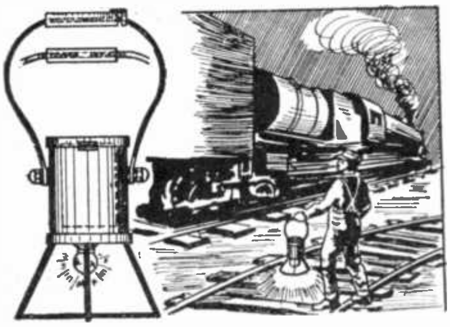
Yours truly,

NORMAN PETERSON,

Concord, California.

Latest Electrical Patents

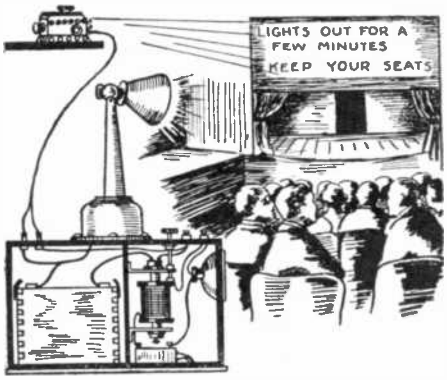
Electrical Railway Lantern



This lantern is provided with a large electrical battery lighting a small but powerful incandescent bulb. The novel feature of the invention is the use of the supporting arms as part of the electrical circuit of the lamp. The arms are threaded at the upper ends and screwed into an insulating handle. By turning this handle the operator can bring the ends of the arms together and thus close the circuit.

Patent 1,504,869 issued to G. W. Comer, Chicago, Ill.

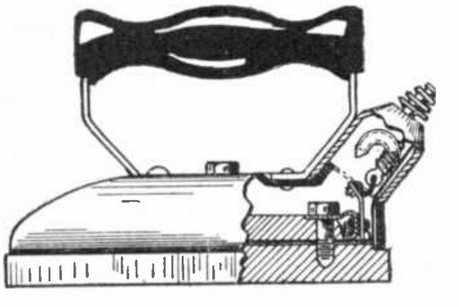
Automatic Emergency Light



The invention shown above is an emergency lighting system to be used in theatres, churches, and similar places where a temporary disconnection of the main lighting system might cause disturbance. By means of solenoidal relay an emergency lighting circuit is closed as soon as the main lighting circuit is opened. Simultaneously with the lighting of the emergency lamp a stereopticon projects a sign on the screen requesting the audience to keep their seats.

Patent 1,511,097 issued to O. W. Althowf and L. S. Blueta, Berwick, Pa.

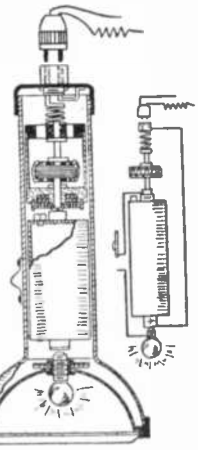
Safety Electric Sad Iron



The electric iron shown above cannot overheat. A sealed U-tube, having one leg surrounded by a small heating coil in series with the main coils of the iron, contains a conducting liquid. Normally this liquid closes the circuit of the electric iron by making contact with two electrodes sealed in the tube. When the iron approaches an excessive temperature the liquid evaporates and condenses in the upper leg of the U-tube, thus opening the circuit. By tilting the iron the liquid is again brought into operating position.

Patent 1,511,282 issued to D. Ulrey, Wilkinburg, Pa.

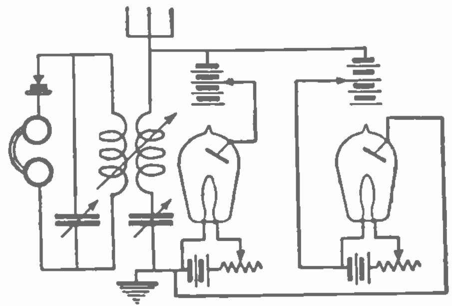
Storage Battery Flashlight



Attempts to provide flashlights with storage batteries have in a large measure been unsuccessful but the invention illustrated above apparently involves features which can render the device commercially feasible. Besides the miniature storage battery, made to fit the flashlight case, it contains a small replaceable electrolytic rectifier carrying sufficient electrolyte for a single charge. The rectifier is carried in an insulating case which during the charging period is filled with water.

Patent 1,506,302 issued to T. M. Hopkins.

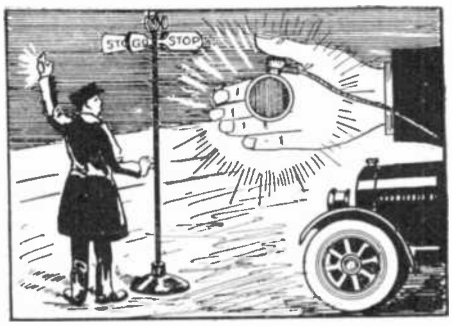
Anti-Static Circuit



By means of the circuit shown above the effects of atmospheric disturbances are considerably reduced. Two rectifying tubes are shunted across the tuning inductance and capacity in the antenna circuit. When, due to static, the potential across their terminals reaches a predetermined value, these tubes form a low resistance shunt across the primary inductance and thus reduce the static disturbance in the receiver. The critical voltage of the tubes is adjustable.

Patent 1,504,600 issued to Q. A. Bracket, Pittsburgh, Pa.

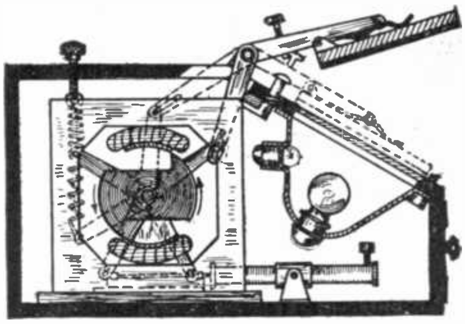
Portable Signal Lamp



As shown in the illustration this electric signal lamp contains a small incandescent lamp in a compact case which lamp is connected to a flashlight battery carried in the pocket. The circuit can be made or broken by means of the push-button operated by the thumb, the entire case being attached to the fingers by means of a small strap.

Patent 1,504,980 issued to J. Schultz, New Britain, Conn.

Photographic Printing Machine



The invention here illustrated is a device for printing photographs in large numbers. The pressure of a button closes the electrical circuit of the electro-magnets which attract the armature. The latter is linked to a moveable arm which swings down and presses the negative and the sensitized paper against the glass plate, beneath which a printing lamp is located. This movement closes the circuit of the printing lamp and the time of exposure is determined by the adjustment of the apparatus.

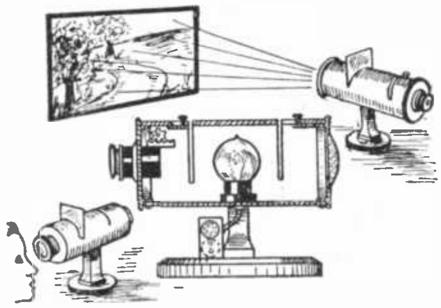
Patent 1,510,718 issued to G. Rekers, Rochester, N. Y.

Illuminating Time-Piece

A very neat and useful electric table-lamp is illustrated above. The rim of the lamp reflector is graduated in hours and a pointer operated by a clock mechanism mounted above the lamp indicates the time. Though such clocks seem novel at the present time they were well known and much used during the 16th and 17th centuries.

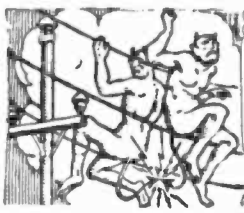
Patent 1,508,876 issued to C. E. Dressler, New York, N. Y.

Stereo-Radioscope

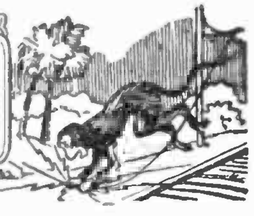


This apparatus combines in one unit the means for stereopticon projection and for the close examination of pictures. An adjustable magnifying device provided with an eye-piece enables the operator to make a close examination of the pictures, which, when placed in the other slot indicated in the diagram, can be projected through a large lens on a screen.

Patent 1,504,989 issued to B. L. Slitzer, New York, N. Y.



SHORT CIRCUITS



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

Here Marjorie lies.
  Instead of a bun,
A socket she tasted
  While the current was on.
—HELEN R. HICKS.

Here are the remains
  Of J. Henry Von Kluck
Whose wet ironing cloth
  Touched an extension plug.
—B. MILLER.

Rests 'neath this sod
  Poor Henry McBryer.
He stepped in a puddle
  Holding a live wire.
—B. VAN ANTWERP.

This stone marks the grave
  Of darling old Pete;
His socket was grounded
  And so were his feet.
—MAX HAGSPIEL.

DEAD OWL KEEPS WYMORE IN DARKNESS

Wymore, Neb., Oct. 3.—Electric lights again blinked here Thursday night after a night of darkness caused by an owl that fell across high voltage transmission lines from Marysville, Kas., short circuiting the city's supply. Linemen discovered the dead owl and removed it.

Mouse Darkens Half a City, Causing $20,000 French Fire

Copyright, 1924, by The New York Times Co.
Special Cable to THE NEW YORK TIMES.

PARIS, Oct. 2.—One small mouse at Lille succeeded last night in throwing half the city into darkness and causing $20,000 damage.

At the Central Electric generating plant the inquisitive little animal got itself mixed up in the machinery, causing a short circuit. It was burned to a cinder immediately. But the alternating turbine burst into flames and a large part of the big plant was destroyed

Freak Lightning

A FREAK bolt of lightning struck the upraised shovel of a workman at Salem, O., split into three parts and jumped to three different houses. In one house it stunned six-months-old twins. Weather boarding and plaster were torn from the second house. The third house was a bungalow, just completed, which was damaged slightly. The workman was uninjured

Dank, dismal this grave
  Of Mr. Frederick S. Rushes
Whose motor ran swift
  While he worked on its brushes.
—L. GABAR.

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.

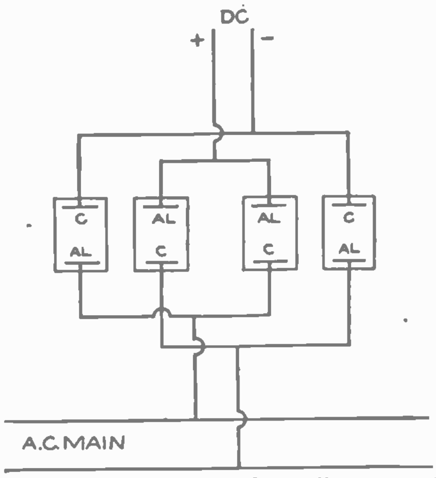
Kindly oblige us by making your letter as short as possib'e.

Electrolytic Rectifier

(488)—J. J. Muller, South Ozone Park, N. Y., requests:

Q. 1.—A diagram of a four-jar electrolytic rectifier.

A. 1.—The rectifier is shown diagrammatically in the figure. The electrodes may be any pair of polarizing and non-polarizing metals, but the best known cells use aluminum for the positive electrodes. Carbon or lead is suitable for the other electrode. Sodium phosphate will serve well as electrolyte, the chief requirements being the formation of a film of aluminum hydroxide on the aluminum electrode. The electrodes must be of sufficient area to prevent overheating. For more detailed information refer to "How and Why," query 396 in the April, 1924, issue of the PRACTICAL ELECTRICS.



The diagram shows a four-cell electrolytic rectifier provided with aluminum and carbon electrodes. While such rectifiers have been constructed for heavier currents, the experimenter will find its operation most efficient on currents of less than one ampere.

Weighing an Electron

(489)—T. F. Thomson, Chicago, Ill., asks:

Q. 1.—How is it possible to weigh an electron?

A. 1.—The mass of an electron is determined by an indirect process. By means of an apparatus similar to that described in the August issue of PRACTICAL ELECTRICS, in the article "The Cathode Ray Oscillograph," the ratio of the charge to the mass of the electron is determined. Then the charge carried by the electron is determined by condensing oil or water on it and observing the rate of fall of resulting charged drop of oil under the influence of gravitational and electrostatic fields.

Q. 2.—If the current is due to electrons emitted by the filament in a vacuum tube, why is the current influenced by the voltage between plate and filament?

A. 2.—The potential difference between filament and plate establishes an electrostatic field which exerts a force on the electrons. The motion of the electron thus becomes accelerated and this acceleration increases when the field increases, and therefore the current increases. However, the number of electrons emitted by the filament being limited, a plate voltage is soon reached which will cause the electrons to fall into the plate as rapidly as the filament emits them. This is a condition of saturation.

Speaking Motion Pictures

(490)—J. James, New Rochelle, N. Y., asks:

Q. 1.—How does the "speaking motion picture film" work?

A. 1.—One type depends for its action on the secondary radiations emitted by sodium in a photoelectric cell, when ordinary light impinges upon it. It is well known that when light rays fall on a clean sodium surface the latter emits photo-electrons. Since these radiations are very weak the impinging light ray is trapped in a tube as shown in the diagram and reflected several times between the walls, which are coated with a film of sodium. The ionization so caused renders the gas in the tube conductive and a weak ionization current flows between the grid (G) and the sodium film. By means of amplifiers the effect is magnified and transmitted to a loud speaker.

The modulation is accomplished by means of a thin strip alongside the picture film, on which the light and dark portions vary in intensity, according to the voice to be transmitted. The light reaching the sodium film passes through this film and is thus modulated in intensity. The ionization current will then vary in proportion to the intensity of the impinging light.

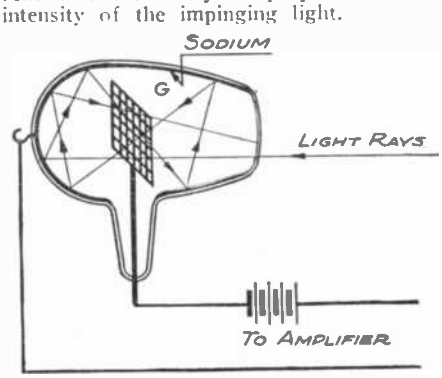


Diagram of a sodium photo-electric vacuum tube; a surface of metallic sodium emits electrons when light falls upon it, and these carrying their charges form a virtual conductor.

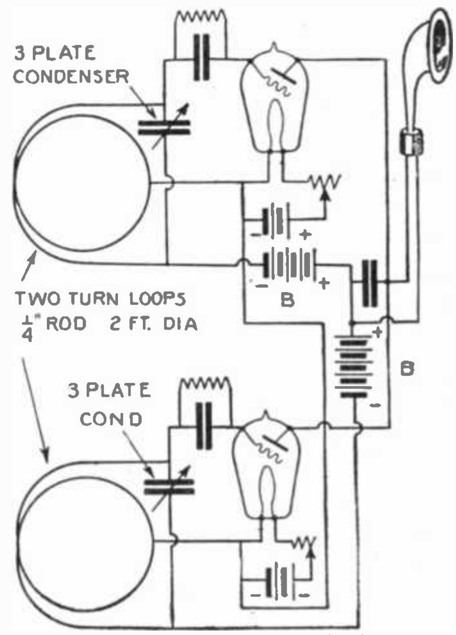
Underground Treasures

(491)—Rev. Price, Bonham, Texas, inquires:

Q. 1.—Is there any electric machine or rod of any nature that will enable us to locate money underground?

A. 1.—We know of no such device. Articles on this subject have appeared in back issues of PRACTICAL ELECTRICS and in other publications, but judging from the reports of those who tried the various schemes, none work. Theoretically the devices should work, but in actual practice there are so many variables that it is practically impossible to obtain an accurate reading. The small volume of weight of any buried treasure make it out of the range of the most delicate instrument.

We are giving a suggestion that some experimenter may work out. We have not tried it and cannot guarantee results. The principle is this: Those who have used regenerative radio receivers know perfectly well that when the receiver is oscillating and a carrier wave is heard by the heterodyne action, the approach of the hand or body near the oscillating circuits causes the audio frequency beat note to vary in pitch. In fact, the note can be made very high or low by simply moving the hand. The note also varies when a metallic object is placed near the oscillating circuit. Thus by making the circuits sufficiently sensitive we can move the apparatus over the surface of the ground until we approach a buried metallic object, which will change the frequency of the audio howl. The depth at which we can detect the presence of the metallic object depends upon the sensitivity of the apparatus, which can be made as sensitive as desired by using currents of short wave-length or extremely high frequency.



A form of electric balance is illustrated above. The beat note produced by the interaction of two circuits oscillating at different frequencies is altered when conducting substances are brought near one of the two loops shown in the circuit. The apparatus may thus serve as a detector of under-ground metals.

In the illustrations we show two oscillating circuits, using the ordinary vacuum tube. These are oscillating at slightly different frequencies, and both feed into the same output circuit, setting up a loud howl in the loud speaker. This howl may be adjusted to a frequency of 1,000 cycles. The frequency of the oscillating circuits is in the neighborhood of 6,000,000 cycles, or 50 meters wave-length. The presence of a conducting object several feet away will cause a great change in the audio note.

The Electron Valve Converter

(*Continued from page* 186)

of 170 amperes between the cylinder and the filament. However, these electrons do not reach the plate when the filament current is flowing, since they are deflected by the intense magnetic field set up by the current. This field prevents all electron flow even at a potential of 200,000 volts between cylinder and filament.

In other words the filament is heated by a heavy current giving rise to a large electronic emission, but this same current by the action of its magnetic field prevents any electrons from reaching the plate and thus no "plate" current flows, while the filament current is on. But if the filament current ceases after it has brought the filament to the proper temperature the magnetic field will collapse while the emission will continue, and therefore a current will flow between the anode and the filament. Thus, if the filament current is made alternating the plate current will flow every time the filament current is zero.

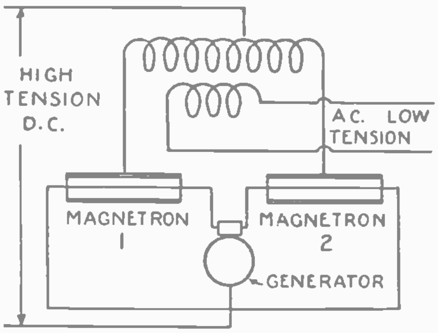


FIG. 6

This diagrammatic view of the electronic converter shows the disposition of two Magnetron tubes in connection with a specially designed generator supplying the filament current. This unit will receive high tension D.C. and supply low tension A.C. of any frequency or receiving low tension alternating current it will supply high potential D.C.

Fig. 6, represents a converter system comprising two magnetron tubes, one transformer with a central tap in the high tension winding and a generator of special design supplying a filament current of constant value but regularly interrupted. While this current flows through one tube the current in the other is zero, and vice versa. At any instant, therefore, the plate current flows through only one tube.

Now, suppose it is required to convert a high tension D.C. into a low tension 60 cycle A.C. The generator is adjusted to supply a current (see wave form in Fig. 7) interrupted 60 times a second. Since the plate current flows only when the filament current is zero the current in the transformer will alternate at a frequency of 60 cycles per second. This would be the action of the converter at the receiving end of the line. At the generating end it is required to convert A.C. into D.C. Here the generator supplying the filament current is driven synchronously with the A.C. generator so that the filament current is interrupted in synchronism with the alternator current. The current is thus reversed twice, first by the A.C. generator, and then by the converter system, and the resulting effect is a direct current in the high tension winding of the transformer.

The remarkable advantages of such system are manifest. Not only does it make long distance high potential transmission possible but offers an exceedinly flexible arrangement, the frequency of the converted current at the receiving end being entirely ndependent of the frequency of the A.C. generator. Such unit has been shown to be capable of converting 10,000 kw. at an efficiency of 96%. Furthermore the life of a magnetron is 60,000 hours, that is about seven years of continuous operation.

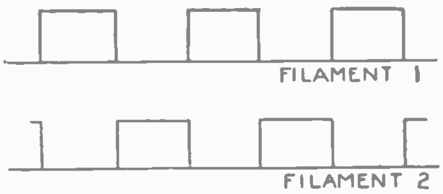


FIG. 7

The Figure illustrates the wave form of the filament current generated by the specially designed generator indicated in Fig. 6. Note that while current is flowing through the filament of one tube the current back of the other is zero.

The Ark of the Covenant

(*Continued from page* 163)

say she was perfect and would have to offer the design to the U. S. government, so she remained a peaceable machine, ostensibly built for pleasure, and her fighting kit lay oiled and ready in the strong-room of the workshops.

II

Milliken Is to Lose the *Merlin*

As I watched Milliken dance around his pet, I began to have an absurd feeling of guilt about taking her away. The mechanic was sure to be aggrieved, and I wondered how I was going to break the news to him. He stepped back and gazed at the machine with a rapt expression.

"Don't you think," he said slowly, "that the band round her could be widened, Mr. Boon? I don't mean much. Ju-u-st a morsel. Ju-u-st about a sixteenth of an inch either side, to show up her lines prettier?"

"I had a notion of widening the band considerably," said I solemnly, to string him a bit, "about four inches altogether. Then I thought of bringing the blue right round the engine boss, and stencilling a wreath of emerald-green leaves round her nose, bringing the design right round with the band. Then perhaps a row of vermilion dots either side of the blue strip would brighten her up——"

He was gazing at me with his jaw dropped.

"Huh!" he said contemptuously. "Why don't you finish her off like a circus wagon and be done with it? Want to make her look like a swing-boat at a fair——?"

He broke off and grinned.

"You got me that time," he admitted.

"Looks like it," said I. "You and your 'ju-u-st a morsel!' Come up to the office, Milliken. I want to talk to you."

When I had finished telling him of the robbery and of my plans, he put a hand on each knee and scowled at me fiercely.

"Do you mean to tell me you're giving up your work here to go crook-hunting?" he demanded.

"You've said it," I replied. "I've got to stand by the old man in the best way I can, Milliken. He's up against a big thing."

He thought for a minute.

"Well," he said slowly. "I don't know that I blame you. Your father's worth all you can do. But turning the *Merlin* into a private limousine—huh!"

"I have to give him the best I've got, don't you see?"

"Why don't you recondition the *J. V. B. 7?*" he asked. "She's quite a good bus yet, up to about three hundred kilometers per, and more of a passenger machine than the *Merlin*—plenty quick enough for your dad's purpose, I'd say. It'd be a shame to use the *Merlin*. You don't want everybody down at Battery Park swarming over the old girl, do you?"

"Wouldn't do them much good if they did," said I, "but you're right. I'd rather they didn't all the same. I tell you what, Milliken. I'll take you with me to the Battery and you can fly the *Merlin* back. Then I'll phone you in the late afternoon and tell you when to come and pick my father and me up in the evening. Meantime, you can be putting the engine back into the *Seven*, and getting her into order. And, let me see—who is there among the men who could handle her for my father if you and I were otherwise occupied?"

"Young Didcot could. He has his ticket, and knows the *Seven*. He's a good pilot—only, a bit careful."

"Didcot, of course," I agreed, for he was a pupil of my own. "I like the careful streak in him, especially as it doesn't come from concern for his own skin. Well, that's the idea. We'll have a bite for lunch, Milliken, and then we'll get back to the Battery as quick as we can."

Soon after noon Milliken and myself boarded the *Merlin* and set off for New York. The silencer was on, and before we had been in the air a couple of minutes she was nipping along quietly at three hundred and eighty.

"Let her out, Mr. Boon!" Milliken, the tempter, whispered in my ear. "Open the cut-out and let her rip!"

I pulled back the cut-out lever—and the air suddenly was hideous with noise. I opened the throttle carefully.

The *Merlin* Passes Beyond the Range of the Speed Dial

Breathless, we watched the speed dial. The pointer travelled in tiny jerks up the scale: three-eighty-five—six, seven, eight, nine—three-ninety! Gradually, steadily, and the roar of the engine now a screaming, rising note, the pointer crawled round the dial.

A quick look at Milliken, who was sitting in the toggled seat behind me, showed me his ugly old mug streaming with perspiration. His gaze was fixed on the speed dial, and his lips were moving. For myself, my jaws were clenched enough to hurt. Round, round went the pointer: Four-eighty-five—six, seven—back to six—seven, eight—eight—a little more throttle—nine, nine—four-ninety! Creeping, jerking, the pointer travelled—five hundred!

That was the extent of the dial. I had a curious fear that to open the throttle any more would be to burst something. The dial said five hundred, and that was the limit of endurance. I couldn't stand any more and I throttled down. The pointer went back quickly—and I whipped in the cut-out.

Milliken saw the movement, and his lips went quicker. But I could not hear him. My ears were still filled with the roar. The silence was appalling. I tried to speak, but could not hear myself. Then, gradually the sound of a voice came to me as from a great distance.

"Hell!—I knew she would! Heaven!—I

The Ark of the Covenant

knew she would!" it came. "By the holy old keeno, Methuselah, there's nothing to touch her. She's a daisy and a duck! Why'n hell can't they make six-hundred dials? You peach—oh, you little bird! Oh, boy!"

It was Milliken, the normally silent, unpacking his heart of words!

Gardiner's Bay to the Battery in Eighteen Minutes

Eighteen minutes after leaving Gardiner Bay we were tying up at the Battery seaplane jetty. I had to shake Milliken to make him realize we were there.

"Wake up, Milliken! We're there!"

"Yes, yes. I know." He cast a look of scorn at the fleet of machine around the jetty. "Look at them!" he cried. "Just you look at the pack of baby carriages! Oh, you bird!" he apostrophized the *Merlin*.

"Bird be damned!" said I. "There isn't a thing on land or sea that's like her!

A feeling of great exhilaration possessed me as I walked up Broadway. My mind worked at amaging speed, and I found myself gathering impressions of the things around me quicker than I had ever picked them up before. The traffic appeared to crawl, and although I was whacking along as quickly as my legs would let me, I seemed to be travelling at a snail's pace. It was an uncanny feeling, I may tell you.

III

The Securities Are Found! The Mystery Grows

My father, when I got to him, had an astonishing piece of news.

"The stolen securities have been found!" he said right away.

"What! Where?"

"In the Post Office. The lot of them, from all five banks, in envelopes addressed to various hospitals and institutions——"

"Good heavens!" I yelled. "Then that ass Glover was right!"

"What's that?" my father asked in a bewildered sort of way. "Glover? Who's Glover?"

I told him of the interview with the Post Office official.

"It's a mighty queer affair, Jimmy," he said, "and a mighty queer gang of crooks. They got away with a couple of million in securities—all of which have been recovered at the Post Office. In gold they've got away with about two and a half million——"

"If you get the scrip back, what's your total loss?"

"Two hundred and fifty-three thousand odd dollars in gold. It's a tidy sum, but in itself could not affect a bank like ours seriously. The danger is in the rumors that all our gold was taken and in the loss of public confidence. There might be a scare, and a run on the banks."

"No sign of that yet?"

"Not so far, but the news hasn't got into the country yet," said my father. "There's something of a panic in Wall Street already. The markets have all gone bluey."

"I hope you're wrong in your prophecy, dad."

"I hope I am," he said calmly. "But the cheap press is working up a fine scare. A lot of harm will be done if they keep on with it. You'd think the facts amazing enough without distortion, but some of these newspaper fellows have let their imaginations run riot."

A new point came to my mind.

"Two and a half million in gold, dad," I asked him, "what would that weigh?"

Over Three Tons of Gold!

"Eh, what's that? Let me see now." He figured for a minute on a sheet of paper. "Over three tons, I make it."

"Bother your old scale of weights," I laughed. "What's that in kilos?"[1]

[1]*The U. S. A. adopted the metric system of weights, etc., in 1929.*

"You'd better figure it for yourself," the old man said grumpily. "I've just worked the thing out from ounces troy to avoirdupois."

"My word," said I presently. "That's over three thousand kilos—three, nought, four, eight—to be exact. Say a man can heft twenty-five kilos at a time. That makes a hundred and twenty-two journeys to remove the stuff."

"Trying to work out the composition of the gang?"

How Long the Robbers Had to Work

"That's the notion. How long would you say it would take a man to carry twenty-five kilos from the strong-room to the front door?"

"How much is twenty-five kilos?"

"Fifty-five pounds, old scale—as near as doesn't matter," said I.

"That's a pretty good rough guess for an ingot of gold," the old man said. "Let me see now! Up the stair—round—swing door—better make it three minutes for the double journey."

"A hundred and twenty-two journeys of three minutes each makes it six hours six minutes to remove the stuff—that is, given that the other banks average the same for carrying distance. Even with old-fashioned oxyacetylene plant—and it seems to me something better was used—they could get into the banks and vaults in about fifteen minutes, but to cover any difficulties, as for instance the bursting of the internal compartments of the strong-room and such, let's say twenty minutes altogether. Five banks at twenty minutes each adds one hundred minutes to the total, and brings us up to eight hours working time."

My father scratched his head at this.

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.

"It was all done inside two hours," he protested.

"Yes, I know," said I, "but eight hours has to be distributed among a certain number of men. Four men could handle the work in two hours, were it not for the cumulated hundred minutes that must have been spent in breaking into the banks one after the other—supposing they had only one oxyacetylene plant. Let's say five men for a start and see how long they'd take to do the trick. Have you the actual figures of the gold taken from each bank?"

He handed me a list. On a basis of journeys of three minutes each, adding twenty minutes for the breaking-in in each case, I worked out the bare time that five men would need to handle the contract:

Nat. Met.	$ 253,500	or	13	journeys	28	minutes
Guaranty T...	360,250	"	18	"	31	"
Subtreas.	1,056,000	"	52	"	52	"
Dyers' Nat. ..	450,100	"	23	"	35	"
Trade Bank ..	480,250	"	24	"	36	"
					182	minutes

"Then five men with only one cutting plant couldn't do it?" said my father.

"No, nor could ten men with only one plant do it inside the two hours. Ten men with two acetylene sets could, though. But fifteen men with three sets could do it better. One squad for this bank and the Guaranty, another for the Subtreasury, and a third for the Dyers' and the Trade."

Possible Anæsthetic Bombs

"M'm," the old man murmured. "Well, how do you think they worked it?"

"The thing that stops our theorizing right off is the anæsthetic that was used. What puzzles me is that the thing is possible with poison gas, and that no crooks have hit on the dodge before. But say that some one has discovered a new general anæsthetizing gas leaving no ill effects. A big four-thousand-kilo truck—three and a half tons, dad—comes down Broadway, drops a gas bomb and five men in gas masks with a cutting plant at this bank. It drops another bomb by the Guaranty Trust. Goes on to the Sub-treasury, where it drops another bomb and another five men. It drops a fourth bomb at the Dyers' and goes on to the Trade, where the last gang and bomb are dropped. It waits until the Sub-treasury is cleared, then it picks up the stuff from the Trade and Dyers', Guaranty, National Metallurgical, with the men, then goes on to the Post Office and drops the securities in the box."

"You think that's the way of it, do you?" said my father. "It sounds reasonable enough, especially as we know the district was not properly surrounded by the police until the two hours were over——"

"That's the point," said I. "They might have used three trucks, or four—or even five. The thing must have been organized to go like clockwork in any case. If I were the police, I'd be searching every garage in the city. The brain that organized the coup would see at once that to take the stuff into the country would be to extend the time in which they'd be in danger of capture red-handed on the open road."

"It's a notion," said the old man. "I'll phone it to the detective staff right off."

"By the way," I asked, "has anything come out about the boxes found at the Post Office?"

"Not a thing, so far. I haven't heard anything."

"Then I'll go uptown and see if Dan Lamont has made anything out of the gold tarnishing. What time will you be ready to start for Hazeldene?"

"Make it seven o'clock."

I left him at the telephone, and in passing out dictated a telegram to Milliken asking him to be at the Battery at seven.

The newsboys were still busy about the streets and were doing an enormous trade. I bought several of the staider journals before calling up an automobile to take me to Dan Lamont's. The first one I opened in the car had a piece of information that, if true, knocked the bottom out of my theory of the trucks straight away. It appeared from the accounts given by several individuals who had been driving automobiles in the smitten district that when the drivers became unconscious the engines of their vehicles had stopped. One man, who had been driving an electric truck, had switched off the power just as soon as he felt himself go faint.

(*Continued on page 204*)

The Ark of the Covenant

(Continued from page 202)

To my mind the fact about the gasoline-driven cars strongly confirmed my idea of a gas. I imagined then that only some agent present in the air could have affected all the automobiles round Wall Street in the same way, and I was chagrined to see that the one vehicle driven by electricity in the district at the time was ruled out as evidence by the fact that its driver had stopped it himself. The street cars were of no value in this regard, because of their self-stopping devices. What would have happened to the truck if the driver had fallen asleep before he could switch off the power? I was inclined to think that only a wall or something of the sort would have stopped that truck, and that it would have come to a smash.

If my idea of a gas was right—and I could see no other explanation for the mysterious sleep or for the stopping of the internal-combustion engines of the automobiles—my notion that the thieves had used trucks for their coup was useless. There was the possibility, however, that knowing the effects of their gas on engines using the air to carburet the gasoline, the thieves either used electric lorries or had some specially arranged engines using compressed air. Such was my fantastic theory, based on a very crude mistake which I had all the training to avoid. I ought to have had more sense.

IV

It was beginning to be difficult to keep track of all the threads that were woven into the mystery, and I'll confess that right there in the automobile I was in something of a panic when I thought of the job I had taken on. Every new point that came up deepened the obscurity in which the whole affair was wrapped, and I was entirely in sympathy with one of the newspaper men whose business it was to write up the robbery. This fellow attributed the whole thing to a master criminal:

THE CRIME OF THE CENTURY!
The Sleeping City.
BIGGEST BURGLARY IN HISTORY BAFFLES THE BULLS!
Master Mind Behind the Wall Street Mystery?

The imagination is staggered (it ran) by the possibilities opened up by this morning's outrage on the five banks. If by wiping out the consciousness of the denizens of the Business Center of a Great City for two hours a gang of criminals can clean that area of all its movable wealth (for the loss was vastly exaggerated), who can foretell where such operations will stop? Millions of dollars have been lost in the robbery. Five of the most important banks in the country have been crippled. The criminal no longer is satisfied with guerilla raids on the law-abiding world. He has declared War!

Organized efficiency is the keynote of this startling coup. In the execution of their fell purpose the gang of criminals have not wasted a single movement. The attack was made with the precision that indicates a leader of genius. Behind it is the brain of a master crook, a Napoleon of Crime. The mind that could conceive the plan of doping a whole district by mysterious means and so organize the manœuvres of his subordinates is not the mind of the ordinary denizen of the Underworld. It is the mind of a Warped Genius.

To connote the evidence is a matter of difficulty, for there is no evidence to connote. The mind of the master crook has seen to that . . .

The writer goes on for half a column an dsucceeds in telling how bewildered he is. Then he draws a dramatic picture of the scene, as he imagines it, during the two hours:

. . . It is like a City of the Dead. About the silent streets recumbent forms of sleeping men are huddled in the doorways or are spread across the sidewalks. Here and there, with his useless club beside him, lies the blue-coated guardian of the peace. A faint gleam of white from another inert figure shows where the clubman has been overcome, stricken down by the mysterious sleep that has fallen like death upon the idle and the occupied alike. Automobiles, with their brilliant headlights throwing the level beams insisted upon by law, are drawn up in the roadways, and seem to carry cargoes of dead men. It is as though some intangible power had stopped all movement with the wave of a magic wand. From the elevated railway on Sixth comes the roar and hum of a passing train. . . .

That was a point I had missed—and what about the subways?

. . . and from pleasure districts uptown is heard the quiet murmur of the traffic, the subdued echoes of moving people. Except for these, the silence is the silence of Death.

Suddenly, under the pillared mass of a great building, a pinpoint of light emerges, and it grows into a blinding glare. Oxy-acetylene! It lights up a cluster of masked men and flashes off their goggles of blue glass. With unhurrying speed they do their work, and in their unconcern cast no glance at the huddled forms around them. . . .

There's a lot more like that, before he begins to tell of the first glimmer of dawn, in which shadowy companies assemble and break up, man by man, each going his own way—I suppose with twenty-five kilos of gold apiece! Well, I had not thought of a perfect army of crooks to manhandle the stuff. He finishes up on a great note, like an old-time "movie" subtitle:

And the Mind that conceived all this, the Arch-crook, the Master Criminal, brooded the while over the conquered City. For the thousandth time, maybe, he connoted his plan of campaign, and smiled to think that it could not fail. The whole of civilized America lay at his mercy, and he had the power, plus the will, to bring ruin and chaos to its prosperous centers. The wealth of the nation was his for the grasping.

Malign this personality must be, but is it the motive power of a new anarchistic movement against established order? Is it, by any chance, the Master Mind behind a recrudescence of the Idea we used to know as Bolshevism? Until the identity of this Napoleon of Crime is established, until he is immured in our strongest prison, he, with his secret and mysterious weapons, has the wealth of the Nation at his Mercy!

If this Master Mind is to be beaten, only a Master Mind can do it, and we beg leave to doubt if the present Chief of Police, the spineless and supine Conrad Dickermann, fills the Bill!

With all my own theories gone astray I was, as I say, quite in sympathy with this writer in his bewilderment. What sort of crooks were they who were capable of relinquishing two million dollars in negotiable securities? It is true that there would have been some difficulty in disposing of the scrip, in the face of the broadcasting by radio of the descriptions, but the thing was not impossible. The newspaper man was right when he said that the robbery was a masterpiece of organization, for in whatever way it was effected, there must have been the slickest co-ordination between the members of the gang. Nor was he far wrong in attributing the organization to a "Master Mind." Something of the kind was behind

(Continued on page 206)

"BUILD YOUR OWN" WITH "RASCO" PARTS!

Buy from the Oldest and Original Exclusive Radio Parts House in the United States

We pay ALL transportation charges in U. S. ALL GOODS SENT PREPAID IN 24 HOURS

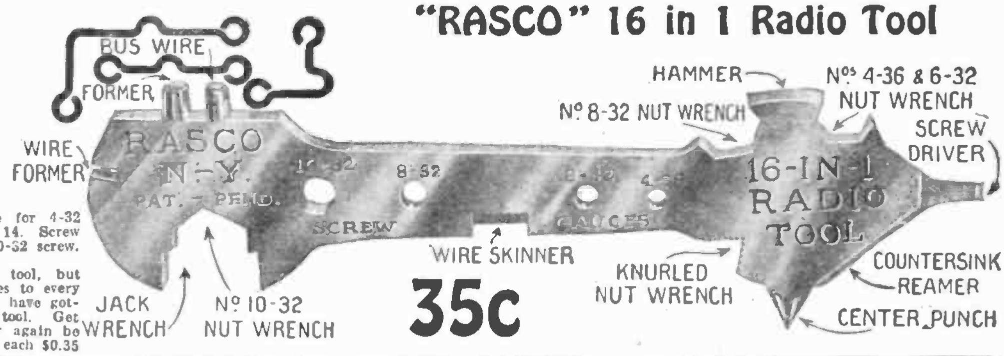
Order direct from this page.

NEW AND EXCLUSIVE "RASCO" GOODS

Money refunded if goods do not satisfy

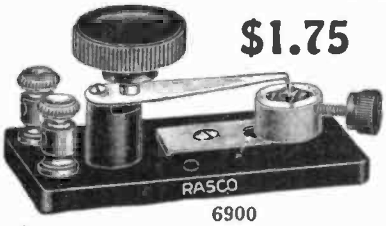
"RASCO" 16 in 1 Radio Tool

HERE it is! The radio tool that will bring happiness to all radio experimenters and constructors. Here is a tool that does 16 different things and does them well. A tool that does practically everything required in building your radio set. The tool is built of hardened steel, size exactly as per illustration, highly finished. Here are some of the uses: 1. Screwdriver. 2. Center punch. 3. Countersink and reamer. 4. Bus bar wire bender. 5. Bus bar and wire bender for 8-32 screw. 6. Bus bar and wire bender for 6-32 screw. 7. Socket wrench for jacks. 8. Socket wrench for 4-36 nuts. 9. Socket wrench for 6-32 nuts. 10. Socket wrench for 8-32 nuts. 11. Wrench for knurled nuts. 12. Screw gauge for 4-32 screw. 13. Screw gauge for 6-32 screw. 14. Screw gauge for 8-32 screw. 15. Screw gauge for 10-32 screw. 16. Knife for wire skinning.
These are only the important uses of the tool, but many other uses will readily suggest themselves to every radio experimenter. You will wonder how you have gotten along before without the 16 in 1 radio tool. Get one of these happiness tools. You will never again be without it. J4800 RASCO 16 in 1 Radio Tool, each $0.35



Crystodyne Detector. For All New Oscillating Crystal Circuits

(PATENTS PENDING)



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$1.75

Here is a detector which has been especially developed by us for the new Crystodyne circuits. This detector while using the natural mineral zincite can be used with any other crystal as well. Several unique features are embodied in this detector. To begin with it is the only detector that has a sliding crystal cup with perfect contact arrangement and which cup not only slides but rotates with an eccentric motion. (Note slot A.) By means of the small knob the cup slides easily so that any point of the crystal can be brought into contact. A new crystal can be inserted immediately by unscrewing the small knob. The contact plate which at the same time forms the catwhisker is made of spring steel. The combination of steel-zincite is the only one that was found practical for the Crystodyne oscillating crystal. Note the micrometric adjustment that can be made by means of the large knob bearing against the steel spring. This raises and lowers the steel point to the finest possible degree. The base is of bakelite, all parts nickel plated and polished.
J6900—Crystodyne Zincite Detector with Crystal $1.75
J6900—Natural Zincite Mounted Crystal especially tested for Crystodyne work, fits any crystal cup..... .60

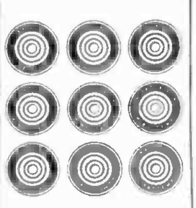
"RASCO" Snap Switch

This switch is intended as a battery switch to disconnect your "A" batteries.
Only one hole to drill. No tools required to mount, use your finger and thumb. Also this switch takes up a minimum of room, much less than other switches, the bare of the switch measuring only 1¼x½". All metal parts nickel plated. A switch you will be proud to possess. J4850—RASCO Snap Switch. Each 25c

4850

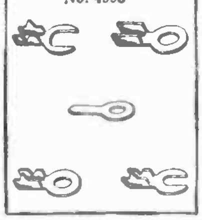
25c

Rasco NAME PLATE ASSORTMENT No. 4994



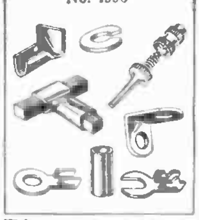
This Name Plate Assortment Packet contains Nine Binding Post Name Plates as follows: one Aerial; one Ground; two Phones; one "A" Bat. —; one "B" Bat. +; one "A" Bat. + "B" Bat. —; one "C" Bat. +; one "C" Bat. —. J4994 Nine Name Plate Assortment.... $0.20

Rasco LUG ASSORTMENT 50 LUGS 5 DIFFERENT STYLES No. 4995



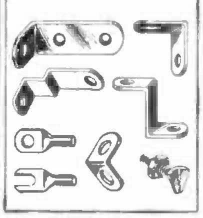
This Lug Assortment Packet contains fifty of the most important lugs for the man who "Builds His Own" as follows: 10 lugs for 8/32; 10 for 6/32; 10 prong lugs (solderless) 6/32; 10 ditto 8/32; 10 flat type 6/32. All lugs are tinned. J4995 Lug Assortment...... $0.22

Rasco RADIO NEEDS ASSORTMENT 108 PIECES No. 4996



This assortment contains 108 pieces as follows: 36 "T" Wire Bus-Bar Connectors; 4 Adapter Bushings (to fit ¼" dial to 3/16" shaft); 4 Separable Phone Tips; 4 Angle Brackets; 24 Lock Washers; 36 Assorted Lugs, already tinned for easy soldering. J4996 "RADIO NEEDS" Asst. $0.48

Rasco RADIO HELPS ASSORTMENT No. 4997



Here is an assortment that everyone building a radio set needs. Contains the following: 12 Assorted "Perfect" Lugs. 6 Grid Leak Mountings. 4 Dial Markers. 6—1475, 6—1476 3—1490, 2—1505 Brackets. List Price of all parts, $1.32. J4997 Radio Helps Asst.... $0.98

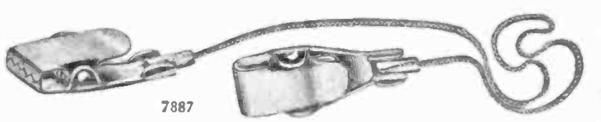
RADIO DIAL BUTTON

You are interested in radio;—you have a radio set, or you are a radio experimenter. You know it and your friends know it; but suppose you casually meet another radio man. He will not know that you are interested in radio, nor will you know that he is. For you and every radio enthusiast the new radio dial button has been created. It identifies you immediately and will help you and everyone else to break the ice when "Greek meets Greek."

The new emblem is a small button measuring ¾ in. in diam. It is an exact replica of a standard modern radio dial. It has a raised knob and the dial graduations are exactly like the best radio dial. Along the lower circumference the word "RADIO" is set in gold. The entire dial is made in best black enamel. All lettering, figures and graduation marks are inlaid gold on enamel. The knob part is also in gold. Best gold plate is used. The button is equipped with a screw back so that the emblem can be attached to your button hole in a few seconds. The most beautiful radio emblem ever made. Thousands are already being worn and soon everyone interested in radio will wear it. Get one or more of these buttons today. Made of best materials. It will positively not tarnish and it lasts for years.
J7799—"Rasco" Radio Dial Button, each $0.25

"RASCO" Clip Leads

Here is something that every experimenter has been waiting for impatiently. This is a flexible silk-covered conductor to the ends of which are soldered strong brass spring clips.
Instead of using wires to make your connections—screwing and unscrewing binding posts



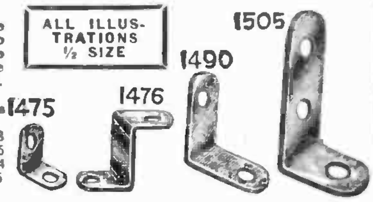
7887

—a clip lead hooks in a jiffy onto any wire, any binding post or other conductor in order to make a safe experimental connection.
"RASCO" CLIP LEADS come in two colors, green and red, to distinguish connections. Brass clips have powerful grip. Length of clip lead, one foot.
J7887 RASCO CLIP LEADS. Each.... $0.12
Dozen lots 1.35

"RASCO" Brackets

Here is a line of small brackets evolved especially for the man who "Builds His Own." They can be used in a number of different ways—to hold tuning coil tubes; inductances; spider webs, etc.; to hold up panels; to attach various instruments to baseboards, etc. "Rasco" brass brackets are stamped from heavy metal and have been designed to do the work right. They are nickel-plated and carefully finished.
All illustrations are exactly half-size. Every builder needs at least a dozen of these. Order them now and save money and effort.
J1475 Brass Angle Piece, 5/16" wide x 7/16" high. Each.......... $0.03
J1476 Brass Bracket, ¾" high x 2 lugs ½" long. Each.............. .05
J1490 Brass Angle Piece, size ¾" x ¾". Each...................... .04
J1505 Brass Angle Piece, size 1½" high x ⅝" long.................. .05
Dozen lots, each style 15 percent discount.

ALL ILLUSTRATIONS ½ SIZE



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Write or wire for territory that is still open on the specialties described on this page. These articles are widely advertised and you will have a demand for them almost immediately.

We shall be glad to send samples to responsible and rated concerns. Address all wholesale inquiries to

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The Ark of the Covenant

(*Continued from page 204*)

it all. Where neither he nor his fellows were at all helpful was in suggesting a reasonable explanation of the anæthesia.

V

Radium Bromide in Unheard of Quantities in the Boxes in the Post Office

I was hoping that Dan Lamont would perhaps have come on something that would help to explain the mystery, for I was certain that if any scientist in America was better equipped than Dan for making the discovery, he was so obscure as to be useless. Dan is a top-notcher.

I found the little chap in a great state of excitement, and as soon as he saw me he pulled out his loose change and began to rattle it in his cupped hands like mad.

"You've found the thing that tarnished the gold!" I exclaimed.

"No," he said.

"Then you've hit on the dope that was used?"

"No."

"Then what the devil's all the excitement about, Dan?"

"Jimmy," he said solemnly, "a wonderful thing has happened. At this moment there is in New York more radium bromide than was ever known to exist in the whole world!"

"Well, what about it?"

"What about it! What a phlegmatic ass you are, Jimmy! Don't you realize what it means?"

"No," said I, merely to egg him on.

"It means that experiments in radio-activity, in physics, in therapeutics, can be carried on on a scale undreamt of up to now. It is immense! Great Christopher and the hard-boiled egg! Do you know what it means in money alone—the value of the stuff?"

"Thousands, I suppose?"

"Don't be a fat-head, Jimmy. It means millions, millions! Radium worth several millions of dollars was sent to five of the scientific and surgical institutes in the city this morning."

It came to me in a flash.

"In square black boxes, unstamped through the Post Office!" I yelled.

"Yes," cried Dan. "How did you know?"

"Because I just missed seeing them this morning," I said. "Is there any clue to who sent them?"

"Not a thing," said he. "Where they come from nobody knows. Just after you left me this morning, I was called up by the Post Office to go down there in a hurry. You know I'm supposed to be all right about explosives ever since I handled that I. W. W. outrage for them in 1925? Well, they had an idea that something of the sort was on again, and they called me in.

"When I got down there, I found a group of officials round five black boxes, containing heavy lead cases. I thought their explosives idea was mad, and I pried up the thick lid of one of the cases with a screwdriver. Inside the case was a heap of pinkish salts. I could hardly believe my eyes, for it seemed to me to be one of the radium compounds—either chloride or bromide—with the usual barium impurity in it. I got away from it, quick, and had them shutter all the windows. By good luck I had a tiny scrap of willemite in my pocket, and in the darkness, held above the salts, it gave off a lovely glow. I had no doubt. It was radium—heaps and heaps of it—and worth a fortune!"

(*Continued on page 208*)

BURIED TREASURE can still be found in CHEMISTRY

Good Chemists Command High Salaries

and you can make yourself independent for life by unearthing one of chemistry's yet undiscovered secrets.

T. O'CONOR SLOANE, A.B., A.M., LL.D., Ph.D.,

Noted Instructor, Lecturer and Author. Formerly Treasurer American Chemical Society and a practical chemist with many well known achievements to his credit. Not only has Dr. Sloane taught chemistry for years but he was for many years engaged in commercial chemistry work.

Do you remember how the tales of pirate gold used to fire your imagination and make you want to sail the uncharted seas in search of treasure and adventure? And then you would regret that such things were no longer done. But that is a mistake. They *are* done—today and everyday—not on desert islands, but in the chemical laboratories throughout your own country. Quietly, systematically, the chemist works. His work is difficult, but more adventurous than the blood-curdling deeds of the Spanish Main. Instead of meeting an early and violent death on some forgotten shore, he gathers wealth and honor through his invaluable contributions to humanity. Alfred Nobel, the Swedish chemist who invented dynamite, made so many millions that the income alone from his bequests provides five $40,000 prizes every year for the advancement of science and peace. C. M. Hall, the chemist who discovered how to manufacture aluminum made millions through this discovery. F. G. Cottrell, who devised a valuable process for recovering the waste from flue gases, James Gayley, who showed how to save enormous losses in steel manufacture, L. H. Baekeland, who invented Bakelite—these are only a few of the men to whom fortunes have come through their chemical achievements.

What Some of Our Students Say of This Course:

I have not written since I received the big set. I can still say that it far exceeded my anticipations. Since I have been studying with your school I have been appointed chemist for the Scranton Coal Co. testing all the coal and ash by proximate analysis. The lessons are helping me wonderfully, and the interesting way in which they are written makes me wait patiently for each lesson.—MORLAIS COUZENS.

I wish to express my appreciation of your prompt reply to my letter and to the recommendation to the General Electric Co. I intend to start the student engineering course at the works. This is somewhat along electrical lines, but the fact that I had a recommendation from a reliable school no doubt had considerable influence in helping me to secure the job.—H. VAN BENTHUYSEN.

So far I've been more than pleased with your course and am still doing nicely. I hope to be your honor graduate this year.—J. M. NORKUS, JR.

I find your course excellent and your instruction, truthfully, the clearest and best assembled I have ever taken, and yours is the fifth one I've studied.—JAMES J. KELLY.

From the time I was having Chemistry it has never been thus explained to me as it is now. I am recommending you highly to my friends, and urging them to become members of such an organization.—CHARLES BENJAMIN.

I shall always recommend your school to my friends and let them know how simple your lessons are.—C. J. AMDAHL.

I am more than pleased. You dig right in from the start. I am going to get somewhere with this course. I am so glad that I found you.—A. A. CAMERON.

I use your lessons constantly as I find it more thorough than most text books I can secure.—WM. H. TIBBS.

Thanking you for your lessons, which I find not only clear and concise, but wonderfully interesting. I am—ROBT. H. TRAYLOR.

I received employment in the Consolidated Gas. Co. I appreciate very much the good service of the school when a recommendation was asked for.—JOS. DECKER.

Experimental Equipment Furnished to Every Student

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The Ark of the Covenant

(*Continued from page 206*)

The Mystery of the Envelopes

"Was anything said about the envelopes?"

"You mean the big envelopes with the securities stolen from the banks? That's the funny thing about the whole affair. No two of the envelopes or packages was addressed in the same handwriting. We tried to connect them up from the fact that they were all unstamped, but it was apparent that ten different hands had written the ten different addresses."

"I think it binds it. Wouldn't you say that the crooks who broke into the banks this morning sent the radium to the institutes?"

"Would you? You can be safe, perhaps, in assuming that the radium was sent by one individual, or group of individuals, and that the envelopes were sent by the thieves, but can you be certain that the two groups are identical? Is it likely that people capable of the Wall Street affair would be the sort to send radium round—like tea?"

"It sounds contradictory—but they sent the securities, that's certain," said I. "And I've got a notion that the mind that could conceive the robbery, and the gas, and the sending of the securities, is quite capable of doing the other. I'm not going to lose sight of the possibility. Have you formed any opinion of how the anæsthetic was administered, Dan? Have you come on anything to explain the tarnishing of the gold?"

Dan rattled his loose change before replying.

"I haven't a ghost of a notion," he said. "The whole thing's a complete mystery. But I have turned the entire laboratory to testing for the stuff that fixed the gold—and I'll explain the anæsthetic somehow—even if it means discovering one with the same powers myself! This thing's got me going!"

CHAPTER FOUR.

The Tale of the Finn

I

I did not mean to leave Dan Lamont that afternoon until we had gone over all the points of the robbery very thoroughly. I have the greatest respect for my friend's mind.

One of the first things Dan did was to piont out where I had made the very sap-headed break in my theorizing. When I told him that the sleep-producing gas was what had stopped the engines of the automobiles, he grinned at me in a sort of sarcastic way.

"Are you chemist enough to tell me what there is in the air that enables the automobile engine to combust its gasoline?" he asked.

"Don't be funny, Dan," said I, and innocently answered him. "Oxygen, of course."

"Clever fellow," he purred. "And now will you tell me what the human engine gets out of the air to help *its* combusiton?"

Right there I saw where I had pulled the bone. It was obvious that a gas strong enough to deprive an automobile engine of its oxygen would have deprived humans of their lives.

I dare say I deserved all the chaffing he gave me, but he rubbed it in all afternoon.

By and by he was sprawling on the floor of his sitting-room, searching the newspapers for further information that might throw light on the mystery. He had managed to get his mop of flaxen hair so tangled up and over his eyes that he looked like one of those silky-haired Scots dogs.

The Ark of the Covenant

"A clue, a clue, a clue—let's find a clue," he was chaffing me. "Let's find a clue on which to base a reasonable hypothesis, my dear Jimmy. I said, mark you, a reasonable hypothesis. The gas that stopped the engines doped the bulls! It may sound all right—but the reasoning is just what might be expected from a mere mechanic."

"Oh, shut it, Dan!"

He shut one eye and recited at me:

"The famous airman, looking for a gas,
Pulls a large bone and proves himself an—
egregious mechanic!"

"You might have rhymed," said I, and threw a cushion at him.

"Oh, that that brain which did the ether
penetrate
Should ossify and fattily degenerate!"

he finished and threw the cushion back at me.

"I've found another curious robbery of last night that seems to have escaped you, you slug," said he. "Come and look at this, Jimmy."

Five Thousand Litres of Gasoline Have Disappeared

I got down on the floor beside him. He had one of the stubby fingers of his childish hand on a paragraph in a newspaper. This briefly stated that five thousand litres of high-grade gasoline had vanished in some mysterious fashion, during the night, from one of the big containers in New Jersey belonging to the Standard Oil Company.

"That's a curious thing," said I.

"It is a curious thing," Dan agreed. "Somebody gets away from the financial district with over three thousand kilos weight of gold—and on the same night some one else gets away with five thousand litres of gasoline. What do you know about it, son?"

"Seems to be a craze for weight-lifting sprung up."

"Looks like it," he murmured. "Now, here's another funny story——"

He pointed to another paragraph tucked away on the same page. This reported the abstraction of a large amount of eatables from a big provision store, also in New Jersey, during the night, but here gold dollars had been left to pay for the goods taken away.

"You're not connecting those two things up with Wall Street affair, are you, Dan?"

He took out his watch.

"It's now twenty minutes to four," he said calmly. "We can be over beyond Newark inside the hour with my roadster, if you'll drive. We'll see if the things do connect up."

At the Gasoline Station

At the gasoline station we got little information. Nobody could tell how the fuel had been taken. The station had been closed on the Sunday night, and had been left in charge of a watchman, the manager informed us, and the watchman had sworn he knew nothing about it.

"Did the watchman by any chance confess to having fallen asleep?" I asked the manager.

"He swore he hadn't," said the official, "but I expect he did. If he didn't, he's in league with the crooks, and the police have got him."

"Stop a bit," Dan Lamont interposed. "You're perfectly certain that the gasoline has been stolen? Isn't it possible that some mechanical device in the tank has failed, that the oil has slipped back to supply?"

"We thought of that," said the manager, "and the mechanism has been thoroughly overhauled. But there isn't any doubt that the outlet pipe was opened in the night and the gasoline taken away."

The Ark of the Covenant

"The watchman is unshaken in his statement that he did not fall asleep?" I asked.

"Oh, yes. He's fixed on that—but he might be lying, don't you see? He's supposed to be awake all night, and to make his rounds at definite intervals. If he had fallen asleep, he wouldn't like to confess it."

"Where has he been taken to?" asked Dan.

"He's at the local station."

"Right," said Dan. "Let's go there, Jimmy."

The watchman was an elderly Irishman, and just the type one would expect to find at the job. He was stubborn to begin with and refused to talk at all. It was the merest chance that Dan addressed me by my surname, and at that the old boy's attitude changed.

"Are ye Mr. Boon, the flyin' man?" he asked.

"That's me," I admitted, "unless there's another of the name."

"But are ye the Mr. Boon that has the works out at the top end av Long Island?"

"That's me."

"Well, ye've got a son av mine workin' for ye—name av McGinty."

"McGinty your son?" said I. "Well, he's a good fellow, Mr. McGinty, and one of my best mechanics."

"Ye make me proud to hear it, sorr," said the old man. "He swears by you, so he does."

After that, everything was easy. The old man admitted that he'd fallen asleep about one o'clock in the morning, but that he didn't understand how it happened. We pointed out to him that it would be better to confess to having fallen asleep, rather than leave the idea that he was in league with the gang that had emptied the tank. He then said he had been sound between one and three in the morning. We questioned him closely, and began to have little doubt that he was victim to the same dope that had put Wall Street to sleep. He had not heard of the bank robberies. We left old McGinty with the assurance that he was not to blame in any way, and that there was every prospect of speedy release if only he'd be frank to the questioning of the detectives in charge of the case.

II

The Robbery (?) of the Provision Store

Dan and I spoke to the officer in charge of the district, and got a promise from him that he would put the idea to the investigator who had the matter in hand.

"It's just as well that you've got that out of the old man," said the police officer. "It seems to me that we're on the way to saving two of our best men."

"How's that?"

"You'll have heard that Schomberg's Stores were broken into about two this morning?"

"Yes. To find out what we can about that is part of our business over here."

"Well, you can hardly call the affair a robbery," the inspector said, "what with money being left to cover the loss and damage to the Stores. But how the place was broken into without the complicity of at least two of our patrolmen, we don't know, and we didn't like the idea. After the news came out about the Wall Street affair, these two men came back with a confession that they'd been asleep, but we had a suspicion that they had only seized on the chance to clear themselves. It did seem a bit far-fetched that the gang that doped the folk around Wall Street, and got away with that haul, would bother to raid a New Jersey

The Ark of the Covenant

provision store and leave money to pay for what they took. But if the old man didn't know about Wall Street, before he admitted he'd fallen asleep, the chances are that he's telling the truth."

"There was no watchman at Schomberg's Stores?"

"No, the place is shut up at night—nobody on the premises."

"Could we see the two patrolmen in question?" asked Dan.

"Easy," said the inspector. "They sleep at the station, and are sort of confined to barracks."

To be continued

Electrical Notes

A desk telephone contains rubber from the East Indies, platinum and asphaltum from South America, silk from the Orient, cotton from the South, coal and iron from Pennsylvania, copper from Montana, lead from Missouri, linen from Ireland, wool from Australia, mica and shellac from India, nickel from Canada, and even a little gold from Alaska. In all these places the task of the Western Electric Company, as telephone builders, begins.

Nowadays the century-old clock in Frank Lindsley's home at Dreahook, N. J., ticks off the time right to the second—thanks to the time signals broadcast by radio, and a good quality loud speaker.

Few persons could win a guessing contest as to what is needed in the manufacture of a private branch telephone exchange switchboard which is so familiar. In the manufacture of the cabinet, which is three feet, two inches wide and two feet, five inches deep, sixty parts made of six different kinds of wood are used, totalling 73 board feet of lumber, all of it especially dried.

Twenty-one wood-working machines are used in making the private branch telephone exchange switchboard cabinet. Its iron and steel framework is composed of 65 pieces of electro-chemically treated material, weighing forty-two pounds. To make these parts, nine metal-working machines are required.

In assembling a private branch telephone exchange switchboard at the Kearny Works of the Western Electric Company, fifty-nine parts of brass are used, 18 pieces of copper, 262 iron screws, 150 square inches of felt, 304 square inches of fibre and 126 square inches of rubber.

Nine different colored wires made into forty different combinations are used in wiring a private branch telephone exchange switchboard. The length of wire used is, in all, 3,909 feet. Eight ounces of solder and 400 yards of tape are required for the wiring operations. Furthermore, 1,506 holes must be drilled.

Thirteen big lead presses turn out more than ten thousand miles of telephone cable at the Chicago Works of the Western Electric Co. every year.

Electrical Voice Investigation

(*Continued from page* 155)

seems, cut off all frequencies above 4,000 cycles, so that they are definitely defective. Another "filter" was tuned so as to cut off lower frequencies, and this had the effect of making the voice sound flat, as it is called, and piano music became "tinny." This, too, it seems, is a feature of the cheap loud speaker.

It will be seen how valuable this work is in the analysis of sound production and in application to the improvement of radio. An interesting fact which was brought out is the almost inconceivably small amount of energy required to produce a sound. A reasonably high powered electric incandescent lamp such as will be used in a large room would consume 50 watts of power. It has been calculated that it would require 5,000,000 people, nearly the population of New York City, all speaking at once, to develop this amount of power. The human ear, it follows from the above, is one of the most sensitive instruments in existence.

Measuring the Amplification Factor of a Vacuum Tube

(*Continued from page 177*)

voltage drop across R_2 to the voltage drop across R_1. Since the alternating current flowing through R_1 and R_2 is the same, the amplification factor becomes the ratio of R_2 to R_1.

From the average of a number of tests on the UV-201A amplifier, we have

$R_1 = 20$ ohms (fixed)

$R_2 = 158$ ohms

$$\text{amplification factor} = \frac{R_1}{R_2} = \frac{158}{20} = 7.9$$

The "dynamic method" is the most accurate method of the three described. As the name implies the actual operating conditions of the tube are very nearly duplicated. This may readily be seen from the fact that the optimum operating values of filament current, grid voltage and plate voltages are used with this method.

Listing the results obtained from the three methods in the order of their accuracy, we have

1. By Dynamic Method Amp'n factor = 7.9
2. By Fundamental Method " " = 8.0
3. By Static Method " " = 7.62

These values are seen to agree within the range of errors introduced by the test methods themselves.

Electric Screw Driver

(*Continued from page 156*)

as some operators prefer it unencumbered by a handle. It contains a clutch; when current is turned on the motor starts turning, but the clutch is disengaged normally and only comes into operation when the bit having been placed in the socket is pressed down against the screw.

There is a fan within the case to cool the motor.

A World of Whirling Atoms

(*Continued from page 165*)

best coal would have to be consumed. The volume of coal burned to yield an amount of energy equivalent to that given by the annihilation of one pound of lead is shown in Fig. 7.

If the reader has followed us thus far, he will see as we do the gigantic possibilities of modern science. As we contemplate these possibilities we are awed by the strange contrasts of Nature, which make possible the liberation of Titanic forces through the action of these infinitesimal constituents of matter. Modern technology has built machines exceeding in size and power, all dreams of earlier generations. Yet, how they shrink into insignificance before the tremendous spectacle of the future!

Shall these altered views of the future of our electro-atomic Universe light joy, or strike terror in our hearts? We see the boon to human welfare in the future liberation and control of these latent forces of Nature; but we recoil with horror before the spectacle of these forces subservient to the competitive interests of man. What dormant evil will be awakened when he finds at hand the means for the complete annihilation of his enemies. The war of the distant future may be a dreadful war of electrons and protons, conducted in a silence unbroken by the usual noise of battle and where a "fall" means not wounds or death but the complete cessation of existence, a total annihilation of substance and mind with no trace but energy left behind.

Volta and the Primary Battery

(*Continued from page* 161)

Urged by the eager spirit of inquiry that characterized his youth and illuminated by a profound emotional insight, his researches continued to amaze the scientific world of his time. His eventful career reached a climax of achievement with the discovery of the Voltaic Pile. Everywhere his discovery was hailed with acclamation.

Men like Volta are rare figures in the history of mankind. There have been other great men of science, but few who could dedicate their life to the study of inanimate nature and yet retain a love of the simpler but more significant humanities. Volta saw science in its deeper human significance. His numerous discoveries are but incidental offsprings of his larger studies of science. Studies that, while possessing all the rigor and thoroughness of the scientific method, were ever tempered with that sympathy for the arts which gave birth to his earlier poetry. It was in the realization of this rare character of Volta that the civilized world, in May, 1899, paused in its routine, to celebrate the centennial of Volta's most far reaching discovery, the Voltaic Pile. We illustrate on page 161 some of Volta's discoveries and those few of his experimental apparatus which had been preserved by his countrymen. Much was destroyed by a conflagration in Como, where his original apparatus was on exhibition.

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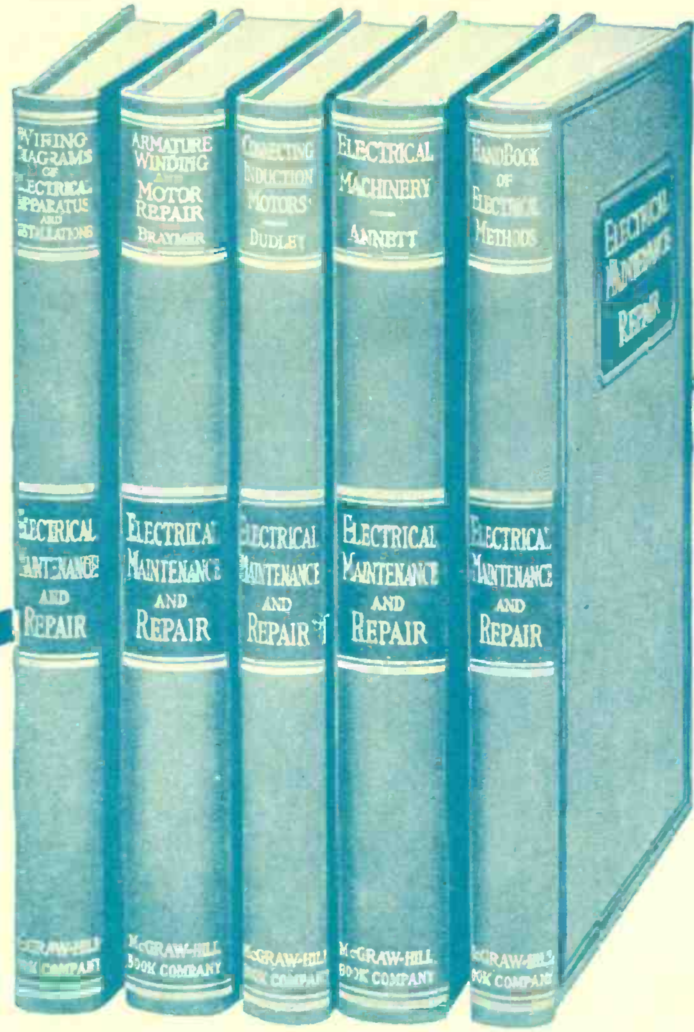

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