October 1925 25 Cents

The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

12 Pages of EXPERIMENTAL RADIO

HOW TO MAKE

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SEE PAGE 820

EXPERIMENTER PUBLISHING COMPANY, NEW YORK, PUBLISHERS OF
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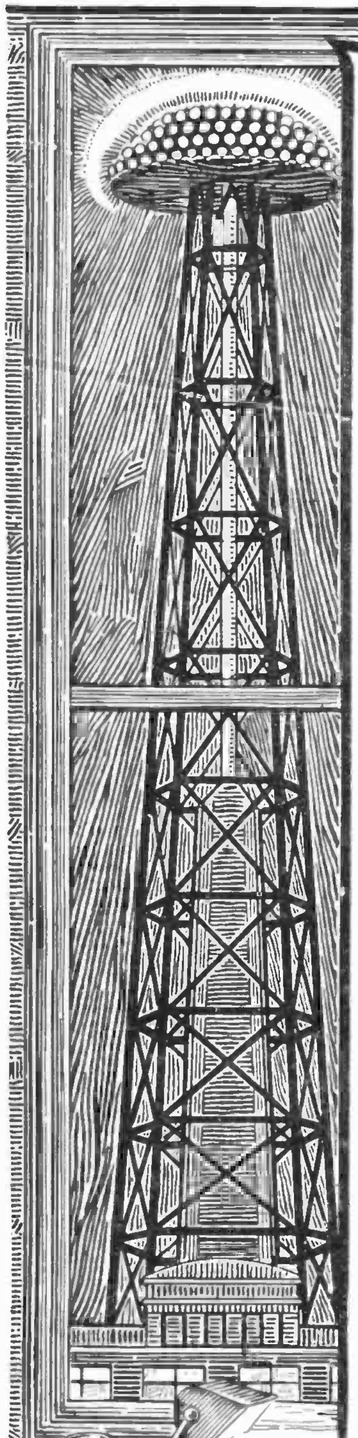

The EXPERIMENTER

Vol. 4 **Contents** No. 12

FOR OCTOBER

IMPORTANT ARTICLES IN NOVEMBER ISSUE

PREPARATION OF DYES AND PIGMENTS. A popular chemical treatment of the difficult subject of artificial dyes. The preparation of fluorescein is treated in some detail.

TESTING INSULATING MATERIALS. A brief account of the most up-to-date methods of measuring the phase difference and dielectric constant of insulating materials. The article is clarified by detailed illustrations.

LIQUID HYDROGEN. An interesting account of apparatus employed at the Bureau of Standards for the liquefaction of hydrogen gas.

THE LULUDYNE. An exceptionally splendid article concerned with the evolution and perfection of a radio receiver, based on the ideals and high character of a wonderful girl in whose honor it was built.

TRANSMITTING PHOTOGRAPHS BY CABLE. A discussion of the method of photo transmission used in the recent communication of Gertrude Ederle's picture from England to America.

MAKING A SELENIUM CELL. A profusely illustrated article on the construction of a sensitive experimental selenium cell.

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As a special service to our readers, we will write the letters for you, thus saving your time and money.

Just write the names of the products about which you want information, and to avoid error, the addresses of the manufacturers, on the coupon below and mail it to us.

If the advertiser requires any money or stamps to be sent to pay the mailing charges on his catalogue or descriptive literature, please be sure to enclose the correct amount with the coupon.

We will transmit to the various advertisers your request for information on their products.

This service will appear regularly every month on this same page in THE EXPERIMENTER.

If there is any Manufacturer not advertising in this month's issue of THE EXPERIMENTER from whom you would like to receive literature, write his name, address and the product in the special section of the coupon below.

TEAR ALONG THIS LINE

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Experimenter Publishing Co., Inc., 53 Park Place, New York, N. Y.

Please advise the firms listed below that I would like to receive detailed information on their product as advertised in the........................issue of THE EXPERIMENTER.

NAME	ADDRESS (Street—City—State)	List here specific article on which you wish literature.	If Catalogue of complete line is wanted check in this column.

Use this space if you desire information from a manufacturer whose advertisement does not appear in this month's issue.

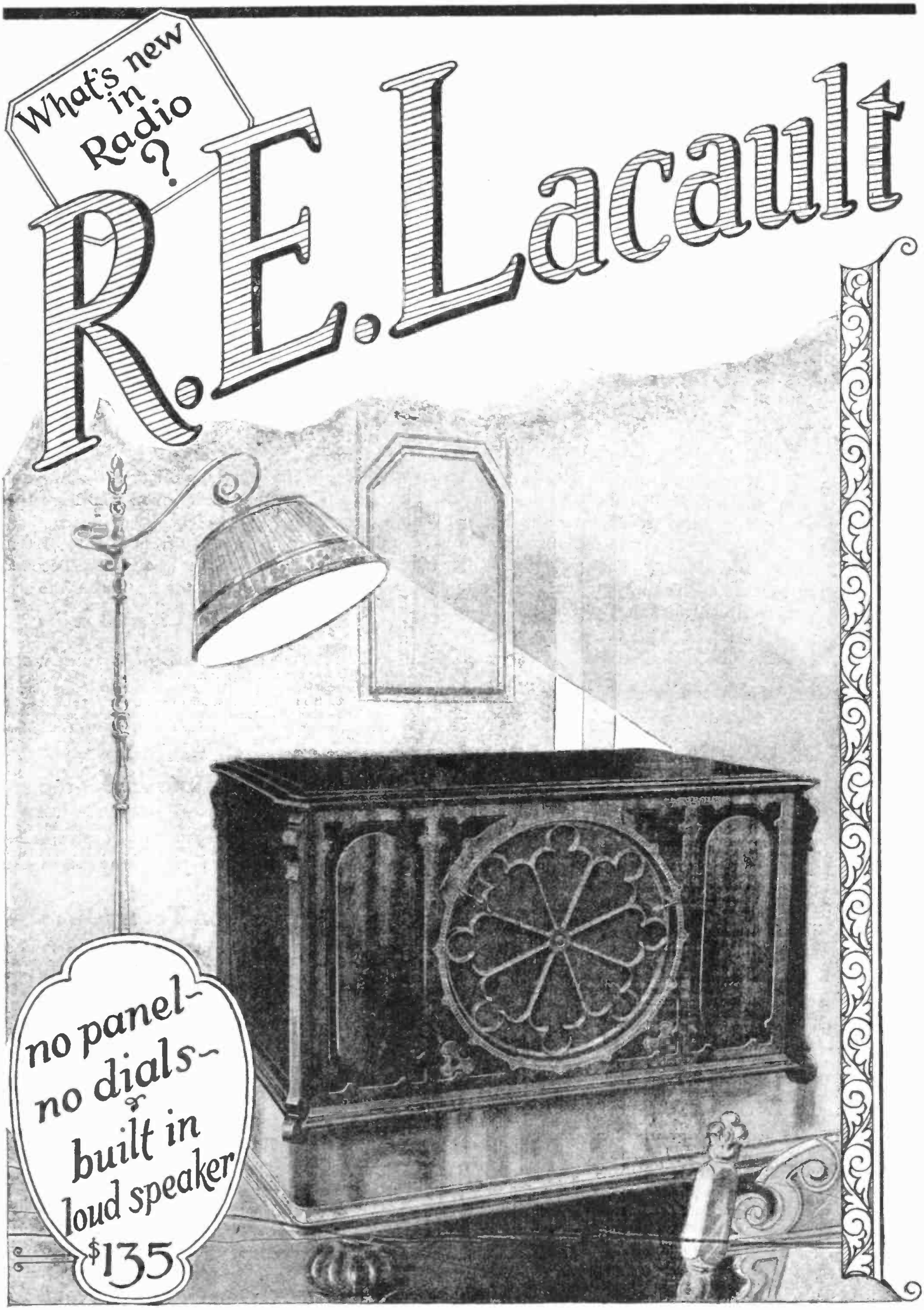
NAME	ADDRESS (Street — City — State)	

Your name.. Dealer's name ....

Your address.. His address..

☐ If you are a dealer, check here. City.............................. State.................. City.............................. State..................

10-25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R. E. Lacault
no panel-
no dials-
&
built in
loud speaker
$135

Leads Again

The Greatest Advances in Radio Design are Embodied in the

new ULTRADYNE

MODEL L-3

R. E. Lacault

Developments which have taken place in our plant over a period of a year, under the personal direction of R. E. Lacault, E.E., formerly radio research engineer with the French Signal Corps Research Laboratories, now stamp the new Ultradyne as the most remarkable radio receiver — remarkable in uniqueness of design, method of tuning, compactness, selectivity, clarity and volume.

To protect the public, Mr. Lacault's personal monogram seal (R. E. L.) is placed on the assembly lock bolts of all genuine Ultradyne Model L-3 Receivers. All Ultradynes are guaranteed as long as these seals remain unbroken.

R E L

IF the Ultradyne Model L-3 were merely another new receiver, its influence in the industry would be little felt.

But it is in reality the first step in the general revision of radio receiver design which is bound to follow its advent.

For the new Ultradyne Model L-3 is an entirely new type of receiver —radically different in appearance and method of operation—gives finer results from finer engineering. Employs 6 tubes, is completely assembled and wired ready for the tubes and batteries.

It has no dials—no panel—no needless controls. Two levers, an exclusive Ultradyne feature, give you control of the entire broadcast program. Its operation is practically automatic—simply slide the pointer to the station you want and adjust the volume control, soft or loud as you like.

Loud Speaker and "B" Batteries self enclosed in a beautiful cabinet that is far from mechanical in design and an ideal mahogany furniture piece for the most charming home.

This new Ultradyne Model L-3 gives you the best there is in radio —truer reproduction than you have ever known before.

Ask your dealer for a demonstration. The contrast between the Ultradyne and other receivers is so marked that the desire to own one will be bred there and then.

Write for descriptive folder

ULTRADYNE

MODEL L-3

PHENIX RADIO CORPORATION

114H East 25th Street :: :: New York City

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COMPARE!

KENMAN 5—MODEL 1926

Since 1913, twelve years, we have been manufacturing the finest grades of radio apparatus. This is the reason why you, as a discriminating radio buyer, should prefer the Kenman 5 Receiver.

For *artistic* design .... *See it.*
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For clearness without howls, squeals or distortion .... *Hear it.*

Then for *price,* with any other 5-tube set-*Compare it*

Compare the Kenman 5 1926 model with any 5-tube receiver at any price. Under equal conditions, its performance will compare with or excel any receiver of its kind on the market. You can pay more but you cannot buy more.

Your Money Back If Not Satisfied

Any Kenman dealer will be glad to demonstrate the exceptional properties of this receiver without any obligation on your part, or if your dealer cannot supply you we will ship you direct on receipt of price with a full money back guarantee if you are not satisfied.

Features of the Kenman Receiver.

Genuine Westinghouse Bakelite throughout, synchronized low loss condensers, calibrated transformers, and other parts in keeping with the high standard we have set. The cabinet, 16" x 9", is a work of art, not alone a radio cabinet but a beautiful piece of furniture, two tone mahogany finish equipped with piano hardware. We have done away with the bothersome binding posts, all outside connections and loud speaker hookup are made by clips, installation is a matter of seconds. Another novel feature is the A—, B— and Ground all on one connection, doing away with howls, squeals and distortion. Rheostats control voltage and volume, also filament control jack for phone use.

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Radio Manufacturers Since 1913

Volume 4
No. 12

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

October
1925

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

Experiments To Try

By Hugo Gernsback

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

EVERY so often some experimenters begin to conjecture what to experiment on next. As I have pointed out many times heretofore, there are experimenters who experiment for the instruction of it, and those who experiment because they hope not only to gain fame or recognition, but financial success as well.

It is of the latter that I wish to speak now. When experimenting, in order to reap financial rewards, it is of course, necessary to pick out or to choose a subject for which there is or should be a big demand. It is the things that are in big demand by the public which are financially successful as a rule. It may not always be apparent that an article will be very successful, because the public has not yet been agitated on it, and no demand for same exists; and it is necessary to create a market by making the public realize that here is something better. The metal bottle top, the safety pin, the typewriter, the telephone, and radio, are all articles that were not necessary to the public before their invention. As a matter of fact, all of these things were looked at askance at first.

Nevertheless we all know the moral contained therein, and when we are experimenting we should always keep such goals in mind. In the radio field, for instance, a good line to tackle is the loud speaker. Radio has now been so standardized that the broadcasting as well as receiving sets, while not perfected to the nth degree, are certainly excellent; but the one fly in the ointment is the loud speaker. Given a perfect loud speaker, you should be unable to distinguish the human voice from that rendered by loud speaker. In a good telephone receiver, and a good radio set, no distortion and no blasting is apparent. The transmission is well nigh perfect. But the minute you put on an average loud speaker, a nasal twang, distortion, and blasting become painfully apparent.

I have always maintained that the diaphragm and the horn type loud speaker is all wrong. Quite a while ago in MODERN ELECTRICS for March, 1909, I described Professor Peukert's experiments which had to do with talking dynamos and talking electro-magnets. Here we have no diaphragm and no horn. All we have to do is to hitch Peukert's electro-magnet to a resonant body, and we should have excellent quality of reproduction. I should be glad to hear from those who have experimented along these lines.

There is still another line of radio experiments that might prove very fruitful. We now use vacuum tubes almost exclusively in our radio sets. However, there is no reason why we should not use detectors of the crystal variety exclusively. In order to receive a signal we first, as a rule, rectify it in a detector, then amplify. We, however, can also amplify it before we detect, by means of radio frequency transformers. The usual detector, such as the galena, cannot be used as a potentially operative device. The carborundum detector, however, can be used with a voltage and therefore becomes a potentially operative device, the same as the vacuum tube in some respects. It should not be impossible to devise some means whereby such crystal rectifiers could be used as amplifiers, just as we use the tube as an amplifier without using it as a detector. That an exceedingly low-priced set which should also be a good one could be produced with such a scheme is not impossible, though it seems so. The proper arrangement would undoubtedly net a tidy sum to the successful experimenter.

One of the country's great banes is the insect known under the familiar name of bedbug. The other day, in New York City, the health authorities had to evacuate a metropolitan theatre, which had become so infested with the insects that further performances were called off. It became necessary to refurnish and redecorate the entire theatre at a cost of thousands of dollars. While certain poisonous gases are now used to rid private houses and large buildings, such as theatres, of this pest, still not much headway is made, because, while the insects themselves are killed, the eggs as a rule are not, so after a short while the insects appear again in greater numbers.

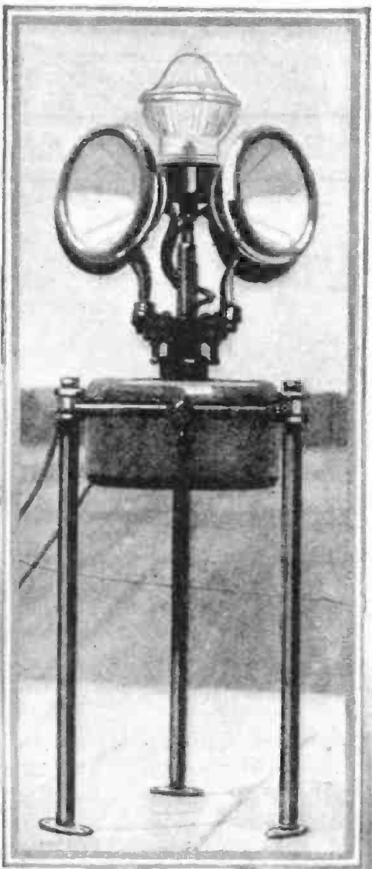
The same is the case in practically every apartment house and a great many homes. The nuisance is more prevalent than many of us care to admit. This is a chemical problem and it should be possible for a good chemical investigator to do some experimenting by breeding these insects in a safe place, under laboratory conditions, and determining what chemical will exterminate them best.

To be sure, there are now so-called exterminators, but while they kill the insects they do not kill the eggs. They are usually in the form of a more or less harmless fluid which can be applied without trouble to furnishings, drapes, etc., without discoloring them, but as soon as evaporated the eggs hatch out and the trouble begins anew.

What is needed, then, evidently, is a fluid of this kind that has the quality of killing the eggs as well as the insects. Extended and methodical experimentation here is necessary and a fortune can be reaped by the experimenter who is successful in his quest.

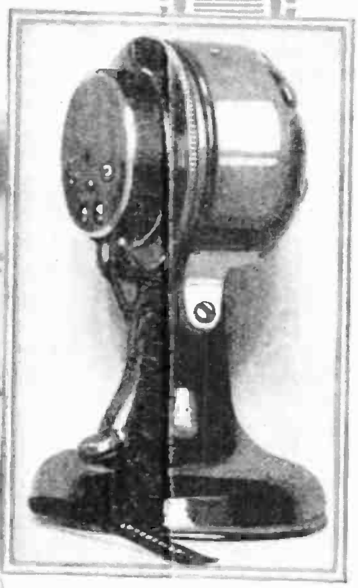
Mr. Hugo Gernsback speaks every Monday at 9 P. M. from Station WRNY on various radio and scientific subjects.

New Things Electric

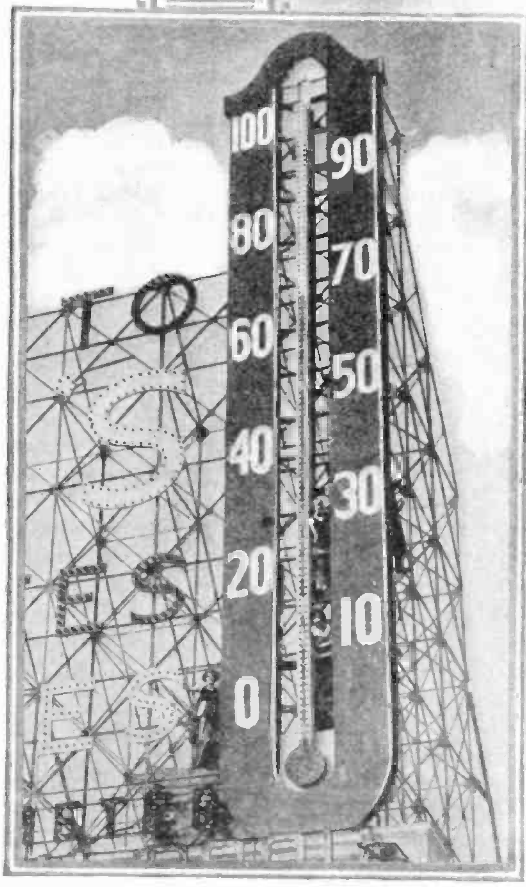


The air mail route between New York and Chicago is marked by 75 signal lights such as that shown at the left. Four Ford headlights are mounted on a turn table revolving six times in a minute. This turn table stands on a tower 30 to 50 feet high. In addition to these five million candle-power beacon lights seventy-five in number are posted along the route.

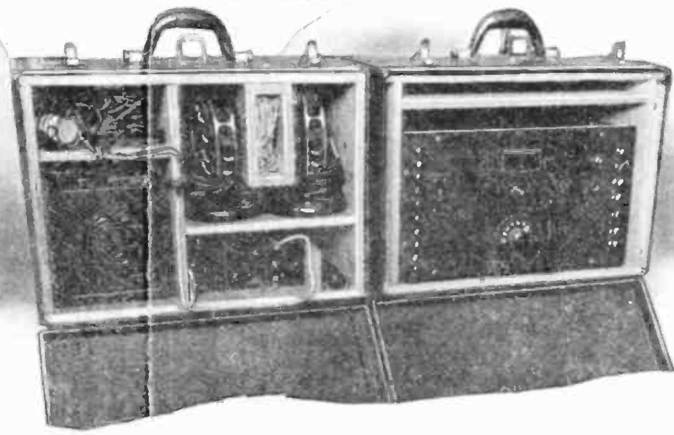
The Misses Elsa Wells and Virginia Darby invade the sanctuary of the Hall of Fame at New York University with a portable radio set. Their four tube reflex and regenerative circuit is here giving a musical treat to Peter Cooper whose statue is seen at the right.



An electric fan motor case converted into loud-speaker for radio. T. E. Styles of Athenia, N. J., removed the motor of an electric fan and placed over the opening thus made an ordinary loud speaker unit. The only additional part necessary is a flange for the unit, but if the fan is quite small, even that is not needed. At the illustration on the left the completed table talker is shown.



The mercury in the largest thermometer in the world located at Atlantic City, N. J., was renewed recently while bathing girls posed on its framework. The "mercury" consists of new electric bulbs which record the temperature at night. By day, the mercury is represented by an endless belt, each degree being half a foot in height.

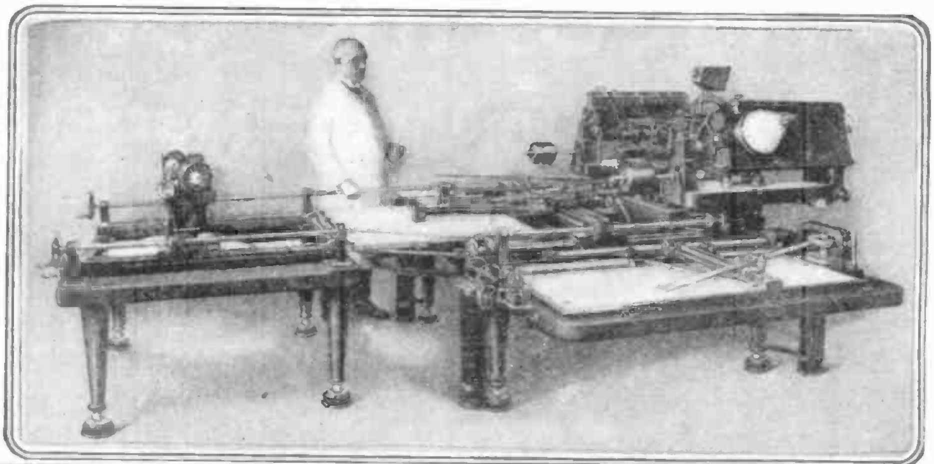


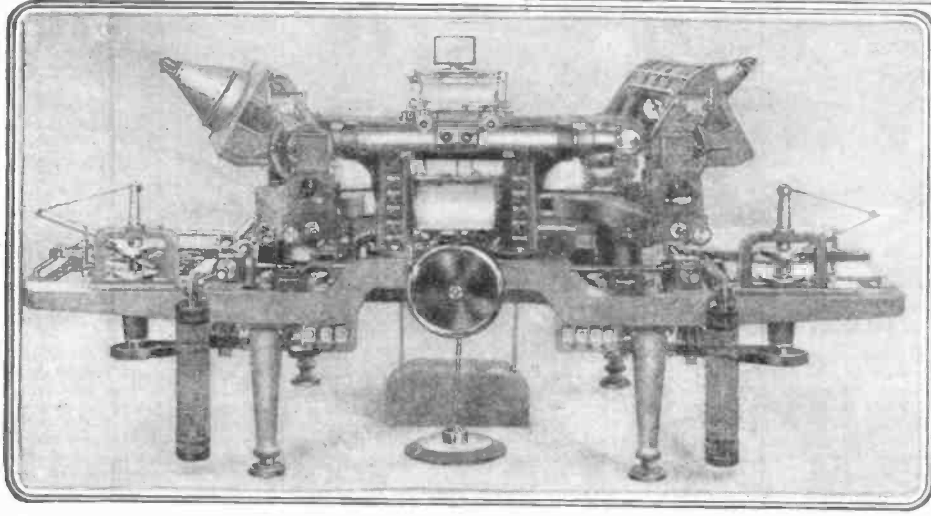
WRNY makes use of this most compact of all broadcast station remote control equipment. The valise at the right contains the remote control amplifier. In the top compartment at the left are the headphones of the control operator. Beneath this is a specially constructed light 40 ampere hour 12 volt "A" battery. In addition the valise contains the two microphones used on remote control work and the "B" batteries. The lower right hand corner holds a compartment for tools.

Maps by Electricity on Airplanes

By H. T. Wilkins

A REMARKABLE German invention which in the near future may play a prominent part in throwing open to civilization new and savage lands, hitherto unmapped by land and marine geographers, is the Autocartograph, devised by a Dresden engineer, Professor Dr. Hugershoff. Ordinarily, maps are built up on a framework of trangular surveys by theodolites on land, or by various surveying instruments on the deck of a hydrographical survey steamer. They may also be based upon aerial photographic views taken by an observer on an airplane flying hundreds of feet above the earth. In each case, the results of the observations are transferred by hand to a series of field sketching maps, the foundation of the subsequent finished charts.





The photographs show a remarkable invention of a German engineer, Dr. Hugershoff, by means of which accurate maps can be prepared on an airplane flying over the area under investigation. Elevation and other topographical features are mechanically depicted by means of this machine, which is called the autocartograph.

Dr. Hugershoff's Autocartograph will, it is stated, plot accurately by mechanical and electrical means a topographical map in one-tenth of the time required by the older hand methods. He looks not at the ground itself, but at a steroscopic view of the same.

The Autocartograph consists of two periscopes, which, when set on an airplane aloft in the air, pointing down vertically or obliquely over a landscape far below, or on a level with the earth (where an airplane survey is not in question), give a steroscopic view of the territory it is desired to map. The level or elevation of the two telescopes is fixed during the survey, and any distortion of the views of the landscape given by the telescopes is corrected by hand-adjustable planes and prisms set in front of the lenses.

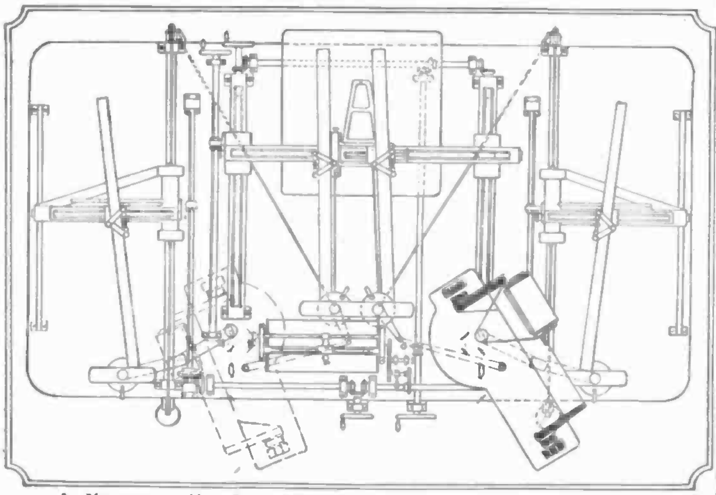
Working in co-operation with the telescopes constituting a giant-steroscopic camera are two theodolites, coupled together, and these latter aid the instrument in measuring heights, distances and contours on the area below the observer, or at his level.

By rotating carriers holding the photo-plates, horizontal distances on the ground surveyed are obtained and heights (or vertical angles) are found by revolving the mirror-planes in front of the lenses of the telescopes.

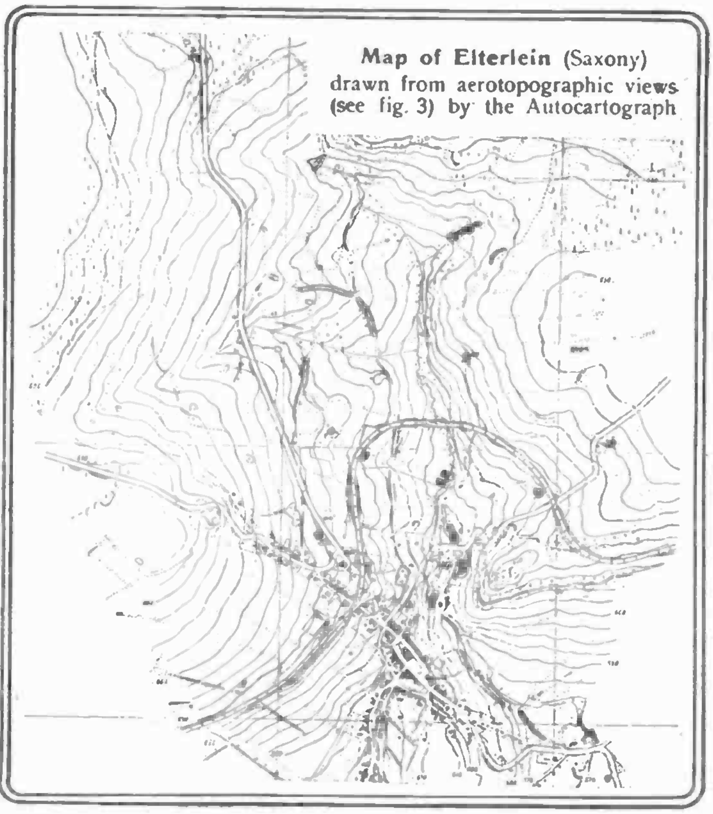
Both rotary movements of photo-plates and mirror-planes are registered on movable scales forming part of the map-making system of the Autocartograph. It measures heights, not by calculation, but mechanically.

The observer who is watching the landscape through telescopes, has two hand-wheels to right and left of his seat, and, by moving these, as required, he can operate mechanical plotting-pencils which map out hills, rivers and the heights, distances and contour lines of the country, so as to be reproduced on a chart at some distance from his seat. If he wants to mark on the chart details as to vegetation, minerals, rocks, marshes, he can do so by the aid of a second plotting-sheet, operated from his seat.

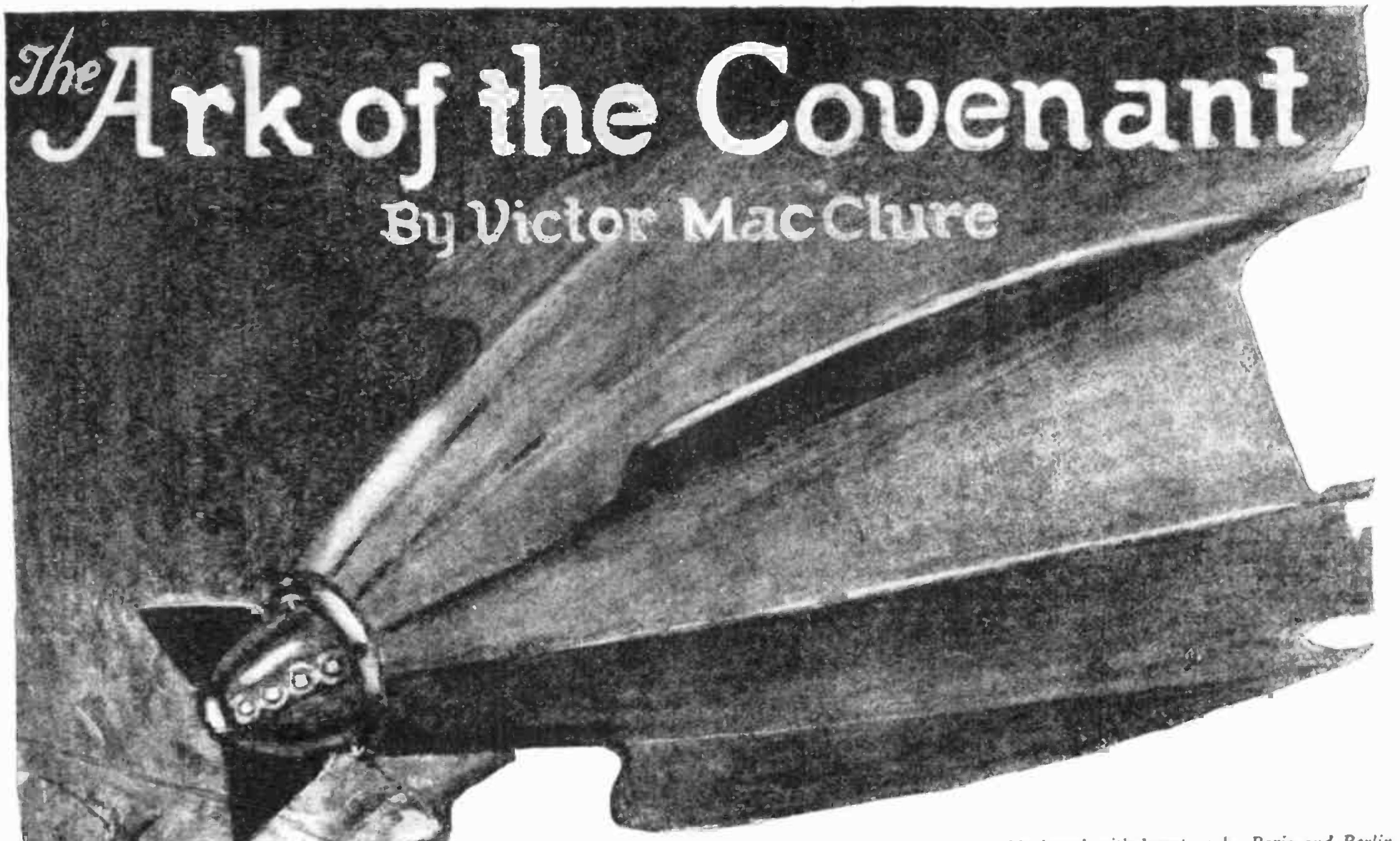
Plans or elevations of landscape features of the terrain are obtained by easy adjustments of the scales and plotting arms of the Autocartograph.



A diagrammatic plan view of the autocartograph with a sample of its work shown at the right.



Map of Elterlein (Saxony) drawn from aerotopographic views (see fig. 3) by the Autocartograph



The Ark of the Covenant

By Victor MacClure

"The Ark of the Covenant floated down the main cavern on her own power. . . . For a moment she hung steady over the entrance basin. . . .

[What Has Gone Before]

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

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

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

The airplane Merlin, the fastest of all airplanes, takes an active part in the story. The mystery deepens when it is found that some millions of dollars of securities have been returned to the banks, but a slightly larger amount of gold has been taken. Anaesthetic bombs are thought of. A provision store has been robbed and money left to pay for what was taken. Thousands of gallons of gasoline have disappeared from a Standard Oil Station.

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

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

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

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

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

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

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

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

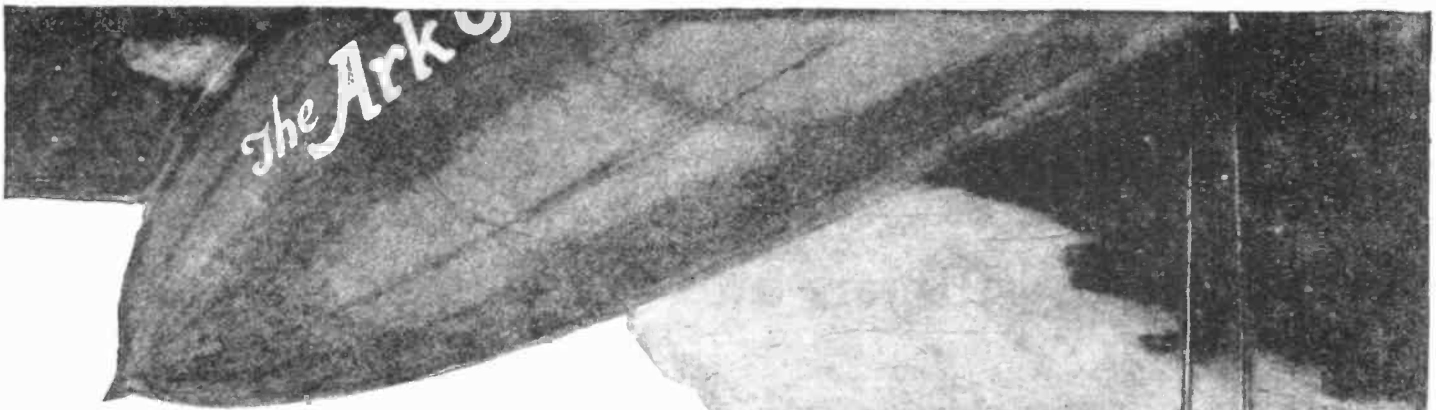
Now comes the story of the formation of the League and the gathering of a crew. A new element and a new gas have been discovered; the earth is drilled for the gas. The great dirigible proposed is described, and tests with the spectroscope and electroscope reveal strange substances in the earth of the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

CHAPTER IV

The Deluge

I

It is not for me, Sholto Seton, one-time commander in His Majesty's royal navy, and always more man of my hands than of the head, to venture an explanation of that marvelous polythalamous geological freak known as the Plateau of the Red Scar; nor is it mine to fathom the processes of nature which brought the treasures, culminating in the radium pocket, to the casual and groping hands of the members of the League of the Covenant. I am fain to rest content, as was my Master, that the gifts



were there for our seeking, and to accept them with reverence in my heart. But to those who seek explanations—whether it be that the work of their lives bids them ask or that they are possessed of an idle, if itching, curiosity—the slight notes of my Chief have been edited and amplified by men of science, and lie open to all who have the wit to understand.

The task that lay to my hand there in the heart of the Amazon forest was plain. I had to keep the crew cheerfully at work, maintain a real, though carefully veiled discipline, and find ways and means for bringing the dream of the Master to realization; to second, in my blundering fashion, in a bewildered fashion sometimes, the working-out of the amazing conceptions of his untiring brain.

Of the concrete, then, I have the knowledge at least to speak fairly. Of the abstract and theoretical, I can only set down the results I saw. And with motives, personalities, characters, I must—to lapse wittingly into Scots—just hirple along.

It was like the Master to be concerned over the possible effect of the radium rays on Lin Greensleeve and me. The little man, who could not heal the great burns so far advanced on his own frail body, made both of us strip and undergo a medicated bath and ointment preventive treatment of his own preparing. For some time no day passed but that he would have us appear for examination.

Nothing, I am convinced, held terror for our fragile little Chief as concerned himself, but, under his habitual repose of manner, Lin and I thought we read a mortal terror for us. However that may be, in the end we were pronounced to be without scathe.

Making a Lead Shield for Handling the Radium

Members of the crew were strictly forbidden to enter the passage or go near the cave until we had taken steps to secure the contents of the radium cache, which the Chief on inspection declared to hold an astonishing quantity. We had no lead in the cavern, but one of the mechanics remembered that the floor of the *Clutha's* engine-room was covered with the metal, and some men were sent down to the wharf to rip it off and bring it to the cavern.

The Chief designed a leaden shield. This had two ingeniously jointed arms ending in box-like mitts, which permitted the handling of a little spade by one, and the holding of a thick lead case in the other. A view of the operation of case and spade was given by a periscope, and light was thrown on the subject by electric bulbs attached to the top of the leaden screen.

When this contrivance was ready, Lin Greensleeve and myself cleared away the débris on the cave floor, by working with spades from behind two lead shields. The débris was removed, the working screen was pushed against the aperture of the cache, and Lin, whose hands were more fitted in size for the box-mitts than my great fists, spooned the precious salts into the case, and when the crevice was cleared, the lid was dropped home. The treasure, worth an enormous fortune, was deposited in a little cave right in the heart of the cave system.

Lin Greensleeve now made a survey with proper instruments, and found the right spot for breaking through into the other passage. Within a day or two the passage to the radium cave was impassable by reason of the fumes from Lin's furnaces. He was not cheated, for when the dampers were up, the roar of the draught through his furnaces rivalled the waterfall in filling every cranny of the caverns with noise.

Membership of the Covenant for Peace

The position of affairs with the League at this time was so:

We had, apart from the Master, sixteen men signatory to the Covenant for Peace—Devonridge, Greyson, Fitalan, Haynes, Lippencott, Curtis, Greensleeve, Whittaker, Grumstock, Higgins, Dane, Thetford and myself—thirteen at work in the cavern. Outside were Travers, Lippencott and Brooks in America, Smithers at the storehouse down river.

We had perfected the Chief's laboratory, harnessed the waterpower of the fall and provided ample electricity for all requirements; we had secured our oil supply, and were able to refine it and store the pure spirit and lubricating oils, and we had wax for our electrical instruments; the gas for lifting our airships was available in great quantity, and we were able to reduce it to its liquefying constant and to store it; our engine-shop, up to date in every particular, was in full working order; we had the building slips ready for the erection of the dirigibles, and we had the living accommodation for our full complement of fifty men all ready for occupation.

Development of the Anaesthetizing Gas

The plans for the Chief and his experiments were well advanced. He had standardized his formula for, and was ready to manufacture, the anæsthetizing gas. He assured me that he was nearing the end of the development of the power that was to bring the world into line with the ideas of the League. In addition to this he and Thetford, as a relaxation for the Chief, had prepared numerous instruments for the

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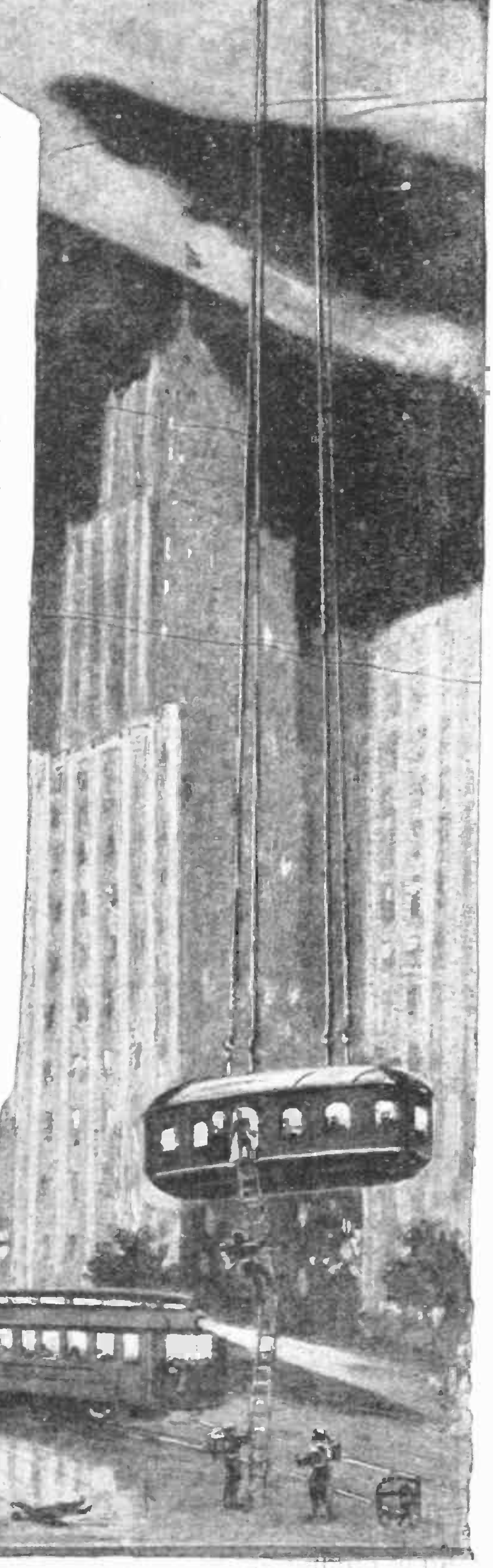
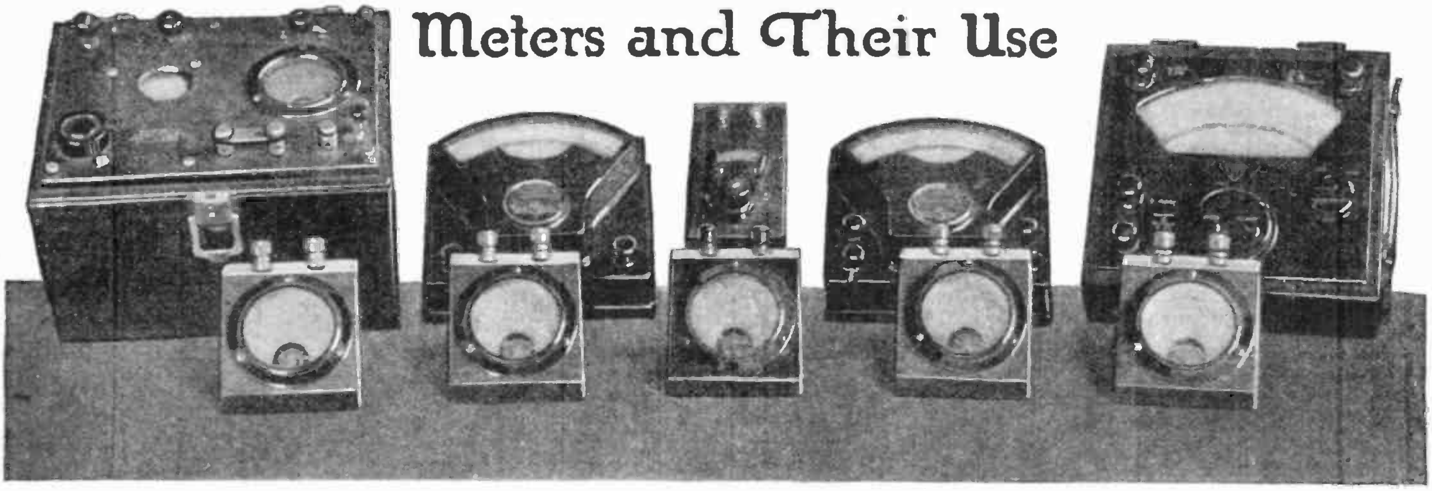


. . . just around the corner of the street was a stopped motor truck, over the dashboard of which two men sprawled unconscious . . . I entered the gondola and was pulled up with the rest of the gang—

EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

Meters and Their Use



An array of miscellaneous meters which are indispensable for laboratory work: wavemeter, ammeter, ultra-sensitive galvanometer, voltmeter, multimeter, thermo-couple ammeter and various other indicating meters.

ELECTRICAL measuring instruments are generally called meters. There are a large variety of these instruments, and they are designed to measure three classes of currents and voltages—direct and alternating and radio frequency.

Electrical measuring instruments used on either direct or alternating current may be classified as *indicating, integrating* and *recording*. The first type of instrument gives the value of the electrical quantity at the moment of observation. The second type takes into account time as well as the electrical quantity, the two constituting a rate unit, as for example in the watt-hour meter which gives a reading proportional to the product of the average power and the time, giving the quantity of energy that has passed through it in the time between readings. The third type, or recording instrument, draws a curve or other graphical representation which depicts the variation of an electrical quantity with time.

Radio frequency meters are mainly of the indicating variety. True, we are familiar with the cathode ray oscillograph which is a recording meter and others of its kind, but their use is restricted to the research laboratories chiefly for the reason of their prohibitive cost.

Direct Current Meters

There are many types of instruments which have been designed for the measurement of direct current and voltage, but the very best and the one which has found the widest application is the pivoted-coil, permanent-magnet, direct reading instrument. Its principle of operation is readily understood. Balanced in the field of a fixed permanent magnet, which is provided with soft-iron pole pieces, in order to give a uniform radial field in which the coil moves, there is a light coil free to turn. The motion of this coil is opposed by a counter force of two spiral springs which also serve the purpose of carrying the current to and from the coil.

For the necessary measurements of direct currents in a radio transmitter, such instruments as the following are available:

	Ranges
Filament Voltmeter	0 to 3, up to 0 to 12 volts.
Filament Ammeter	(Getting to be obsolete.)
Plate Voltmeter	0 to 100 up to 0 to 3,000 volts.
Plate Milliameter	0 to 3 up to 0 to 1,000 milliameters.

Before going any further and into the discussion of alternating current instruments, it will be well for us to review the use of each particular instrument.

The life of any vacuum tube depends on the way it is being handled. It is a well-known fact that the life of a tungsten filament tube is increased fully 100 per cent. by cutting down the current to 3 per cent. less than normal. Similarly, the life of a tube is shortened 50 per cent. if the current is increased to 3 per cent. over normal rating. It has been found that voltage control is far preferable to current control, as it can be shown that the filament with the former will operate at more nearly constant temperature and its economic life will be longer. Further, for a given change of the filament rheostat, the voltmeter will show about double the change that will be indicated on the ammeter, which means that twice as close a check can be kept for proper operation at specified characteristics. Thus the

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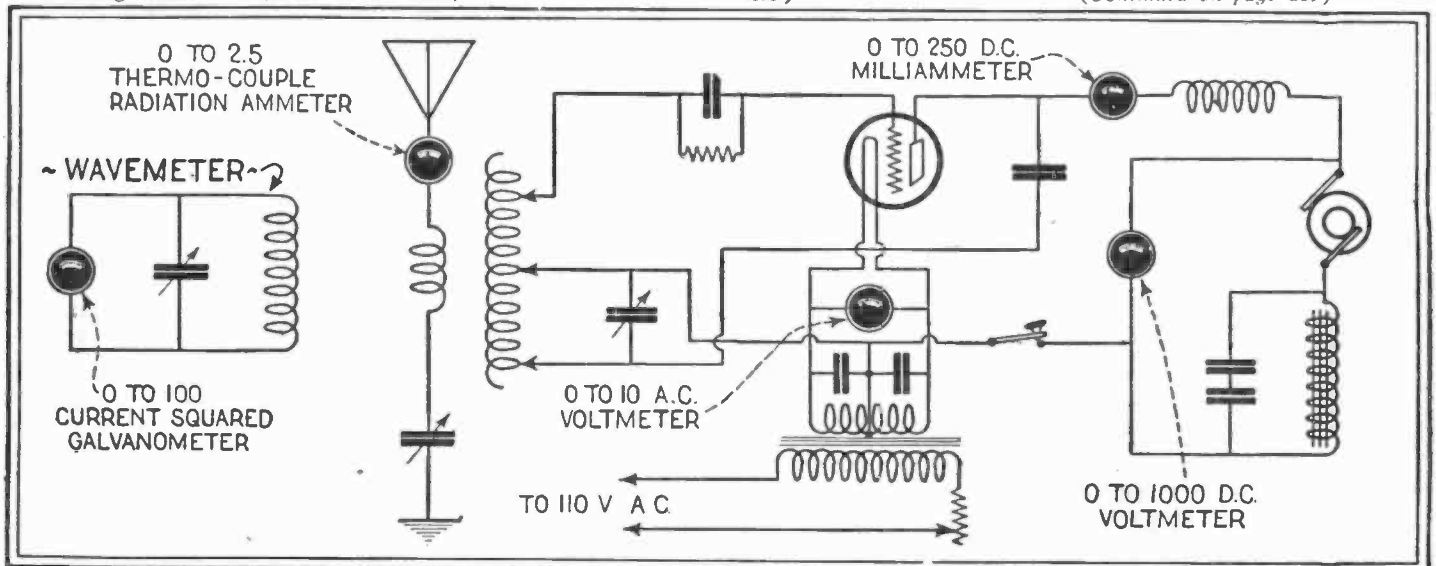

A transmitter completely equipped with the necessary meters as shown, is bound to "reach out."

Conducting an Amateur Station

By L. W. Hatry, 1 OX

PART II

BREAKIN

This is a genuine time-saver.

Breakin is a term referring to the ability to receive while sending, which makes it possible for one operator to break into the transmission of another and stop him if necessary. In ordinary communication, it is necessary to wait until a man is through sending to talk back at him. Interference may make it impossible to hear him, yet he continues his transmission until through. *Breakin* makes it possible to call him while he is talking, warn him that he cannot be heard, tell him to wait and tell him when to go ahead again. The time it is possible to save in thus avoiding repeats is obviously a decided advantage. *Breakin* has its procedure; particularly abbreviated, very effective and certainly a necessary bit of knowledge.

HOW TO BREAKIN

Most *breakin* systems suggested are very complicated. They require relays and other trick layouts. While these are good, they are also clumsy and, often, expensive. Besides, there is a *breakin* system that can be used which will cost nothing. It consists in leaving the antenna connected to the transmitter at all times and receiving without any on the tuner. This works particularly well with the wave-lengths below 85 meters and with increasing effectiveness as we go down, but it will work well on the 150-200 meter band.

A second method is to use another antenna connected to the receiver. This second aerial should not be very long nor very large. It can be 25 or 30 feet long with rather good separation between it and the transmitting aerial. It works partly of itself and partly through capacity to the larger aerial. Some operators use bedsprings, electric light socket antenna plugs and similar trick arrangements to achieve the ability to receive while sending. This does not mean that one can receive when holding down the key. It is to be admitted that the general text of this has sounded that way, but we were leading up to this explanation. This means that one can receive in the silent spaces between dots and dashes or between words. Too much energy is imparted to the receiver, whether in tune or not, from the nearby transmitter, to allow reception when the key is down. That the transmitter outside can be heard at all is the necessary thing to make possible *breakin*.

BREAKIN OPERATING PROCEDURE

Assume a station has been called. Assume he is familiar with *breakin* procedure. Assume that he has not only been called, but that he has answered with an OK acknowledgement. To find out if he can or will use *breakin*, the *breakin* abbreviation "*bk*" is used: *e. g., 5KK 5KK u 2KK 2KK bk? ga wl u tri QSR Europe, etc.* The break request does not stop transmission, an actual interrupting call by 5KK could do that. If 5KK can use *breakin* he will make a single long dash or a series of dots and then call 2KK shortly, say "*bk ok k*" and copy 2KK, prepared to break his transmission when needed. The series of dots is the preferable way, for it allows the breaker to listen between them for the stopping of transmission by the other station. As soon as the sender stops, the breaker can give his reason for the interruption; as, ... *QRM* . — . . . (wait). Perhaps this "wait" will be followed by other "waits" as warnings and to prevent worry until the breaker can finally say *k* again. There should be no need for the using of calls in a *breakin* communication. Partly because it should not be used save where good received volume is present and partly because it would prove clumsy and unnecessary. After a break and the go ahead following the stoppage, the man stopped resumes transmission, beginning with the word he stopped with.

The beauty of *breakin* shows up when it is necessary to ask for repeats. Instead of waiting for the whole message to be sent if a word is missed, one breaks when one misses, repeats the last word copied, follows it with a "?" and gets it repeated with the text that follows; *e. g.,* . . . . *sailed ? k*. The man broken into restarts with "*sailed*" and continues.

If 2KK, sending, was getting interference on the wave of 5KK, with whom he was working, so that he could not hear 5KK if he should attempt to break, he should warn 5KK. The warning is easy to give. Assuming *QRM* to be the trouble, the following example shows how to go about it (starting in the middle of a fictitious conversation): "*yes om — . . . — QRM no bk pse — . . . — we wkd 6KK last nite es he said QSA — . . . — ga bk ok nw — . . . — mebbe wk every dist tonite, etc.*" Thus you see that the receiver is warned first not to break and later that he can break because of better receiving conditions.

Breaking another fellow becomes interesting when used in casual conversation. He can be interrupted with snappy come-backs, comments and such, all in a manner that gives the code-talk all the pleasures of actual conversation. The dozen and one conveniences that *breakin* adds to the game can be realized only after trial. By all means try it.

GENERALITIES—USING ABBREVIATIONS

The way of code is always long and often weary. Abbreviating and abbreviations are a necessary evil, that often causes confusion in the minds of the uninitiated. There is only one rule: abbreviate where possible, but not if confusion will result. Another thing to remember is that the number of abbreviations are few and abbreviations do not include the majority of common words. In other words, you do not need an "approved" abbreviation for a word to shorten it. Shorten the word in question to suit, provided it remains recognizable. For instance, if one were to start to say *via* radio this: *I'm going to buy a new hat for ten dollars*. He would very likely change it to read about like this: *Im byg new hat fr 10 dlrs.* The only reason for not dropping the *e* from *new* is that *nw* is the generally used abbreviation for *now*.

There are many words so common that they have acquired nearly standard abbreviations. Among these are: Now—nw; thanks—tnx; please—pse; way—wa; you—u; weather—wx; where—ware; to—2; that—tt; going—gg; see—c; why—wy; yours—urs; distance—dx; hear—hr; with—wi; before—b4; there—tr; what—wat; are—r; your—ur; whether—wtr; been—bin; and—es. There are some others, but these are the more ordinary and serve to give you an idea. A little time spent on the air will give a much better idea as to how abbreviation of words actually occurs. One more example will not be amiss. This sentence will do: 1 *mre xampl wl nt b amis.* The older operators are less guilty of abbreviating than the younger ones. The older man would rather be right than repeat.

KEEPING LOG

This is a very important part of a station. It is up to the owner how the log is finally kept and up to the writer to give a concrete plan to start on. By no means are you to form the conclusion that some one system is recommended above all. Start off with a system by all means, but let it grow into your own.

Commercial companies who require a complete log have a very simple sheet. A similar arrangement would prove excellent for the amateur station. Notice the illustration. Amateurs cook up their own with additional columns referring to "volume" or similar items of interest. However, the "Remarks" column leaves plenty of space for all this added information without the actual need of ruled columns. It is a simple and complete log.

A single day is allotted at least one sheet, and never less than one. This last is true because it very much simplifies a search through the log for a check-up. However, some do not do this because it is more economical not to. This is mainly true when the log sheets are purchased printed ones. However, the loose-leaf log, while undoubtedly convenient and very likely the best, is not a necessity. Low-priced composition books with stiff board covers make first-class logs. They certainly have the advantages of cheapness and compactness. A four or more column log, similar to what we have shown, can be kept in them. When a book is filled it can be filed away easily and conveniently, being a handy unit of so many weeks or months. In the book, as well as with the unit pages, a new day should start a new page.

Every log day starts at midnight and is kept through to the next midnight. Do not start the log through the tenth and continue into the morning of the next day under the tenth heading. This causes unnecessary and unpleasant confusion and is inaccurate.

Above all, keep a useful log. The log should record all the radio activities of the station. If you change power, mark it in the log. If the antenna is disconnected and the clothesline used, make an entry of the fact. If the tuning of the transmitter is changed, make a log note of it. Then, if something unusual results, you have something to check back to, on which can be laid the blame. A correct and complete log of your station activities will tell more about it than all the guesswork or memory practice in the world. And unrecorded log data is only memory practice—poor practice at that, too.

OPERATING HOURS

This is something you will adapt to suit yourself, but some suggestions will not be amiss.

Stay up all night once or twice and learn when the fellows who bother are not on the air. Be on when they are not. That's the best bit of advice in the bunch.

In general, mornings are the best time to

(*Continued on page 839*)

Sound and Audio Frequency Amplification

By Theodore H. Nakken*

PART II

IN the preceding article a short explanation was given of what constitutes sound, how sound is transmitted by vibrating air particles and is detected by the ear. Great stress was laid upon the fact that the vibrating air particles communicate a composite vibration to the ear-drum and the hearing mechanism, and we were told how to actually analyze this complex sensation into its components.

From this it follows easily that if only we succeed in duplicating these composite vibrations in some way or other, it is not at all necessary to use the air exclusively as the sound-carrying medium. It is only necessary to cause the air particles in the vicinity of the listener to execute the same vibrations, to create sound. Thus, if we convert the vibrations causing the sound into some other form of energy, later reconverting this energy into air vibrations, we have recreated sound. Moreover, if this double conversion has been done in a purely neutral way, *i. e.*, if the conversion has been completely faithful, the sound recreated can in no way be distinguished from the original sound, and we would have perfect reproduction.

This is the constant aim of all those experimenters, whose studies bring them in contact with sound phenomena, and there is not the least doubt that perfection will be attained in the near future, even as today a very high degree of perfection has been attained. And in no small measure this approach to perfection has been made possible and was stimulated by the comparatively young science of radio broadcasting and radio reception.

We may say in short that in radio reception two main processes are involved: The first is the conversion of the sound to be broadcast into electrical energy in such a form that it can be radiated, at the broadcasting station. The sound waves after their first conversion into electric currents are then used to influence high frequency oscillations which are radiated into space in the form of so-called electromagnetic waves.

The second process is the conversion of the energy arriving by means of these electromagnetic waves at the receiving station into electrical vibrations and then into air vibrations—into sound—and thus the actual reproduction takes place at the receiving station. We are here concerned solely with the reproduction, with the receiving station, and therefore will try to give suggestions as to improving some parts of the apparatus used here, and thus we must dismiss the transmitting process with a very few remarks. Transmitting engineers are constantly striving for perfection in this branch of the art, because there is still place for many little improvements, and after all even the most perfect receiver depends for quality upon the quality of the program received. Every improvement at the transmitting station automatically benefits the quality of reception in all receiving apparatus.

We will now briefly analyze the different functions in the average receiver, which will bring us to the subject in hand: audio frequency amplification.

From the broadcasting station are sent out the electromagnetic waves mentioned before, which serve as a carrier for the sound currents, hence the name "carrier waves." These waves have an extremely high frequency, far above the capacity of the ear; and this is necessary, as otherwise these carrier waves might interfere with the quality of reception. Hence when we can "hear" the carrier wave in a receiver, it is an indication that the carrier wave is not pure—and then the carrier wave impairs some of the quality of transmission. Right here is one of the problems which transmitting engineers are constantly trying to solve with a view to improve transmission.

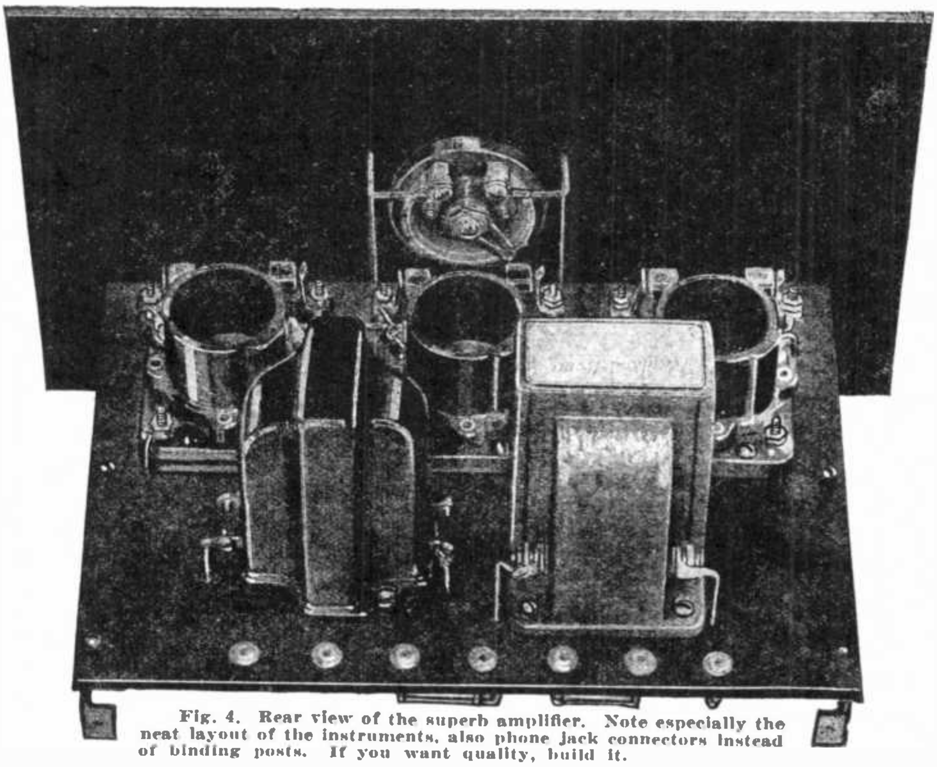

Fig. 4. Rear view of the superb amplifier. Note especially the neat layout of the instruments, also phone jack connectors instead of binding posts. If you want quality, build it.

When these carrier waves pass an antenna, which has been tuned to their frequency, they cause alternating currents to flow in that antenna. As the waves are radiating in all directions, it does not matter at all where the receiving antenna is located. These alternating currents correspond in every respect to the characteristics of the passing waves, and thus if the carrier waves vary in accordance with the sound currents, the oscillating or alternating currents in the receiving antenna will vary in exactly the same way. Of course the alternations are of a frequency too high to be heard, so if a sound-reproducing instrument is placed in the path of these currents, there will be no response whatsoever.

Generally, in order to receive signals as strongly as possible, the currents in the antenna due to the passing waves are amplified in some way or other, and this process is called radio frequency amplification. In this process (when proper design is employed) there generally is little or no distortion—hence we will not go into this subject.

Whether or not radio frequency amplification is employed, we must then in some way or other separate the actual sound currents from the carrier currents, in order to use the sound currents to actuate the reproducing instrument. The currents so obtained are called the audio frequency component. This process of separating the audio frequency component is called detection—with which we will deal more in detail later, because in this process lies one of the main reasons for distortion in reception.

The sound currents obtained by the detecting process are mostly too feeble to effectually operate a loud speaker instrument, and therefore these currents are generally amplified to such an extent that they have the desired magnitude, after which they are used to operate the loud speaker. Both in the amplifying process and in the loud speaker we find more reasons for distortion, and thus we have to pay the closest attention to the instruments used here.

As nearly no independent constructor can build a satisfactory loud speaker, its purchase is largely a matter of buying the best the market affords. In this respect there is no real advantage as between instruments equipped with a horn or the so-called cone types; in both classes there are instruments that attain the best reproducing qualities as yet offered. An absolutely perfect type suitable for the home receiver does not exist at the present time, but to all intents and purposes some of the better types give a quality of reproduction that far surpasses any other type of sound-reproduction. Yet slowly but surely the loud speaker is approaching its final stages of evolution, and it may be assumed that in a few years the loud speaker will cease in all respects to be a source of distortion, and of faulty reproduction.

This then leaves the pure audio frequency amplification process, in general all that happens after detection of the signal, to be dealt with, so that now we can approach this process with a full appreciation of its importance in relation with the other processes.

The true amplifying instrument is the vacuum tube. It alone opens up untold possibilities, which we are realizing to but a small extent undoubtedly, and one of its properties is amplification—a thing only desired but considered impossible a few short years ago. We will review in short its construction and operation.

In a highly evacuated glass bulb we find a fine metallic filament, surrounded by a long metal wire, generally wound in a spiral, which after completion may be flattened. This spiral is supported by one or two stems, and is carefully insulated from the filament. This structure is called the grid. Surrounding both filament and grid we find a plate, again supported separately and insulated. Plate, grid and the two legs of the

*Research Engineer, Radiall Co.

filament are provided with leads, which extend outside of the tube. These leads are connected to four prongs with which the tube is provided.

When now in some way the filament is heated, in practice by means of an electric current, it emits electrons, which we might call small particles; in fact, the smallest we know of, carrying negative electricity, or constituting electricity itself. Being negative, these electrons are attracted by any positive body in their vicinity, while they are repelled by negative bodies.

As is generally known, the plate of the tube is now made strongly positive by means of a so-called plate or B battery. Thus the electrons are attracted by this plate and all of them would at once fly towards it, if the grid were not present.

This grid, however, is kept at a negative or zero potential, and thus repels some or all of the electrons; in other words, prevents some or all of the electrons from reaching the plate. When the grid is made strongly negative, it repels all of the electrons, so that none reach the plate, and thus no current flows in the plate circuit. As the grid gradually is made less negative, its repelling action slowly decreases, and thus it allows more and more electrons to pass through it to the plate, in this way establishing a plate current. Thus it is seen that the grid completely controls the amount of current flowing in the plate circuit. At a certain moment all of the electrons are allowed to reach the plate, and then the so-called saturation point has been reached.

Now in a well made tube a certain change in grid potential always causes a definite change in plate current, except of course in the condition when no plate current is flowing or when the saturation point has been reached. These conditions are, however, not sharply defined, but approached in a slow manner, so to say, and therefore the tube is rarely operated at these points. How the tube behaves is generally expressed by its so-called characteristic curve, such as the one pictured in Fig. 1. In that drawing we see that any change in the grid voltage is accompanied by a definite change in plate current, at least between points A and B on the curve, which is called the straight part of the characteristic. The way of finding the current flowing at any potential of the grid is to trace a line from the grid voltage indication vertically till it crosses the characteristic—and then from the crossing point horizontally to the left, where the plate current is read.

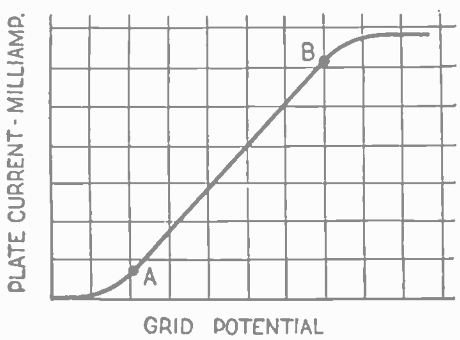

Fig. 1. The straight part of the characteristic between A and B, is best for amplification purposes.

But—and this is an important point—when the grid becomes positive, it starts attracting electrons itself, just as the plate does. This condition can become so pronounced that the plate current actually decreases on account of the number of electrons absorbed by the grid and therefore no more become available for the plate current. Now when grid current flows it always results in the true proportionality between grid voltage variation and plate current becoming lost, thus causing the tube to distort. This is the main reason why it is necessary to prevent the grid from ever becoming positive.

From these considerations we can understand that if we succeed in applying the sound currents obtained in the process of detection to the grid in such a way that the potential of the latter is varied in proportion to the current fluctuations, we will then observe corresponding changes in the plate current of the amplifying tube. And these plate current fluctuations will be much stronger in the majority of cases than the original currents used to cause voltage variations on the grid, hence the amplification obtained. Now as long as the tube is operated on the straight part of its curve, it will amplify without distortion.

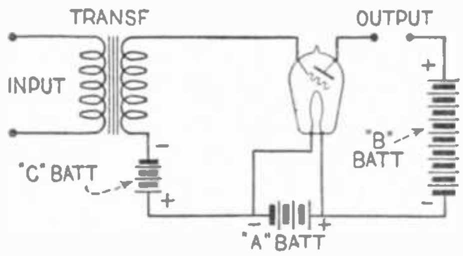

Fig. 2. Showing the relation of a "C" battery in an amplifier circuit. The "C" battery saves considerable "B" battery current.

As stated before, we must prevent the flow of any grid current, or rather we must prevent the grid from ever becoming positive, and thus absorbing electrons. Why this is can be easily seen by the following argument: If the grid is made positive by an impulse and momentarily attracts electrons, these electrons will cause a drop in potential of the grid, and hence the increase of the plate current will not be proportional to the voltage originally applied to the grid, which means that distortion occurs. And so it is imperative to give the grid such a negative potential, that under no circumstances impulses applied to it in the positive direction will cause it to have a positive potential with respect to the filament, and this negative potential we can provide very easily by connecting a so-called "C" battery between filament and grid, the positive pole of the "C" battery being connected to the filament, the negative one to the grid. We must then at the same time adjust the plate voltage in such a way that the tube normally functions in the midpoint of its characteristic curve. In this way, then, the plate current can be caused to decrease and increase to an equal amount by the action of the grid and all distortion due to grid current is prevented. It is comparatively easy to find the proper plate voltage and "C" battery potential, as instructions for these factors are always packed with every vacuum tube. Generally the use of a "C" battery is called biasing of the grid, and its potential is called the grid bias.

The practice of biasing the grid has a secondary effect, which is extremely useful. It limits the amount of plate current, and thus helps conserve the plate batteries. But the main reason for its use is always the fact that it is necessary for distortionless amplification.

We will now see how we can cause small currents to influence the potential of the grid of our tube in order to obtain an amplified plate current variation. There are several ways of accomplishing this, and in this article we will deal with one of them, transformer coupling.

A transformer suitable for use with audio frequency currents consists of an iron core, upon which are wound two coils of wire. When now in one of these coils the primary, alternating currents or fluctuating currents are flowing, there will flow a so-called induced current in the other one, the secondary, whenever a change in the current in the primary occurs. In this way we are able to transfer electrical energy from the primary to the secondary, and in this respect the instrument is marvelously efficient. When well constructed, it is possible to obtain from the secondary more than 97 per cent. of the power in the primary—an efficiency that stands unique in the whole world of power transfer.

Now not only is power transferred from the primary to the secondary, but we can also change at will the voltages of the circuits, because the voltage ratio in the two coils depends only on the ratio of the number of turns in primary and secondary; and so, if we give the secondary the greater number of turns, the voltage developing currents are higher than that in the primary—and we have stepped up the voltage. By giving the secondary the smaller number of turns, we can step down the voltage.

We have seen that the grid of the amplifying tube operates by voltage only, as we take preventions against current flowing in the grid circuit—and therefore we will try as a matter of course to apply the highest possible voltages to this grid, and if our coupling to the amplifying tube takes place over a transformer, we will almost without

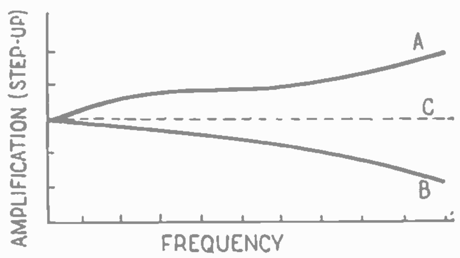

Fig. 5. What happens when a by-pass condenser is shunted across the primary of a transformer.

exception employ a step-up transformer. The way the transformer is coupled to the tube under application of a "C" battery is shown in Fig. 2.

We see there that the secondary in series with the "C" battery is placed between the grid and filament of the vacuum tube, and therefore when currents are flowing in the primary, every variation of these currents will cause induced currents in the secondary, and the grid potential will fluctuate accordingly, thus causing the plate current to vary in accordance with the fluctuations of the grid potential. The currents for the primary are mostly obtained from a preceding vacuum tube, and we may employ the current variations obtained in the plate circuit in any way we wish to operate a loud talking instrument, or also to flow in the primary of a second transformer, whose secondary acts upon the grid of a second amplifying tube. In this way we obtain a two-step amplification.

We will now look into the demands which must be satisfied by the transformer in order to get distortionless amplification, and thus obtain quality reproduction. As was stated before, the current flowing in the plate circuit is governed by the grid potential, and it appears that the tube has a certain internal resistance. This internal resistance is that which exists between filament and plate. When normal filament heating is employed, the usual value of resistance lies in the proximity of 20,000 ohms for the "A" type of tube. Of course, the heavier the electronic emission from a filament, the less plate-filament resistance and therefore the greater will the plate current be. This will result in a heavier drain on the "B" batteries and unless biasing "C" batteries are employed, the cost of operating such tubes becomes high. Now it is necessary, in

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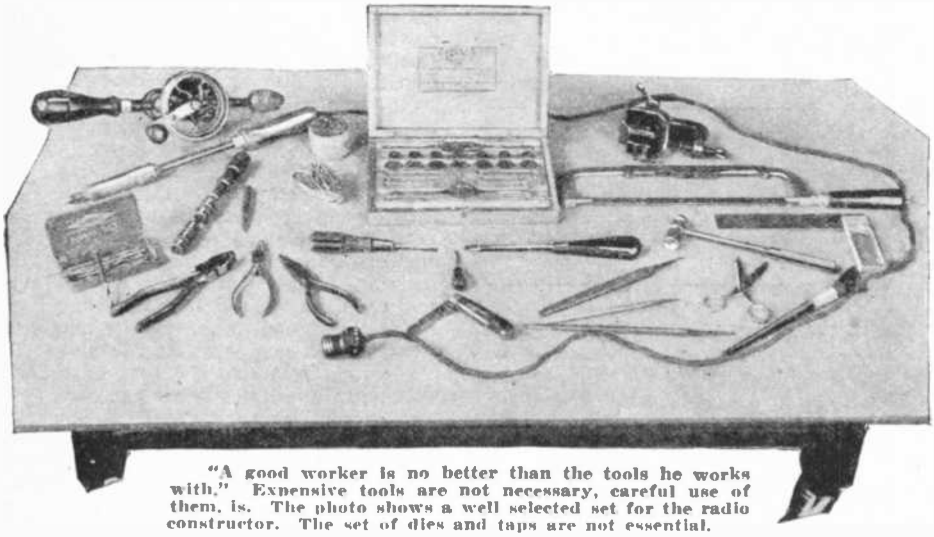
Tools for the Radio Man

By Robert Hertzberg



"A good worker is no better than the tools he works with." Expensive tools are not necessary, careful use of them, is. The photo shows a well selected set for the radio constructor. The set of dies and taps are not essential.

ONE of the qualities that makes radio experimenting such an alluring hobby is the fact that it calls for neither an extensive knowledge of mechanical processes nor for an expensive layout of mechanical tools. This feature of the pastime, probably more than any other, is what makes possible the home construction, by inexperienced persons, of so many excellent and successful receiving sets.

However, some tools are required for the work, and the man who finds himself fascinated by radio can make no wiser move than to equip himself with them at the outset. In fact, he should buy tools first and radio instruments afterward; if he favors the radio instruments first he will quickly discover, upon his first attempt to assemble the parts, that *fingernails make poor screwdrivers, scissors indifferent wire-cutters and breadknives ineffective hole borers.*

The actual tools required for the home radio laboratory are few and inexpensive. Those mentioned in the following list will fill every requirement that set-assembly or set-repair will present.

(1) *Hand drill with chuck to take drills up to ¼-inch; assortment of drills from 1/16-inch to ¼-inch.* Small drill stocks especially suited for radio work and costing only about $3.00 are made by all the big tool firms like Yankee, Millers-Falls, etc. The drills themselves should be of the best steel; cheap ones are useless after one excursion through a bakelite, hard rubber or celeron panel.

(2) *Electric soldering iron; 2 oz. can of Nokorode or other solder paste; pound roll of soft wire solder.* There are dozens of small irons designed for the fine soldering jobs encountered in radio work. A good one costs between $2.00 and $5.00.

(3) *Small detachable vise.* The jaws should be 2½-inch or 3-inch wide, and the clamp large enough to fit comfortably on the edge of a table or window sill. It should cost not more than $1.50.

(4) *Hacksaw.* A perfectly good one can be bought for as little as fifty cents.

(5) *Three pairs of pliers.* These are important items, as pliers are the most frequently used tools in radio construction. One pair should be of 6-inch size, side-cutting, and with square, heavy jaws; the second should be 5-inch size, side-cutting, and with jaws that taper to a point; the third should be 5-inch, non-cutting, and with tapered, round-nose jaws. The imported nickle-plated junk should be carefully looked over; the bright finish covers weak steel. Good pliers are made in this country by Krauter, Pexto, Utica and others.

(6) *Three screwdrivers.* These are also important tools. One should have a 5-inch blade, another a 3-inch one, while the third should have a very slim blade that will fit set-screws and the like. Cheap screwdrivers are poor investments; there are screws without number in radio parts, and they can be properly tightened only with strong tools.

(7) *Small ball-pene hammer.* Nails are rarities in radio sets, but there are many holes to be center-punched. A most excellent all-metal hammer can be purchased in any of the Woolworth emporiums for the munificent sum of ten cents.

(8) *Carpenter's square, 6-inch size.* One is indispensable for marking instrument locations. A good one is obtainable for a dime.

(9) *Three files.* One should be flat and about an inch wide at the base; the second should be three-cornered, about ⅜-inch on a side, and the third round, about ¼-inch in diameter. All three will cost thirty cents.

(10) *Strong jack knife.* One of the "Boy Scout" type is extremely handy.

(11) *Small pair of scissors.* Scissors are cleaner and quicker than a knife for trimming insulation and cutting tape; they cost only two nickels.

(12) *Steel center punch.* One is necessary for locating holes in panels.

(13) *Brush.* A round, long-haired one helps clean dust and shavings out of inaccessible corners and crevices.

(14) *Set of "Spintities,"* or socket wrenches, a very necessary adjunct.

That's all. The writer's own tool box contains these instruments and no others, and with them, during the past eight years, he has constructed receiving and transmitting sets embodying practically every circuit that has appeared in print.

The entire absence of wood working tools such as rip, cross-cut and back saw, brace and bit, chisels and a plane will be noted. Although it is unquestionably a good thing to have these on hand, the little woodwork radio sets require does not warrant their outright purchase. Completely assembled cabinets and nicely squared baseboards, all cut to fit standard panels, are priced so cheap that it will avail the home mechanic nothing to attempt to duplicate them in his kitchen workshop. Besides, planing can be done properly only if the work is securely fastened in a large vise which in turn is solidly bolted to a husky timber work-bench, and such an arrangement is decidedly impracticable in the average apartment or small house.

The lack of things like taps and dies also invites inquiry. These items are not costly, but frankly they are unnecessary. Fully 99 per cent. of the threaded fittings on radio parts are of 6-32 or 8-32 size, and attachments of these dimensions are available in such number and variety that the radio experimenter need never worry about fussing with his own threading. The writer has had a complete set of taps and dies up to ¼-inch for more than five years, and the only time he ever used the devices was when he wanted to remove the rough edges from a batch of new condenser mounting screws.

The tang of the flat file makes the best reamer imaginable for working out large holes for condenser shafts after the largest drill in the hand drill set has been used. The steel at the tang is slightly annealed, and therefore will not break off if the tool is twisted too suddenly. This is also very convenient for enlarging holes that are just too small to pass instrument fastening screws, especially if the panel has already been mounted and cannot be clamped down securely for another drilling.

The soldering iron, of course, is an absolute necessity. So much has been written about the art of soldering in general that nothing need be said here about it. The writer wishes only to admonish the embryo experimenter to learn to solder well before he even looks a radio catalogue in the face.

The pliers need little explanation. The pair that will see the most service is the 5-inch tapered nose pair, as it can be made to reach into awkward corners to hold wires being soldered, to tighten all manners of small nuts, to adjust springs, and to serve a dozen other purposes. The heavy pair is generally useful for wire cutting and for securing larger nuts. The round-nose pair is reserved entirely for making loops in bus bar, and for this function alone it justifies its cost. It should not be used for tightening things, as the thin, round jaws will spring out of shape and will frequently cause the handles to bite a piece of flesh out of the user's palm. This has happened more than once to the writer, so he knows, painfully, whereof he speaks.

The long brush is a surprisingly useful object, and is something no owner of a set should be without. It gets into all dust-collecting corners and crevices and cleans them out as thoroughly as if a vacuum cleaner had been applied to them. It is many times more convenient than a rag, for rags have an annoying habit of pushing dust and dirt into cracks and under little ledges; it can be forced into right angle bends that no finger-stiffened cloth can possibly reach.

The tools described in this article are by no means the only ones that find use in an experimental radio laboratory, but they will fully satisfy all the usual needs of the radio experimenter of limited means. If a man can afford such delectable luxuries as a power drill press and a lathe, for which most "fans" would give their right hand, he should by all means purchase them and install them in his workshop. He will find them exceedingly helpful, but not absolutely necessary.

What some workers can accomplish with an ordinary knife and screwdriver, others cannot duplicate with the most expensive apparatus or machinery. The knack of using a tool in the correct manner comes not only from experience, but from learning from others. To use a hacksaw blade as a file or the sharp point of a drill as a punch is as bad a practice as drilling a hole with a chisel.

Audio Frequency Amplifying Transformers

By Florian J. Fox*

THIS article was written with a double purpose in view: to help the experimenter in his selection of audio frequency transformers, and to arouse some interest in the problem of audio amplification in more technical minds. Such interest should lead to the publication of information useful to us all.

Whenever you read a paper on A.F. amplification, you are always certain to find this statement in one form or other. "For maximum amplification, the input impedance of the transformer should equal the output impedance of the tube." This statement is true and can be substantiated both mathematically and experimentally. Such statements are in general based on a single frequency. Telephone engineers, for instance, base their calculations on what they believe to be the average voice frequency, namely, 800 cycles per second.

What radio engineers should strive for is quality of reproduction, not maximum amplification, and I wish to show that strict adherence to the above-mentioned law does not produce best quality.

If you match impedances at 800 cycles, then the condition for maximum amplification does not exist for other frequencies. This is so because the tube output impedance remains practically constant, while the input impedance of the transformer varies directly with frequency. This condition must necessarily affect the quality received. The greatest loss is at the low frequencies. At 100 cycles the mis-match in impedance is 8 to 1. Fortunately above 800 cycles the effect of mis-match is not so serious, because a greater portion of the voltage generated in the tube appears across the terminals of the transformer. This will be clear later if it is not already so.

Were it not for an "aural illusion" this loss of low frequencies would be very serious. Occasionally transformers were measured which showed a real loss at 100 cycles, and yet when used in a receiver these transformers actually seemed to pass 100 cycle tones. A noted engineer has shown that the ear could affect the brain with notes that did not exist. If 200, 300, 400, etc. cycle tones were sounded simultaneously it was found that the ear also seemed to hear the common difference frequency; namely 100 cycles. If an instrument, then, is rich in harmonics, even though the fundamental is low and does not pass the audio amplifier, their common difference, equal to the fundamental, will make it appear that the fundamental is actually present, which accounts for some of these poor transformers giving better results than they theoretically should. However, it goes without saying that any notes produced in this way can not have the naturalness and proper relative weight that the original may have. Let us then strive to obtain the original as near perfection as possible.

Since the grid of a tube is essentially a voltage operated device, we should try to

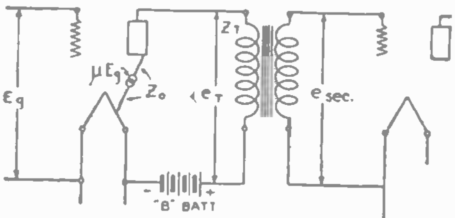


FIG. 1 $e_T = \mu E_g \left(\frac{Z_T}{Z_o + Z_T}\right)$

Analysis of the existing impedances and voltages in an amplifier circuit. From the above, it can be readily shown that for maximum amplification, it is necessary to have the input impedance of the transformer equal to the output impedance of the tube.

place the maximum possible voltage on the grid for *all* the frequencies in the voice range. (The voice frequency band is now generally taken between 60 and 8,000 cycles). This can be accomplished by making the transformer input impedance as high as possible. The slight loss in amplification (for the law of maximum amplification is violated) is more than worth while, when the improvement in quality coincident with such loss is considered.

The following tables and curves have been made on the assumption that the voltage E_t across the transformer primary is proportional to the ratio of its input impedance Z_t to the total impedance $Z_o + Z_t$ of the output circuit. It is to be remembered that the plate circuit of a tube can be represented as a circuit in which the generated voltage, μEg, the tube impedance Z_o, and the transformer input impedance Z_t are connected in series. See Fig. 1. Two commercial transformers are considered, one whose primary inductance is 5 henrys, and another whose primary inductance is 50 henrys. Incidentally, there are only two or three transformers on the market having a primary inductance of 50 henrys or more.

CASE I

Ratio 3:1 Pri. L = 5 henrys

$Z_T = 2\pi fL$

Zo of tube assume 20,000 ohms

Let $\mu Eg = 1$ volt

Frequency cycles per sec.	Primary impedance Z_T	Voltage across primary e_T	Secondary voltage e_{sec}
100	3,140	.14	.42
1,000	31,400	.61	1.84
5,000	107,000	.84	2.53

CASE II

Ratio 3:1 Pri. L = 50 henrys

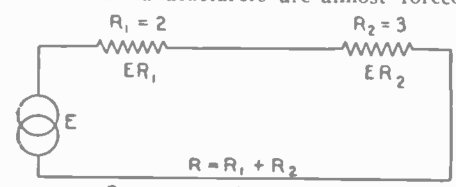
$Z_T = 2\pi fL$

Zo = 20,000 ohms

Let $\mu Eg = 1$ volt

Frequency cycles per sec.	Primary impedance Z_T	Voltage across primary e_T	Secondary voltage e_{sec}
100	31,400	.61	1.84
1,000	314,000	.94	2.82
5,000	1,070,000	.98	2.96

Although the above tables are not strictly correct they show clearly what it is desired to emphasize; namely, that the frequency characteristic of a transformer is tremendously improved by the use of a high impedance primary. Notice particularly the increased amplification at the lower frequencies. It is possible to design the core and control the distributed capacity of the winding in such a way that the overall amplification does not increase from say 1,000 cycles up. This is done in many cases, and results in a very flat and uniform amplification characteristic. Let us now consider the question of turn ratio. What is the correct ratio? 10 to 1? 5 to 1? 2.7638 to 1? In my opinion there is no correct ratio. However, the whim and fancy of the public must be satisfied after some one has misinformed it and the manufacturers are almost forced



$E_{R_1} = E\frac{R_1}{R_1 + R_2}$ $E_{R_1} = \frac{2}{5}E$ ALSO $E_{R_2} = \frac{3}{5}E$

FIG. 2

Circuit analogous to Fig. 1 showing that in this characteristic series circuit the current is the same in all parts, but the voltage across each resistance varies according to the value of the latter.

to produce all sorts of ratios. I do not wish to create the impression that the use of two different ratios in an amplifier is foolish. It has its advantages, when low impedance transformers are used. The characteristics in general will not be similar, so chances are the overall characteristic curve will be flatter. Where several stages are used, it may be necessary to use lower ratios in order that the total amplification is not sufficient to seriously overload the last tube.

From the standpoint of maximum voltage amplification with the least number of stages, the higher the ratio the better. The only drawback is that it is extremely difficult to produce a good high ratio transformer. If a transformer has a primary inductance of about 75 henrys, it would require a tremendous secondary winding to produce a 10 to 1 transformer. Even if such a transformer were made it is almost certain that the distributed capacity of the winding would be so large as to ruin the amplification at the higher frequencies. In general, then, distributed capacity, physical dimensions, and cost will limit the number of secondary turns. In that case, the manufacturer of such a transformer has a good and legitimate reason for producing an odd ratio.

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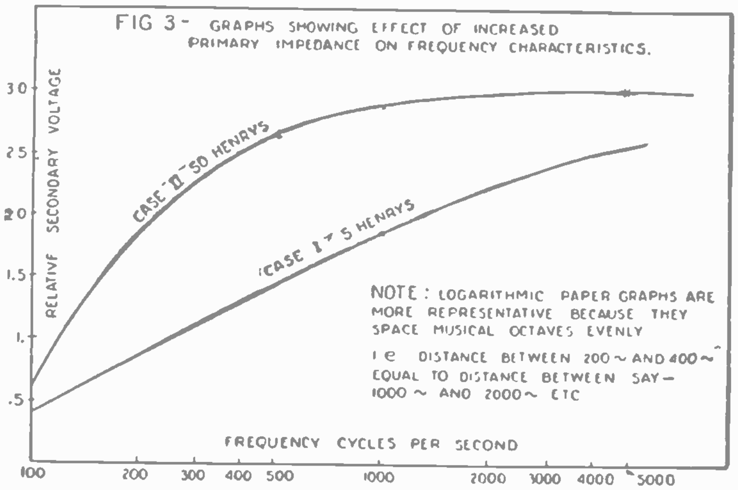

Graphical representation depicting the effect of increased primary impedance. Note that the secondary voltage rises considerably and that the frequency characteristic of a transformer is vastly improved.

*Chief Engineer, Grimes Radio Engineering Co.

Radio Outfit In a Headset

By Phillippe A. Judd

FIG. I

No, dear reader, this picture is not one of a Martian, but shows what the well-dressed radio man will wear in the near future. Imagine a complete radio receiving set contained within a headset surmounted by a small but efficient loop antenna, and you have the correct version. No extra antenna or ground connection to be annoyed with and the author guarantees good results within a radius of ten miles.

One of the receiver shells contains a miniature variable condenser, the details of which are given in the drawing on the right. Only careful work will result in a good job and as the success of the tuning lies with the accurate construction of this instrument, good workmanship is stressed.

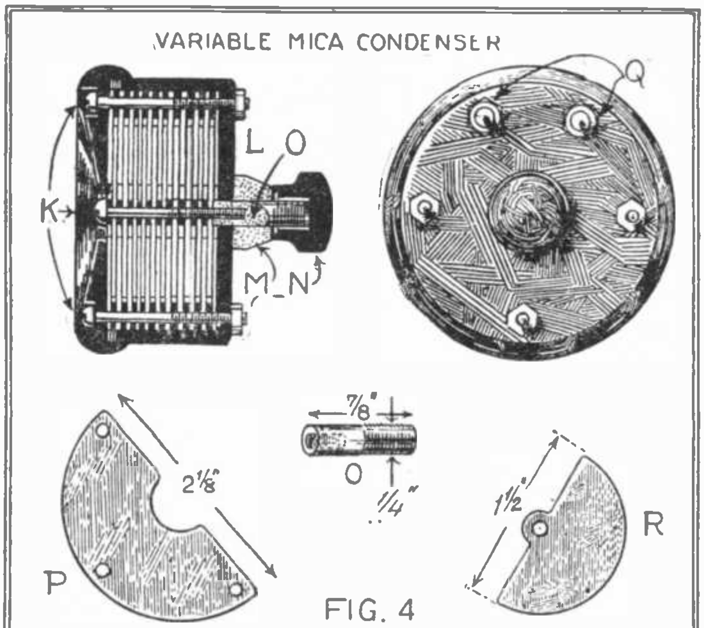

FIG. 4

Drawings by the Author

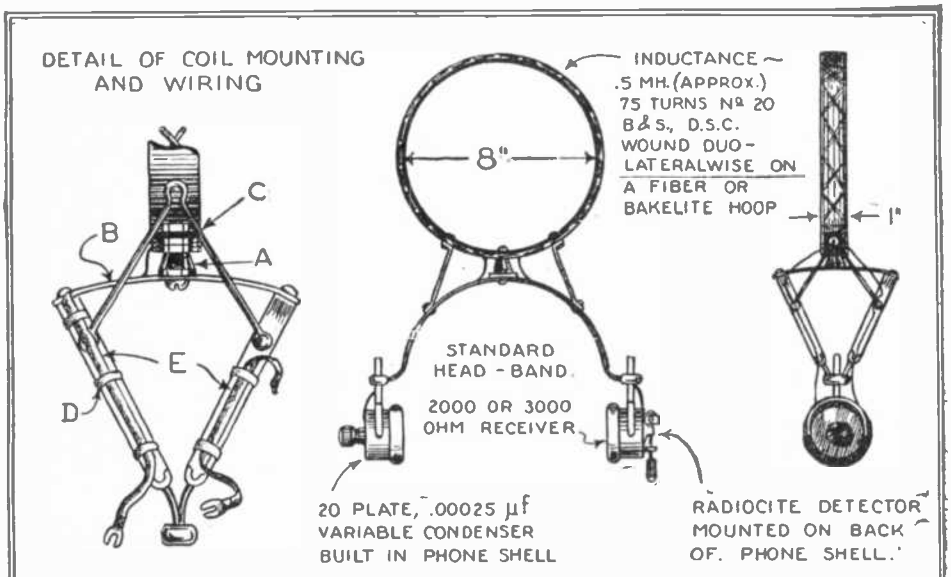

FIG. 2

The constructional details of the complete receiver are shown above. Note that the loop is wound in duo-lateral fashion and consists of a large number of turns of wire. Small rivets are used to fasten the various parts.

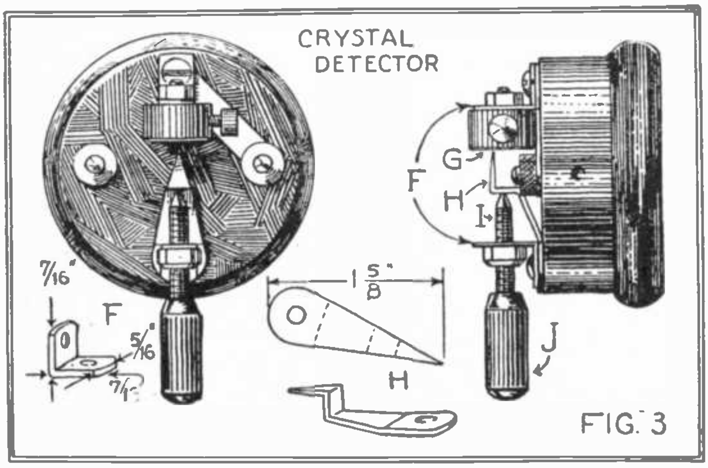

FIG. 3

How the crystal detector is mounted on the back of one of the phone shells. Be careful, in the selection of the crystal, to get a very sensitive one.

YOU have had, during the past year, countless freak receiving sets thrust upon your attention. These sets have ranged in size from miniature ones built upon finger rings to monstrous instruments built for advertising purposes. Some of them worked—some of them did not. Now, my dear reader, pray have patience, for you are about to be introduced to one of the freakiest of all freak sets. Meet the Receiving Set set in a Headset. Looks kind o' goofy, doesn't it? But—it really does deliver the goods! That is, it'll pick up anything on the air within a radius of ten miles.

Fig. 1 shows the set assembled and in use. Tuning is accomplished by means of the specially constructed variable condenser which is shown occupying the templar position on the right side of the old gent's cranium. A telephone receiver, of the standard type, and having a crystal detector mounted upon its back, covers his auditory appendage upon the other side. The King Tut-like insignia seen projecting above our friend's dome is nothing more or less than an eight inch diameter duo-lateral wound loop, which serves as the inductance of the set.

Constructional details are given in Figs. 2 and 3, while Fig. 5 shows the hook-up used. The condenser has a capacity of .00025 mfd., and is built in a phone shell. This necessitates a very compact arrangement of the plates, and is accomplished by using twenty plates of copper-plated mica. The mica plates are first carefully cut to shape, and are then rubbed with a lead pencil, so that they become covered with graphite.

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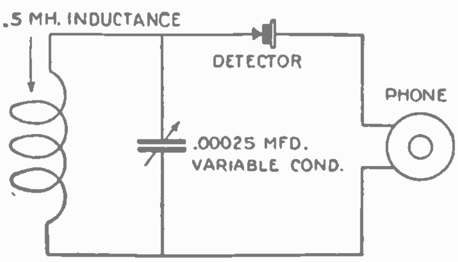


FIG. 5

The simple wiring diagram of the unique receiver. Simplicity and results are its slogan.

A Word About Panels

By Sidney E. Finkelstein, A.M.I.R.E.

THE radio art has seen a great number of stimulating successes which play on the credulity of the uninitiated and result in renewed increase of sales and enthusiasm. The introduction of the short waves, of low loss condensers and of low loss inductances and many other new and interesting features have greatly influenced the buying public and have, in a large measure, increased radio sales.

One of the articles which has enjoyed considerable publicity and advertisement is the radio panel. There are quite a variety of panels now on the market, and for each are claimed certain specific points of superiority.

Just why do we use insulating panels? Why use them at all, or why not use metallic panels? In the face of these questions it will be well to carefully review the facts.

In the first place a close scrutiny of the mounted apparatus will reveal that in modern practice all rotors, whether they be from variometers, couplers, variable condensers or rheostats are at ground-potential, or plainly, grounded. Except of course for apparatus in the plate circuit of the receiver the above holds good for both primary and secondary circuits. Again, since shielded panels are used, why use any insulation at all? It certainly does sound and is ridiculous!

There is, however, one valid reason why insulating panels are used, which is because their use greatly enhances the appearance of any receiver. To date it has not been possible to create a lustre, gloss or finish on a metal panel which is comparable to those on hard rubber, bakelite, celeron or formica. True, fanciful designs and pleasing color combinations have been created, but as yet one has to see an approximation to the appearance of the original insulating panels.

The set builder who is looking for a good and substantial panel must bear in mind to look for a material which will fulfill the following requirements:

1. Desirable color.
2. Desirable surface finish.
3. Low phase difference.
4. Low power factor.
5. Low dielectric constant.
6. High specific resistance.

A definition of the terms included between numbers 3 and 6 are in order and are given herewith so as to enable the reader to fully comprehend the meaning of the various terms and their relationship.

Phase Difference. An insulating material when placed in a region of electrical stress will absorb small amounts of electrical energy which results in the generation of heat. The absorption is expressed in angular measure—in degrees. The ideal insulation, dry air or perfect vacuum, would give an angle of 90°, while for all solid or liquid insulation it will be less than 90°, as a result of energy losses. This variation from 90° is known as the *phase difference*. Thus, for example, a pure grade of hard rubber when new has a smaller phase difference than some phenol-resin materials. Metals would then be perfectly useless as panels and an insulating panel of the lowest phase difference is most suitable.

Power Factor. Another way of expressing phase difference is to use the term *power factor*. The power factor is the sine of the angle of phase difference. Phase difference and power factor are often expressed in per cent.

Dielectric Constant. This term is a factor and is also known as *Specific Inductive Capacity*. It is best understood in this way: Under given conditions a condenser having air as the insulating medium between its plates will have a certain capacity. If the air is replaced by another insulating material, a different value of capacity is obtained. The dielectric capacity of the material is expressed as the ratio between the latter and the former. It is thus an abstract number. The lower this number is, the better is the insulating material.

Specific resistance of a substance is the resistance that a piece one sq. cm. in cross section and one cm. long offers to the flow of current. It is sometimes referred to as the resistance "per cubic centimeter." The unit of resistance being the ohm, and a megohm being one million ohms, it is interesting to note that the resistance of an average panel is in the neighborhood of a million megohms per cubic centimeter. The higher the specific resistance, or as sometimes called the volume resistivity of a panel, the less the leakage that is liable to occur.

Those properties which have been dealt with were purely of an electrical nature. It would be well to consider those physical and chemical properties which are necessary and constitute the essentials of a good panel.

A good panel must have mechanical strength, rigidity, and must not warp. It should be non-hygroscopic, it should not bleach in sunlight and must not give or flow under the pressure of tightening bolts. Besides being easy to manipulate and drill, it should be chemically inert to the extent that it will not deteriorate with age. Of course, resistance to ordinary acids which may accidentally be spilled on it, is a very desirable property. It should be able to keep its gloss or lustre for a long time.

For the average size panel, which may range from 7 by 14 inches for a three-tube regenerative set, to 7 by 42 inches for an eight-tube superheterodyne, a thickness of 3/16ths of an inch will serve the purpose. Thinner or thicker material is not necessary, or, in fact, advisable, since the mechanical requirements do not warrant it.

The only things which may be said concerning metal panels are first, that it is preferable to use a metal having high conductivity, painted with enamel so as to prevent oxidation and corrosion; second, that all parts above ground potential must be carefully insulated with bushings, and third, that all inductances should be kept as far away from the panel as possible in order that undue absorption may not be caused.

There have recently appeared on the market several radio receiving sets without a panel and although their appearance is radically different from what we have been accustomed to seeing, it is safe to say that, like the automobile industry, the radio industry will produce different styles of sets from year to year.

Wood panels as used in early days have almost entirely disappeared. They are used once in a while by the experimenter who desires to mount a combination of various pieces of apparatus and who is not willing to risk spoiling an expensive panel until he has decided upon the correct design.

Many amateurs use wood panels in short wave receivers and get very excellent results. Warping, surface leakage and looks evidently hold no terror for them.

In conclusion, the author would place particular stress on keeping the panel of the radio receiver free from finger prints, dust and lint, as the appearance of a highly finished panel may be greatly impaired by such defacing marks.

Radio Outfit In A Headset

(*Continued from preceding page*)

They are then placed in the usual copper bath and are electro-plated. They will require a relatively heavy coating of copper.

The phone shell is drilled as shown in Fig. 3, to take the 4/32 brass machine screws. Eighty-four brass spacing washers, .025 inch thick (outside diameter 9/32, inside diameter 4/32), are used in assembling the plates. The shaft is a 4/32 machine screw. The piece (O) is an adapter, threaded to take the shaft, and also to fit the knob (N). (M) is a brass bushing taken from the base of a binding post; it is shellaced to the phone shell (L). The dimensions of the plates will, of course, depend upon the case used.

The inductance, a coil of 75 turns of No. 20 D.S.C. magnet wire, wound, duo-lateral-wise, upon a fiber hoop, 1 inch wide and 8 inches in diameter, is mounted atop the head-band by means of the pillar (A) and the brackets (C), Fig. 2. The coil's capacity is .5 mh. (approximately). (A) is a hard rubber bushing through which a 6/32 machine screw passes, thus clamping the coil to the brass strip (B), which is in turn riveted to the head-band. The two brackets (C,C) are bent up from buss bar wire and are also riveted to the coil and the head-band.

The detector is mounted on the back of the composition receiver shell. Details of its construction are given in Fig. 3. Two small brass angles (F) are used to support the crystal cup (G) and the tension screw (I). (H) is a nickeled brass pointer, bent as shown in the detail, and is used in place of a cat-whisker.

All wiring is accomplished by means of copper ribbon, 3/16 inch wide by .005 inch thick, incased in cambric tubing. This is led up over the head-band, as shown, and is held in place by the rubber bands (D,D,D).

With a little patience and care, one will be able to duplicate the unique set and have something which, besides being a novelty, will actually give excellent results under favorable conditions.

Remote Control

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

BEFORE entering upon a discussion of the various methods of accomplishing the remote control of a transmitter, let us see why such type of control is sometimes necessary or desirable.

It often happens that the transmitting apparatus of a station because of lack of room or other necessity, is located in some part of the house that is not heated in winter or that is too hot to work in, in summer. Then again, many transmitting amateurs have entered matrimony and the "better halves" object to their spending evening after evening in the radio room. If, therefore, you move your transmitting set to a distant location so that she (the "better half" of course) will be happier, and install remote control, everything will be fine and you will still be able to operate your set continuously.

A third reason for remote control is that your own yard may be so arranged that a good transmitting aerial cannot be erected. Possibly a few hundred feet away there may be space where you can put up a good antenna. This is what happened in the case of 1BM, whose remote control system is illustrated in Figs. 2 and 3. He built his antenna more than one thousand feet away from his home, erected a shack directly under it for housing the apparatus and ran only two leads to his house and to the operating room. In this way, after once tuning the transmitter, he could enjoy all the comforts of home combined with the delights of radio.

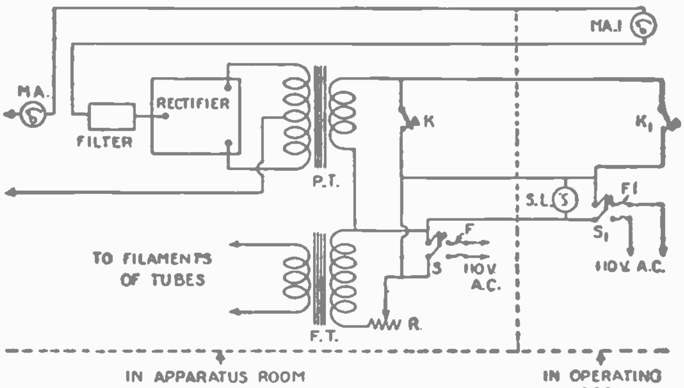


FIG. 1

A good system of remote control using current supply at both the operator's station and at the transmitter itself. A second milliammeter is employed as well as a signal light to denote that everything is going in good shape when the "juice" is turned on.

At 3MO the actual transmitting apparatus was installed on the third floor of the house. It was put in in the winter time, but as the summer months came around, it was found that the room was too hot for comfortable operation. Remote control was immediately figured upon, and the system shown in Fig. 1 was worked out and installed. Perfect satisfaction has been obtained and the results are all that can be desired. In the writer's opinion, the system shown in Fig. 1 is superior in many ways to 1BM's, although the latter holds some advantages of its own. In the first place there are no comparatively high voltage leads running over long distances as in the system used by 1BM. This is a great advantage where the operating room is more than 30 or 40 feet away from the apparatus room. However, in the case of 3MO, the operating room was directly under the apparatus room and the leads used were only about 25 feet long.

Let us now go into a detailed description of these two systems. Undoubtedly if you need remote control, one or the other of these systems will suit your purposes. If not, the ideas as given will undoubtedly enable you to evolve a system that will work under your own peculiar conditions.

In Fig. 1, that part of the transmitting apparatus which is affected by the remote control addition or connected to it, is shown to the left of the dotted line. The only instruments and apparatus that are used in the control room aside from the receiving set are shown at the right of the dotted line. It will be seen that five leads are brought from the apparatus to the control. It is a wise precaution to use what is known as BX cable for these leads, and, in fact, the wires that carry 110 volts A.C. will have to be of this type.

The first thing to figure out was how the two transformers could be controlled, as they must be turned on separately. It was found that the Allen-Bradley primary rheostat (R) in Fig. 1 could, after being once set in the required position, be left there indefinitely. Of course, line voltage fluctuates somewhat and therefore it is a wise precaution when using a five-watt tube to set the filament voltage at 7 or with a 50-watt tube at 9. In this way any rise in the line voltage will probably not be sufficient to push the filament voltage above maximum and your tube will be safeguarded in this way. Be sure that you connect your rheostat in the position shown. If you connect it in the common lead between the two transformers, the filament voltage will drop considerably when the key is pressed.

You may wonder why two keys, two switches and two sources of power are shown in Fig. 1. The reason for this is that complete control was desired at each end of the system. This facilitates tuning and operation to a great degree and fully repays the operator for the additional trouble of installing the extra key and switch. Of course, it must be remembered that under any conditions, switch (S) must be opened when switch (S1) is to be closed and *vice versa*.

When working in the operating room you will always have the light of the tube to remind you that the switch is closed. There is nothing like this at the remote control end, and so we will make provision for it. A signal lamp (SL) in Fig. 1 is connected across (S1). When this switch is closed, the lamp lights. It also lights if switch (S1) is opened and switch (S) is closed. Therefore, it serves to tell you whether or not you need to close switch (S1) before starting to operate. The two keys (K) and (K1) were also installed for convenience. It can thus be seen that the entire transmitter can be completely controlled from either end. By all means do not forget to use fused switches at both ends. The fuses are indicated by (F) and F1). The use of 6 ampere fuses here will protect your lines and prevent trouble.

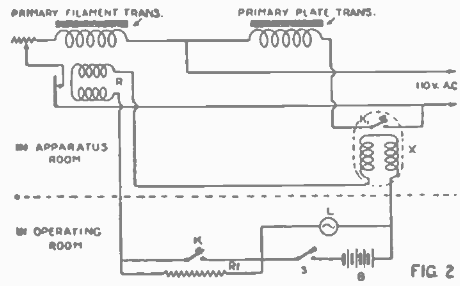


FIG 2

The excellent method of remote control shown above should be used wherever possible. A single switch and a key used in conjunction with two relays, are needed.

Since the milliammeter is the trouble-indicator of a transmitter, some provision should be made for its location at the operating end. If anything whatsoever goes wrong with your transmitter, the plate amperage will fluctuate, and by noticing the reading of your milliammeter occasionally, you can readily see whether or not everything is going on as it should at the other end. Therefore, two milliammeters were installed at 3MO. They are indicated by (MA) and (MA1) in Fig. 1. Two leads are run from the apparatus to the control and the two meters are connected in series as shown. (The meters are, of course, not in the oscillating circuit.)

Now let us refer to the unique two-wire system used by 1BM. The circuit diagram is shown in Fig. 2. If you wish to use a milliammeter at the control end, and this addition is by all means advisable, connect it in the same way as shown in Fig. 1. Inasmuch as this circuit is not part of the real remote control circuit, no changes will have to be made in Fig. 2 for the installation of an extra meter.

In the operating room, a 6-volt storage battery B—a switch, S—a resistance, R1—a key, K—and a 6-volt signal lamp, L—are installed. The additions to the transmitting apparatus are a relay, R—and a home-made piece of apparatus indicated by X—. The latter is detailed in Fig. 3. It merely consists of an ordinary transmitting key and sounder mounted on a base. The key is elevated above the base by means of a large wooden block and is placed at such a height that its lever will be on a level with the sounder lever. These two are then bolted together as shown and the apparatus is ready for use. It can be made in a few moments and with little if any trouble. The purpose of this little instrument is to close the primary circuit of the plate transformer in accordance with the pressing of the key (K) at the remote control end. The relay, —R, serves to close the filament circuit.

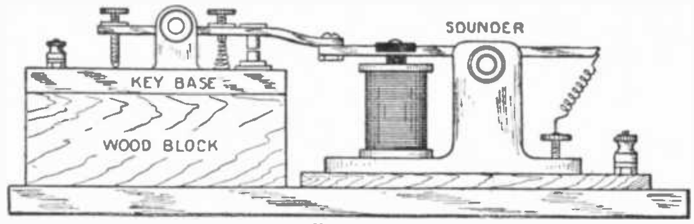


FIG. 3

Showing the detailed construction of the electromagnetically-controlled key as denoted by "X" in Fig. 2. It can be worked at high speed.

(*Continued on page* 854)

O O

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

SERIES AND PARALLEL CONNECTIONS

A GREAT deal of confusion has always existed among radio fans as to exactly what are the parallel and series connections which occur in the tuning circuits of a radio receiver.

In speaking of parallel or series connections, the circuit is always considered with respect to either the *emf's* in the circuit or the paths that the current can take in flowing from one point to another. The series arrangement can conveniently be considered as a cascade arrangement, in which the source of *emf* and all the other pieces of apparatus are connected in a complete series from one terminal of the source of *emf* to the other terminal. The current has to flow into one piece of apparatus, then out of it and into the next, out of this and into the next, and so on, until the circuit is completed. There is only one path which the current may take in a series circuit.

In the parallel arrangement, however, there are several paths which the current may take in passing around the circuit. Thus, suppose we have the arrangement shown in Fig. 1 below. In flowing from the terminal of the source of *emf*, *a*, to the other terminal, *b*, the current can take two

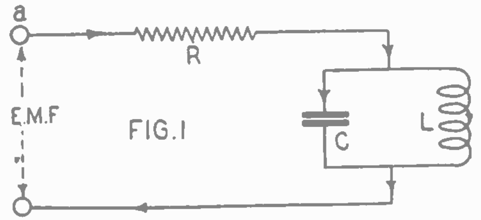


FIG. I

paths, one path through the condenser and the other through the coil. The coil and condenser are therefore connected in parallel. It must be noted, however, that in flowing from *a* to *b*, the current must first pass into the resistance, then out of it, then into the parallel arrangement, out of it, and thence back to *b*.

If we therefore regard the combination of coil and condenser as a single unit, as would be the case with a coil having distributed capacity, we could say that the *emf*, the resistance and the parallel combination are all in series. The whole question, therefore, is decided by the number of paths the current can take in flowing between the terminals of the source of *emf*.

11-11

O O

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

RADIO CALCULATIONS

THE study of radio, in a complete way, will involve the application of about as much mathematics as almost any other branch of science does, excepting perhaps astronomy. But it is not necessary for most of us to go any further into the theory of radio transmission than what will be covered by the application of what may be termed high school mathematics. This includes algebra and trigonometry. But even all this is not quite necessary for most of us, who are not making a living at radio, but who are merely interested in it as we derive pleasure and recreation from the study. A great deal can be done by the experimenter if he has only a rudimentary knowledge of algebra.

To help those who wish to be able to apply some of the simple formulas which continually arise in radio design, we will review from time to time some of these elementary principles. Very few are required for our purposes.

The first thing to understand is what a formula, or equation, as it is also known, means. A formula or equation is merely a statement of equality between two quantities. For instance, if there are 10 coulombs of electricity flowing into a condenser per second, and this flow of electricity continues for 2 seconds, there will obviously flow into it a total of 20 coulombs.

If we let "I" represent the number of coulombs per second which flow into the condenser, and also let t represent the number of seconds, the total quantity will be $I \times t$. The formula may be expressed as

$$I \times t = Q$$

in which we let Q represent the total quantity. Thus if as above I is equal to 10 coulombs per second, and t is equal to 2 seconds, then Q will be equal to

$$10 \times 2 \text{ or } 20 \text{ coulombs.}$$

Likewise, if I is 30 and t is 4, we have $30 \times 4 = 120$ coulombs. For convenience we usually omit the multiplication sign and simply write the formula as $It = Q$.

The conception of current as explained in this radio data sheet is a very important one to get straight. It will be noted that current is the "rate of flow of electricity," that is, the *rate* at which quantities of electricity flow through a conductor. The conception is somewhat similar to that of the capacity of a water pipe. The capacity of the water pipe may be expressed as so many gallons of water per minute, signifying that during each minute so many gallons of water are carried through the pipe, just as during a second, so many coulombs of electricity are carried in a wire in an electrical circuit.

14-20

O O

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

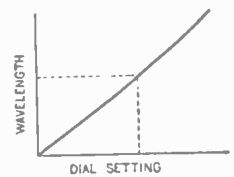
VARIOUS FORMS OF VARIABLE AIR CONDENSERS

[Straight Line Wave-Length Type]

IN radio data sheets 5-10 and 5-11 the classification of condensers, according to their use, and an explanation of the straight-line capacity type, were given. In this data sheet we will discuss the straight-line wave-length type. For reasons which will be explained later on, it often becomes desirable to make the plates of condensers of such shape as to cause certain quantities in tuned circuits to vary in a predetermined manner.

For instance, suppose, for various reasons, we should wish to be able to tune in on our radio receivers wave-lengths which vary uniformly with respect to the setting of the condenser. This corresponding division on the dial would represent corresponding meters of wave-length. The upper limit of the broadcasting wave range is 550 meters and the lower limit is slightly below 210 meters. The whole 100 divisions on the dial must therefore cover a range of 550-210 or 340 meters, which means that to have the various wave-lengths uniformly distributed, there will be 3.4 meters covered by every division on the dial.

The calibration curve of such a condenser is as shown in the figure. It will be noted that this is a straight-line; hence the name "straight-line" given to the condenser. It will also be noted that the line has a uniform slope, which



means equal increases of wave-length with equal increases of dial setting. This uniform change rate is characteristic of all straight-line (or linear) charts such as the one shown here.

This form of curve will be very nearly the same as that of the calibration curve of a receiver, the tuned circuit of which includes a constant inductance and a condenser of this type.

5-12

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

CONNECTIONS [Continued]

FIG. 1 is seen to be a simple series circuit. There is only one path the current may take in passing around the complete circuit. This path is from one terminal of the battery, through the filament, through the resistance and back to the battery. Another series circuit is shown in Fig. 2 in which the plate coil, the plate to filament resistance and the phones are all in series. In Fig. 3 we have a parallel connection where the current coming down from the antenna has two paths through which to flow. In Fig. 4 we have a series connection, for the *emf*, which arises *within* the condenser formed by the antenna and ground, causes a current to flow successively through the antenna (capacity), the coil, and the condenser. In Fig. 5 we have another series connection. This is the secondary tuning coil in series with the variable condenser. This may look at first sight like a parallel connection, but it must be remembered that the *emf* is generated *within* the windings of the coil, and therefore it can be regarded as in series with the rest of the circuit. The *emf*, the coil and condenser are therefore in series. The grid to filament resistance, however, is considered as in parallel with the condenser, for obviously there are two paths through which the current will divide in passing from *a* to *b* in Fig. 5, one through the condenser and the other through the grid filament resistance.

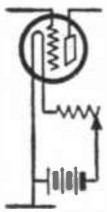


FIG.1

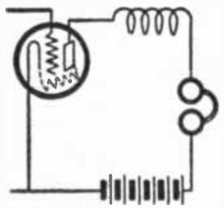


FIG.2

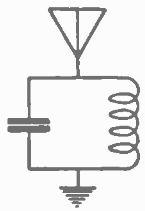


FIG.3

FIG.4

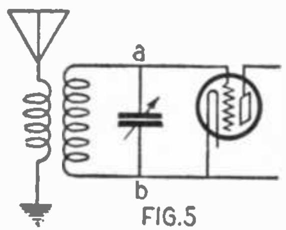


FIG.5

11-12

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

RADIO CALCULATIONS [Continued]

NOW suppose we state the problem the other way: if a total of 20 coulombs of electricity has flowed into the condenser in 2 seconds, obviously there are 20/2 or 10 coulombs of electricity flowing into it per second. This is the *rate* at which the electric charge is flowing. The formula is expressed as

$$Q/t = L$$

Now compare this equation (or formula) with the preceding one (sheet 14-20). Thus:

$$It = Q \text{ and } I = \frac{Q}{t}$$

It would not have been necessary for us to perform the reasoning in the above paragraph, if we but knew the rule which would enable us to convert from the one form to the other. Note that the only way in which these equations differ is in that the letter t has been removed from the left hand side, and put on the right, at the same time changing it from the upper position to the lower. In other words, we have divided both sides by t; on one side the t's cancel out, for anything divided by itself equals unity. Thus:

$$It = Q, \frac{It}{t} = \frac{Q}{t} \text{ or } I = \frac{Q}{t}$$

This rule holds for every form of equation. We can transfer any quantity from one side to the other, simply by changing its position from upper to lower or vice versa. It must be understood, however, that it must be a complete quantity. If I were represented by the sum of two quantities, such as I_1 and I_2, we would have

$$(I_1 + I_2)\ t = Q \text{ or } (I_1 + I_2) = \frac{Q}{t}$$

At the same time we are learning elementary mathematics we are learning the laws of electricity. The equation It = Q is known as Coulomb's law, and the letter (or symbol) is the current in the circuit. In electrical parlance, then, if there are Q coulombs of electricity per second flowing in a circuit, then the current in the circuit, represented by I, is Q/t. The current is expressed in amperes. It will be noted, therefore, that the current (called amperage) is the *rate of flow of electricity*. It is merely a measure of the rate at which the electric charge or quantity is passed along through the circuit.

14-21

The EXPERIMENTER Radio Data Sheets

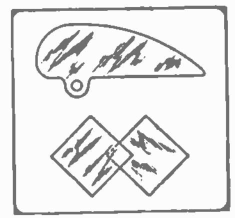
By Sylvan Harris

VARIOUS FORMS OF VARIABLE AIR CONDENSERS [Straight Line Wave-Length Type] [Continued]

THE next question that arises in this study is, what conditions are imposed upon the plates as to their shape. Also what quantities are they, upon which these conditions depend. The answer is found in studying the formula

$$\lambda = 1884\ \sqrt{LC}$$

which has been explained before, and in which λ expresses the relation between the wave-length in meters of the circuit, its inductance (microhenries) and its capacity (microfarads). Now, in tuned circuits, we generally use a constant value of inductance, so that we can take this value, extract its square root, and then multiply this into the number 1884. This will give a ceratin constant which we will call K, and the formula becomes $\lambda = K\sqrt{C}$. To obtain a linear (straight-line) equation connecting the wave-length with the dial setting, we can let the capacity vary according to the square of the dial setting. If we do this, we will obtain the relation $\lambda = K_1 D$ in which K_1 is another constant, and D is the dial setting. This is the linear equation, which we wanted. But it must be noted that this required the capacity to be proportional to the *square* of the dial setting. It is from this relation, therefore, that we get the name "square law" which is often applied to this type of condenser.



The shapes of condenser plates coming from this relation are shown here. There are two shapes. These were discussed in detail in the August RADIO NEWS.

5-13

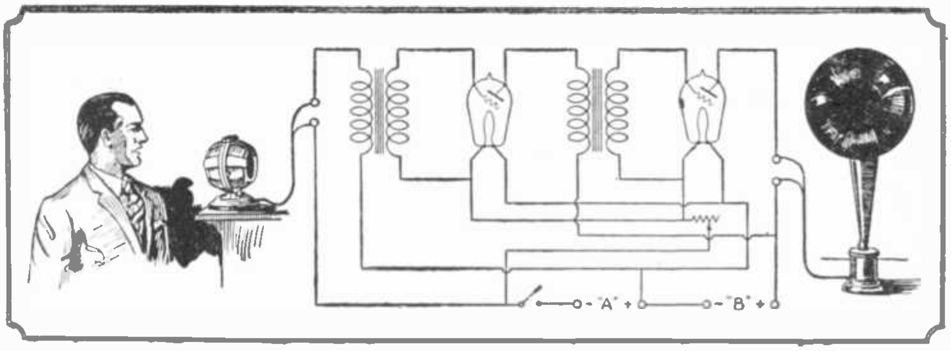
CUT ALONG PERFORATED LINES

A High-Class Broadcast Type Microphone

By M. Joffe

BESIDES being a useful article at an amateur transmitting station, the microphone described on this page is very ornamental, and adds a businesslike appearance to the place. However, its use is not limited solely to a transmitting station, but it can be used in conjunction with a two-stage audio amplifier as a loud speaker system.

The microphone is built up from various odds and ends generally to be found lying about the workroom. It consists of the base from an old desk stand telephone, its microphone button and diaphragm and outer brass supporting shell. The casing, which gives a resplendent air to the instrument, is the moulded bakelite form of a low-loss type variometer or fixed coupler from which the windings have been removed.



Showing how the microphone, two stage amplifier and loud speaker are hooked up. With such an arrangement the voice is amplified many fold and it is possible to address large audiences.

If you will note carefully the photo at the bottom of this page you will see that the microphone button and diaphragm are suspended by means of four heavy rubber bands. These bands are fastened to the main framework by clamping them between the two variometer segments and are attached to the microphone proper by means of the screws contained therein. The rubber bands are tightened just enough to allow the microphone to vibrate freely. They furnish an excellent means of support and completely eliminate noises produced by jars and other vibrations.

After the microphone has been assembled, its interior is carefully fitted with fine mesh copper gauze. Then the bakelite shell and enamel base are both rubbed with a light oil to give a high glossy finish to the instrument. Equipped with a phone cord, it is impossible, except for its unique and pleasing design, to tell it apart from a standard and expensive microphone.

To demonstrate its practical utility, the microphone was connected in series with the primary of the input transformer of a two-step transformer coupled audio frequency amplifier. The same storage battery which supplied the filament current for the amplifier tubes was used to supply the microphone current. A loud speaker was connected to the output and with 250 volts potential on the plates of the tubes, sufficient volume was obtained so that the voice could be heard for some distance.

Here are a few suggestions as to what can be done with such an outfit:

1. If the microphone is placed at one's bedside, and if the loud speaker is nestled in a corner of the maid's room, all one needs to say is, "Nora, I'll have breakfast in bed this morning."

2. At parties, it is possible to use the device and have loads of fun with it. Thus, with the loud speaker and microphone hidden, questions asked of an idol or other symbolic figure can be answered with rapidity and accuracy.

3. When, in colloquial terms, one is told to "hire a hall," he can bring his loud speaker system with him and address the audience without feeling as though those in the rear cannot hear him.

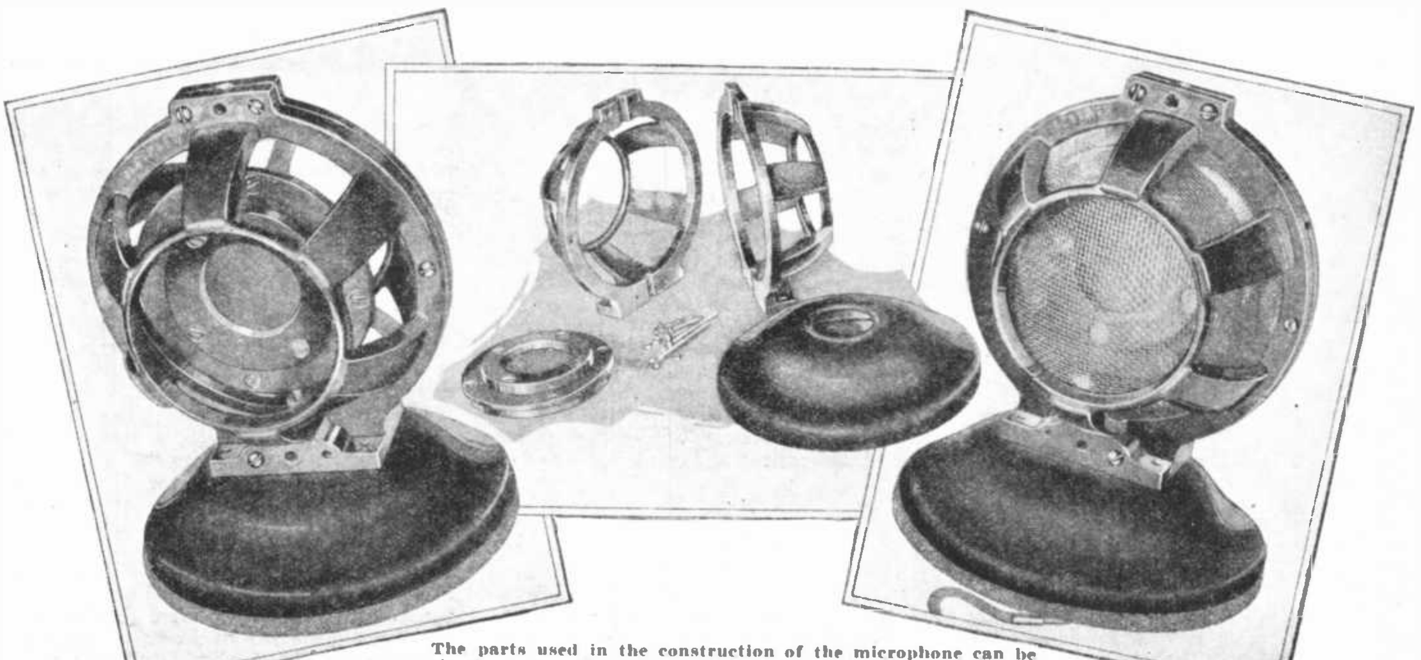
4. In offices, where large assemblages are to be spoken to, all requirements are filled very nicely by this loud speaker system.

And so it is possible to enumerate many other useful channels in which this instrument may be used.

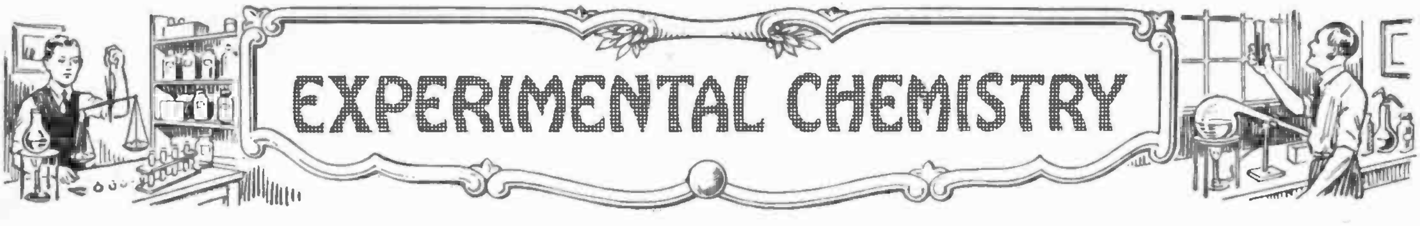
In the wiring diagram it will be noticed that a single switch controls the battery current and the operator must remember to shut off the current when the instrument is not in use.

Although not shown in the wiring diagram, a volume control in the shape of a 200 ohm potentiometer connected across the microphone terminals can be used to advantage. This will allow of a surprisingly fine control and it will become possible to use the outfit to better the effects of singular parlor tricks which can readily be performed. Phonograph music can be made to roll up to great volume after having started from what appears to be far-distant and very faint music. Fanciful ghost stories can be told with awesome impression, as on a Hallowe'en evening when "spooks" are supposed to be running around freely.

The ever enthusiastic amateur can add a red and green pilot light, together with a switch control and a number of other refinements which will occur to him as he uses it and by placing the receiver of the house telephone in front of the microphone, he can allow all the members of the family to listen-in on his conversation with his best girl!



The parts used in the construction of the microphone can be seen in the center, the microphone in the process of "evolution" at the left and the completed "mike" at the right.

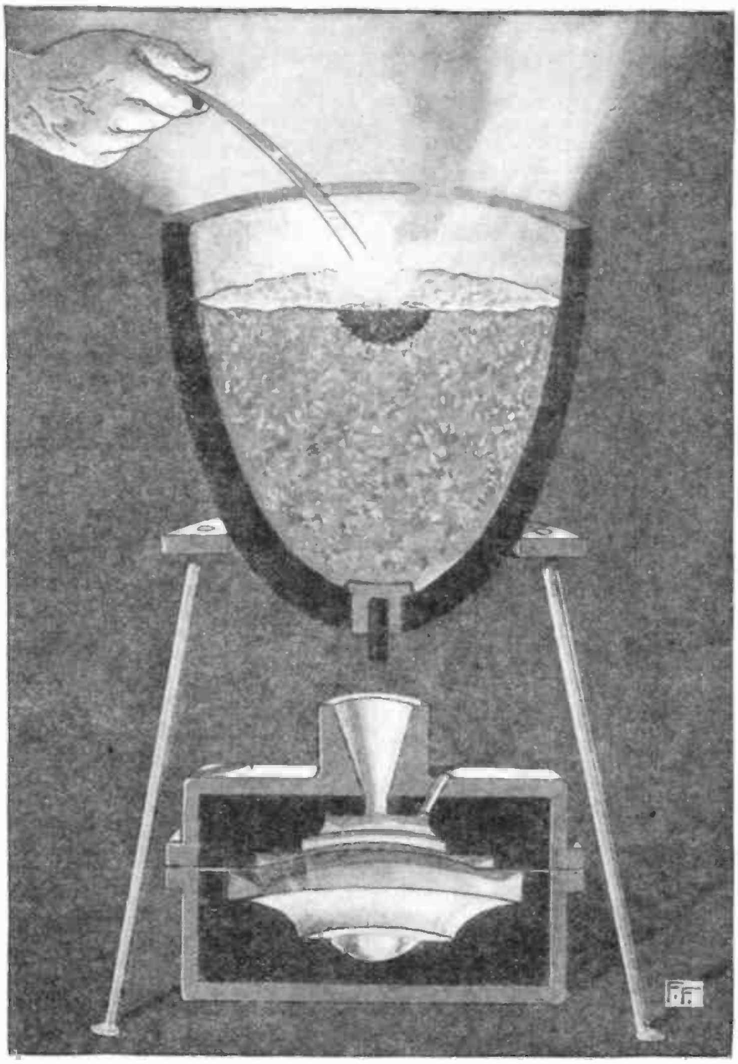


How To Make Thermit Experiments

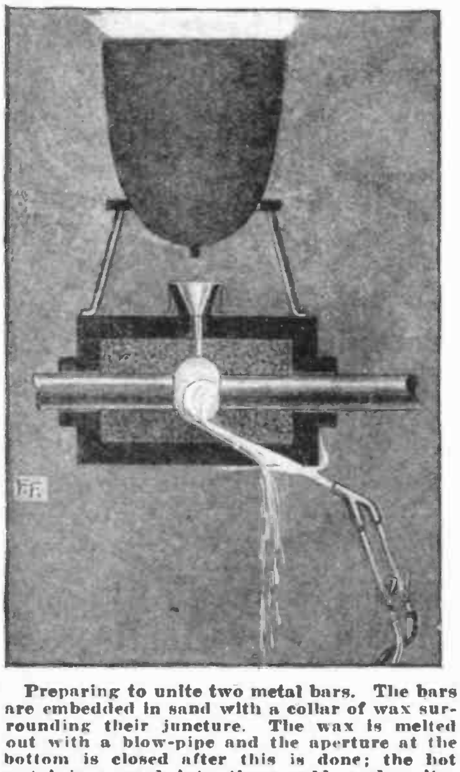
AMONG the most important developments in metallurgy of the last few decades has been the treatment of metals, principally of iron, in the line of what is called autogeneous soldering. Elihu Thompson did fine work in his electric welding process, and since those days the use of the blow-pipe flame, oxy-acetylene and the like, have led to remarkable results in the joining of pieces of metal.

The Goldschmidt Thermit process is very interesting for our readers because it is a veritable triumph of metallurgy, and while applicable to the heaviest type of work, producing heat of extremely high degree and concentrated absolutely at the place where it is required, it can be operated within the laboratory on a very small scale as a matter of interest and even to secure practical results.

The process is simplicity itself; finely divided metallic aluminum is mixed intimately with the powdered oxide of the metal to be produced. We will assume it to be iron; in such case magnetic oxide of iron, Fe_3O_4 gives excellent results. These are mixed in their proper proportions, calculated from the atomic and molecular weights; thus eight atoms of aluminum will be required to react with three molecules of the above iron oxide, the aluminum combining with the oxygen forming aluminum sesqui-oxide and liberating nine atoms of metallic iron. The exact weights required to produce a given quantity of metallic iron are a matter of simple chemical calculation. The ratio of the weight of the oxide of iron to that of the aluminum used in the process should be roughly 3 to 1.



The thermit deflagration. A piece of magnesium ribbon is used to start a little deflagrating mixture bedded in the thermit mixture and this causes the thermit mixture in the crucible to violently deflagrate; the aluminum reduces the metal oxides mixed with it generating enormous heat. To withdraw metal from the bottom the iron plug is driven up and the metal streams out and the plug is melted and disappears. A little bit of magnesium ribbon may be stuck into the deflagrating mixture and lighted.



Preparing to unite two metal bars. The bars are embedded in sand with a collar of wax surrounding their juncture. The wax is melted out with a blow-pipe and the aperture at the bottom is closed after this is done; the hot metal is poured into the mould, and unites with the bar, leaving a collar of metal around it.

Other metals, however, have to be dealt with, and in each case an analysis of the raw material, as the oxide may be called, has to be made. The process is simplicity itself; metallic aluminum with its great affinity for oxygen, if mixed with an oxide of most other metals, forms a deflagrating mixture, and if the deflagration is started in any one part of the mixture, it spreads rapidly through it, enormous heat is produced, the melted aluminum oxide rises to the surface as a slag and the pure reduced metal, iron or other metal lies below it. The operation is done in crucibles, so-called magnesite crucibles, and ordinarily intractable metals melt and become as liquid as water.

If we consider that this process puts it in our power to produce a mass of iron ordinarily almost impossible to melt, and to get this iron as liquid as water so that it can be cast, and the degree of heat is such as to enable it to act on other metals merely as a heating agent, it will be seen what a powerful instrument is here.

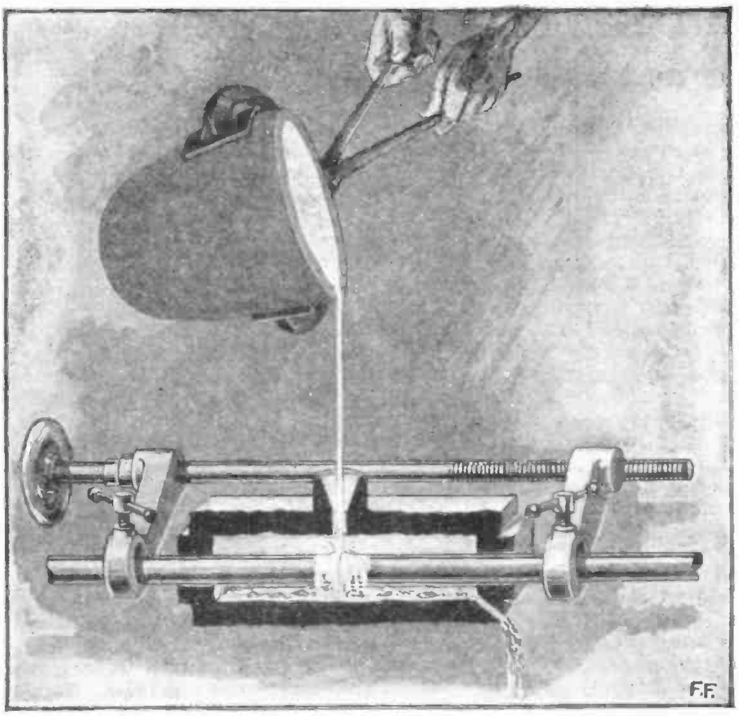
Our illustration on the cover gives an idea of how it may be used in the laboratory for experimental work. By means of it various metals, cobalt, nickel, copper, manganese, iron and others, can be brought into a pure metallic state ready for casting into ingots or in moulds.

The first thing to be done is to perform the calculations. Suppose that pure Fe_2O_3 is to be reduced to metal. The equation is of the simplest order in this case

$$Al_2 + Fe_2O_3 = Al_2O_3 + Fe_2$$

We have used subscript numbers throughout. It will be seen that each atom of aluminum, whose atomic weight is 27, liberates or reduces to the metallic state 1 atom of iron whose atomic weight is 56, so that the ratio of the metals will be 27 to 56. But as the molecular weights of Al_2 and Fe_2O_3 are as 54:160, this ratio gives the working figure.

The iron oxide must be in powder and intimately mixed with the aluminum. The mix s placed in a magnesite crucible with a hole drilled through the bottom like a flower-pot, and a little plug inserted therein. This may be a little bar of iron or even a bit of a large nail, and when in place is coated and covered with some magnesite composition. The crucible is now filled perhaps two-



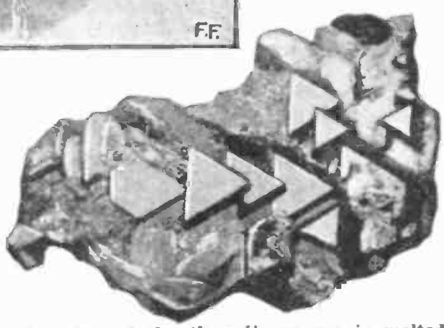
Welding pipes together by the thermit process. Top pouring causes slag to issue and fall upon the pipe; then when the metal strikes the juncture, the slag prevents it from welding thereto and by the screw clamps the ends of the pipe are pressed together and unite.

thirds full with the mixture and a little cavity is made in the top of the dust-like contents, and in this a mixture of barium binoxide or potassium chlorate with powdered magnesium is placed. Other substances may be used for this purpose.

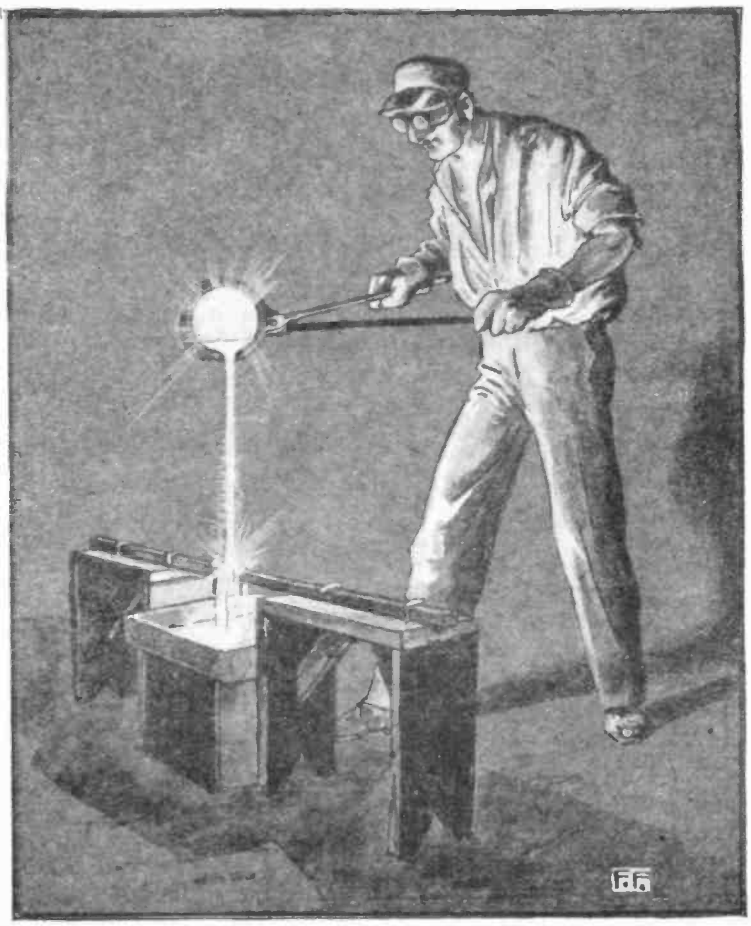
Next a piece of magnesium wire is ignited and the burning end is touched to the mixture in the little cavity. The effect of this is that an intense deflagration takes place in the mixture in the cavity; this spreads with great rapidity to the contents of the crucible. The reduction described takes place in a few seconds, and if the plug in the bottom of the crucible is knocked upwards, the melted metal will stream out and can be used in various ways. As we show it, it is supposed to be making a small casting for a motor pole-piece.

One very interesting and curious feature is that if a small quantity is operated on, the magnesite is such a poor conductor of heat that a crucible containing liquid iron can be held in the hand.

If two bars of iron are to be united end to end, they are placed in a sand mould with their ends perhaps half an inch apart and abutting against a cheese-shaped cylindroid of wax. The whole is bedded in sand. When all is ready, the wax is melted out by an acetylene blow-pipe flame; a little gate is provided at the bottom of the mould for this purpose. The wax of course melts readily and pours out. The hole or gate is plugged up with moulding sand. Next the melted metal, which should be as much as possible of the exact composition of the bars if a uniform result is required, is run into the mould through a gate at its top from the bottom of the crucible in which the thermit reaction is taking place. This fills the little cavity left by the melted wax and the enormous heat causes the ends of the bars and the metal just introduced to become one. The bar can be bent and twisted at this point without giving way; it is as good as any other part of the piece. The little annular projection which surrounds the bar can be chipped, turned or milled off if desired. In many cases it is required to leave pieces attached to the object being treated, in which case the mould is shaped so as to cast them to exactly the proper shape and size. The most varied results can be produced in this way, and all these things too can be carried out by the experimenter in the laboratory.



The slag of the thermit process is melted alumina, the substance of the ruby. The process suggests the possibility of making synthetic rubies, and above is reproduced a magnified photograph of some of the crystals.



Top pouring again is used in the open upon a metal bar. It will be seen that the uses of the process are endless; here they are used to cut metal as if it were wax.

So far we have spoken of bottom castings, but an unperforated crucible can be used and the metal can be poured from the top, in which case it will be accompanied by the slag. Top pouring can be used where the melted metal is used only as the producer of heat. Suppose two iron pipes are to be joined. The ends are cut off so that they will fit closely, one against the other. The pipe is held between two blocks of cast-iron with recesses turned out so as to hold the pipe and form a hollow, cylindrical space around it. There is an opening for pouring the metal in and one for it to escape by. Pouring from the top the melted slag first enters the mould and coats the pipe with alumina. Next comes the metal, but this cannot come in contact with the pipe on account of the coating of slag, so all it can do is to heat it to an intense heat. At the proper time by means of screw clamps, the ends of the pipe which are butting together in the cast-iron mould are pressed together and they are so softened by the heat that a perfect joint is produced, which sometimes is so exact as to be almost invisible.

The temperatures attained in the thermit process are so high that they are above the measuring range of any pyrometer, and therefore cannot be measured directly. Professor Richards, of Lehigh University, has calculated that in the reduction of magnetic iron oxide (Fe_3O_4) by aluminum the temperautre reached is at least 5,000° F.

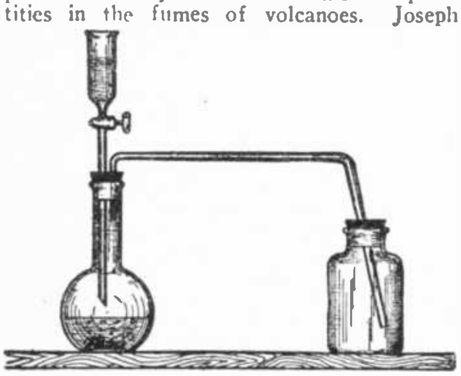
The temperature varies, of course, with the particular oxide that is being reduced and also with the fineness of the mixture of oxide and aluminum, as this last controls the speed of the reduction. The finer the mixture, the quicker the reaction and the higher the temperature. With some oxides the reaction is extremely rapid. For example, with cobalt oxide (CoO) the action is so violent that about 8½ pounds of cobalt is all that can be made in one reduction. One large manufacturer of cobalt, who filled an order of 100,000 pounds of the metal,

(*Continued on page* 841)

Sulphur Dioxide and Its Properties

By Eugene W. Blank

SULPHUR dioxide is a gas with a characteristic odor reminding one of burning sulphur. It is a poisonous gas; a very small amount in the air affects the eyes, while a large quantity, such as is given off in copper smelters, will kill the surrounding vegetation. It is absorbed by the blood, forming sulphuric acid, which finally poisons the body. It is found in small quantities in the fumes of volcanoes. Joseph Priestly produced the gas in 1770 by the action of hot concentrated sulphuric acid on mercury.



Collecting sulphurous oxide by upward displacement of air. The gas is a little more than twice as heavy as air and therefore can be thus collected. The funnel tube need not dip into the liquid because of the stop-cock.

It can be prepared by placing some copper gauze in a small flask and adding a small quantity of concentrated sulphuric acid. Heat the flask carefully with a small flame and when the reaction begins to take place, cautiously smell the gaseous product. Silver, mercury, copper, or charcoal can be used to produce it; the last named substance is the one used on an industrial scale.

Another method of preparing the gas consists in heating a mixture of manganese dioxide and sulphur. The mixture can be most readily heated by placing it in a dry test tube and applying heat. The action is as follows:

$$MnO_2 + S_2 \rightarrow MnS + SO_2$$

Manganese dioxide + sulphur → manganese sulphide + sulphur dioxide

Although the gas can be prepared by the foregoing methods, the following reaction takes place more readily and safely. It consists in decomposing sodium bisulphite with dilute sulphuric acid. Arrange the apparatus as the illustration shows and place in the flask some sodium bisulphite covered with a small quantity of water. Add sulphuric acid through the thistle tube and collect the evolved gas by the upward displacement of air, this being necessary since the gas is very soluble in water. The gas is twice as heavy as air and is a non-supporter of ordinary combustion. Metallic potassium and magnesium will, however, burn in it. Ignite a piece of magnesium ribbon and lower it into a bottle of the gas.

Sulphur dioxide unites with many peroxides to form sulphates. Place a small quantity of lead peroxide in an ignition tube and heat while sulphur dioxide gas is passing over it. The lead peroxide will glow brightly, forming lead sulphate.

Place a small amount of dry sodium peroxide in an old salt shaker or container with a perforated top and shake it into a bottle of the gas. The tiny particles will glow owing to the rapid evolution of heat.

Collect a bottle of sulphur dioxide gas and place a glass plate on the mouth of the bottle. Now prepare a bottle full of hydrogen sulphide gas by the reaction between iron sulphide and sulphuric acid. When a bottle of hydrogen sulphide gas has been collected by the upward displacement of air, place it mouth downward on the bottle of sulphur dioxide gas and slip the glass plate from between the two bottles. Sulphur is deposited when the two gases mix. This is believed to account for the deposits of sulphur found in volcanic regions. If the gases are thoroughly dried, the reaction does not take place.

$$2H_2S + SO_2 \rightarrow 2H_2O + 3S$$

Hydrogen sulphide + sulphur dioxide → water + sulphur

When an electric spark is passed through a cylinder of the gas, it dissociates or breaks down and sulphur is deposited on surrounding objects. If a strong ray of light is passed through a cylinder of the gas, it appears transparent, but in a short time the gas dissociates and misty strata form in the tube. This disappears if the gas be left in the dark for a short time. The dissociation can be explained as follows:

$$3SO_2 \rightarrow 2SO_3 + S$$

Sulphur dioxide → sulphur trioxide + sulphur

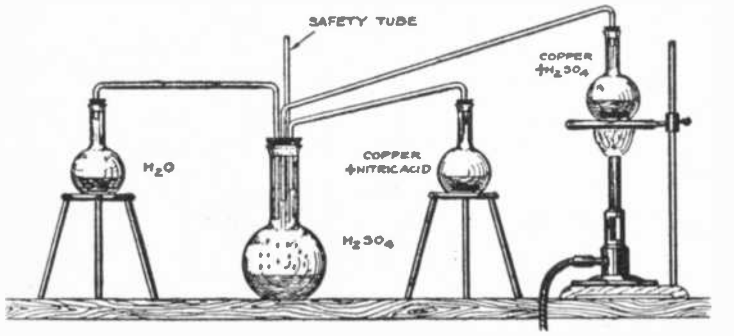
Tyndall was the first to observe this change and it is accordingly sometimes called Tyndall's effect.

The gas is a powerful reducing agent. It reduces red potassium permanganate to a light colored manganous salt, chromates to chromium salts and ferric to ferrous salts.

Allow some sulphur dioxide gas from the generator to bubble through a solution of potassium permanganate. In a short time the dark red solution will become colorless.

Prepare a solution of potassium bichromate and to it add a small quantity of alcohol. Warm the mixture and pass in some sulphur dioxide gas. In a short time the orange color of the solution disappears and a green chromium salt is formed.

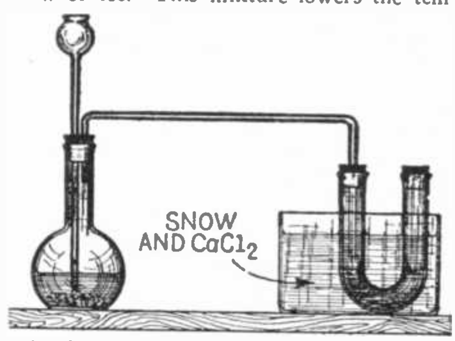
An aqueous solution of sulphur dioxide gas is strongly acid and behaves as an acid. The solution is thus commonly known as sulphurous acid and the gas itself as sulphurous anhydride. Sulphurous acid is a powerful bleaching agent and is widely used to bleach sponges, flannels and various articles of food. The bleaching action is due to the reducing power of the acid and the colored compounds are not permanently removed, but only reduced, and on exposure to the air the color gradually returns. In a bottle of sulphur dioxide gas place some moistened colored fabrics and a red rose. The articles in question gradually lose their color.



The old-fashioned way of making sulphuric acid, carried out in the laboratory. The flask provided with its safety tube, represents the lead chamber. The gases are evolved by the two flasks on the right and steam is supplied from the flask on the left.

An interesting experiment can be performed if the experimenter can procure a small amount of rosaniline hydrochloride (fuschine hydrochloride). Dissolve about .2 gram of the dye in 15 cc. of water and pass in a stream of sulphur dioxide gas until the liquid is saturated. The red solution will become colorless; dilute to about 200 cc. with water and keep in a dark bottle. If a small amount of the solution is allowed to remain in contact with the air, the color will return. This solution is used as a test for aldehydes. Add a small quantity of formaldehyde to some of the solution; the original color is restored.

Sulphur dioxide gas is easily liquefied; at —10° C. (14° F.) the gas liquefies at atmospheric pressure Thus it is readily liquefied by thoroughly drying the gas and passing it through a tube immersed in a freezing mixture of calcium chloride and snow. Arrange the apparatus as shown and prepare the gas by the reaction between sodium bisulphite and sulphuric acid. Pass the gas through the drying bottle, which contains sulphuric acid, and then into the U-tube immersed in the freezing mixture. A good freezing mixture to use consists of 2 parts of crystallized calcium chloride with half its weight of snow or ice. This mixture lowers the temperature of surrounding objects to a temperature between 0° C. (32° F.) to —43° C. (—45.4° F.). As the gas passes into the U tube, it condenses to a clear, transparent, limpid liquid which boils at —8° C. (17.6° F.) and solidifies at —70° C. (—94° F.). Liquid sulphur dioxide is much used commercially and comes on the market in thick glass or iron tanks. The containers are never quite filled to the top. The liquid sulphur dioxide readily dissolves phosphorus, iodine and sulphur.



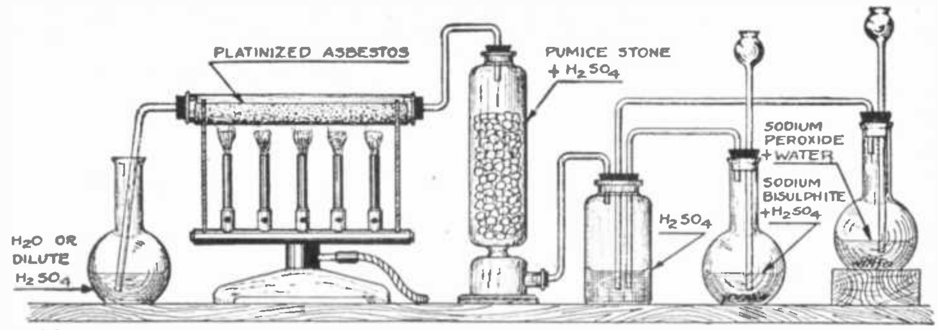
Condensing sulphurous oxide gas to a liquid by refrigeration. The U-tube is surrounded by a mixture of calcium chloride and snow.

Sulphuric acid is made by oxidizing sulphur dioxide to sulphur trioxide and dissolving the latter substance in water or in dilute sulphuric acid. The oxidation of the sulphur dioxide is accomplished by passing the dried gas mixed with oxygen or with air —to supply the same—over platinized asbestos (contact process) or by mixing the sulphurous oxide and air with nitrogen oxides in large lead chambers (chamber process).

To duplicate the chamber process on a small scale the apparatus consists of a large flask fitted with a rubber stopper through which several tubes pass. One leads to flask —D— (see drawing) which contains copper and sulphuric acid for preparing the sulphur dioxide gas. On a large scale the gas is obtained by roasting iron pyrites or by burning sulphur. A second tube connects with flask—B— containing copper and dilute nitric acid to produce nitric oxide. A third tube leads to a flask half filled with water.

To start the experiment flask—B—is gently heated and the nitric oxide passes into the large flask, where the greater part of it combines with the oxygen of the air forming red nitrogen peroxide. This large flask represents the lead chambers which are used in an acid plant. Flask—D—is now heated and the sulphur dioxide which is evolved passes into the large flask decolorizing the red fumes, nitrosyl sulphuric acid being formed. Finally steam is passed into the flask and the nitrosyl sulphuric acid being decomposed gives rise to the sulphuric acid which collects at the bottom of the flask.

To prepare the acid by the contact process arrange the apparatus as shown in the illustration. The wash bottle contains concentrated sulphuric acid and the drying tower contains pumice stone saturated with sulphuric acid. Sulphur dioxide and oxygen gas are passed into the drying bottle, and from thence the dry mixture of gases passes into the combustion tube where under the influence of some plantinized asbestos heated to approximately 400° C. (752° F.) combination takes place between the gases. The sulphur trioxide passes on and is either absorbed in dilute sulphuric acid or water. Instead of the expensive platinized asbestos ferric oxide, copper oxide pumice stone, etc., have been used, but they are not as satisfactory as the platinum.



The contact process of making sulphuric acid experimentally carried out in the laboratory. The perfectly dry mixture of gases is catalyzed by platinised asbestos.

The oxygen for the above experiment is most readily made by the action between sodium peroxide and water. Place the peroxide in a flask and allow the water to drop on the compound from a separatory funnel or dropping funnel. For our experiment an approximate temperature is only needed, but on an industrial scale the temperature must be very carefully regulated since the trioxide dissociates under an excess temperature. If the experimenter does not have platinized asbestos, it can be readily prepared. Select some clean asbestos and separate the fibres to a certain extent, allow to soak in a solution of platinum chloride, place in a crucible and ignite. When cool, the platinized asbestos is ready for use.

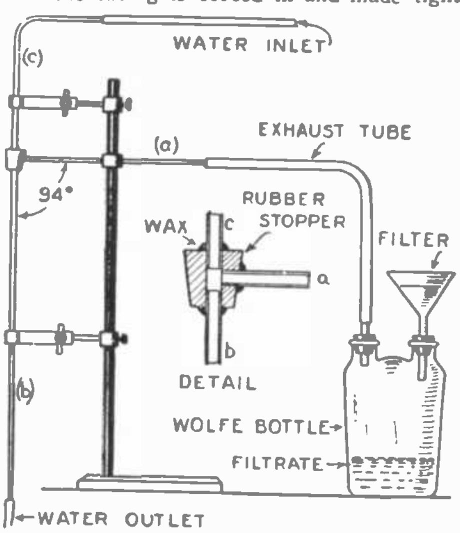
The sulphurous oxide is supposed to be produced by the action of sulphuric acid on sodium bisulphite.

Time Savers In Qualitative Analysis

By W. A. Sperry

THE amateur who does much qualitative analysis finds that as a general thing a great deal of time is wasted in filtering and in other necessary manipulations.

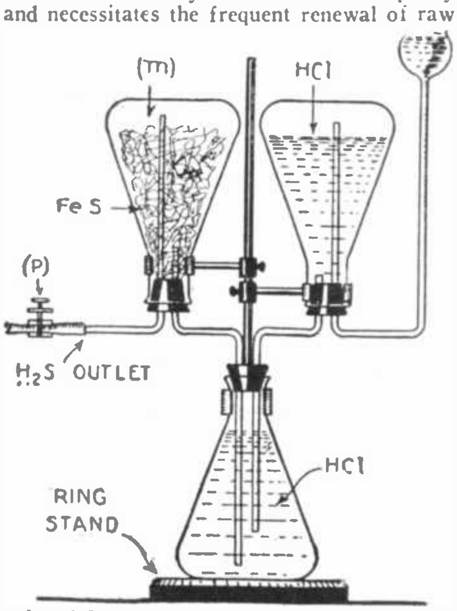
The possession of a standard filter pump or water injector is very seldom enjoyed by the experimenter, but as a time saver it "can't be beat." The construction of such a pump, which will render continuous service, and is capable of lowering the pressure in the filtrate vessel to 100-200 mm. of mercury and possibly even less, requires very little in the way of materials and even less in the way of skill. The pump proper consists simply of three pieces of glass tubing and a one-hole rubber stopper. This is drilled laterally so as to reach the central hole from the side, and the tubing is forced in and made tight with sealing wax. This acts as a "tee." If desired, the exhaust tube (a) may be sealed directly to the drop tube (b) allowing enough of the drop tube to project above to form the injector tube (c), thus making an integral glass assembly.



A very simple filter pump which can be constructed by anyone from glass tubes and corks with rubber connections.

It is best to make the drop tube as long as is practicable. The pump is clamped to a support and the injector tube is connected to a water tap, while the exhaust tube is continued to one neck of a Wolfe bottle. The other neck of the bottle receives the funnel stem, in which the filtering is done.

A generator for hydrogen sulphide and other gases is quite essential for work in qualitative analysis, but one contrived from a test tube usually lacks sufficient capacity and necessitates the frequent renewal of raw material. The generator described here, however, being a reproduction of the Draper modification of the familiar Kipp principle has all the advantages of the latter, yet can be easily assembled in a short time from standard laboratory equipment. The illustrations are self-explanatory, and it should suffice to say that by shutting off the cock (p), the increasing gas pressure in (m) forces the acid away from the ferrous sulphide, FeS, thus stopping the action.



A sulphuretted hydrogen generator. If the connections are followed out it will be seen to provide for the accumulation of excess of gas in the lowest of the three flasks.

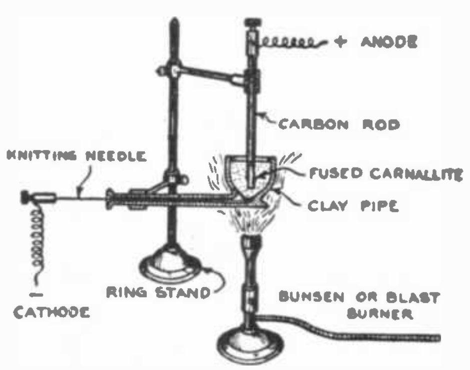
Making Magnesium in a Tobacco Pipe

By Eugene D. Lieber

MAGNESIUM is practically prepared by the electrolysis of carnallite, a double chloride of magnesium and potassium and having the formula $MgKCl_3.6H_2O$. If carnallite cannot be procured, a mixture of magnesium chloride and potassium chloride may be used.

A solution of 20 parts of crystalline magnesium chloride, 8 parts of potassium chloride and 3 parts of ammonium chloride is evaporated to dryness on a platinum dish over a water bath, and the residue fused over a blast burner. Pour the molten liquid into the bowl of the clay pipe heated over a Bunsen burner as shown in the illustration. The knitting needle is put down the stem of the pipe and the carbon rod sunk into the bowl.

The needle is connected to the terminal of a direct source of E.M.F. so as to become the cathode while the carbon is made the anode. The molten mass is now covered with a layer of charcoal dust and the current turned on (about 10 volts and 8 amperes should be used) The current is allowed to run for a half an hour while keeping the mass molten by means of the Bunsen burner. The whole is then set aside to cool. When the mass is broken up in a mortar, the small globules of magnesium metal scattered here and there throughout the melt can be picked out and washed clean by means of alcohol. The object of the charcoal powder is to protect the metal from oxidation.



Making magnesium in a tobacco pipe. Electrolysis is applied and globules of magnesium metal will be found after the fused mass has been treated for half an hour.

More Kinks for Chemical Experimenters

By Raymond B. Wailes

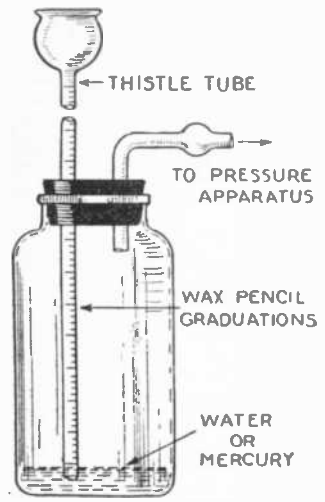


FIG. 1

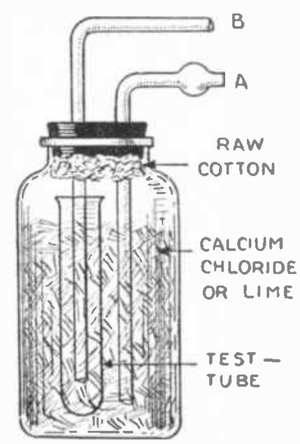


FIG. 2

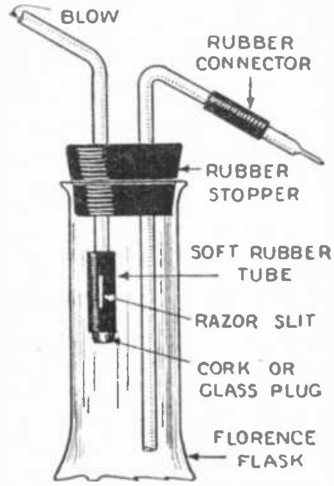


FIG. 3

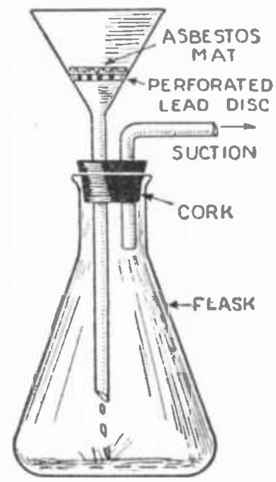


FIG. 4

Fig. 1. A simple extemporized pressure gauge using a graduated thistle tube to give the scale. Fig. 2. Effectual drying apparatus using the simplest material for its construction. Fig. 3. Valve for a wash-bottle so that the outflow will last for some time without mouth blowing. Fig. 4. Apparatus for rapid filtration with a suction pump.

MANY devices have been described in past issues of THE EXPERIMENTER for producing varying degrees of air pressure in the laboratory. A simple gauge to determine the exact pressure is shown in Fig. 1. This water gauge consists of a bottle fitted with a cork carrying a thistle funnel and an L tube to which the gas under pressure is connected. The thistle funnel is marked in inches and quarter-inches with a colored wax pencil, or by slightly filing a mark at the exact inch and quarter-inch marks with a dull file. The bottle is charged with about 1 inch of water. Pressure from outside source applied to the L-tube forces the water up the thistle funnel and the pressure in inches and fractions of

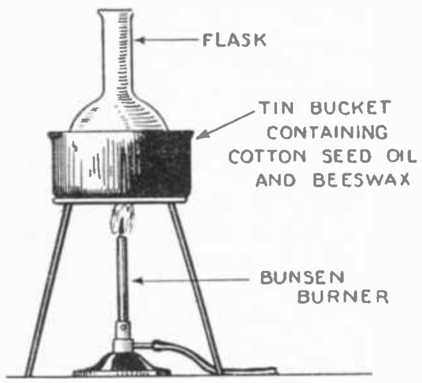


FIG. 5

Fig. 5. A mixture of cotton seed and oil and beeswax is used for heating chemical vessels. The mixture is solid when cold so there is no danger of spilling.

inches of water are read at the water meniscus. For higher pressures use mercury instead of water.

Many experiments require perfectly dry gases for their carrying out. To dry a gas it is generally passed through strong sulphuric acid or calcium chloride (dry solid). Of course, ammonia gas could not be dried by passing it through strong sulphuric acid, for it would react and combine with it. An efficient drying apparatus can be made from a test tube, a bottle and two lengths of glass tubing bent at right angles at one end. Insert one glass tube through the cork of the bottle and then into a test tube. Fill the test tube with granular calcium chloride and insert the whole into the bottle. Fill the bottle with calcium chloride and insert the second glass tube through the cork and into the calcium chloride in the bottle outside the test tube. Pass the gas to be dried through the inlet tube and it will issue from the other in the dry state. The gas, passed through tube (B) will pass up through the calcium chloride in the test tube, which dries it partially, and then passes down through the calcium chloride in the bottle and issues from tube (A), making a double passage. Dry lime (unslaked) can be substituted for the calcium chloride if desired in the drying of some gases. Gas may be led in through (A) if desired.

The experimenter does not have to keep blowing from his lungs into the wash bottle in his "lab." By means of a simple valve attachment, one gust of breath is forced into the wash bottle flask, which, due to the valve, cannot escape.

The wash bottle proper consists of a Florence flask fitted with two tubes, as Fig. 3 shows, one of them ending near the bottom of the flask. The flask is filled with water. Blowing into the shorter tube forces water out of the longer tube. If the short tube is fitted with a piece of rubber tubing 1½ inches long, which has a longitudinal razor slit in its side and whose end is plugged tightly with a cork or closed length of glass tubing, the air from the lungs will issue through the razor slit, but will not be able to escape backward, thus causing a steady stream of water to issue from the long tube. A short length of open tubing can also be thrust through the cork if desired, the finger being placed over its upper end when starting and lifted from it to stop the stream.

Filtering with the aid of suction speeds up laboratory work. A perforated disc of lead laid horizontally in a funnel will support a watery paste made with finely divided asbestos, which is poured over it. The water will drain through the disc and leave a mat of asbestos. Applying suction at the short tube of the flask removes some of the air from the bottle and sucks the asbestos tightly against the perforated lead disc. The apparatus is then ready for filtering solutions by pouring them into the funnel and then starting the suction.

Flasks can be safely heated in an oil bath instead of in a water bath, or on a sand bath, if high temperatures are to be applied to them. The flask is partly immersed in a vessel of oil and the pail is heated by the Bunsen burner. Oil is liable to spill out when not in use, so, by using cottonseed oil containing beeswax in the proportions of 2 or 3 of wax to 8 or 10 of oil, a bath can be had which is solid and non-spillable when cold. It can be used up to temperatures of about 300 degrees, when it reaches the flashing point.

The laboratory bench usually has a shelf above it. By clamping a burette clamp to this shelf and then putting an iron rod in the clamp jaws and, in turn, placing another burette clamp upon the rod, a support can be had which will carry the average apparatus for heating, titrating, filtering, soldering, etc.

Many of us digest our solutions by heating them in a beaker covered with a clock glass, the glass preventing loss by spattering. Frequently it is not advisable to use a beaker for the reaction, which might be violent. In this case a flask is generally re-

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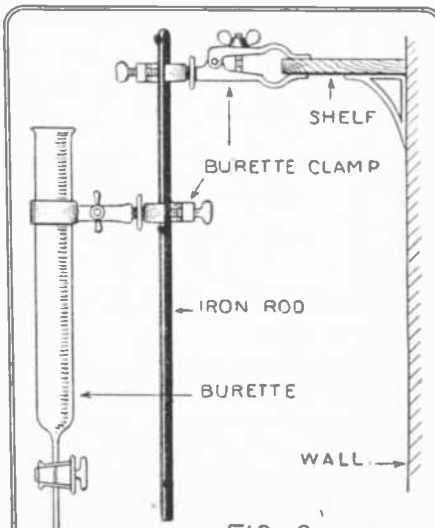


FIG. 6

Fig. 6. A quickly constructed burette holder, a substitute for the regular permanent stand.

Simple Wire Apparatus

By Ronald T. Symms

THE few examples of laboratory apparatus illustrated will not only prove useful in themselves, but will suggest to the mind of the experimenter many similar articles for kindred purposes.

Most of the appliances may be made of tinned wire, since it possesses sufficient stiffness to spring well and to hold its shape, and at the same time may be bent into any desired form. Besides, the tin coating makes the wire unoxidable and gives a good appearance. The only tools necessary are a small vise, a pair of pliers and several cylindrical piece sof wood, broom handles or dowel sticks.

Fig. 1, a tripod stand, easily formed by twisting three wires together, is used for supporting various articles to be heated.

Fig. 2 shows a pair of hinged tongs useful for handling heated articles, and when provided with two notched corks, as shown at C, are adapted for holding test tubes and flasks. These tongs are made by winding the wires of one half round the wire of the other half to form the joint, as shown in detail at B, and bending each part at right angles. The form of the ring end may be changed to adapt the tongs to other uses.

Fig. 3 shows a spring clamp which may be used for holding small articles to be soldered or as a pinchcock.

Fig. 4 represents an easily constructed stand for test tubes. It may be used to accommodate any number of tubes and the legs may be screwed to a wooden base to make the stand more stable.

Fig. 5 is an excellent form of pinchcock opened by pressing the two thumb pieces.

Fig. 6 shows a stand of adjustable height for supporting the beak of a retort or to hold conducting tubes in position.

Figs. 5 and 7 show stands of adjustable height for supporting the beak of the retort or to hold conducting tubes and a very simple retort stand with several sizes of rings.

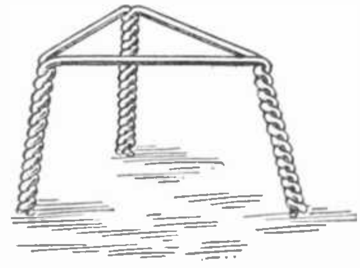
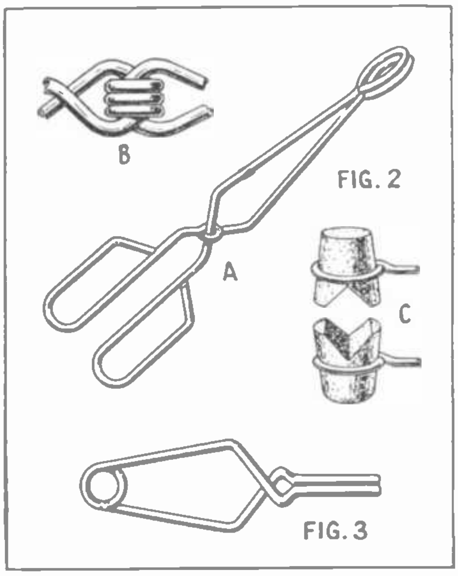
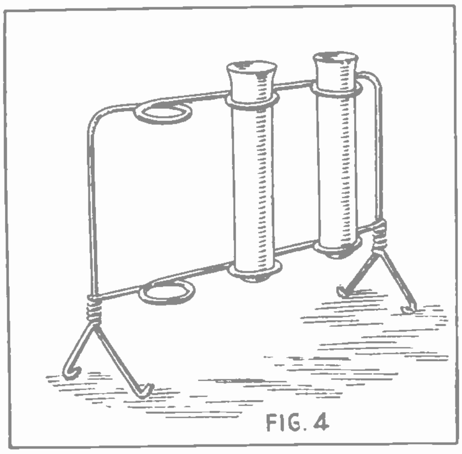


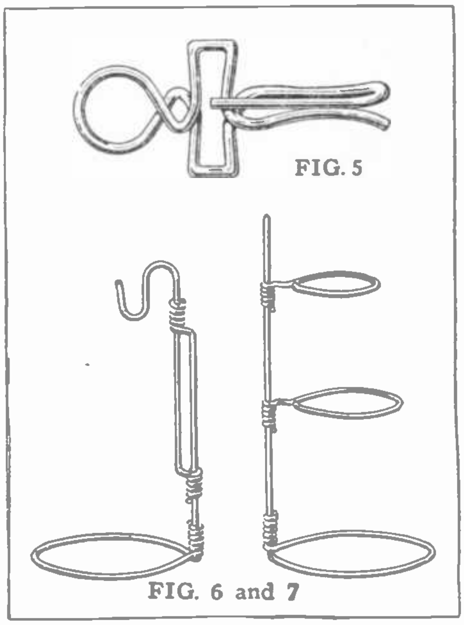
FIG. 1

The familiar wire triangle of the chemist is shown in Fig. 1; it has its legs bent down so as to form a small tripod.



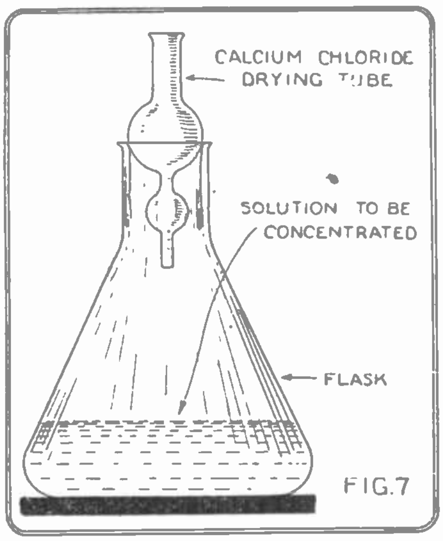


In Fig. 2 is shown a convenient tongs, made of wire, whose pivoted joint may be constructed as shown at (B). By introducing corks into the rings at the end of the jaws, (C) a test tube holder is produced. Fig. 3 is a spring pinchcock. For its construction care must be taken to have spring tempered wire. Brass wire is excellent. Fig. 4 shows a very nice construction of a test tube rack made of wire. In Fig. 5 is shown another construction of pinch-cock and below are two stands, one a regular retort stand and the other a stand for holding the beak of the retort. It will be observed that both are adjustable for height.



More Kinks for Chemical Experimenters

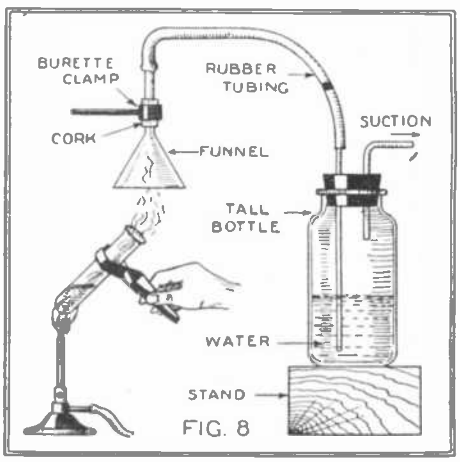
(Continued from preceding page)



The calcium chloride drying tube is used to prevent spray from escaping from a flask when a solution is being boiled therein.

sorted to. An ordinary calcium chloride tube inserted in the flask will prevent any material from being thrown out.

Elimination of obnoxious gases from the experimenter's laboratory is a problem. Many of the gases, such as sulphur dioxide, hydrogen sulphide, chlorine, hydrochloric acid gas, bromine, etc., are soluble in water. By passing these gases through water the disagreeable odors can be avoided. An extremely simple method of removing the gases is shown in one of the illustrations. A funnel, inverted, is used as the hood and the reaction vessel generating the gas to be eliminated is held under the funnel. The funnel is connected with a wash bottle by means of a rubber tube. Suction is applied to the wash bottle and sucks the gas through the water, in which it dissolves. Of course, more than one bottle of water can be used, and several may be connected in series. Reacting substances can be placed in the water too. For instance, if hydrochloric acid gas is being generated, it will dissolve in the water until the water becomes saturated and then the water will actually give off the gas. By adding lumps of lime or sodium hydroxide to the water, acid vapors can be neutralized.



A substitute for an evaporating chamber; for work on a small scale an arrangement of this sort is excellent.

Signal System for the Home

By Thomas W. Benson

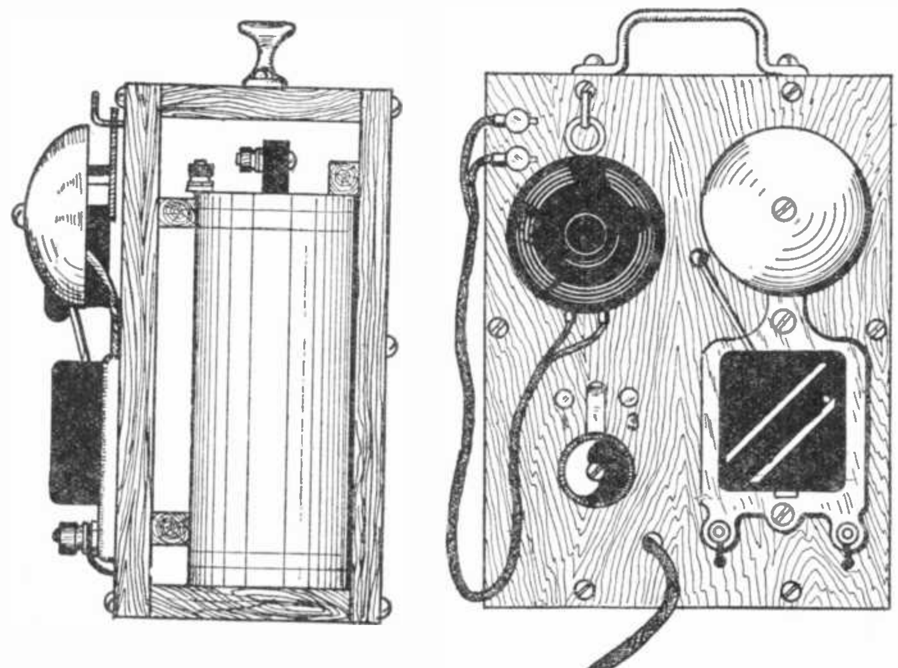
THIS system started in a very peculiar manner and was devised to meet a unique condition at first, but its usefulness caused it to be gradually extended till it is in regular everyday use and has proven a necessity.

The writer's better three-quarters was in the habit of putting the baby to sleep in the little coach on the porch. Then if she had occasion to do the washing in the basement, it was difficult to tell whether the baby was awake and crying when the washer was running. After imagining she heard a cry, and running up to see and finding it a false alarm a dozen or so times, she put it up to me as the acting genius in the concern to devise ways and means to eliminate the running.

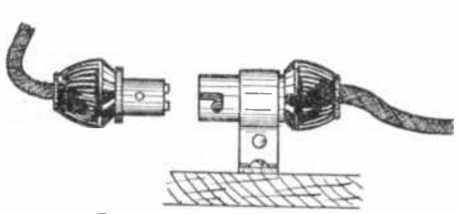
Naturally a telephone with the transmitter on the coach and the receiver in the basement occurred to the writer and a pair of wires were run from the porch to the laundry. Bayonet sockets were used at both ends of the pair of wires so that the transmitter could be plugged in at one end and a battery and simple telephone receiver plugged in at the other end. The scheme worked to perfection, two dry cells mounted in a plain box furnished the current and a simple single pole switch served to close the circuit when the house chief wished to listen in.

And next she wanted the system extended to the bedroom, so that when the lad was put to bed at night she could listen in on him from the porch or the kitchen. This simply meant an extension to the pair of wires with additinal outlets and again its usefulness was proven.

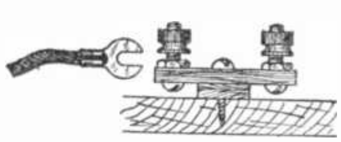
Then the possibilities of the system were



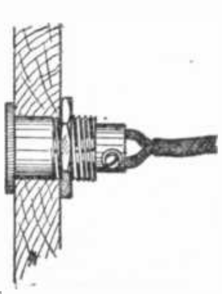
A portable signal box which may be attached in any room of the house to the signal system. With the switch thrown to point 3 the instrument connects to a microphone located at some other part of the system, while contact point 1 throws a signal bell into circuit. This bell may be operated by a push-button in another room.



PLUG AND SURFACE RECEPTACLE



LUG AND TERMINAL POSTS



Types of bayonet sockets which may be used in connection with home signal system described in this article. The one shown at the left is of the double contact flush bayonet type.

brought out clearly and it was overhauled and a few more devices were built to make the present signal system. It can be duplicated by anyone for a few dollars and will be money well spent.

The basis of the system is a pair of wires running to every room in the house with outlets located at convenient points. The outlets may be bayonet sockets as employed by the writer. These come in several styles, both flush and surface mounting, and a neat job is readily made. Where a less expensive job is desired, terminal blocks can be made up from small strips of fibre with two binding posts as shown in Fig. 1, which also shows the two types of bayonet sockets that will meet most conditions. With the sockets the regular plugs are used, while lugs serve to make connections when binding posts form the terminals. Ordinary annunciator wire. No. 18 D.C.C., serves admirably for this system and is reasonable in price. All the outlets are connected in parallel and the splices should be soldered and taped to prevent poor contacts.

The signal box is the next thing to be considered and can be made up to suit individual ideas; the box used by the writer is shown in Fig. 2. It consists of a plain wooden box, the back of which is removable and held in place with four screws. Two battens one-half inch square are placed behind the front panel to hold the dry cells away from the panel, and a cleat across the back is located at such a height that the cells are held firmly to the base. On the front of the box is mounted an electric bell or buzzer, a three-point switch and binding posts for a watchcase receiver, and hook to support it. The instruments are wired as shown in Fig. 3 which gives all the details of the assembly of the box. To connect the signal box to the system a six-foot length of flexible cord is fitted with lugs or a bayonet plug according to the type of terminal used. This is the principal accessory required.

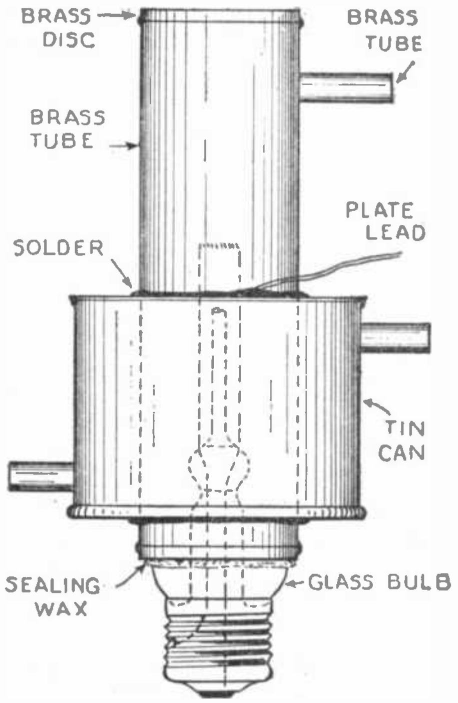
In addition there is required a telephone transmitter fitted with a clip made from spring brass and riveted or bolted to the back of the transmitter shell. The type of clip used by the writer is shown in Fig. 3 and was made from an 8-inch length of 1/2-inch wide brass strip 1/16 of an inch thick, bent to the shape shown. The 8-foot length of flexible cord is connected to the terminals of the transmitter and of the proper attachment mounted on the other end of the cord. The remaining part of the system is an 8-foot length of flexible cord fitted at one end with a pear push button with a plug or lugs on the other end.

Now as to how these instruments are used. In the case of the youngster asleep on the porch or in his room the transmitter is clipped to the coach or to the side of the crib as the case may be; the other end of the cord is plugged into the nearest receptacle. At any other place in the house where observations are to be made, the signal box is plugged in with the switch in the off position. To supervise the baby it is only necessary to throw the switch to "point 1" and listen. Care should be taken to return the switch to the off position or the batteries will be run down. This use of the apparatus has saved thousands of steps and helped keep peace in the home.

(Continued on next page)

Improvements In Power Vacuum Tubes

By Harry R. Lubcke



The illustration shows a modified form of a two-electrode power vacuum tube, a modification of one originally designed by Dr. R. G. Harris and described in a previous issue of THE EXPERIMENTER. One of the improvements suggested in this article is the use of a standard incandescent lamp base by means of which the power tube may be conveniently connected to a lamp socket.

IN the December, 1924, issue of the EXPERIMENTER, a description of a home-made power tube was given by Dr. Russell G. Harris. As will be noted by referring to the article, the tubes were mainly of the two electrode type, being for battery charging rectifiers and similar appliances. The tubes as shown were rather laboratory instruments than practical "tungar" tubes.

As a result, upon constructing one for practical purposes the writer developed the type shown in Fig. 1. In this tube the construction is simplified, and, by means of the standard plug at the bottom, it can be inserted in an ordinary socket which serves as a support besides providing convenient filament connections. Instead of the glass "windows" at each end of the tube as in the laboratory model, the top is soldered tight to a round brass disk. Only one sealing wax joint is needed, and that at the bottom, so only one water cooler or "jacket" is required.

In constructing the tube a piece of brass tubing 1½ inches outside diameter, 5 inches long, was used. A solid brass disk was soldered to the top; another with a 1-inch round hole was soldered to the bottom. A ¼-inch hole was drilled near the top in which a ¼-inch brass tube, 1½ inches long, was soldered as shown for the vacuum connection. For the water jacket a tin can, 2¾ inches in diameter, was secured and was cut off so as to be only 2 inches high. A "Campbell's" soup can fits these specifications. Two ¼-inch holes were drilled for the water inlet and outlet on opposite sides into which pieces of ¼-inch brass tubing were also soldered.

From a piece of sheet "tin" (sheet iron with a tin coating) a circular piece 2⅞ inches diameter was cut and provided with a hole in the center 1½ inches in diameter so that it would fit down over the brass tube and form a cover for the water jacket. This was soldered to the tube and to the tin-can water jacket. A piece of wire was soldered in as shown for the plate connection. When made according to these dimensions the tube will be compact and stable when placed in the socket.

The "mash" and lead-in wires were obtained from a 75- or 100-watt lamp as explained by Dr. Harris, but instead of cutting off the base it was retained along with about one-half of the globe as shown in the figure. By this procedure we gain several desirable features in one stroke. These include a vacuum tight mash for the lead-in wire assembly; a standard base, rigidly connected to the mash, and a modified "window" through which the degree of ignition of the filament can be determined.

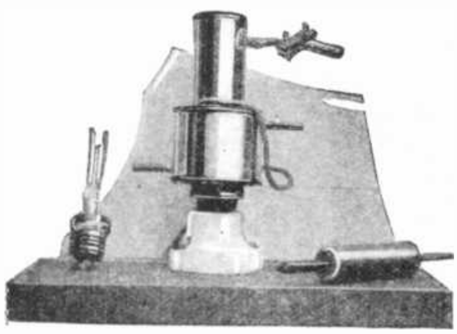
The bulb can be cut very successfully by a hot resistance wire. What is left will be the bulb proper and will make a very good flask as already described in THE EXPERIMENTER. The glass supporting column found between the two lead-in wires is broken off in the middle with a pair of pliers so that it will not interfere with the filament.

For spot-welding the filament to the lead-in wires a pointed flashlight battery carbon was found to be much more satisfactory than a nail which Dr. Harris recommended. With the nail the filament wire would weld to the nail rather than to the lead-in wires.

After the filament was spot-welded in place, a piece of sodium metal was placed in the tube proper and then the lead-in unit was put in place and sealed with sealing wax as described above. A piece of rubber tubing will be necessary on the vacuum connection for connection with the pump. This should be put on with shellac and bound with cord to make it vacuum tight. A pinch-cock must be placed on the tubing to close it after the vacuum is obtained. Commercial pinch-cocks were not strongh enough to give a vacuum-tight seal, so one was made using two pieces of ⅛-inch brass 5/16-inch wide and 1¼-inch long, provided with two 8/32 bolts which screwed into tapped holes on the ends of one brass piece, the other having holes drilled in it large enough to pass the bolts without binding.

With the author's tube a commercial aspirator pump produced the vacuum. An air pressure of about ½-inch of mercury was secured. A mercury vacuum indicator was made of the mercury barometer type. The top of the tube was left open and connected in the vacuum line. The degree of vacuum is indicated by the height to which the mercury rises, which was as high as 29 $\frac{3}{16}$-inch with the author's apparatus.

It is recommended that metallic sodium be used to remove the oxygen. Metallic calcium was tried, but it was impossible to heat it enough to remove the oxygen properly. Calcium melts at 800° C. (1472° F.), a temperature which cannot be reached, because the solder of the joinings would melt, as its melting point is about 440° C. (824° F.). Sodium melts at 96° C. (204.8° F.), a little below the temperature of boiling water, and hence it can be liquefied easily, effectively removing the last traces of oxygen. It was found that the sodium vapor is also necessary to furnish ions for the conduction of current from filament to plate, for with the calcium no plate current could be obtained when the tube was used as a rectifier.



A photograph of the finished power vacuum tube mounted in a lamp socket for filament connections. The screw base carrying the anchor leads for the filament is shown at the left. Notice the rubber tubing at the top. The tube is evacuated through this vent which is then clamped air tight. During operation, a cooling stream must flow through the water jacket. A stiff rubber tube must be used, which will only close when stiffly clamped.

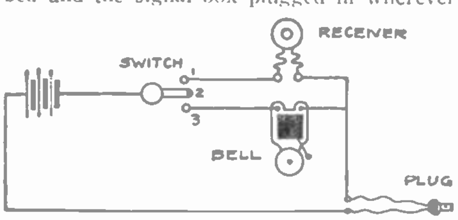
Signal System for the Home

(Continued from preceding page)

When there is sickness in the home, the push button cord is plugged in near the sick bed and the signal box plugged in wherever the person liable to be called may be. During the night it is in one of the bedrooms and moved downstairs during the day.

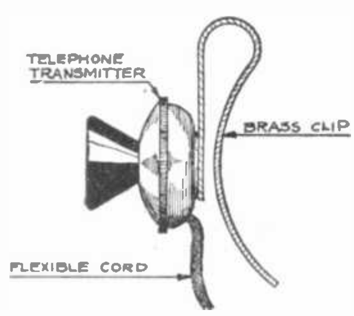
In the summer months radio reception is wanted on the porch. It is a simple matter to fit the loud talker so it can be plugged into the porch receptacle while another cord fitted with a jack and plug connects the radio set to the system. In a similar manner the loud speaker can be operated in any room in the house.

Then in between times the system is used to wake the tardy riser in the family, and for this purpose the "boss" has discovered that the push button rig is unnecessary and simply sticks a fork in the kitchen outlet and wiggles it around till it closes the circuit. Sometimes I think the system works too well.



WIRING DIAGRAM OF SIGNAL BOX

By means of the switch either a telephone receiver or a signal bell may be connected to any plug in the signal system. To watch the baby located in another room, the receiver is used in connection with a microphone mounted near the crib.



The microphone provided with a brass clip by means of which the transmitter may be attached to perambulator or crib. The flexible cord is made about eight feet long and carries a bayonet plug at its other end.

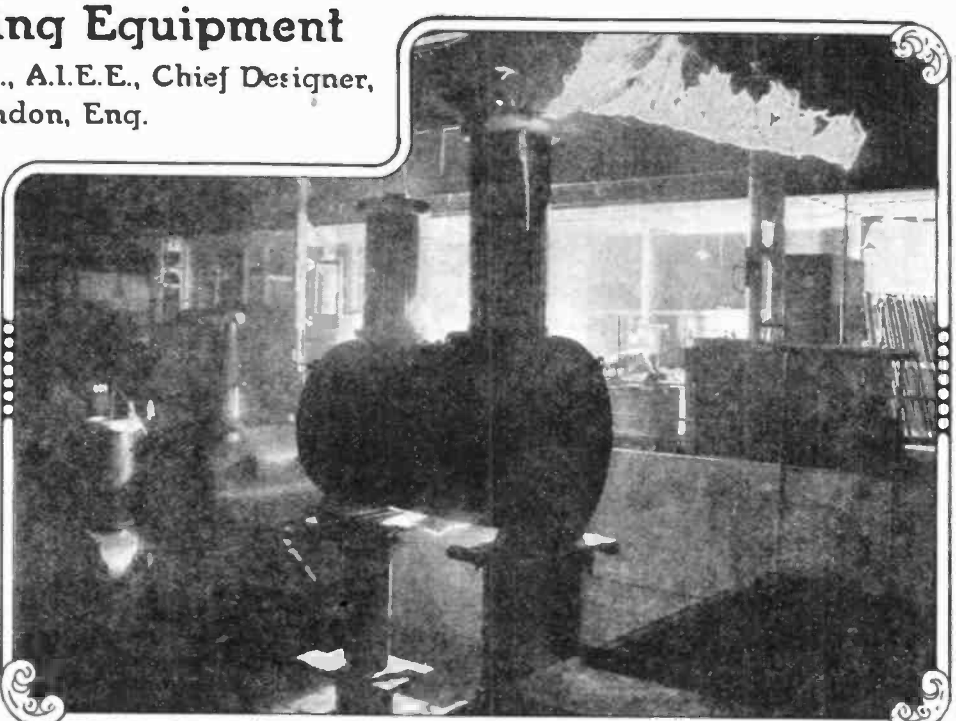
High Voltage Testing Equipment

By E. T. Norris, A.M.I.E.E. Assoc., A.I.E.E., Chief Designer, Ferranti, Ltd., London, Eng.

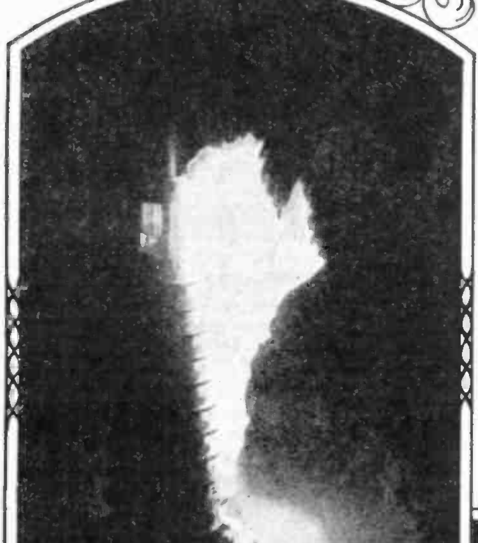
THE trend of electrical power transmission during the last forty years has been steadily in the direction of higher voltages. Electrical and mechanical difficulties, which at one time seemed insuperable, have been overcome until at the present time pressures up to 220,000 volts are used commercially for transmission purposes, and in many countries pressures of 110,000 to 150,000 volts are common. Although such high voltages have not as yet been found necessary in England, any English manufacturer of high voltage apparatus competing in British and foreign markets finds it necessary to study intensively the insulation problems and electrostatic phenomena associated with these pressures.

Electrical apparatus suitable for a working pressure of 154,000 volts, say, requires test pressures up to at least 500,000 volts, whilst experimental and development work will increase this figure still further. The production, therefore, of pressures up to 1,000,000 volts to ground has become an industrial necessity.

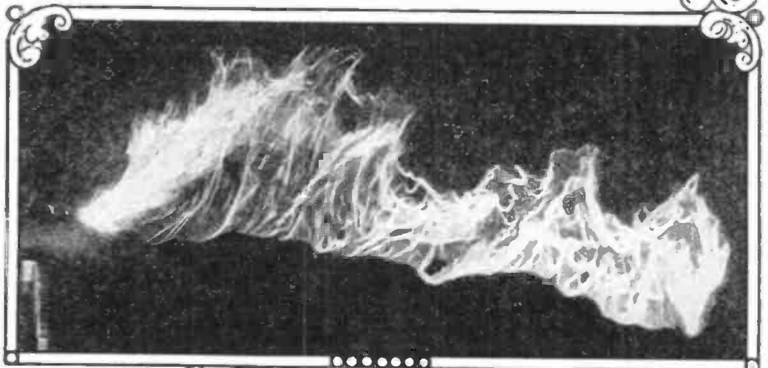
In the design of testing transformers to meet these requirements, the insulation problems involved in the construction of transformers for working voltages become greatly accentuated. Voltage stresses represent-



A 1,012,000 volt discharge in the laboratories of Ferranti, Ltd., England. This spark bridges a gap, nine feet six inches long. This is achieved by the cascade connection. This as well as the other photographs on this page were taken at night by means of the arcs themselves.



A discharge over the bushing of a power transformer at a potential of 380,000 volts. The high voltage testing equipment shown on this page was designed especially for such insulator test.



A sustained arc at about 970,000 volts across a gap of 109 in. The cobweb effect noticeable in the discharge is caused by the low frequency alternations of the current. Each white line indicates the crest of a current wave.

A flash-over between the tank of one transformer and the connecting lead to the primary of another transformer. The total high tension pressure was 920,000 volts, and the voltage between the flash-over points 305,000. The corona discharge extends over 20 inches from the metal cap of the high tension terminal.

ing three or four times the rated value for power transformers become normal working conditions for testing transformers. Experience gained in the construction of these transformers is thus directly applicable to the design of power transformers, and indeed, has influenced it to a large extent for working pressures down even to 6600 volts.

It is part of the normal duty of a testing transformer to puncture insulation and to flash over insulators and spark gaps, thus practically short-circuiting its high tension winding. Such abrupt changes in the electrical circuit conditions set up transient voltages and high frequency oscillations which may cause abnormal stresses in parts of the winding. Voltages between turns and coils of a transformer winding of ten and twenty times normal have been actually measured. These transients may be very considerably reduced by protective devices and by suitably proportioning the internal inductance and capacity relations of the windings.

Cascade Connection

Many testing transformers in single units for voltages up to 500,000 volts have been successfully built by Messrs. Ferranti, Ltd., and electrically much higher voltages could be obtained. For pressures above 350,000 volts, however, the cost of a single unit increases rapidly, and mechanical difficulties arise. Abnormally large sheets and pieces of insulation are required; transport and erection on site become real problems. These difficulties may be avoided by a system known as hte cascade connection. In this method two or more transformers are connected in such a way that their high tension voltages build up to the required pressure. Each transformer commences where the previous one left off so that a pressure, say, of 1,000,000 volts to ground could be obtained from three similar transformers each of 333,000 volts. Fig. 1 shows the diagram of connections for such an arrangement. Each transformer has the usual primary winding t_0-t_1, and high tension winding T_0-T_1, one end of which is earthed or connected to the tank and the other end insulated for 333,000 volts. A tapping T_2 is brought from the insulated end of the H.T. winding such that the voltage between leads T_1 and T_2 is equal to the primary pressure t_0-t_1. These two leads are brought up through the H.T. terminal and connected to the primary winding and to the uninsulated end of the H.T. winding of the second transformer. Since these leads are at a potential of 333,000 volts above ground, the whole of transformer No. 2 must be insulated for this voltage by mounting it on supports of porcelain, bakelite or other insulating material. The leads T_1 T_2 of transformer No. 2 will now have a potential of 666,000 volts to ground and are connected in a similar manner to the primary winding of transformer No. 3, which must be insulated for this voltage. The lead T_1 of transformer No. 3 will then have a potential of 1,000,000 volts R.M.S. to ground, although the maximum winding insulation in any transformer is only for 333,000 volts.

An alternative arrangement using the cascade connection even more economically is shown in Fig. 2. Specially wound transformers are employed, having the mid-point of the H.T. winding connected to the tank and each end provided with tappings suitably insulated. For a million volt set of three transformers each unit would be wound for 333,000 volts, but the maximum pressure to be insulated for would only be 167,000 volts. All three transformers will now require insulating from ground. This, however, presents no difficulties even for the largest transformers.

Figs. 1 and 2 show the electrical connections only and are not space diagrams of the windings.

While the cascade connection simplifies the insulation and electrostatic design, it may present unusual electromagnetic problems. The small portion T_1-T_2 of the H.T. winding of the first transformer in Fig. 1 must carry the combined no-load currents and rated K.V.A. load currents of transformers Nos. 2 and 3.

Under these conditions the leakage reactance between the relatively small winding T_1-T_2 and the primary winding is so high that compensating windings are necessary to maintain the voltage. Moreover, the no-load K.V.A. of a high voltage testing transformer is greatly affected by the internal capacity of the windings. This is distributed in so complicated a manner that it is difficult to calculate and must be determined by actual measurement. In order to study the magnitude and importance of these factors and their effect on the operation of the cascade connection, a number of testing transformers in construction were fitted temporarily with the necessary cascade windings for experimental purposes.

1,000,000 Volt Tests

Three of these transformers—forming part of a 300,000-volt testing equipment for Messrs. The Western Electric Company, Ltd. —were connected as shown in Fig. 1. The second and third transformers were mounted on temporary insulating supports composed of wood structures and bakelite paper cylinders.

The space available was limited and it was difficult to get sufficient clearance between the transformers.

Preliminary tests were carried out to check the high voltage measurements. At

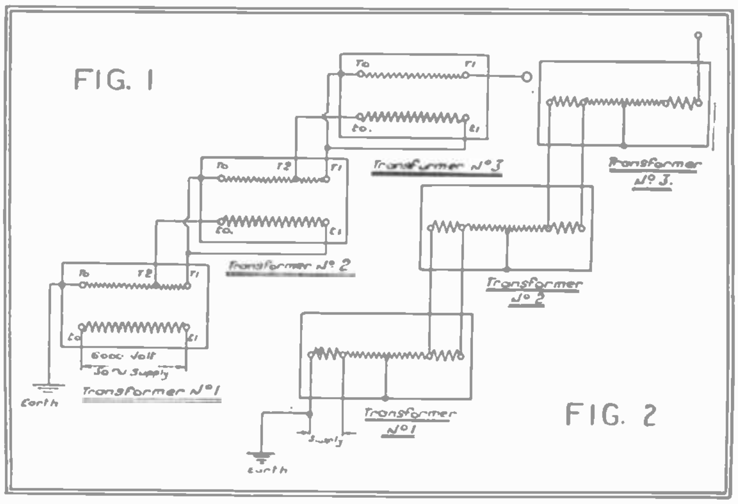


Fig. 1. Diagram showing the cascade conection. All transformers are mounted on supports of porcelain or bakelite. The lead T_1 of transformer No. 3 has a potential of 1,000,000 volts to ground. Fig. 2 shows an alternative arrangement.

300,000 volts the H.T. voltage was measured by spark gap, electrostatic voltmeter and by voltage ratio to the primary winding. All three readings agreed within one per cent. Higher voltages were measured by ratio and by point spark gap as spheres of sufficiently large diameter were not available. It is probable that the voltages thus obtained were correct within 2 per cent.

Fig. 3 shows a flash-over between the tank of No. 2 transformer and the connecting lead to the primary of No. 3 transformer. The total H.T. pressure was 920,000 volts, and the voltage between the flash-over points 305,000. As there was no protective device or ohmic resistance to limit the discharge, the arc was powerful and of intense brilliance. The corona discharge extends over 20 inches from the metal cap of the H.T. terminal and is very pronounced. The surface of the cap was smooth and of large radius.

Fig. 4 shows a sustained arc between points spaced 9 feet 6 inches apart. The humidity at the time of the test was 69 per cent., the barometric pressure 30 inches and temperature 17° C. (62.6° F). Under these conditions the flash-over voltage between points D inches apart may be expressed in the form:

$$KV = 20 + 8.7D$$

This gives a pressure of 1,012,000 volts R.M.S. to ground for 114 inches spacing.

A limiting resistance was connected in series with the spark gap on the earthed side.

When the arc had been maintained for some seconds, flash-over occurred between the foot of the tank of transformer No. 3 and the side of the testing pit, and can be plainly seen in the photograph. Here again there was no limiting resistance, and the flash was explosive in character, dazling white and fat. It is probable that this discharge was due to transient disturbances. The distance of 90 inches indicates a pressure much in excess of 667,000 volts, the normal potential of the tank above ground. Apart from the resistance in the main point gap circuit, no high frequency protective devices were used to damp out transients or high frequency oscillations in these tests.

The discharge broke down the insulation of a 220-volt D.C. motor control switch mounted on a pillar behind the H.T. terminal. The resultant power arc is clearly shown.

A sustained arc at about 970,000 volts across a gap of 109 inches is illustrated in Fig. 5. The cobweb effect caused by the fifty period alternating supply can be clearly seen. Each white line indicates the crest of a wave. The distance between two adjacent lines represents 1/100 of a second. For short durations, where the arcs are not superimposed, the time of a discharge can be calcultaed from the number of these lines.

A dry flash-over at 380,000 volts of an oil-filled power transformer bushing is shown in Fig. 6.

Transformer Construction

The transformers are of a special core type construction developed especially for high voltage testing work. The H.T. and L.T. coils are concentric, the L.T. coils being single layer spiral coils extending the whole length of the core leg. The H.T. conductor is covered with manilla paper after the manner of a paper insulated cable, and wound in cross-over or disc coils. These coils are mechanically rigid without depending on the strength of the H.T. conductor.

The insulation between H.T. and L.T. windings consists of oil spaces interleaved with bakelite cylinders; the latter as much for mechanical as for electrical strength. The remainder of the insulation is chiefly presspahn specially treated and impregnated.

In the arrangement of insulation between the H.T. winding and frame the main consideration is to control the dielectric field so as to avoid uneven stressing of the material due to field direction or strength, or to unsuitable permittivities.

An interesting illustration of the general application of these principles lies in the fact that the method of insulation originally developed and adopted for these high voltage testing transformers has been directly applied to ordinary power transformers from 5 K.V.A. upwards with distinct increase in economy and reliability.

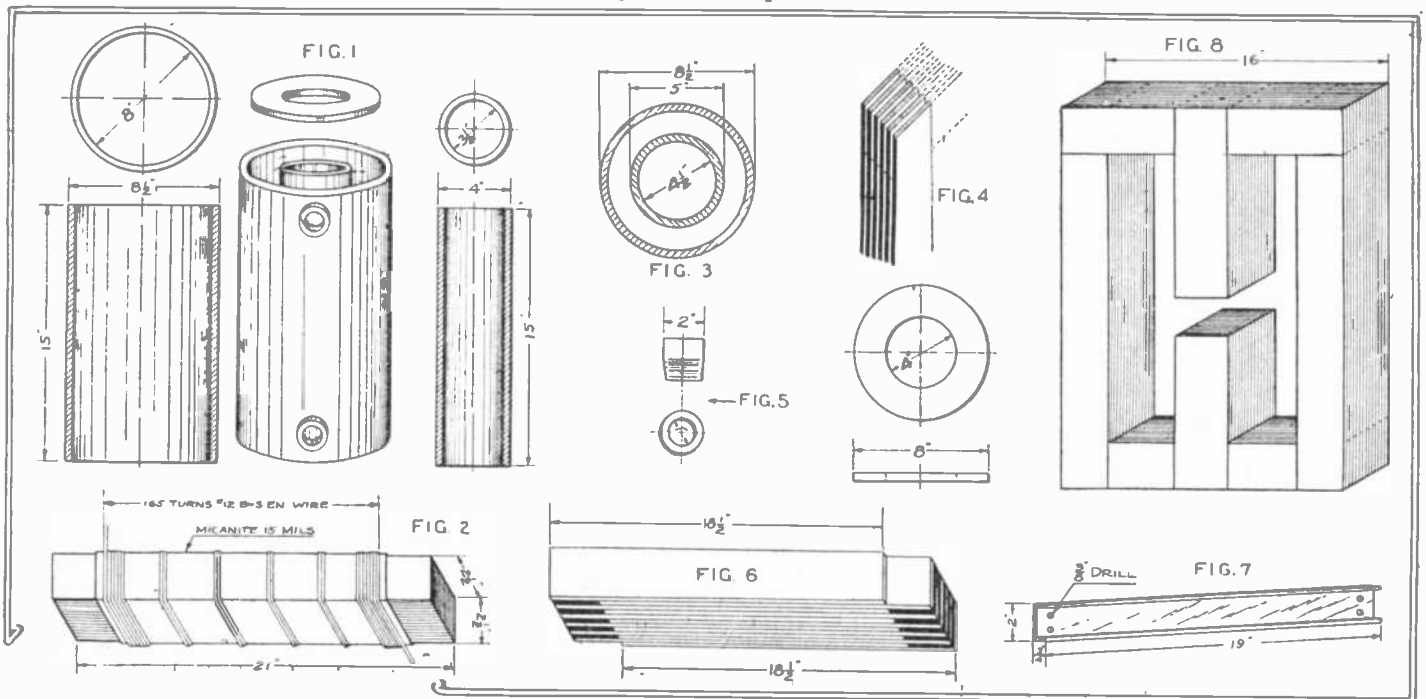
For voltages much above 200,000, the insulation clearances necessary for the H. T. connections and testing areas make the cost of the building an important item, particularly if a crane has to be provided for handling the transformers, apart from the cost of the crane itself. The present type of transformer is so arranged that no crane is required, either for erection or for examination or inspection after installation. The transformer is mounted on rollers running on rails forming part of the tank. To remove the transformer, the tank endplate is unbolted and the terminals disconnected; the transformer itself can then be rolled out without disturbing the H.T. terminal.

The transformer is assembled in its tank completely filled with oil under vacuum before leaving the works. The H.T. terminal is oil filled and acts also as a conservator vessel for the transformer, the oil level rising and falling inside the terminal. An oil seal calcium chloride breather is also fitted.

The transformer is arranged on its side in the tank to reduce the overall height. The H.T. lead and winding insulation both form part of the H.T. terminal arrangement, thus still further reducing the height. It is possible to transport by rail a testing transformer for pressures up to 350,000 volts, assembled in its tank, and completely filled with oil, so that no drying out or other attention should be necessary on site.

Electric Water-Tank Heater

By A. N. Capron



Dimensional drawings of the different parts of an electric heater for heating water. Figures 1 to 3 cover the construction of the water jackets, within which the water is heated and through which it circulates. Figures 4 to 8 show the construction of the heating coils and core.

If we take a 1-k.w. transformer and place around the primary a continuous metal cylinder, there will be induced therein a low potential, but a very heavy current will flow, owing to the low resistance of this cylinder; in a very short while this cylinder will be red hot.

When we short-circuit the secondary of a transformer, a large displacement takes place in the return flux, thereby causing severe losses; but, if we place a leakage gap between the cores, this will not only keep the primary current to a reasonable amount but will compel the displaced flux to thread through the cast-iron cylinder, producing eddy currents, and—more heat. All this heat is utilized by the water flowing through the cylinders, result—99° efficiency.

The water-heater shown is rated at 1 k.w. and can easily be made by an amateur mechanic, excepting the welding of the cylinders. This welding must be perfectly done, as the cylinder must be water-tight, even under 10 pounds' pressure.

The yokes should be made after the cylinders, cores, etc., are mounted and the piping fastened. The last pieces of piping should be right- and left-hand threaded; it is not advisable to use union couplings, as they retard the flow of water.

The whole assembly is very neat and commercial in appearance, the cores and yoke of the transformer are held together by the channel-iron clamps and should be tightened up properly. The cylinders might be covered with an insulating asbestos jacket to keep in the heat, and the appliance fitted to the water-tank with 1½-inch piping.

The following is the list of materials required for the construction: 350 feet of No. 12 B. & S. enameled copper wire; 400 feet 1/16-inch asbestos thread; 45 pounds iron strip, 29 gauge, 2½ inches wide; 10½ pounds iron strip, 3 inches wide, 10½ and 8 inches; micanite, 16 inches wide, 5 mils thick, 100 inches long, in pieces 36 and 64 inches, respectively; two cast-iron cylinders, 8½ inches outside, 8 inches inside, 15 inches long; two cast-iron cylinders, 4 inches outside, about 3½ inches inside and 15 inches long; four cast-iron discs, 8 inches in diameter and ¼ inch thick; two pipe nipples, 1 inch inside and 2 inches long; eight 1½- to 1-inch reducing elbows; eight 1-inch elbows; six 1½-inch pipe tees; 3 feet 1-inch pipe; 4½ feet 1½-inch pipe; four channel-iron yoke clamps, 2 inches wide, 19 inches long; eight ⅜-inch bolts, 4 inches long, with nuts. Cylinders are to be welded at edges to discs, the nipples being first welded to the outer cylinder; the inner surfaces are ground smooth. Cast-iron is the material recommended for the cylinder, but other pipe material can be used. The central cylinder must be large enough to go over the primary winding and micanite insulation.

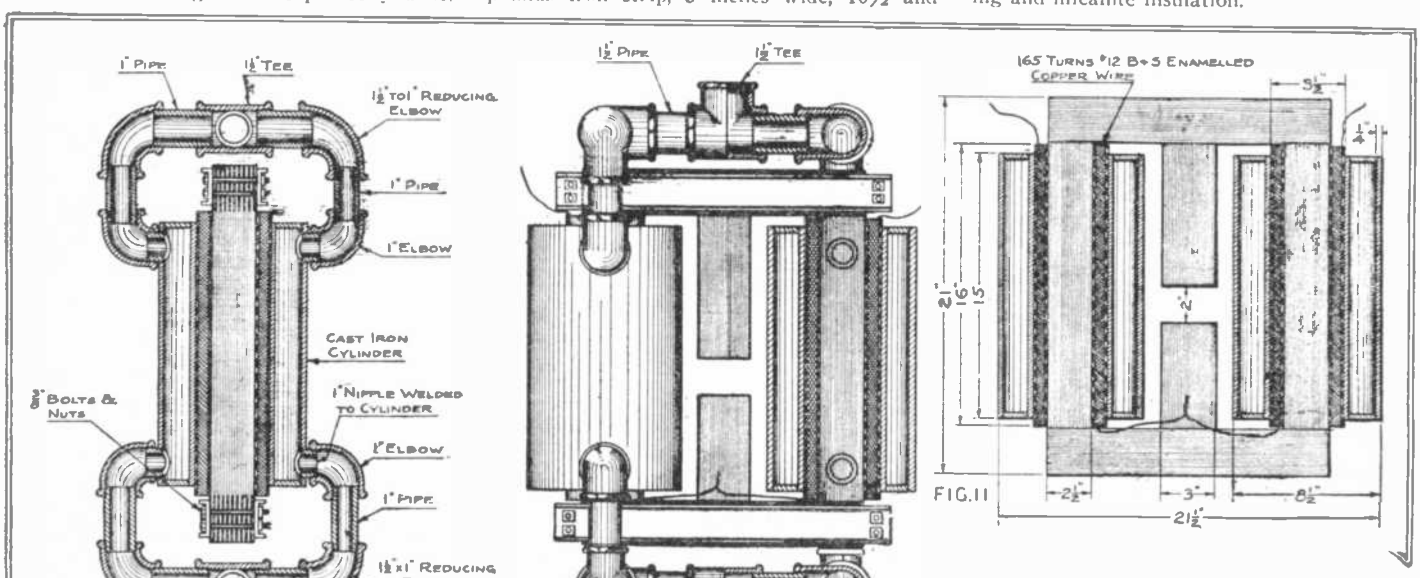


Fig. 9 is a section of a single heating element; Fig. 10 shows the two elements, side by side, one in section and one in elevation, with pipe connections; Fig. 11 shows the two heating elements in section.

Standard Lamp

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

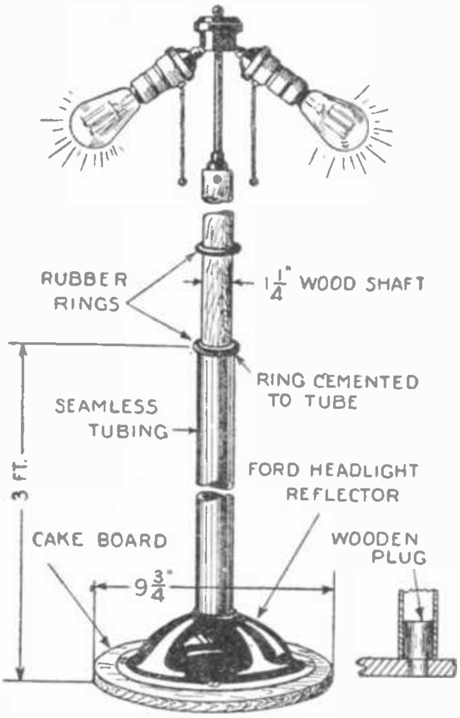
THE base of the lamp which we illustrate is a round disc of wood about ⅞-inch thick and 9 or 10 inches in diameter. Discs of this description are sold in hardware stores as breadboards to be used on the table; while the one which is shown in use in this lamp is quite plain, having only a slight beading around its edge, they can be procured of quite high decoration, with carving around the edge. If possible it is well to get one of larger diameter than specified.

On this is mounted the reflector of an automobile headlight; in the lamp illustrated a Ford headlight reflector is used. In the exact center of the disc, a hole which may be ¾-inch in diameter is bored a corresponding hole is cut in the center of the reflector, which hole may be a little larger. The size of these holes depends on what sized material is used in the construction.

The upright standard which carries the lamp is in two pieces; the lower is a piece of seamless tubing, and in the lamp illustrated the upper piece was made of a curtain pole. It is here that the fine point of the construction enters. Tube and pole must be so selected that the pole will slide up and down the tube without friction and yet with a snug fit.

As these lamps are made, the tube may be from 2 ft. 6 inches to 3 feet in length, and the pole is a little shorter.

The hole which is cut in the exact center of the Ford reflector must be of such a size that the tubing wlil fit it very closely. Into the lower end of the tubing a wooden plug is driven, and this fits the hole in the board, the tighter the better. The tube is thrust through the reflector, the plug is driven into the hole in the base board, and sighting along the edge of a door, the pole is moved until vertical, and the reflector is screwed firmly in the position which best holds the pole. Four round-headed, blue steel screws are quite enough to hold the reflector, and it will be seen that it is the reflector which



The floor lamp rests upon a cake board. On that is a Ford reflector. It will be seen that under the arrangement as depicted the standard is held very rigidly, its lower end passing through into a hole in the cake board. Its appearance, if well done, is quite attractive.

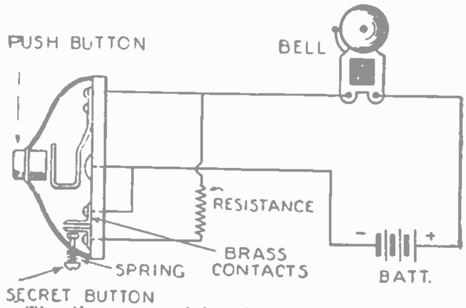
A view of the lamp showing its size in proportion to the figure. It is now in use and has filled a very nice place in a little summer cottage in the Adirondacks.

determines the vertical position of the standard.

Two heavy India rubber rings were found which exactly fitted the pole, one of which was a very tight fit for the tube. One was secured to the tube with shellac varnish; the one on the pole could be slid up and down by the hand and fitted tightly enough to serve for adjusting the height. Three-quarters of an inch upward gives a sufficient diameter for the standard and the easiest way to secure the two pieces is to use a piece of the pole as a template when you buy the tubing. In the lamp illustrated the curtain pole had to be reduced perhaps $\frac{1}{32}$-inch in diameter, and this was done with rasp and sandpaper and a perfect fit was secured. Any kind of lamp fitting may be fastened to the top.

One great point in the construction of the lamp is to get the india rubber ring of the right size. A ring which is a very tight fit for the tubing will be a somewhat loose fit for the wooden shaft; the tubing of course should be thin. The slight difference makes the rubber ring on the shaft a perfect adjusting element. It may appear that the base is a little small; this can be extended if desired by three projecting feet made of little rods of wood screwed to the base, or a larger board might be selected.

Secret Contact Push Button



The diagram explains the construction of this secret button; no one would ever see the hidden push-button and the resistance makes the one bell give two sounds; it will be known whether it is an inmate or a stranger who is ringing.

THE illustration shows the construction of a two-contact button, which can be connected with the bell system in the home.

The advantage of this device is that when an outsider presses the regular button the bell rings full strength, but when a member of the family presses the secret button the current goes through a resistance which weakens the sound of the bell.

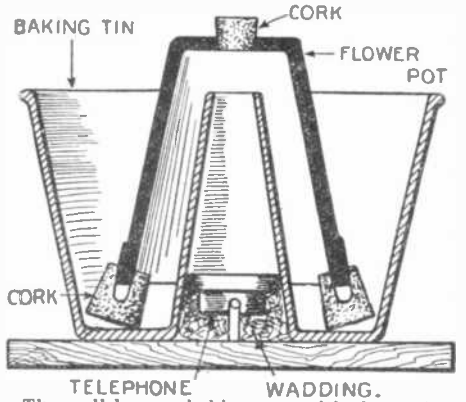
Contributed by THOMAS MCCARTIE.

Baking Pan and Flower Pot Loud Speaker

FROM a German contemporary we take the following description of a loud speaker made with a flower pot and baking pan.

A telephone (K) is fastened by pressure in the base of the central tube or truncated cone of the pan and the space around it is packed with wadding as shown. Over the top pot is inverted and supported on corks at its rim. The hole at the bottom is closed with a cork cut off so that no parts will project through the bottom.

The telephone is now connected to the receiver and the position of the flower pot as regards its height above the cone of the baking pan is so regulated that it gives the best loud speaker effect. There are three corks equally spaced around its rim.



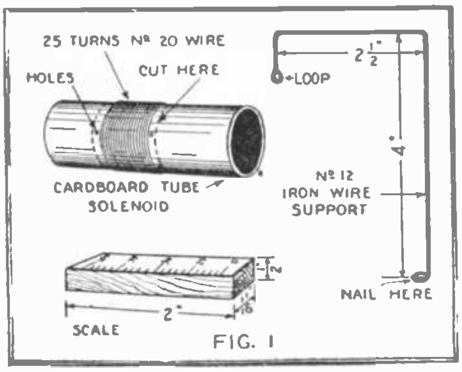
The well known baking pan with the conical piece in the center surmounted by a flower pot carried by corks provide the elements for a loud-speaker. It is a substitute for the trumpet or horn.

Straight-Line Ammeter

THIS ammeter, while of very simple construction, is, nevertheless, extremely sensitive. It eliminates all springs, cases, magnets, etc. It is composed of a baseboard, a solenoid, two binding posts, a wire support, a small wooden block, a straight-line scale and a suspended iron wire and pointer.

The following materials will be needed for the construction: A cardboard tube taken from a burnt-out flashlight battery; about 40 feet of S.C.C. or S.S.C. wire, No. 20; a short length of iron wire, about No. 12 gauge; a ½-inch board, 2x5 inches; a small piece of cardboard for making the scale; a block of wood 2 inches long and 11/16-inch thick by ½-inch wide; a short piece of silk or cotton thread; 6 or 8 inches of No. 20 or 22 iron wire. Two iron core wires taken from a Ford spark coil will do for this part.

Punch a small hole in the side of the cardboard tube, about ½-inch from one end; push about 6 inches of wire through, bend



Details of the parts of a straight line ammeter, showing the construction of the coil, the scale, and the wire support which carries the movable member. The scale as the name of the apparatus implies has uniform divisions, and so is easily read.

it on the inside to prevent slipping and commence winding the coil around the tube. The number of turns is 25. When the coil is finished, punch another hole, push the end of the wire through and cut off all but a short piece.

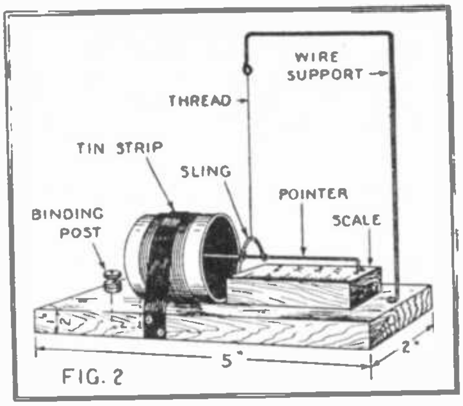
The tube can now be cut down until it is but a little longer than the coil. The coil and tube can be given a coat of shellac or paraffin wax. Take a piece of iron wire (No. 20 or 22), about 1½ inches in length, and bend a loop in each end; also bend it in the center, to make a sort of stirrup. Tie a piece of thread to the middle, then run about 5 inches of iron wire through the end loops and squeeze the loops together so that they will hold the straight wire securely. Bend down one end of this wire, about ¾-inch from one end, to serve as a pointer.

By means of a piece of tin ½-inch wide, strap the solenoid to the baseboard. Connect the ends of the solenoid winding to the binding posts. Nail or screw the small wooden block to the baseboard in a line with the center of the solenoid and glue the piece of cardboard to it. Nail the wire support to the baseboard and, after finding the correct height, tie the thread to the loop in it. Compare readings with those of a standard ammeter and mark the scale in tenths of an ampere. It will be seen that the wire index moves longitudinally in the line of its length as varying currents in the solenoid affect it.

A voltmeter could be constructed in the same way, but, instead of No. 20 wire, it should be wound with 500 or 1,000 turns of No. 36 wire.

This ammeter costs but little and the amateur could, therefore, afford to make several of them.

Contributed by EDWIN N. BREEDLOVE.



A view of the assembled line ammeter. The device though constructed of very simple parts is considerably accurate.

Electric Insect Killer

By R. W. EVES, Kingston, Jamaica

ALTHOUGH the 110-volt house lighting potential is ordinarily not fatal to the human body, it is very effective for electrocuting small animals and insects. Once the apparatus shown is set up, it requires little or no attention, as it is automatic in its action, and there is no danger in having it always connected.

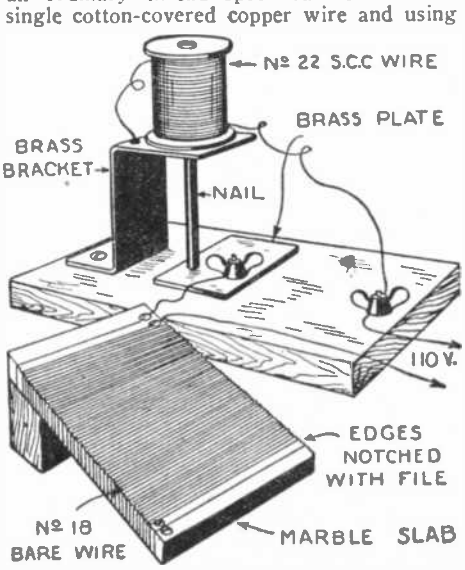
The device consists of a 10 × 12-inch slab of slate or marble with copper wire wound on it; the edges are nicked with a file to hold the wires in place. Care must be taken to get the nicks about ⅛-inch apart, so that the wires will run close to each other, but do not touch.

The wire used for this purpose is preferably No. 18 and must, of course, be bare. Two separate lengths are wound side by side so that the alternate wires will be of opposite polarity when connected to the circuit.

The ends of the wires are securely fastened to a pair of 3/32-inch brass screws at opposite corners of the slab to prevent the wires from unwinding; the heads of these screws project far enough below the slab to prevent the wires from touching the surface of the table upon which it is laid, and single screws are provided on the other two corners so that the slab will rest solidly.

It is not advisable to connect the wires of the slab directly to the lighting circuit, as a small piece of metal, accidentally dropped on the wires, will blow the fuse, so that a circuit-breaker in series with one of the wires should be provided to prevent this.

The construction of a simple one is shown: It consists of a solenoid made by winding an ordinary thread spool full of No. 22 single cotton-covered copper wire and using



This is a variation on the old theme of electric insect killers. In this instance a circuit interrupter was provided to prevent damage from short-circuit.

a small wire nail, with the head clipped off, as a plunger. The solenoid is mounted on a brass bracket, which is bent to the shape shown, and screwed to a wooden base. Through this bracket, directly under the hole in the spool, a hole is drilled for the plunger. The spool is held on the bracket securely by wood screws driven in from underneath. The height of the bracket should be a little less than the length of the plunger.

A small brass plate is fastened to the base so that the plunger rests on it when in its normal position, and a thumb-nut is provided on the screw that holds this plate in place. A second screw and thumb-nut are provided as a separate terminal on the base, and to this terminal one end of the solenoid is soldered. Connections are then made to the lighting circuit and to the killer.

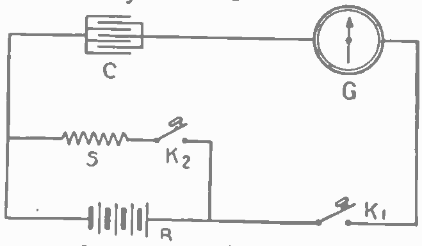
The action of the solenoid is as follows: Current passes through the solenoid and over the bare wire of the killer whenever any two wires of opposite polarity are brought into electrical contact with each other, either through the body of the insect or a piece of metal, shorting them.

As soon as the current becomes excessive, as it would naturally be in the latter case, the plunger is pulled up into the solenoid, and this breaks the circuit. The moment the current is broken the solenoid is demagnetized and the plunger drops again to its normal position, but if the same current still flows, the process is repeated continually, causing the plunger to vibrate rapidly. In operation, the killer should, therefore, be set on a slant, so that every time an insect is killed it promptly falls off, preventing any long-continued operation of the circuit-breaker.

The device can be left connected without any danger to the house wiring. If desired, a fuse can be inserted in the circuit.

Measuring Internal Resistance of a Cell

By DAVID TERRIERE



From the readings of the galvanometer G when key K_1 only is depressed, and when K_1 and K_2 are both closed the resistance of the battery B may be computed. The resistance of the shunt S is known.

THE following is a description of the best arrangement by which the internal resistance of a cell may be determined.

It consists in placing a condenser (C) (the capacity of which may be from ⅓ to 1 microfarad) in circuit with the battery (B) to be measured, a galvanometer (G) and a tapping key (K_1).

At any point between the battery and the condenser is arranged a shunt (S) connected to a second tapping key (K_2). To use this arrangement (K_1) is pressed down and the deflection (d_1) of the galvanometer noted, still keeping the key (K_1) depressed. (K_2) is also depressed and the deflection (d_2), which takes place in the opposite direction, is read off. The calculations are as follows: The internal resistance is equal to the resistance of the shunt S, multiplied by the deflection (d_2) divided by (d_1) less (d_2) or

$$R = S \frac{d_2}{d_1 - d_2}$$

To obtain the most satisfactory results from dry cells, the internal resistance of the battery should be as near as possible to that of the external circuit resistance.

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

First Prize, $25	Second Prize, $15	Third Prize, $10	Honorable Mention
B. G. Switzer	Roscoe Betts	Howard Ward,	Walter Johnson
707 S. Washington St.,	121 North Dubuque St.,	Box No. 106,	1913—12th Ave.,
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First Prize
Electric Arc Soldering Iron

THE soldering iron illustrated is somewhat of a departure from the conventional type of electric soldering iron, as it uses a small electric arc for its heating element.

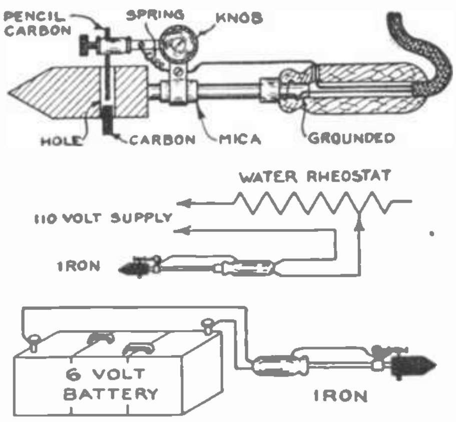
The arc electrodes are composed of a flashlight battery carbon which fits into the ⅛-inch hole in the iron, and a pencil lead, held in place by a binding post, which in turn is fastened to a lever arm.

A copper band is fastened securely around the shank of the iron, being well insulated from it by mica as shown above.

At the junction of the lever arm and the copper band a small knob is placed, with which to control the arc.

The iron may be either used on a storage battery or on 110 volts in series with a water rheostat. One terminal is connected to the copper band, the other is grounded on the iron.

To operate the iron, the pencil carbon is turned down until it comes in contact with the flashlight carbon and is then turned slightly upward until a small arc results. The iron needs but little attention while soldering, simply turning the knob down occasionally.



A very ingenious soldering iron heated by an electric arc, produced within the body of the copper bolt.

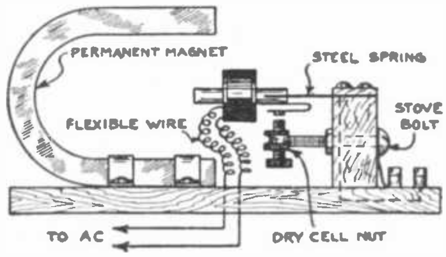
Second Prize
Interrupter

THE interrupter illustrated here is so constructed that an alternating current puts it in motion.

A permanent horseshoe magnet is placed upon the baseboard as shown.

The armature can be made from a section of a large nail or stove bolt. The coil wound on the armature should consist of a number of turns of fine wire, which best suits the purpose of the builder and the potential of his circuit. If a low voltage A.C. is to be used, about a hundred turns of wire will suffice. However, if a high voltage is to be used, such as that of the lighting circuit, a much higher resistance will be required.

At one end of the armature a steel spring is inserted and soldered. The spring is securely fastened to an upright block as shown. Enough of the spring is left free to insure free movement of the armature, but not so much as to deprive it of the necessary elasticity to respond to the cycles of the current. A short wire connects the spring with one of the binding posts.



A vibrating current interrupter adjustable for frequency of an A.C. lighting circuit, made of simple material.

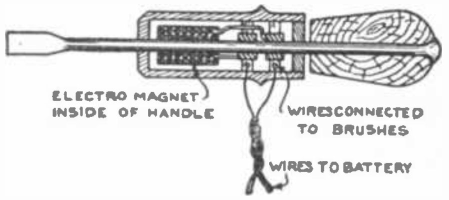
> **$50 IN PRIZES**
>
> A special prize contest for Junior Electricians and Electrical Experimenters will be held each month. There will be three monthly prizes as follows:
>
> | | |
> |---|---|
> | First Prize | $25.00 in gold |
> | Second Prize | $15.00 in gold |
> | Third Prize | $10.00 in gold |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

Also soldered to the armature is a spring contact point. This point makes interrupted contact with the adjustable stationary point, which is constructed from a stove bolt and nut, and a dry cell bolt and nut as shown. The stove bolt is connected by a wire to the other binding post. These posts terminate the interrupted circuit.

Third Prize
Electro-Magnetic Screw Driver

THIS screw driver is supposed to be especially adapted for small iron or steel screws. The handle is constructed in two sections; one is the ordinary handle of a screw driver; the other is a tubular section through whose end the blade emerges and which is free to rotate. This tubular section contains the magnetizing coil surrounding, and attached to, the shank of the screw driver, with its terminals connected to two slip-rings, also on the shank and insulated therefrom.

The current is carried to the coil by two brushes, one for each slip-ring, connected to the outside circuit. To use it, the front section is held stationary by one hand and



An electric screw-driver. The trouble incident with the ordinary appliance due to the twisting of the flexible cord or wires, is avoided here by slip-ring and brush connections.

the tool is operated by turning the rear portion with the other hand. The idea of using the brushes and slip rings is to avoid twisting the flexible cord.

Honorable Mention
Electric Fountain

THIS fountain makes a very pretty display when used in connection with lawn parties or for beautifying effects on a lawn.

Make a light frame 9 inches square out of ¼-inch material, as illustrated in Fig. 1. To the cross piece attach a pulley 3 inches in diameter. This pulley must be centered as accurately as possible on the frame and then made secure. Now get a round piece of wood 2 inches in diameter and 2½ inches long. Center this upon the pulley and secure to the pulley firmly. With a ⅜-inch drill, bore a hole through the center of the apparatus that has just been completed.

Get a box big enough for the frame to revolve in freely. In the bottom of this box fasten a block which has a pin ⅜-inch in diameter and about 3½ inches above the top of the block.

Now get a small battery motor and mount it on the side of the box so that the pulley

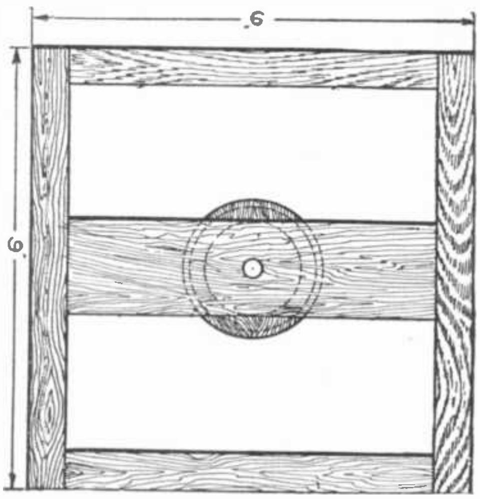
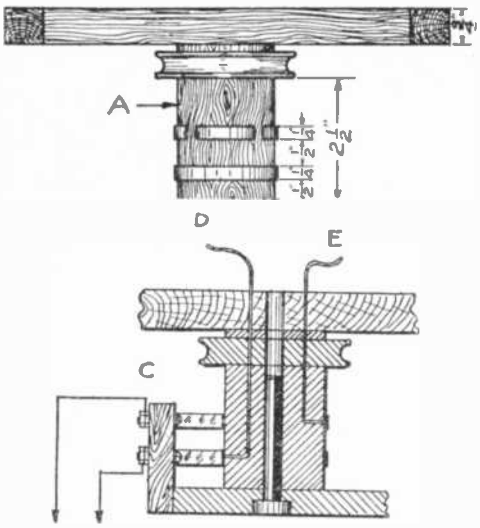


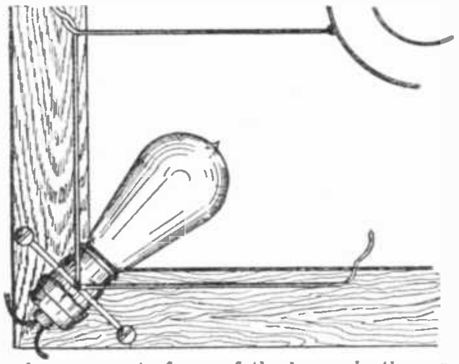
Fig. 1. The base of an electric fountain constructed of simplest material. The central pulley is used to rotate the apparatus by belt connection to a motor.



Elevation of the shaft, pulley, contact segments and slip-ring of the rotating portion of the electric fountain, and below the section of the same showing also the brushes and pivot.

is in line with the pulley on the frame which revolves on the pin located in the bottom of the box.

Now take the frame with the drive pulley and 2-inch piece of wood and proceed to wire the same. About ½ inch from the turned piece (A) a brass strip is fastened around it. This part is hard to make and to work well should be finished neatly. It should be soldered and smooth in order that the outer surface will not catch on the brush used to make the contact. About 1½ inches from the lower end four segments of a circle are fastened so as to leave spaces of about ¼-inch between the ends. Fig. 2 illustrates this clearly. A cross section showing the wire connections from the brass ring and segments to the lamps and where they lead out on top is shown at—B. The contact brushes are nothing more than strips of brass fastened to an upright (C) made of wood and fas-

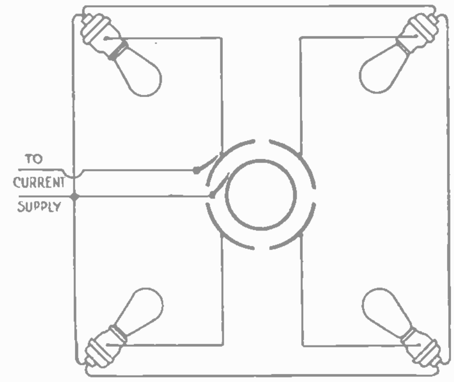


Arrangement of one of the lamps in the corner of the base of the electric fountain, showing how it is held in place.

tened to the block which is in the bottom of the box. Use two nuts on each bolt between which the wires are fastened for the source of current.

The wiring diagram is shown in Fig. 3. The wire (D) from the ring is run to the base of each lamp of which there are four. The wires (E) from each segment are fastened to each screw ferrule of the lamps and the ends left bare and open as shown between the lamps. A lamp is fastened to each corner of the frame on the top as shown in Fig. 4 with a piece of heavily insulated wire wrapped once around the screw ferrule and the extending ends held with staples. A piece of bright metal placed under each lamp serves as a reflector.

Smooth the top of the box and tack a layer of felt around the edge. Now lay a piece of glass the size of the box on its top and place a lawn sprinkler of the fountain type on top of the glass. The globes as they light beneath the spray illuminate it and make it look very pretty. The water illuminated by the lamps looks like streams of light. Each light is turned on in succession as the frame revolves in the box, and by using different colored globes an exceedingly beautiful effect is obtained. If the bared ends of the wires are twisted together between them, the lamps will all glow at once. Small lamps may be used or large ones.



Connections for the flashing of the four lights of the electric fountain, showing slip-ring and commutator segments in diagram.

A Convenient Resistance Unit

By Harry R. Lubcke

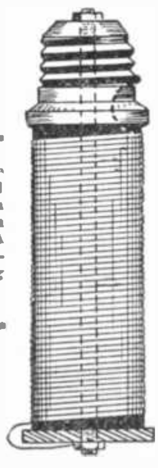
It often happens that the experimenter has need of a resistance in the 110-volt line for spot-welding, a miniature arc light, or the like. This can conveniently be put in place of one of the plug fuses in the main switch of the laboratory or in any available socket if constructed as shown in Fig. 1.

A resistance coil from an electric heater is used as the resistance element. The resistance of the unit can be varied to suit conditions by using more or less turns of the resistance wire. For spot-welding small wires, etc., all the turns of the coil as it was originally wound should be used.

As shown in the figure a discarded plug fuse is used to provide the means of screwing the unit into a socket. The brass rim, the mica, and the center contact rivet are removed. A piece of threaded rod (8/32 or 6/32) passes through the hole formerly occupied by the center rivet and up to the top of the resistance coil. It is held in place by two small nuts, one at each end and fastens the plug and resistance coil firmly together. A circular piece of either metal or insulating material with a hole to accommodate the rod serves to fasten the rod and coil form as shown.

The lower end of the resistance coil is soldered to the outside threaded brass piece of the plug in the same place as the fuse wire was. The rod and coil are then put in their proper places and the top end of the coil is connected under the nut used to tighten up the assembly.

A very handy resistance unit can be constructed out of a plug fuse and a heater element, used in portable room heaters. A discarded plug fuse provides means for screwing the unit into a socket.



Rocking Boat Illusion

By L. B. Robbins

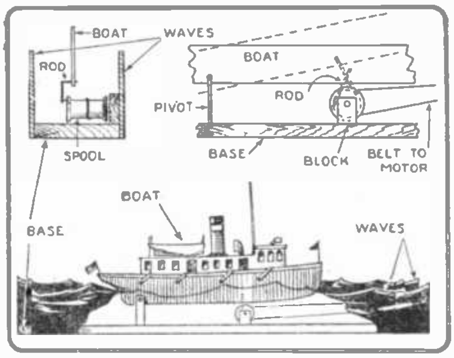
FOR those who love boats, the following describes an illusion that will be very interesting and will give something different to do with a toy motor.

Look through a lot of old magazines, calendars, etc., and you will probably be able to find some colored pictures of boats, waves, etc. What you really need is a boat—any type will do—about 10 or 12 inches long, and two strips of waves, 18 inches or so long and about 3 inches high. Of course, if these cannot be found, it will be necessary to draw them for yourself and color to suit.

Paste the waves on heavy, stiff cardboard and then cut them out to shape. If possible, arrange the wave-strips so that when they are laid together the peaks of waves on one strip will come between the peaks of the waves on the other one. This will give them perspective and a more lifelike appearance when spread apart.

Make a baseboard the length of the wave strips and about 4 inches wide. Tack a wave strip on each edge so that they both face in the same direction. This forms a sort of trough.

Fasten an upright stick to the base in the center and about a third of the way from one end. This is the pivot stick and should be connected through the bottom of the boat near the stern with a stiff wire, which allows the boat to swing up and down on it. Then, about 6 inches ahead of the pivot, glue a small square block of wood against the nearest wave strip, as shown in the diagram. Fit a small bolt through this into the trough, on which will turn a common spool. The other end of the spool should reach just beyond the center line of the base. Then



By means of the ingenious mechanical device whose details and assembly are illustrated above, an effective illusion of a boat in a stormy sea can be produced.

connect the edge of the spool flange to the bottom of the boat, a few inches from the bow, with a stiff wire connecting rod. It will be noted that these two connections should be so arranged that the boat is lifted in proper relation to the waves when looked at from a normal eye level. The side and end diagrams illustrate the mechanical arrangements and should be easy to follow with a little study.

Set the completed device on a shelf so that the eye will look at it about as shown in the cut. Connect the spool to a toy motor some distance away by a long belt of heavy thread. Slow the motor down, if possible, and, standing off a few feet, the boat will rock up and down—just as though a heavy sea were running and the boat was trying to make home port before the storm broke. The larger the spool flange and the nearer its edge the rod is connected, the greater will be the pitch of the boat as the spool revolves. Altering the speed of the motor will change the speed of the rocking motion. A large picture frame placed in front of the waves and a suitable background and side scenes will make the illusion even more effective.

What Our Readers Think

Questions on A.C. Coils and Magnets

Editor, THE EXPERIMENTER:

I am a profound enthusiast of your magazine and have been reading the letters sent in by other readers. I have a few questions and criticisms concerning the articles which are printed every month. In one of the letters on page 412 of the April, 1925 issue, comment is made about too much space being given to radio and radio articles, about which I am sure very few care. I, for one, would much rather have that space given to electrical and mechanical articles. There are other magazines which specialize in radio and which are perfectly capable of handling the subject. I am very much interested in radio myself, but cannot see the necessity of placing a lot of such articles in THE EXPERIMENTER. Why not limit the articles in THE EXPERIMENTER to chemistry and physics?

When I get my copy of THE EXPERIMENTER from the bookstand, I generally peruse the entire contents and pick out the articles worth while reading. I have been reading your magazine nearly three years and in almost every issue there have been ideas which have been foolish and impossible to say the least. I am very well versed in electricity, both in theory and practice, and can tell offhand whether an idea is correct or not. Up to the present time I have not said anything, but I am taking this chance to say a few things against the contribs, not against the staff.

In the October, 1924 issue there appeared an odd advertising stunt which appeared very practical and novel. But the author failed to note that when a coil of wire is brought near an energized alternating current magnet, and its ends are connected, a current is induced in the coil in such a way as to oppose the field producing it, consequently pushing the coil away from the pole of the magnet. Using an iron core in such a coil only heightens the effect. Thus, instead of the revolving A.C. magnets pulling the movable coils around on the glass plate, the magnet would tend to repel them and cause them to remain motionless as the A.C. magnet revolved.

In the November, 1924 issue, on page 55 another advertising stunt was written up. In this case a powerful A.C. magnet was to pull a carefully balanced coil and lamp down through the water, the lamp to light up as it descended towards the magnet. When the current energizing the magnet was turned off, the coil and lamp was to rise again due to the buoyancy of the lamp. This would not work because as soon as the current was turned on in the magnet, a state of repulsion would be set up and the coil would be repelled, thus not moving at all. Furthermore, in order to cause any induced current in the floating coil at all, the magnet would have to be of prohibitive size. Maybe the author of this article does not know that the intensity of a magnetic field varies *inversely* as the *square* of the distance from the pole. This alone would prevent the device from operating as is stated.

Please do not take these remarks too literally, as they are meant well. Wishing you heaps of luck in your work, I remain,

Yours sincerely,
Appleton, Wisconsin — Lloyd W. Root.

(In the article you refer to in the October, 1924 issue, the A.C. magnet would attract the iron core of the coil, the attraction being of course less than if it were a D.C. magnet. If the coils had no iron core then they would be repelled as you state.

Your criticism of the other article in the November, 1924 issue, applies to the caption but not to the article. You will find that the lamp and coil are a little bit heavier than the water they displace, so that the lamp with its coil will sink, but the current energizing the magnet repels the coil and forces it up. In this way it is kept mysteriously in motion.

As regards the intensity of a magnetic field, varying inversely as the square of the distance from the pole, there is no such fixed rule, as the rate of variation in attraction depends on the shape of the magnet core and its relation to the winding.

We are always glad to receive criticism and thank you for your kind expressions of appreciation.

We are giving much thought to our Radio Section and can assure you that our readers appreciate it. We have to think of all our friends, and a great proportion of them, turn at once to these pages.—EDITOR).

From the Author of the "Fish Attractor" in the July EXPERIMENTER

Editor, THE EXPERIMENTER:

I notice comment on my article "Fish Attractor" in your July issue by M. T. McKinley of Illinois.

He claims it is illegal in most states to use it. But, below his letter, you printed authority to show its legality in New York, Massachusetts, Connecticut and New Jersey.

I also found it legal in Oklahoma (my state), Washington and California. However, in Mr. McKinley's state, Illinois, it is illegal. As to the other states, I cannot say. The only laws which preclude its use are those against using artificial light to attract fish and were made originally to mean use of a light to spear fish. In some states the law says this specifically. It is legal there. In others, though not against the spirit, it is undoubtedly illegal.

As to the many laws against fishing in the night, I would say that five or six feet below the surface, and especially in muddy water, it is dark enough to render the device effective in daytime.

Oklahoma City, Okla. — Edgar Welch.

(This is interesting as supplementary to our rather limited category of states allowing such fishing. Our previous correspondent cannot have carried his investigation very far afield.—EDITOR).

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

An Opinion of Our New Magazine

Editor, THE EXPERIMENTER:

I want to write and tell you what I think of your new magazine and also ask a few questions.

I got the last number of PRACTICAL ELECTRICS and thought it was fine, but regretted very much that it had no chemical articles. In this number I saw the announcement about the new EXPERIMENTER and as it was to have some chemical articles I bought a copy and read it three times the first week. I wish you could give many more chemical articles, though I have kept each of the new numbers and would like to know if you sell a binding in which to keep 12 copies for use as future reference. I would also like to know if you could furnish me a list of chemical supply houses in America, also the addresses of the best writers of chemical articles in the EXPERIMENTER.

Yours truly,
S. E. STUART.

El Paso, Texas.

(We have no special binder. The size is standard and you will have no trouble in getting one from your bookstore or from a mail order house.

For our writers address them care of THE EXPERIMENTER *and we will forward your letters.*

Eimer & Amend, New York; Queen & Co., Philadelphia, are old established houses. Also try mail order houses.—EDITOR.)

Appreciation from a Radio Reader

Editor, THE EXPERIMENTER:

I have made the short wave receiver shown in the July issue of THE EXPERIMENTER on page 596 and it works just fine; KDKA on 100 m. and 2XK on 109 m. came in so loud I can hear them 20 feet from the phones.

Yours,
Sandy Lake, Pa. — De Forest Urey.

The Experimenter's League

Editor, THE EXPERIMENTER:

In your July issue you publish a letter, the writer of which is anxious to get into touch with other experimenters; in your comment you suggest that an Experimenters Society would be very helpful.

The Scientific Research Society was founded, as its name implies, for experimental work—originally it was a Radio Society, but its scope broadened so considerably that it was thought advisable to change its name. The members are interested in experimental work of all kinds, and they would be pleased to hear from other experimenters.

In the event of an Experimenters Society being formed we should be ready and willing to act as the British Branch thereof, and our Secretary for the time being as Secretary for the Experimenters Society in this country.

Any of your readers who would like to correspond with our members on scientific subjects should write direct to me saying in which subject they are interested. I will then pass the letter to one of our members for reply.

In conclusion, I may say that subjects of special interest to our members are:
1. Radio; Any experimental work. 2. Photo-electricity. 3. Microscopy. 4. Bacteriology. 5. Photography. 6. Electricity; Any experimental work. 7. Model engineering.

Yours faithfully,
Arthur H. Bird, Hon. Sec.

The Scientific Radio Research Society,
44, Talfourd Rd., Peckham, London, S.E. 15,
England.

The Amateur Chemical Club—Some Laboratory Suggestions

Editor, THE EXPERIMENTER:

I have been a reader of your EXPERIMENTER magazine ever since it has been for sale, and I think it is a great improvement over *Practical Electrics* as it deals with a greater variety of subjects. I think your Chemical Department is one of the best features of your magazine and would like to see it grow as the EXPERIMENTER is the only magazine that deals with this subject and there are many magazines which deal with other branches of science.

In your last issue I noticed a letter from one of your readers who was interested in starting some kind of an amateur Chemical Club. As I have lost last month's copy of THE EXPERIMENTER I would be very much obliged if you would let me know his address. I am sending a few suggestions that may be helpful to fellow chemists. Also I think it would be a good idea for THE EXPERIMENTER to put in more experiments of deeper and more educational type as it advances.

Labels for Bottles

A very neat label for bottles containing acid, etc., can be made by purchasing a box of Dennison's No. 201 labels which are marked with a colored pencil or crayon and pasted upon the bottle. Over this label is poured a coating of melted parowax. After the wax is set, scrape off the excess from around edges. The bottle is then ready to receive acid. This treatment renders the label indestructible by strong acid or caustic.

Note on Calibrating Home Made Thermometers

In calibrating home made thermometers it is necessary that the stem as well as the bulb be immersed in the liquid, or a correction will have to be made on the calibration, which is very difficult.

Yours truly,
Wood-Thornton Lab. — Gorden G. Fletcher.
Jacksonville, Fla. — Asst. Chemist.

(We are very glad that you appreciate our Experimental Chemistry department. Many of our readers have written to us expressing their enjoyment and approval of that section. In its combination of scientific treatment and popular exposition and explanatory illustrations it is unique. We also thank you for your laboratory notes.

The address you request is R. V. Ambrose, c/o Redpath Bureau, Columbus, Ohio.—EDITOR.)

Liquid Air Experiments

Editor, THE EXPERIMENTER:

I think THE EXPERIMENTER is ideal and its name is highly deserved. I wish you would put an article on making the apparatus and handling of "Liquid Air." I believe, liquid air is interesting, and that many experiments can be performed with it as with the "Tesla Resonator."

Thanking you in advance, I am,
Carrick, Pa. — E. L.

(To make liquid air a rather expensive apparatus is required. Liquid air can be purchased from manufacturers, but is also expensive. Experiments with it are numerous, but from the facts given above, it has hardly seemed to be adapted for our columns. It was treated in illustrated article in "Science and Invention" of August, 1920.—EDITOR.)

A.C. and D.C. Motors—A Correction

Editor, THE EXPERIMENTER:

I am a subscriber to THE EXPERIMENTER of which I just received the September number in which I read the article, "Operating D.C. Motors on A.C." I noticed three mistakes in the last paragraph.

First, he mentions the series type machine gives the most constant speed when used as a motor and the most constant voltage when used as a generator. I think he meant the shunt wound type.

Second, he states that series and shunt wound motors turn in the same direction whether used as dynamos or motors. This is correct for the shunt type, but the series generator will operate in the opposite direction as a motor, regardless of the polarity of its terminals, provided there is no change in the connections of the armature and field windings in respect to each other.

Third, he states that weakening the field of a motor decreases the speed when we know it increases. This is not meant as a "knock" to the magazine, as I think it is the best there is on the market.

Yours truly,
C. J. VERA.

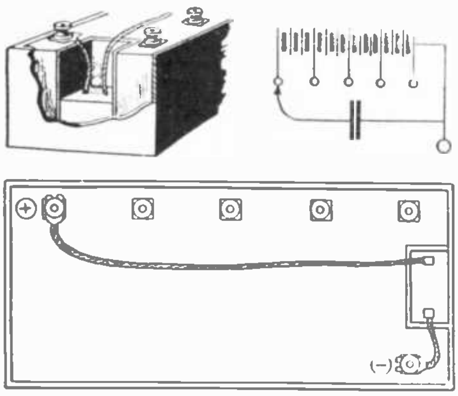
Chicago, Ill.

(All we can say is to quote from the Roman poet, Horace:

"Good Homer sometimes goes to sleep." Someone here was guilty of some such somnolence. In justice to Mr. Secor, the author of the article, we must say that the paragraph criticized was not written by him, but was added to his article subsequently.—EDITOR).

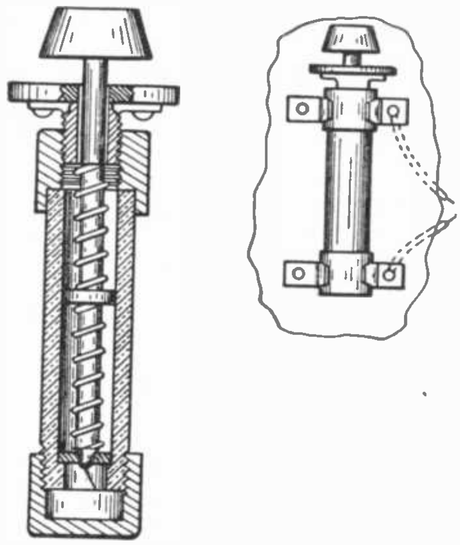
Latest Electrical Patents

Combination Battery and Condenser



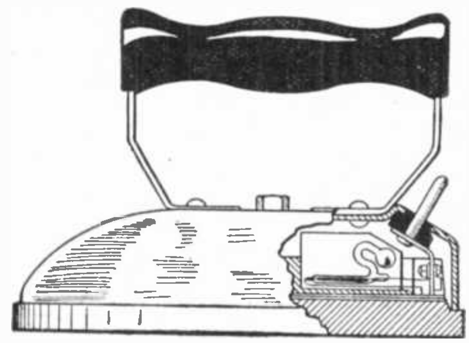
It is claimed by the inventor that bridging the B-battery with a condenser eliminates "battery noises." In this device the battery and condensers are mounted in one unit.
Patent No. 1,533,525 issued to Harry R. Van Deventer, N. Y. C.

Crystal Detector



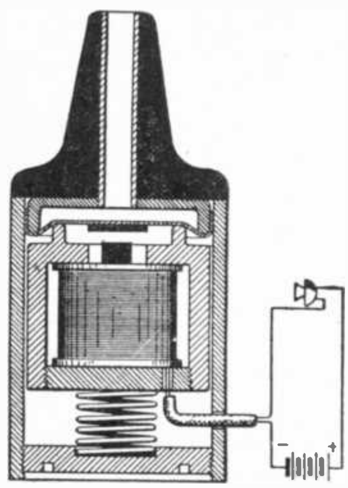
The arrangement provides a firm mounting for the detector contact. A detector is mounted like a cartridge fuse and its setting is readily adjusted.
Patent No. 1,536,971 issued to George A. Rosenfelder, Pittsburgh, Pa.

Mercury Thermostat



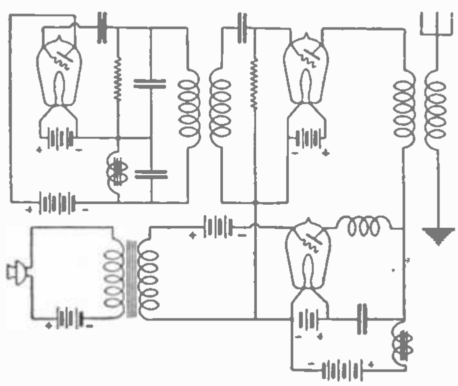
The mercury which normally maintains connections between two terminals, when subjected to excessive temperatures, evaporates and condenses in the spherical reservoir. The circuit is thus broken and to resume operation the iron must be tilted.
Patent No. 1,533,233 issued to Leslie N. Crichton, Edgewood, Pa.

Ear Telephone



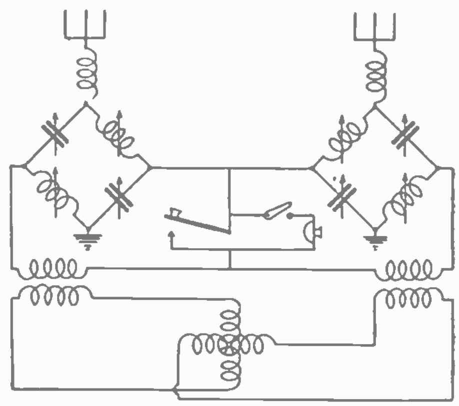
In this ear telephone a very small iron diaphragm is mounted on animal skin which is held taut by the rims of a so-called pot magnet pressed up by a helical string.
Patent No. 1,545,525 issued to H. Sell, Berlin, Germany.

Modulation System



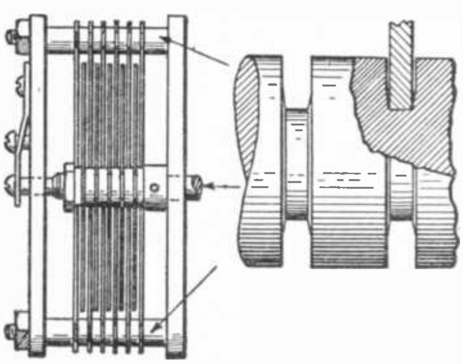
It is claimed that the system of modulation here illustrated is unusually effective and efficient and produces no variations in the frequency of the carrier wave.
Patent No. 1,533,653 issued to W. A. MacDonold, Hartsdale, N. Y.

Transmission System



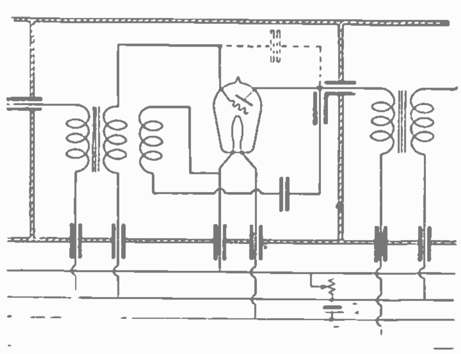
Two antennae connected to two networks supplied by a two-phased generator, normally radiate at phase opposition so that the resultant radiation is zero. When the key is depressed, however, the phases of the currents in the two systems are shifted and the signal is radiated.
Patent No. 1,533,223 issued to L. W. Chubb, Edgewood Park, Pa.

Rotary Condenser-Plate Mounting



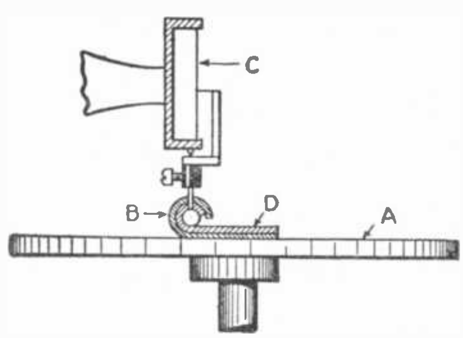
An unusually firm mounting is made possible by tapered grooves into which the plates are pressed. In this way difficulties arising from differences in plate thickness are eliminated.
Patent No. 1,536,954 issued to B. R. Webster, Chicago, Ill.

Hazeltine Neutralizer

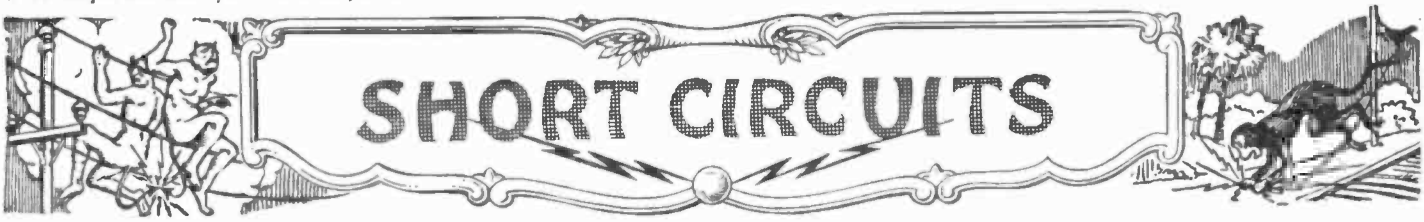


The invention for which Hazeltine became famous has been finally granted a patent. To-day, almost all people using radio are familiar with the neutrodyne system, and so this patent needs no further explanation.
Patent No. 1,533,858 issued to L. A. Hazeltine, Hoboken, N. J.

Electrostatic Loud Speaker



As the metal disc (A) rotates in friction with the gelatin (B) while the telephone current flows between the metal foil (D) and disc (A) the friction between the dielectric (B) and the disc (A) alters in accordance with variations in the telephone current. These variations are communicated by mechanical pull to the diaphragm (C).
Patent No. 1,533,757 issued to Knud Rahbek et al, Copenhagen, Denmark.



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!

Requiescat in pace,
Poor Horatius McCan,
Who shorted the electric stove
With a frying pan.
—*F. W. Delanoy, Jr.*

This marks the grave
Of Lena Hitchcox,
Whose rain-drenched hair
Touched a police switch box.
—*Ida F. Rankin.*

Sad was the fate
Of Billy O'Toole.
When a high voltage line
Fell into the pool.
—*Sadie Liebling.*

Here peacefully slumbers
Tony McGable;
His rock drill reached a
Transmission cable.
—*Clement Martinez.*

WOMAN ELECTROCUTED BY WASHING MACHINE

Shocked After Being Warned Appliance Was Out of Order.

Wash day yesterday resulted in the death of Mrs. Anna Morley, 53, at 3715 North Broadway, when she was electrocuted while using a defective electric washing machine. Mrs. Morley went to the home of Mrs. Blanche Prater, 3707 North Eleventh street, early yesterday morning, to use Mrs. Prater's washer. The latter warned her that the machine had not been working properly, and inquired before Mrs. Morley went to the basement, "Aren't you afraid of that washer?"

Shortly afterwards Mrs. Prater found Mrs. Morley suffering from an electric shock, and she summoned aid. Two hours' work with a pulmotor obtained from the Laclede Gas Light Company failed to revive the woman, and she was taken to the City Hospital. At 2:30 o'clock she was pronounced dead. Mrs. Morley is survived by her husband, George H. Morley, and seven children, the youngest of whom is 10 years old.

Beneath this cold sod
Rests Lineman Hein.
Who lost his balance over
A high tension line.
—*Miriam Kantor.*

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

THIS department is conducted for the benefit of everyone interested in electricity in all its phases. We are glad to answer questions for the benefit of all, but necessarily can only publish such matter as interests the majority of readers.
1. Not more than three questions can be answered for each correspondent.
2. Write on only one side of the paper; all matter should be typewritten, or else written in ink. No attention can be paid to penciled letters.
4. This department does not answer questions by mail free of charge. The Editor will, however, be glad to answer special questions at the rate of 25 cents for each. On questions entailing research work, intricate calculations, patent research work, etc., a special charge will be made. Correspondents will be informed as to such charge.
Kindly oblige us by making your letter as short as possible.

Explosive Hydrogen?

(535) John Kroll, Memphis, Tenn., asks:
Q. 1. Is hydrogen gas explosive?

A. 1. Hydrogen gas is often popularly spoken of as being explosive, although it is absolutely non-explosive. If hydrogen is mixed with oxygen, in the proportion of one of oxygen to two of hydrogen, or anywhere near this ratio, the mixture will explode if ignited by a flame or by a spark.

Hydrogen gas is so non-explosive in itself that a candle can be extinguished by being thrust into a jar of hydrogen gas. Owing to the lightness of hydrogen, the jar is held inverted. As the candle passes in it lights the gas at the mouth of the jar, which quietly burns with a non-luminous flame which is barely visible. The candle is held on the end of a wire. On withdrawing the candle, the hydrogen flame at the mouth of the jar re-lights it and it goes on burning. This is an old-time experiment which has been used a great deal by lecturers in chemistry, and it goes to answer your question satisfactorily.

Air consists approximately of one-fifth oxygen by volume. If two-fifths of a cubic foot of hydrogen are mixed with one cubic foot of air, we will have the approximate ratio of one of oxygen to two of hydrogen, and this mixture will explode if a spark is passed through it, or if a flame is used to ignite it.

This is to be noted about hydrogen: The proportion of one to two, described above, may be widely departed from, and the mixture will be found to be explosive over a very wide range of proportions. The limits for hydro-carbons are very much more restricted. We hear a great deal today about the explosion of atoms; it is probably fair to say that all of the atoms hydrogen is the least explosive. This, of course, is theoretical at present.

Ultra-Violet Lamp

(536) Clifton T. Spear, Texarkana, Texas, writes:

Q. 1. To produce ultra-violet rays I have used an ordinary street arc light for therapy of the head, but the hot cinders which fall from it make it impossible to use it with any satisfaction. The writer is of the opinion that if he had a piece of sheet quartz between the arc and the patient's head, the light would answer his purpose. He is using it for a pathological process.

A. 1. The ultra-violet mercury vapor lamp, such as made by the Cooper-Hewitt Company, will be the proper thing to use in your case. Here there is no question of dropping cinders. If you will use an induction coil, use cast-iron electrodes and then you should certainly have the piece of sheet quartz. Remember that the ultra violet light, if at all intense, is too powerful to be used except with great precaution and for short intervals only.

Automatic Warning Stop-light for Motor Cars

(537) James P. Noon, Utica, N. Y., asks:
Q. 1. How would one connect up a stop-light on an automobile so that it would light when the brakes are applied? Have you published the complete wiring diagram of automobiles?

A. 1. Run a wire from your battery to the stoplight on the rear of the car. This must go from the ungrounded end of the battery, then from the other terminal of the battery run a wire to a simple contact so placed that it will touch the brake pedal when the latter is pushed down. The other terminal of the lamp is grounded; the whole thing is so simple that no diagram is required.

For complete wiring diagrams of automobiles we can refer you to a book, but this does not come within our scope, not being at all experimental. If you will look back through our radio section, you will find many diagrams of hook-ups such as you want and we would also refer you to *Radio News.*

Recovering Lead From Old Battery Plates

(538) J. Gallagher, Buffalo, N. Y., asks:
Q. 1. What is the easiest process to change old battery paste (litharge) and the lead grids back to clean lead with the smallest loss?
Q. 2. What is the construction of the furnace like, and what kind of flux is used?

A. 1. Melt the litharge and lead together with powdered charcoal, iron nails and some salts. The heat must be sufficient to melt the salt and can be obtained over a gas range if the crucible is not too large, but a coal fire in an ordinary range will be far preferable. The essential thing is to get a full red heat. The idea of the nails is to take up any sulphur which may be produced in the reaction, and the charcoal is to reduce the litharge to the metallic state. The salt melting on top protects the lead from oxidation. It would not be a bad plan to add a few spoonsful of borax, and some dry sodium carbonate. The latter can be made by drying at a heat well above the boiling point crystals of washing soda.

A. 2. Any furnace which will give a good heat will answer the purpose. Even a plumber's portable furnace will give sufficient heat. It all depends on the size of the crucible. An iron ladle will be perfectly satisfactory and then iron nails will not be required.

Mysteriously Lighted Electric Lamp

(539) Richard Jamison, Detroit, Mich., writes:

Q. 1. I saw a man put an electric light bulb in a glass of water and it burned and gave light just the same as if it had been screwed into its socket. Can you explain how this was done?

A. 1. You will find the mystery explained in our November, 1924, issue of THE EXPERIMENTER, page 55.

Chemical Names, Binary and Ternary Acids and Salts

(540) R. E. Mark, Bayonne, N. J., asks:
I have seen that in the chemistries it is stated that binary salts should have a name ending in ide. How about ammonium chloride which, as it contains three elements, is a ternary salt, or ammonium cyanide. Or worse yet, the ferro and ferri-cyanides?

A. 1. A nicer way to put out would be to say that haloid salts end their names in "ide." In ammonium chloride the ammonium radical NH_4 is treated as a metal, so that ammonium chloride, NH_4 Cl, is taken as being a binary compound, a compound of ammonium and chlorine. A similar understanding applies to cyanides; here the compound CN or cyanogen is taken as if it were a halogen such as chlorine or iodine, and is also treated as if it were an element and the salts which it forms are termed haloid salts and are named as if they were binary salts; as potassium cyanide. Other haloid salts are still more complicated.

The term "ternary" salts is to be understood as applying almost entirely to oxygen salts and etymology must be strained a little bit to restrict its application to such. Of course, as far as the literal significance goes, potassium cyanide might be taken as a ternary salt, but for one fact, and that is, it is not one. The ternary salts (A) either contain as it were two separate instalments of oxygen, one in the metallic oxide and the other in the anhydride (B), or must contain elements of analogous relationship.

An illustration of incorrect nomenclature which has prevailed for many years and which will be found in novels where poisoning is to be described is prussic acid. The termination "ic" appended to the name of an acid unless "hydro" precedes it, indicates an acid containing oxygen. Prussic acid contains no oxygen, is a haloid acid, and its correct name is hydrocyanic acid and the CN compound present in it is taken as corresponding to the atom of chlorine or iodine in hydrochloric or hydriodic acid.

Thus chloric acid is a ternary acid $HClO_3$, while if "hydro" precedes the name we have hydrochloric acid, a binary or haloid acid, H Cl. This shows the import not only of the "ic" termination, but also of the "hydro" syllables which begin the names of haloid acids.

There is a system of omitting the final "e" in the names of haloid salts, sodium chlorid, potassium iodid and the like; this will eventually be universal.

2. Why is CO_2 called carbonic acid or carbonic acid gas, and not carbonic oxide?

A. The correct name would be carbonic oxide. But the other names have clung to it for many decades, and it would be difficult to straighten out the inaccuracy. Then there is another trouble. Carbon monoxide, CO, which should be called carbonous oxide, but never is, has for years been popularly called carbonic oxide. It would be practically impossible to rectify these two errors of such long standing.

Meters and Their Use

(*Continued from page* 808)

filament ammeter is going into discard and will undoubtedly become obsolete in a short time.

To obtain a maximum output and efficiency from a vacuum tube, it is essential that the plate voltage be such as to conform with the requirements specified in the operating characteristic. The design of high voltage instruments to withstand the strains imposed must be such that the instrument shall consume as little current as possible and give an accurate reading under varying loads. The usual plate voltage meter has an external resistor or multiplier, and by using different values of resistance it is possible to read voltage variations over a very large range.

The plate current in any vacuum tube is a measure of its output and its maximum is the limiting value. Also we must bear in mind the fact that a plate milliammeter is a necessity when checking up on a circuit to ascertain whether it is in the oscillatory condition. Thus, when the tube is not oscillating, the milliammeter shows a higher reading than when it is.

Alternating Current Meters

These instruments are of the induction type, so-called because they have a fixed core of laminated iron wound with one or more coils of wire, and a movable element in the shape of a metal disk or cup which is pivoted to move in the air gap of the iron core. The reason that they are called induction instruments is because they depend for their operation on the interaction of the induced currents in the metal disk with the induced field.

For the necessary measurements of alternating currents in a radio transmitter, such instruments as the following are available:

	Ranges
Filament Voltmeter...	0 to 10 up to 0 to 15 volts.
Plate Voltmeter......	0 to 120 up to 0 to 3,000 volts.

It must be remembered that whether the plate supply is direct or alternating, the plate milliameter is always a direct current device, since the tube passes current in one direction only.

Radio Frequency Meters

The radiation ammeter is the most important instrument in a radio transmitter of any type Roughly speaking, the distance covered by a transmitter is proportional to the antenna current, and of course this current is dependent upon the sharp tuning and proper adjustment of the various parts of the circuit.

There are two forms of radiation meters, hot wire expansion type and thermo-couple type. Of these, the latter type is by far superior, the only claim that may be allowed for the former being its relative cheapness. As far as accuracy, overload capacity, small temperature errors and responsiveness are concerned, the thermocouple meter is the best.

Radio frequency meters are surprisingly accurate over practically the entire range of frequencies being used—from 1 to 30,000 meters. A thermo-couple ammeter is simply an arrangement which uses an especially sensitive direct current movement of minute proportions which is actuated by a thermo-couple composed of two special alloy wires welded together. The high frequency current takes the shortest path and heats the welded joint raising the temperature of the thermo junction an amount proportional to the square of the current flowing. An electromotive force is generated in the thermo-couple which is proportional to its temperature, and this feeble current actuates the sensitive direct current movement. Of course, the scale is calibrated in amperes or fractions thereof and the calibration holds for any radio frequency current. Thermo-couple radiation meters can be obtained in scale ranges of from 0 to 0.5 up to 0 to 15 amperes.

Wavemeters which are in reality radio frequency measuring devices, are extremely useful and very simple in construction. A variable tuning condenser and an inductance coil together with some form of indicating device, such as a small lamp or current-squared galvanometer as a resonance indicator, comprise one. This latter instrument is one of the hardiest to have in the radio room. The calibration of such a meter is such that the indications are proportional to the square of the current flowing. A very slight amount of radio frequency energy will operate it and its indispensability cannot be stressed too strongly. One with a scale reading of 0 to 100 will be found to be entirely satisfactory for all purposes.

Aside from the argument that meters greatly enhance the appearance of a radio transmitter, they are a real necessity in obtaining maximum efficiency and for that reason should be used.

As regards meters for receiving sets, the portable pocket variety will fulfill all needs. One requires only a voltmeter having a double range of 0 to 10 and 0 to 100, for testing the "A" and "B" batteries.

The information in the above paragraphs is concerned only with the meters which find general use by the transmitting amateur. There are numerous other meters for a variety of other uses, and in fact so many more that some of them will be told about in future articles.

Conducting an Amateur Station

(*Continued from page* 809)

work. Go to bed early and set the alarm for before daylight. This allows several hours of good fun when static and QRM are at a minimum.

Operate between 10 p.m. and 12 and suffer all the troubles of real interference. The air is so full of squeaks and grunts that it makes one think of a mass of worms, if the relation of sound to matter makes possible the simile.

Between 12 a.m. and daylight there is usually a steady decrease in the number of stations on the air. This is great stuff.

Certainly one should try to have certain nights of the week when he will be assuredly on at a definite time or period of time. This will make communication certain if one is badly wanted at any time, and will earn one a reputation that will prove invaluable.

DX WORK

We are all after distance. But it is an empty goal and should have nothing sacrificed to it. However, there are some things to observe, if we overlook no bets in getting distance.

Make it a point to always give one's call with excellent spacing and clarity. Speed does not help in this, nor does extreme slowness. The emphasis need not be anywhere save on the dashes. If the "dahs" are definite and well out of proportion to the "dits," there will be no confusion. Notice if anyone errs in your call when calling or working you at any time. If he does, lay the blame on yourself and set out to avoid causing the repetition of the misunderstanding. If a call is readable, the man at a distance who hears it will be in position to *QSL* the fact.

RAG-CHEWING

For some reason, of recent months, intercommunication had dropped to an uninteresting repetition of forms. Nobody has seemed to try to be friendly and the last thing one can get from another operator is a friendly few minutes of talk. Many that have operated since the days right after the war can remember the friends they made by a few casual hours spent in chewing "the sock." It was unimportant what was talked about, anything from soup to soap, provided something was learned and a friend made. Also, they can remember that many of their friends were located between 100 and 1,000 miles away.

A consideration that the amateur game is different than the commercial and that there is no great objection to our gabbing among ourselves should bring the realization that there is fun in knowing each other. And we should realize that a fellow amateur can't be known, or anything be learned about him by omnigraphing "*nil hr om cul 73.*" Nor are friends made by cq cq cq cq cq cq cq cq cq cq cq cq, etc.

At any rate, the point of this is plain. In common decency, try to show humanness enough to talk about something besides *cul*. And if you don't know how to start a good talk, write me and I'll tell you.

JUNE 2

TIME	CALLED	CALLING	REMARKS
6:25			ON WATCH - NO QRN.- NOT MANY ON.
7:01	CQ	5222	
7:04	5222	X	GOTTIM! QSA, STEADY AC, SEZ NIL. SEZ I'M VRY QSA.
7:28	2222	X	NO. HES QSA. TRI 'IM AGN LATER, MEBBE PUTTING 2 AMPS IN ANT. NOW. - 80 λ

A very good example of a log sheet as used by up-to-date amateurs. It is so conceived as to contain sufficient information for future reference and to result in the least amount of confusion.

Sound and Audio Frequency Amplification

(Continued from page 811)

order to have the tube act with maximum efficiency upon the transformer, that the primary shall have at least the same apparent resistance as the tube itself. We also have seen that the transformer is only effective when currents of varying magnitude are flowing in the primary. Now the apparent resistance of a transformer primary, its impedance, as it is called, is lowest when the frequency of the variations is lowest, while the internal impedance of the tube is always the same (16,000 to 18,000 ohms or more, depending upon the voltage of the "C" battery). We must then construct the primary in such a way that its impedance is equal to the tube impedance at the lowest frequencies down to a frequency of 32 a second, and even less.

We can increase the impedance of this primary in one way only: by giving it a very high number of turns. The greater its number of turns, the higher its impedance at the lower frequencies, and as the frequency increases, the impedance increases in proportion, so in this way the impedance becomes high over the entire band of frequencies at which the transformer is to be operated.

Actually, there are only a few transformers on the market that have a sufficiently large number of primary turns and thus are capable of working efficiently at the lower frequencies, but during the last year or so there have appeared a number of them that have the desired characteristic, and for quality reproduction only these should be chosen.

Now it is desired at the same time to have a transformer that causes a step-up in the voltage of the circuits handled—and this means that the secondary must have as many more turns than the primary as the step-up requires. This then means that if the primary has a very large number of turns, and thus of necessity is bulky, the secondary is even more so, and this of course rules that your transformer to be efficient can never be a nice little affair that can be tucked away in any convenient corner. The best transformers are bulky, heavy and expensive.

There is more to a transformer than is generally supposed, and the making of the good types has developed into a great art. One of the things to be guarded against is excessive capacity in the secondary—because if this has great capacity or condenser effect, it will be ineffective at the high frequencies. This is caused by the fact that a capacity offers an easy path to high frequency currents and thus the voltages developed will drop below their actual values when capacitative effects are present. But to wind such a secondary with a high number of turns without causing considerable capacitative effects is an art in itself.

Another demand is that the transformer should step up the voltage quality at all frequencies, and show no tendency to favor some one or two frequencies, because in this case these frequencies will be amplified more than other ones, resulting in considerable distortion and bad reproduction.

A two-step amplifier is given diagrammatically in Fig. 3, and the actual amplifier is shown in the photograph, Fig. 4. This amplifier has some unique features, and was built for easy handling and quality reproduction. It may be stated that anyone building this amplifier will experience an agreeable surprise when he hears its performances.

It will be seen that there is but one jack for inserting the loud speaker plug—and this has been done to save wear and tear on the telephone cords. The shifting from the first stage to the second one is accomplished by means of a five-prong jack switch, specially manufactured for this purpose by a Chicago concern. How it is wired can be clearly seen from the diagram. The filaments of the detector and the two amplifying tubes are automatically controlled by means of amperites, thus eliminating rheostat controls. This, by the way, assures one of the fact that the filaments will never be used as so-called volume controls, as is done on too many receivers. Filament volume control too often amounts in practice to volume control by the introduction of distortion, by reducing the maximum plate current available, and thus results in bad quality of reproduction. A volume control is provided in the form of a variable grid leak across the secondary of the second transformer, while when general volume control, also for the first stage, is desired, this grid leak can be replaced by a variable resistor of from 10,000 to 100,000 ohms across the loud speaker jack, as indicated in dotted lines. Both these volume controls will serve perfectly, as they will not change any of the characteristics of the amplified currents.

Two different transformers are used—of which both possess the requisite characteristics in their particular place. The second transformer is one, which has an almost completely uniform step-up characteristic over the entire frequency scale, and therefore causes the last tube to amplify uniformly all currents flowing through its primary from the first amplifying tube. The first one was chosen for an entirely different reason.

When the process of detection was mentioned, it was stated there that in some way or other we would have to separate the carrier wave from the audio frequency component. How the detector does this is not in the scope of our article, and therefore we will only say that this separation is accomplished because the detector acts as a rectifier, and that its plate current is a rectified current. But, and this is important, in this rectified current there is still present the carrier frequency—and we must get rid of this component. This is done by shunting the primary of the transformer, through which

(Continued on page 854)

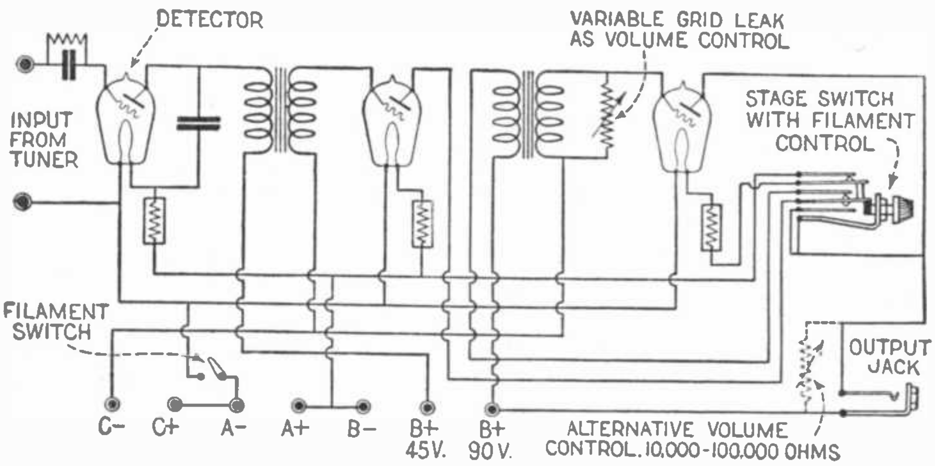


Fig. 3. Circuit of the finest transformer-coupled audio amplifier as yet made. A filament control switch allows using one or both tubes and eliminates the necessity of interstage jacks.

Audio Frequency Amplifying Transformers

(Continued from page 813)

Recently there appeared on the market an extremely fine transformer, undoubtedly the result of a great deal of development. The primary inductance is about 100 henrys. Although no turn ratio is given, it happens to be between 2 and 3 to 1. This manufacturer apparently found it next to impossible to make his turn ratio higher and still retain the superb quality that this instrument delivers.

Obviously, such transformers cannot be made and sold for a small amount. Competition in the radio industry is pretty keen and it is well to remember that because of this, value received is proportional to money expended.

I wish to emphasize the fact that a low ratio transformer is good not only by virtue of its low ratio. It just happens that it is hard to manufacture a good high ratio transformer. I forgot to mention that a tube does not overload so soon when the secondary impedance is low. This is another point in favor of low ratio transformers.

A great deal of work has been done lately on the design of transformers to be used in reflex circuits. Since the primaries and secondaries are shunted by fixed condensers, it is necessary that the transformers have a rising characteristic. That is to say, the amplification should increase with frequency approximately as much as it is attenuated by the external shunt capacities. The rising characteristic can be obtained by the use of a special core made up of fine laminations, and a very low ratio winding of such proportions that the distributed capacity is as low as possible. Although the effective ratio of this transformer is slightly less than 2 to 1, measurements showed that its amplification in connection with a 201A tube was better than that due to a great many transformers having a higher nominal ratio.

There is a very great difference in design between a power transformer built to operate at one standard frequency, and an audio frequency transformer which has to operate over a wide range of frequencies. Impressive advances have been made in the last few years but I believe that there is still considerable room for improvement.

In conclusion let me say that it is foolish to spend money on good transformers and then to buy a poor loud speaker. You cannot get good quality out of a poor loud speaker with the best amplifier in the United States!

The Experimenter's Bookshelf

A Book About Selenium

THE MOON-ELEMENT. By E. E. Fournier D'Albe. 166 pages, including index. D. Appleton & Co.

The author opens his preface by saying: "In this book the reader will find the first connected account of the properties and applications of a chemical element which has raised—and disappointed—more hopes than any other element known."

The element in question is selenium, named from the Greek word indicating the moon, and it is most interesting to glance through the work and find at last so fully treated the various elements affected by light. The author begins by an interesting chapter on the relation of electricity and light and then goes on with his titular subject. Few of us realize that selenium was discovered by the great chemist Berzelius in 1817 and that he gave it its name. The chemist and especially the blowpipe analyst finds that when burned it gives off the smell of rotten horse-radish, which is actually used as a test for it.

An interesting table gives the dates of the development of our knowledge of it and then the construction of selenium cells, which our readers have several times found treated in our columns, is described.

We now come to more complicated apparatus and its application to picture transmission, its operating of relays, and then to the Optophone, the object of which is to enable the blind to read. The author was identified with the Optophone. There were very cutting remarks published concerning his claims, and he certainly had quite a hard battle to fight. A considerable portion of the book is devoted to tests of the practicability of this instrument.

The speed of reading was very slow at first, less than three words per minute originally, yet it seems that one of the blind subjects attained 80 words per minute, nearly half the speed of eye reading. The author claims that the problem of reading for the blind is completely and finally solved. The Photophone or light telephone, the reproduction of a talking film, and the uses of the element in astronomy, come at the end of the book. An adequate index is given.

Radio for the Amateur

THE RADIO MANUAL. By Orrin E. Dunlap, Jr., B.S. xvii, 267 pages, including index. Houghton, Mifflin Company.

The author of this excellent book has had so much journalistic experience that he has succeeded in producing a thoroughly popular, readable treatise on wireless transmission and reception. It must not be supposed that the book is merely to be read. It can be studied, for he gives theories, tells of the troubles incident due to static and the dead spots, discusses the different kinds of waves, describes the Heaviside layer theory, and a system now fortunately being adopted by publishers is followed of having the illustrations on coated paper while the text is on dull surfaced paper, making it agreeable reading.

The whole get-up of the book is unexceptionable, and a nice feature of it is a short radio dictionary, which we would like to have had considerably extended. A table of conventional radio symbols is given. Over seven pages are devoted to the index. The book has the happy quality of being at once a book to be read and a book to be studied.

Chemistry in the Laboratory

A LABORATORY OUTLINE OF SMITH'S ELEMENTARY CHEMISTRY. By James Kendall. 112 pages, including appendix. The Century Co.

Professor Alexander Smith's elementary chemistry has won much commendation from instructors and reviewers, and the writer of this review well remembers the condition into which a year's work in qualitative analysis in the laboratory of Columbia University brought his Fresenius' Qualitative Analysis.—acid and chemicals made of it a dreadful wreck. We have recently had the pleasure of reviewing Professor Smith's book and now we are glad to see a little, comparatively cheap book devoted to laboratory practice based on the larger and more expensive one.

This book can stand a certain amount of chemicals being spilled over it, and we have no doubt that a number of them will be pretty thoroughly used up. In its 108 pages a great deal of work by the author is represented, for condensation is the hardest kind of writing, and the work fills a long empty gap in the chemical field. The student, who faithfully does the experiments described will be a better chemist than many who claim that title.

How to Make Thermit Experiments

(Continued from page 821)

was obliged to make it in lots of only 8½ pounds each.

Oxides of copper are also reduced with great violence and an experimenter should use only a small quantity of the oxides in preliminary experiments.

Barium peroxide when intimately mixed with fine aluminum such as used in aluminum paint will almost reduce spontaneously. The direct rays of the sun are sufficient to start the reaction.

The ruby is of the same compositoin as our slag; it is alumina, Al_2O_3, crystallized by the unknown processes of geologic ages. If it were pure alumina, it would be white and would be called a white sapphire. Some slight impurity gives it the red color. Crystallization will sometimes occur in the melted slag of the thermit process, giving what are really artificial rubies; attempts have been made to produce rubies by this process, coloring the product with an oxide of chromium, and a very good approach to the gem has been made.

Another interesting line of experiments is the production of different metals, but great care is requisite, for some metals go into the disintegration with almost explosive violence. Cobalt and copper are two metals which must be used in small quantities only on account of this danger.

The Ark of the Covenant

(Continued from page 807)

navigation of our ships, and had made models of many contrivances for the controls and the manipulation of our lifting gas. Finally, we possessed a supply of radium greater than had ever been known before in the world, and worth enough money to set us all in luxury for the rest of our lives.

In the matter of creature comforts we were very well off. We had vegetables growing in a clearing down the river; we had fish and venison and wild pig, with occasional snatches of frozen beef and mutton; we had, of course, the best of canned foods, milk, meat and fruit; and we had ducks and chickens thriving in a cave at the south end of our main cavern—the ducks corralled by wire netting.

To reach this point in our preparation had taken over two years, and indeed we had celebrated two Christmas feasts and two Thanksgivings in the big living-cave of the plateau.

We had come to the stage once more when we would have to make a journey to the outside world. By now the materials for our two airships with the necessary instruments would be waiting for us at New Orleans, and we were due to complete the number of our company.

Before setting out on our last voyages, I put the whole of the men on constructing great doors for the main and smaller entrances of the cavern. These we made of trellis-work in heavy scantlings of wood, overlaid with wire nets, and we fixed floating boxes of soil at their bases, planting quick-growing creepers on them. We planted well past the hinges of each flap to a good distance along the cliffs on either side of our waterway. When we returned from our next voyage, the entrances to our cavern were masked with luxuriant foliage.

Getting Recruits in America and England

II

I took Devonridge, Dane and Higgins with me to England for the purpose of recruiting men. Greensleeve volunteered to find some in America, as did the two Lippencotts and Curtis. We went carefully to work on both sides of the Atlantic.

In England, Dane did the best work among us. He found us six skilled mechanics for whose characters he could vouch. I found five good seamen and airmen who had served with me previously, and Devonridge weighed in with two excellent sportsmen of his own type, and a couple of men who had been on his estates.

We each kept our own party and voyaged separately to New Orleans, where we found that Lippencott and his helpers had recruited sixteen good men. There was not a man among the whole thirty-one who did not promise well, and the experience of the next year at the plateau only found a single failure among them. Our total complement, excluding the Master, now numbered forty-seven, and still our tally of men wounded in war was unbroken. I had almost made a point of that qualification to my recruiters, and they seemed to have made much of it.

While my party was in England, Lippencott had had the *Clutha* loaded, but with the number of men we had to carry and the weight of our material, we found that at least two journeys would be necessary. It seemed hardly safe to leave any number of men to kick their heels in New Orleans for some months, so I determined to ship the lot at once. The little vessel was packed, but the spirit of the men was good and they bore the cramping with cheerfulness. The voyage was made at good speed and, except for having to hide the men on passing several of the river ports, we arrived at the storehouse without adventure.

There I gave over the command to Devonridge, with Greensleeve and Curtis as juniors, and when the unloading was done, I took the vessel without further delay down river again for another trip to New Orleans. Here I shipped the last of our material, and a good amount of stores.

On my return to our base on the river I found Devonridge waiting with men to unload. We carried our stuff upstream to the plateau.

I outlined a plan I had conceived to the Chief, which was simply that after two further voyages to America for stores we should burn our boats behind us, and not go back to the outer world until we could make the trip on the *Ark of the Covenant*. The Chief agreed, so when the final two voyages had been made under Devonridge, we ran the poor, trusty little *Clutha* into a creek downstream and felled trees about her, effectually concealing her where I suppose she lies—bless her!—to this day.

We shipped Smithers and his toucan, Nosey, having about broken their hearts by razing the storehouse and bungalow to the ground, and as we proceeded upstream we put charges of giant powder under tall trees behind us so that they fell across the water, securely blocking any passage behind us. In a month or two the way would be nigh impassable.

Thus we cut ourselves off from civilization—except for that which we carried with us—and a full year elapsed before the world heard of us again. Even in the cavern we were shut from prying eyes, for the great doors were now a mass of green, and when we chose we could be very troglodites.

The crew settled down to work with commendable earnestness of purpose, and we had trouble with only one man.

It must be remembered that our company consisted of picked men. We had some of the most skilled engineers, mechanics and electricians that could have been found in Britain or America, and in addition we had others who made up for their lack of skill by willing spirit and remarkable adaptability. The young men from about town, both British and American, where they could not do work in which they had been trained, took off their coats and worked like laborers.

Philip, Marquis of Devonridge, as an example, would take his ex-gamekeeper, one Moggs, off for a day's hunting, and would bring in enough fur and feathers to keep the company feeding well for days; but next day would see his lordship on some rigging work, taking orders from Sam Smithers as cheerfully as he had given them to Moggs on the day previous. Moggs, too, would be found cooking an appetizing meal for the Chief—to whom he speedily became devoted—with the same amiable imperturbability as he had shown in tramping through the marshland after Devonridge. Moggs was a treasure, for he was the only man among us who dared argue with the Chief as to what was the proper time to eat and sleep. In room of Grumstock, otherwise engaged, he made himself an unofficial batman to our leader, cook to the company in general, and factotum at large about the caves.

Another mighty hunter in our midst was Billy Haynes. Haynes had fewer words than any man among us, not even excepting Smithers, and he never was upset, never ruffled. The only time we ever saw him show the slightest symptom of being moved was when Lin Greensleeve decried the merits of Billy's double-barreled English sporting gun in comparison with one of the pump variety from America.

"That's a lot of dam' rot, Greensleeve," said Billy with his widest stare. "Talk about something you know—f'r instance the smelly stuff you work in—and I'll listen to you."

Of Lin Greensleeve I have written something already. He was good in the way that only an American can be. Full of the humorous exaggeration beloved of his countrymen, he could "string," as he called it, the Britons among us with superb ease, and he had the knack of causing laughter, but when he settled down to work he tore at it and hammered at it with a driving force that was a thing for wonder. Young Lippencott, too, and Steven Curtis proved their value, the former combining a drawled wit with a steady application to business, and the latter with no less zeal in harness, and his delightful gift of song always available for our amusement.

The cement that bound us together was devotion to the frail little man who inspired us. He moved in our midst with a gentle aloofness which did not repel. He helped us in our difficulties, out of the deep store of knowledge in his amazing brain, and he tended us in sickness or injury with the extremest skill, though fortunately his ability was seldom called upon on the latter account.

In the hands of these willing comrades, and under the direction of our brilliant leader, the airships steadily grew into shape in their stocks, and at last the time came when the first *Ark of the Covenant* was ready to take the air and the second only waited the performance of the first to allow completion. I think more than myself experienced a thrill of sorts when that night the Chief and myself stepped into the recreation room of our company.

"I have come to tell you, gentlemen," said the Chief, "that to-morrow we fill the ship with gas—and to-morrow night we take the air."

The cheer that went up might have been heard over the Andes in Ecuador!

III

The Start of the Ark of the Covenant and Her Display of Wonderful Capabilities

It was New Year's Eve and a night of bright moonlight that paled the tropical galaxy of stars. The *Ark of the Covenant* floated down the main cavern on her own power. We had fixed taut cables cross-wise over the walls and roof of the cave, so that she would rub against no rock surface. For a moment she hung steady over the entrance basin, then I nodded to the Chief, who was by my side. He gently pulled round the ascent indicator as I belled for half speed, and the ship rose smoothly by the head as we gathered way.

We shot up at a surprising speed, and on the instant I knew of a certainty that I was in command of the finest craft that ever sailed on sea or in air. She was a living thing, obedient, gentle, strong. We tested her thoroughly against the wind and with it, and her highest speed was well over three hundred kilometers an hour. Her balance was perfect.

We closed all apertures and turned on the compressed air, which was also fed to the engines, and we gave her full gas. We rose at dizzying speed, so that I began to have fears for our ballonets. We touched a height close on nine thousand meters, and the earth was lost to us. Higher we went, and it was certain that no known machine could reach us. Yet we found resistance enough for the propellers to cruise at a good speed. We knew that we were safe from all pursuit when we chose.

We came down again and tested her for drift for her turn. She drifted little, and with the help of the pivoted stern cabin she could come about almost inside her own length.

The Chief accepted the wonderful performance of the ship with the greatest calm, for I think he never had a doubt of her capacity. What concerned him more was the working of the various instruments he had invented for our use. First of these was the navigating globe.

This was nothing less than the earth in miniature. For its control the Chief had utilized not only the magnetic rays of the earth, but also in some extraordinary way the pull of the world as it revolved on its axis. The ball, which was the earth in replica, thus was always poised in exactly the same relation to the ship as the earth itself. The globe swung on an elaborate system of gymbals, and its core was taken up by a series of magnets. The whole of this complicated piece of mechanism was inclosed in a gas-filled chamber, the top of which was pierced for a lens, through which the illuminated portion of the globe directly under was thrown magnified by a camera obscura on a vertical ground-glass screen. The ground-glass screen was crossed by two hair lines, their intersection giving the position of the ship over the earth, and the vertical hair her direction. To test the instrument, the Chief bade me fix my own course for some place recognizable, making my own reckoning, and he covered the ground-glass with a cloth.

I fixed on Caracas, and put the ship in that direction at full speed. On my mettle I took no chances. I calculated drift and everything that might throw us out of our course, and when we arrived over the city and pulled the cloth from the indicator, the crossed hairs stood clean on the dot representing the place.

Trying Out the Gas in a Glass Bomb

It was on a plain of the hills behind Caracas that I was first introduced to the directive rays which controlled the cloud of anæsthetizing gas, for here the Chief had a glass bomb filled with the liquid gas and dropped haphazard on the plain.

Below us the gas widened into a luminous cloud. The Chief was working with a box affair which had a sort of lens arrangement on one side and was connected to the high-tension circuit. He and Thetford manipulated this box through a hatch in the cabin floor. As I watched I saw the cloud take shape and move across the plain, now one way, now the other.

We were drifting on the wind with stopped engines, but the cloud was made to travel in advance of us or across our path at the will of the Chief. As I watched, I saw the cloud move toward a series of dots, cattle of some sort, on the plain. It enveloped them, and whatever they were, horses or steers, they were all lying on their sides when it had passed.

"It is enough," said the Chief.

"Have you killed them, sir?" I asked. And he looked up at me very mildly.

"Why, what a question," he said, "and from you, Seton! No, no, my friend, they are only asleep."

As he spoke, he moved the box back and forward quickly and below us the gas cloud was broken and began to disperse.

"That is well for one morning," the Chief said, rising. "Now, Seton, let us be back at the plateau with the dawn."

In the west the moon was low down, and darkness was spreading over the land. Below us no light gleamed, nor often did we catch the faint sheen of water, save only when we sped over the Orinoco itself. Darkness for a space, but for the the light of the stars, and then came that cold tinge of grey in the east.

Quickly faded the grey into pale topaz and chrysoprase, until, as we slanted down to the basin of our cave, it was lost in the glory of the risen sun. Our trial trip was over with abundant success.

IV

Narrow Escape of the Ark of the Covenant From Wreck

Two days after our initial voyage we almost lost the first *Ark of the Covenant* as a total wreck, and a little later it seemed likely that both our ships would be damaged beyond repair.

The second ship still lay in her stocks, waiting for any improvements that might be suggested by the performance of her sister ship. We had taken out *Ark of the Covenant—I* on continued tests, and we had been cruising some hours towards the early evening, when, without warning, we were caught by a tropical storm at a considerable distance from our base. For the storm in itself we needed to care little enough—it would have been possible to ride over it. But we found ourselves in the air with only sufficient petrol for the home run. We had, moreover, no stores aboard to permit any comfort in waiting for the storm to die down. There was nothing for it but to run.

Behind us the storm was rising on a following wind, and it was a question of time if we could be at the cave entrance before the impact caught us. The ship behaved admirably, rolling little, keeping her balance, and speeding like a thrown javelin for home. We dropped into the entrance basin under a sky black as ink. Over us the rising wind was moaning, precursor of swift hurricane. If we could not get the ship into the cave, the chances were that she would first be battered against the cliffs, then lifted and thrown perhaps into the South Atlantic.

Every single man jack ashore was on the guy ropes and numbers of the crew had dropped hardily into the water to help, but the ship swung stubbornly towards the threatening angle of the entrance. They had not the weight to pull her round, and the edge of the hurricane was tearing down on us. From the cabin of the ship I was trying to direct the operations of the men both aboard and ashore, but the noise of the wind made hearing difficult. It came to me that if we did not act quickly, time for action would be past—so I sprang for the deflation gear and spun round the handle. In a second or two there was scarcely a foot of gas in the whole ship, and we sank into the basin. Now I shoved over the controls to half speed.

Deprived of her buoyancy, the ship was easier to handle, and as the men resisted the drive of the wind, we forged ahead into the cavern, our propellers lashing the water and our cabin awash.

It was in the nick of time, for even as her rudder passed the jambs of the entrance, the crest of the hurricane caught the ship and threw her stern against the fender ropes. But we were inside at the cost of strained rudder stays and one propeller-blade broken. The great doors were closed against the storm, which was now upon us with clamorous fury. To restore a measure of buoyancy to the ship, enough at least to take her out of the water, was only a question of turning on our reserve gas. And in a little *Ark of the Covenant—I* was snugly secured by her mooring stays in her own hangar cave.

All this time the Chief had not moved from his position. He had been clinging by his single hand to a rail, and I turned to him with an apology for sousing him and his wonderful instruments. But the only reply I received was one of his extremely rare hand-shakes, and I knew then that I had somehow pleased him.

We went together to the living quarters, and when we had changed I joined him in his laboratory to watch the storm. Fortunately the windows of the laboratory and of the living-rooms were sheltered from the force of the wind, and we caught nothing but the eddies. Outside, the land lay in half light, but it was possible to see that the trees and shrubs near us were bent low and laid flat by the terrific drive of the hurricane. Sometimes a great tree would give, the earth below it would part and the roots would come up majestically into the air with a cloud of broken soil. At times one of these uprooted trees would be lifted bodily and carried through the air like a feather. Bushes were flung high, and the air was filled with débris, whizzing along at lightning speed. I thought of the lines from the "Deluge" of R. L. S.:

> To hear, frae the pit-mirk on hie,
> The brangled collieshangie flee,
> The warld, ye'd thocht, 'twixt land an' sea,
> Itsel' had coupit,
> And for auld airn, the smashed débris
> By God was roupit!

Then came the rain, a grey streaking curtain of it, thickening in texture till it was almost a solid mass of water obscuring the view, its base a teeming mist of shattered drops. Thicker and more dense it grew, till the roar of it drowned the voice of the wind.

Suddenly the fall of the water—it could not be called rain—thinned, and a terrible spectacle came before our eyes. The water thinned, gathering to a dense core, and wreathed into a whirling spiral which spun up and up until widened into an inverted cone of leaden cloud, behind which the lightning played in livid sheets and splashes. And the dense column of water moved over the cup north of our plateau, solemnly, majestically, roaring the tune of its march as it went, with undertones of the crashing thunder. Its trail was a wide path of smashed and riven trees and flattened shrub. Over the cup of land the column moved, leaving a sheet of desolate water, until it passed to the spur of hills of which the plateau was the point, and was lost to our sight. Its voice now was muted to a distant murmur, fretted by jagged mutterings of far-off thunder. The drab greenish mauve of the sky lightened to a generous amber.

Of our relief that we had found haven before such an awful visitation let a second silent handshake between the Master and me bear witness. Yet our worst danger was still to come, and we were to find that we had congratulated each other too soon.

The river of the northward cup was lost in a wide sheet of water, and it was apparent that the outlet gorge was too small for quick drainage. We saw that the water of our entrance basin was rising steadily and quickly, which meant that the level of the waterway within the cavern would be rising also. This we found to be the case, but towards nightfall the rise seemed to have found its maximum. We were cheated into a false sense of security.

Other Dangers Impending — The Flooding of the Cavern

The note of our cavern waterfall gave us first warning of the danger. In the years of our sojourn under the Plateau of the Scar, the voice of the fall had ever been a friendly whisper to us. We lived with its solacing murmur always in our ears, and I think we missed it when absent from the cave. But in the middle of the night after the hurricane, we became acutely conscious that its note was changing—growing louder, gaining a suggestion of menace.

The noise swelled into a threatening roar, and as I got up from my bed to dress, the whole cavern was filled with a hoot and rumble which vibrated enough to shake the teeth from one's head like pips from a squeezed orange. It was plain now why the Indians avoided the Plateau of the Scar. The noise was terrifying.

Already most of the men were astir, for the uproar made sleep impossible, and when I got out of the dormitory into the main cavern and pushed home the main switch, the arcs lit up a sight that spelled immediate danger. The column

(*Continued on page 846*)

EDITED BY JOSEPH H. KRAUS

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

Commutatorless D. C. Motor

(18) A. B. Boswick, New York City, N. Y., asks if he should apply for a patent on a commutatorless direct current motor, a model of which he has built and which does give pure D.C.

A. The uni-polar direct current generator which you have designed is not new in principle nor in construction. The difficulty with devices of this nature lies in the fact that they cannot be built on a large scale to give current of any consequence. We, therefore, would advise against applying for a patent upon this suggestion.

Photographs Via Radio

(19) Henry A. Massello, Somerville, Mass., sends many drawings for a system for transmitting photographs *via* radio, and asks our advice upon the same.

A. Your suggestions for the transmission of photographs by radio are far inferior to other methods now employed. You mention that your system is self-synchronizing, and then you attempt to use an alternator in your circuit for accomplishing the synchronization. The difficulty with all circuits of this nature is that alternators at both ends of the line must produce the same frequency at identically the same time in order to give accurate results. Aside from that, your system has not been developed experimentally, and we are confident it would give extremely poor results if made just as described. We certainly would not advise that you apply for a patent upon this idea.

Investing

(20) F. R. Mealen, Newport, R. I., submits to us photographs, specifications and prospectus of an electrical time switch, in which he has been asked to invest. He would like to know our opinion of the marketability of such a switch before putting his money into the device. His other questions are made clear in our answer.

A. There is, of course, a market for electrical time switches, and quite a number of them are being used at the present time. Some are used in store windows, shops and factories to turn off the light at prearranged times; it may be shortly before midnight or about 1:30 in the morning. Such systems are also used on poultry farms in the winter time, chickens having been found to lay eggs in greater number when their daylight period has been lengthened.

In carefully looking over the specifications of the system you have outlined, we are of the opinion that the same possess no material advantages over other time switches, but are in fact considerably inferior to other systems we have seen. The time switch submitted by you necessitates the employment of two clock-mechanisms, each of which is set to go off at a different time, and in this manner the lights are turned on at one hour and off at another. The mechanism employs a regular snap switch arrangement, and of course this feature of it is inexpensive. The two clock mechanisms are expensive, and failure on the part of either one of them will make the device inoperative. The majority of time switches use but one clock mechanism, are much smaller than the system you have outlined, and seem to be more rugged in construction and perform the same work.

Grouping all the facts together, we consider investing in a proposition of this nature to be quite a risk. It may terminate successfully, dependent upon the managers, engineers and finances in back of the work. On the other hand, it may bring no financial return whatever. Of course, gambling with these systems is one means of securing money rapidly if they succeed, and invariably if successful they return a fair value on the investments. A time switch is not as stupendous a proposition as the telephone, the wireless, the telegraph, the Westinghouse air brake or any of those other standard stocks that are constantly being quoted by banking organizations. These appeal to the populace at large. The device itemized by you appeals to but a few storekeepers.

In considering an invention practicability is important but equally essential is the demand for the device.

The Ark of the Covenant

(*Continued from page 842*)

of water from the fall was coming down its passage at such force and volume that it was describing an arc above its normal ledge, shooting clean past the turbine barrier right to the center of the cavern lake.

The level of the water in the cavern was creeping up at an alarming speed, and already the machine shop was flooded, the oil-cave awash, and most of our working floors were under water. I mustered all hands, and we tumbled into launches and barges, or indeed into anything that would float.

Our first concern was to throw open the big gates of the cave entrances, lest they should impede the egress of the water, but this gave little relief.

To save our ships from being crushed against the roofs of their caves was our next thought. We found the first ship so deeply awash that she was straining at her mooring stays. We slackened these, so that she rose until her top was almost scraping the ceiling, but the water mounted so quickly that we found this expedient useless. I would have taken her clean out of the cavern, but the height of the entrance was perhaps the lowest point of all in the great chamber, and with the high level of the risen water that way of escape was barred. All we could do—and a despairing measure it seemed—was to unmoor her and maneuver her to that point in the cave system where the ceiling was highest. I shall not dwell on the strenuousness of our labors, but it may be imagined.

We brought the first ship, as I have said, to the point where the cave was highest, and here we moored her as best we could.

The danger for Number Two was now imminent. She was completed except for her engines, and as yet she was not buoyed with gas. When we went to look after her, we found her, as her sister had been, half immersed in water, with her stays holding her down. The stays were cleated under water and several of the men were about drowned in unhitching them. We succeeded in freeing her—only to be faced by another peril.

The roof of her cave came down in the middle to a sharp ridge, and if she rose higher the danger was that her back would be broken, or at least buckled beyond repair, for we had no rolling mills to straighten her girders. It was out of the question, again, to pull her out to a higher portion of the main cave, since the neck of her hangar was its lowest point. It was Lin Greensleeve who saved her.

Lin took a party of men with picks up to her observation top, and on her upper deck he set them to hewing down the saw-like ridge, which was nothing else than a series of stalactites of varying depths, depending from the line of some transverse crack in the ceiling. They hewed off as much as was humanly possible, and just when Lin, as a last desperate resource, was for putting in one or two of his favorite shots, the water suddenly stopped rising.

We stood by them and examined the state of affairs. We found that Number One still had a couple of meters to spare for clearance, and that the Two, though her fabric was sadly knocked about by the fall of rock from the ceiling, was structurally intact. But the rise of the water for another half a meter would buckle her past redemption.

Lin still was eager to try a small shot or two at the stubborn points of the ridge, but as the water seemed to have found its level, and had not risen for about forty minutes, the Chief and I decided to risk the chance.

We mustered our men and found all present. They were sadly drenched and disheveled, but cheery in spite of chattering teeth and tired limbs. The excellent Moggs had begun to cook early breakfast at the shout of "Spell-ho!" and by the time we trooped into the living-rooms he had gallons of hot coffee and mountains of appetizing food prepared. We were spared further anxiety, for the water remained at its last level for several hours, though the waterfall still roared and threw its column into the middle of the lake.

When the sun had been up several hours, the Chief and I took a launch and began to investigate the rise of the water and its ultimate holding of a maximum level. To take the sudden rise first, though it was the second point of our investigation, this was due to two things. The waterfall was supplied from that lake on the highest step above the plateau. Normally the lake was filled from underground springs, and at its usual level fed our waterfall through a submerged outlet. But with the sudden rise of the lake level, owing to the torrential rain and the cloudburst, its waters began to pour over its lip into a crack which led to a second passage running underground to join up with the normal conduit to the fall. Second, the lake waters found another outlet over the side of the hill and into a course, usually dry, which brought them into the cup of land north of the lower step of the plateau. This, with other streams pouring into the cup, brought the water speedily up to a high level, for the little canyon of our stream to the Innominata was not capable of letting the abnormal influx escape at any speed. Thus the waters of the cup and of our underground lake had only two means of egress: through

the gorge, and through the smaller entrance to our cavern.

When the waters reached a certain height, however, they found two extra outlets. One, we discovered, was in the cave itself—a minor cave on the west side which at its extreme end shelved down to a deep subterranean chasm. The second was a break in the lip of the north cup over which the waters poured into the marsh-land beyond.

We now had learned our lesson, and would know what to do in the event of another storm in the future. When the waters subsided, as they did in the course of the day, we put Number One back in her hangar and brought the Two into the middle of the main cave. Lin Greensleeve had put a few of his small shots into the ridge of the ceiling, and with long leads he exploded them, to his and our entire satisfaction.

One point remains. Our fowls and ducks, which had the highest cave in the lower series, escaped with nothing worse than a bad fright. We found them huddled at the extreme end of their habitation, and Moggs declared the muster complete with the exception of one duck, probably more adventurous than his fellows, who it was surmised had been swept away by the torrent out of the smaller entrance.

CHAPTER V
The Airship
I

We had repaired the damage caused by wind and water to the *Ark of the Covenant—I*, and that inflicted on Number Two by her sousing and the fall of rock upon her. Into Number One we

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The simplest radio outfit made—yet as practical as the most expensive. A crystal receiving set that you can operate and enjoy even though you know absolutely nothing about radio. You receive the RADIOGEM unassembled, together with a clearly written instruction book, which shows you how to quickly and easily construct the set, using only your hands and a scissors. The outfit comprises all the necessary wire, contact points, detector mineral, tube on which to wind the coil, etc., etc. The instruction book explains simply and completely the principles of radio and its graphic illustrations make the assembling of the RADIOGEM real fun.

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Complete aerial outfit for the RADIOGEM, consisting of 100 ft. of standard copper aerial wire and two special porcelain insulators. Price ....50c.

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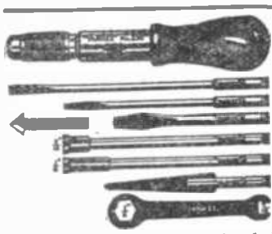
Radio Headquarters for the Finest and BEST Radio Tools



RADIO TOOLSET

This is the handiest set of tools ever made for Radio Work by the makers of the famous "YANKEE" Tools. It contains the following: 1 Rachet Screw-driver, 6½ in. long holding all attachments; 1 Blade, 5½ x 3-16, 1 Blade, 3½ x ⅛, 1 Blade 2½ x ¼; 1 Countersink; 2 Socket Wrenches for all small nuts; 1 Reamer to enlarge holes in panel from ⅛ x ½; 1 Wrench, one end 5-16" square or hex. for jack, other ½" hex., etc.

PRICE per set—No. 701 ....$3.00

HAND DRILL

The hardwood handle is hollow to store drills. Iron frame, nickeled parts, ball bearing three jawed chuck holding and centering accurately round shank drills from 0 to 3-16. Length of drill, 12 inches.

PRICE—No. 303 ....$2 25

WIREBENDING TOOL

For making eyes, loops, bends, and offsets on Bus Bar wire. With this device any Radio Constructor can wire his set to compare favorably with any factory made set. Easier to use and more accurate than pliers. Full directions in box. Made of heavy steel, blued and finished.

PRICE—No. 203 ....$1.00

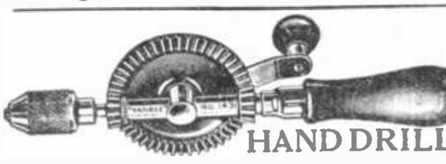
CIRCLE CUTTER

Especially designed for the Radio Constructor. Made of the finest material and equipped with the highest grade high steel cutting bits. It does three things at once. It drills its own pilot, cuts out plug and puts bead or scroll around the hole in one operation. Cuts holes ¾ to 4 in. in diam.

PRICE—No. 402 ....$3.00

401. Same tool but smaller and not fitted with bead or scroll in one operation.

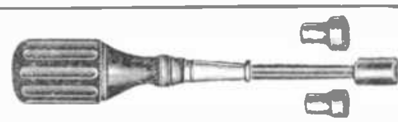
PRICE—No. 401 .. ..$2.00



HAND DRILL

Especially designed for Radio Work by the makers of the famous "Yankee" Tools. A beautiful balanced, small, powerful drill with 1 to 1 ratio of gears for speed. Special chuck 9-32" capacity, to take largest drill, mostly furnished with drill or tool sets. Length over all, 9½ in. Weight 1¼ lbs.

PRICE—No. 302 ... .$2.75

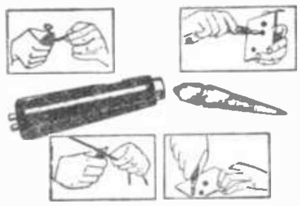


Three-in-One Nut Wrench. Consists of handle with hollow stem 6 inches in length and three interchangeable sockets fitting popular sizes of nuts. The hexagon sockets grip the nut solidly.

PRICE per set—No. 301...........................65c

Side Cutting Nipper, Lap Joint. For cutting all kinds of wire. Jaws hardened and oil tempered. Natural steel finish with polished jaws. Length 6 inches.

PRICE—No. 201 .. ..75c



RADIO HANDI-TOOL

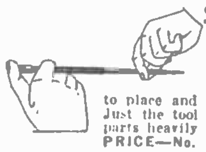
Bends Bus Bar or wire strips and scrapes wire, bores and reams holes, etc. Tool consists of 4 in. black japanned handle, to which is attached wire bending device, with nickeled ferrule and 3 in. long two sided reamer

PRICE—No. 702 ... .50c

TOOL CHEST

Set consists of "LOCK-GRIP" master handle, 5" long, black Rubberoid finish with steel chuck, nickel plated, buffed and with the following 9 tools: Saw, brad-awl, large screwdriver, file, scratch awl, gimlet, reamer, chisel, small screwdriver. Each tool of fine steel, drop forged, tempered, hardened, and nicely finished. Set comes in leatheroid box with tray.

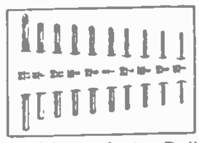
PRICE—No. 703 .. ..$1.85



SCREW STARTER and DRIVER

Holds any screw by its slot with a firm grip, makes it easy to place and start screws in difficult places. Just the tool for the Radio Constructor. All parts heavily nickeled and polished.

PRICE—No. 304 ....$1.00



RADIO DRILL SET

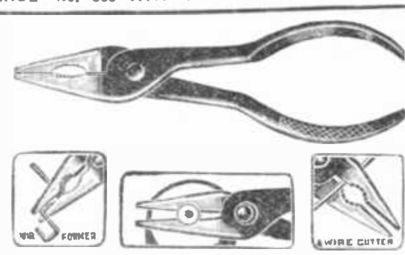
Composed of 10 straight shank twist drills, fitting all hand and breast drills. The selection of these drills has been especially made for Radio Constructors and consists of the following sizes: 1-16, 5-64, 3-32, 7-64, ⅛, 9-64, 5-32, 11-64, 3-16, 17-64. Drills are mounted on white Holland Linen with sizes clearly marked

PRICE—No. 305 ....$1.25

ELECTRIC SOLDERING IRON

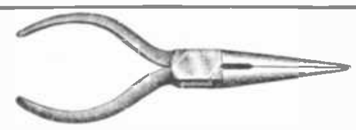
A perfect tool for Radio Work. Operates either on 110-volt A.C. or D.C. The heat element is of Nichrome, which prevents overheating and assures the desired even temperature. Size of Iron, 10½ in. long. A 1-ft. cord and plug is furnished.

PRICE—No. 800 ....$2.00



Combination Plier, Wire Cutter, Wire Former and Wrench. Drop forged, slender but exceptionally strong, 6 in. long.

PRICE—No. 202 ....75c



Long Sharp Nose, Side Cutting Pliers. Just the pliers for the radio constructor. Bends and cuts all kinds of soft wire. Nose 1½ inches long, black body, polished jaws. Length 5½ inches.

PRICE—No. 200 .. ..75c

Order all tools by order number. All goods are shipped free of transportation charges to all parts of the United States and possessions the same day as the order is received.

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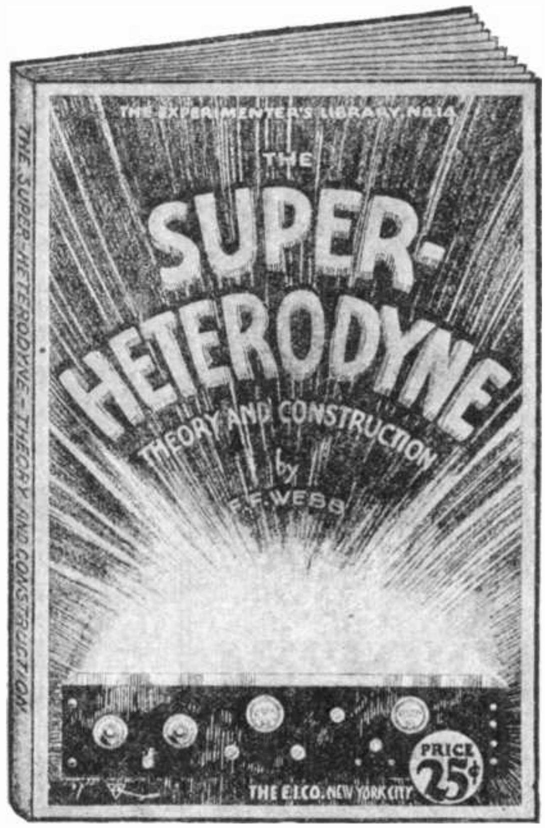

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had installed the last of the instruments invented by the Master for the demonstration of his discoveries. None but he and Thetford were permitted to touch certain of these instruments, for they embodied a devastating power. Two machines alone, so far, were to be handled by members of the crew—that controlling the anæsthetizing gas, and another designed to ward off aeroplane attacks.

The night before our first essay, the Master joined us in the common room and shared our meal. He spoke to us earnestly of the high emprise on which we were about to embark. Never have I seen our frail leader so impressive, nor ever did his tremendous personality so shine from him.

He spoke, as was his wont, in a clear, calm voice—unemotional, with no attempt at drama. He was always the reverse of dramatic, consciously, and by the very negation made himself the nub of drama the most poignant and telling. He simply asked the men to be faithful, to use the power he might have to put in their hands with care for human life, and never to let themselves stray for a single moment from the strictest sense of duty. Finally, he asked them to trust themselves and him.

"We'll trust you, Chief—all right," some of them said.

"I'm sure you will, gentlemen," said the Master. "You have shown me that I can trust you implicitly. You have done well and faithfully in the first phase of your work. No men could have done better. See to it that you finish your course with equal faith, equal good service. If we serve our cause and each other with whole-hearted zeal, we cannot fail."

Twenty-five men were aboard *Ark of the Covenant—I* when we set out in the middle day for the city of New York. We climbed high, out of sight, practically, and, with the heaters and compressed air at work, made our way in direct line for our destination. Our journey was uneventful, and only the steady creep of the map on the navigating globe marked our progress. With the dark we dropped to fifteen hundred meters and breathed fresh air. We were over New Jersey after midnight.

How They Got the Gasoline from the New Jersey Standard Oil Station and Their Excursions Over Wall Street

We lowered our gondola with its crew to a low height, and from there we dropped our gas-bombs on the petrol station. The airship then came down until she was almost nestling on the tops of the sheds. From the airship we let down tubing, and working in gas-masks we robbed the tank of its spirit. The whole operation took less than half an hour.

Thence we proceeded to the business quarter. We dropped bombs at the ends of a long thoroughfare, and one in the center. Again the ship was brought close to the earth, this time so that she lay along the street. The gondola rested on the car lines. To break into the food stores was an easy task, requiring no more than a stout jimmy, and our men began to hand out the stores as Devonridge and I selected them. This occupied an hour, and we came away after leaving money roughly calculated to pay for the goods.

It was now close on three. We mounted high and crossed the river until we lay over Wall Street. The gondola was lowered from a great height, and telephone communication from it gave us our direction. We strewed bombs all about the district—twelve altogether—so that the gas clouds wreathed the streets visibly to us, though invisible to anyone on the ground. We then came down, as indeed the Finn, Klenski saw, close to the roof of the National Metallurgical.

Two parties of seven men, each squad with a flame-cutter of the Chief's invention, attacked the banks. Each party also had a stout little trundle cart, rubber-tired, to collect the gold. One group tackled the National Metallurgical and the Guaranty, while the other attended to the Dyers' and the Trade. The first party had finished loading the gold from its two banks into the gondola, and had begun operations on the Subtreasury, before the other party had completed its work on the Dyers' and the Trade. When the second haul of gold and securities had been stowed, the parties combined forces on the Treasury. We appeared to waste no time, but owing, I suppose, to inexperience, an hour and twenty minutes had passed before our last haul was aboard the ship.

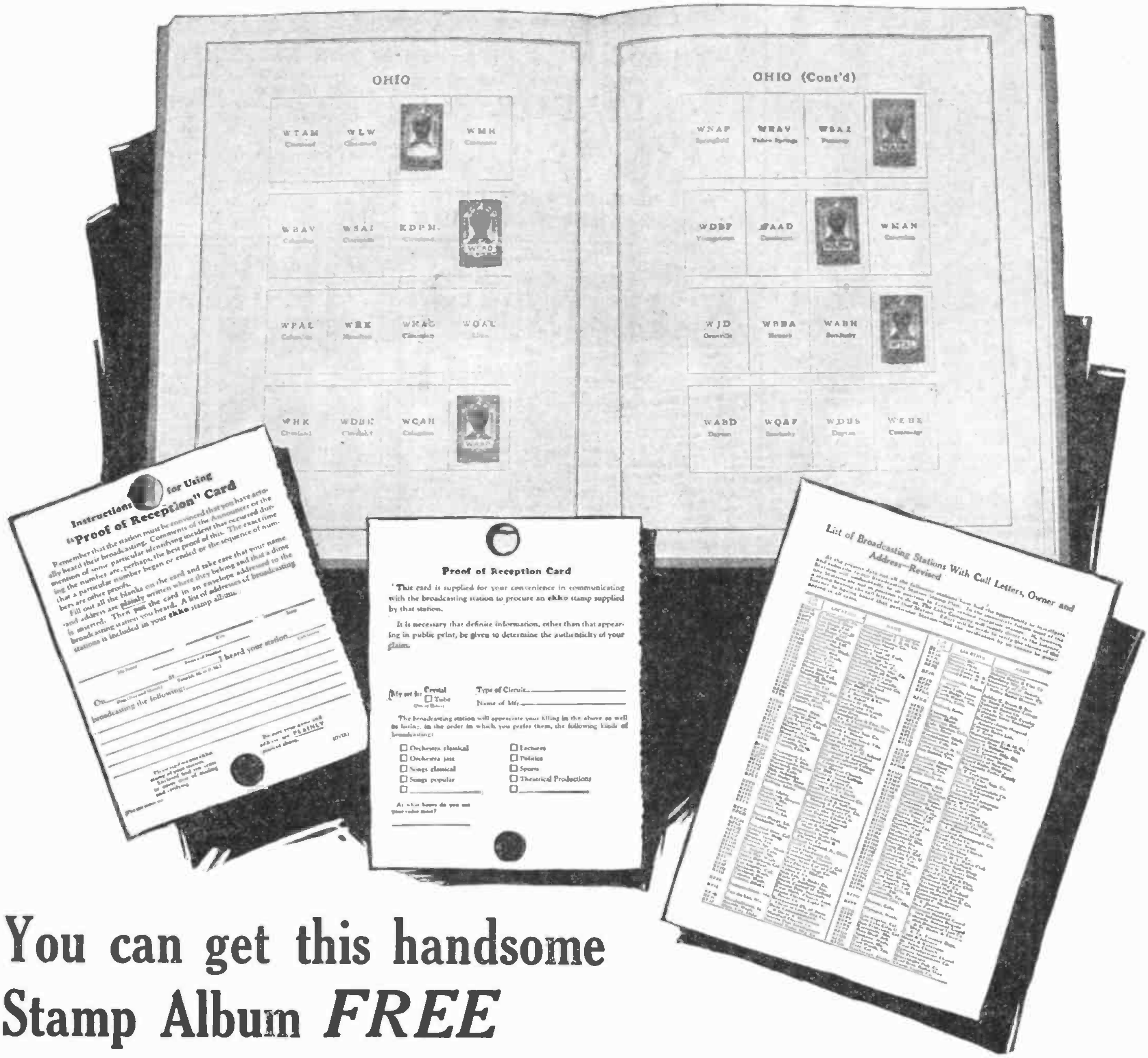
Meantime, according to prearranged plans, envelopes addressed in disguised hands were ready for the securities, and the little lead boxes of radium all prepared. It was my task to drop these into the box at the Post Office.

I walked out of the gassed area by back streets, and was fortunate enough to escape observation, for when I came round by the park above the Post Office, I saw a thickish crowd further down Broadway, apparently trying to find out what was happening at the lower end. Street cars stood one behind the other in a procession, for the Chief had thrown a ray over the area to upset all electric circuits to avoid accidents from the traffic. The vicinity of the Post Office, however, was bare of people, and I dropped my packages into the box unnoticed.

I returned by the same roundabout route, only stopping to put my gas-mask on when I knew I was approaching the danger area. The only person I saw previous to that was a policeman, who was innocently rapping and trying doors. My heart went a little faster as I passed him, but my garb was not unlike that of an officer of the

The New Radio Stamp Fad

Here is the DX Radio Stamp Album just like the ones we owned in our youth, in which were placed the rare stamps of the countries of the world. Some were hard to get some couldn't be purchased for love or money; but the fun of the hobby was the seeking of rare stamps and the eventual possession. So it will be with the DX Radio Stamp Album. There will probably be some stamps you will never be able to own but there will be many you will be proud to have and be able to show to other radio enthusiasts. It's an interesting game. Below the Album is shown the "Proof of Reception Cards" of which a generous supply is furnished with each Album. A dime placed in the hole in the card and sent to the station you heard brings back a stamp for your Album.



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American air police, and he saluted me, wishing me good-night. He could not have known that just round the corner of the street was a stopped motor-truck, over the dashboard of which two men sprawled unconscious.

Altogether, it was a scary business, and I determined in my own mind that on the next raid there would be no going out of the affected area. It was too risky, for I could not imagine what I should have done it the police had completely surrounded the district.

I entered the gondola and was pulled up with the rest of the gang—as I might dub our League—and within two hours of our arrival above Wall Street I was steering the ship high above New York as she made out to sea.

All next day we lay poised over the Atlantic at a great height, and we slept in watches. Towards night we began to cruise about, for we had picked up papers from the banks which gave us information of the *Parnassic*. We saw the oil-tanker, *Westbury*, early, and marked her course for further use.

We saw the *Parnassic* long before we attacked her. Indeed, we followed her easily for an hour before we shot ahead to lower the red riding lamp which stopped her. We had dropped our gas in readiness in her path, and when she hove to we maneuvered it about her. We then swooped down alongside and laid the gondola close by. Our piracy occupied forty minutes.

It was pitiful to see the ship so helpless, and the sight affected the mariners among us very strangely, but there was no ice in the sea near by, or the Chief certainly would have taken measures to restore some of the ship's company to consciousness before leaving.

We now sped after the *Westbury*. The only thing remarkable about this raid was the extraordinary truculence—by wireless phone—of her Yankee skipper. He seemed to bear little love for the navy of his country, and one would have thought that a warning to heave to was the biggest insult he had ever had in his life. But that rasping voice was soon stilled by our gas and we had little difficulty in helping ourselves to the skipper's excellent aviation spirit.

These raids accomplished, we circled wide out to the Atlantic, and were snugged down in the cavern by dusk.

The Result of the Raids in New York and London. The Work in the House of Commons

The news we had of the effect of our raids was meagre, for we picked up very little through our wireless, but that we had created a deep impression we felt sure.

A fortnight after the New York raid we descended on Louisville, and there, besides making off with gold and foodstuffs and petrol, we robbed the newspaper files in one of the banks, a point that has escaped notice. From these journals we gained an idea of the turmoil and consternation our raids had caused.

Among other things we noticed was the fact that the business chaos we intended to bring about by taking the securities had been lessened by their speedy return to the proper quarters, and since the idea was to disturb business as much as possible, as a preliminary to our further plans, we decided that there should be no such mistake made in future raids. It was only because this point had not yet occurred to us that we held to our first procedure in dealing with the Louisville bonds. We had not, of course, then read the newspapers.

The gold which we had collected up to this time, we melted and recast into ingots of our own design. The gold was of no value to us in view of certain powers within the hand of our leader.

Our next raids were to test the staying powers of the *Ark of the Covenant* to the full. We knew from chance messages picked up that the air police of America were active in their lookout, but of the disposition in England and Europe we knew nothing.

The long flight to London was made without mishap, and here, in the Bank of England and elsewhere, we created as much trouble for business quarters as we could. To drop bombs all about the Houses of Parliament and nestle on the terrace was the easiest thing we have ever done, for the district round about was little frequented at the moment. We did not even have to take any precautions against traffic running amok.

This raid was a demonstration of power, pure and simple, and our leaving of the radium beside the mace was definitely done so that it should be quite realized that it was we who had put the Commons to sleep.

My helper in this exploit was Lord Devonridge, and as he had been told of the idea beforehand he was prepared. It was he who blackened the faces of the members of the Front Bench—in revenge, he said, for the heavy taxation of his class which had driven him from the country, and as a reprisal for the docking of the privileges of the Lords.

When I turned to find him thus busy with his prepared cork, my first feeling was one of surprised annoyance, but there was something so ludicrously unexpected in the business-like sangfroid with which he set about the task that continued anger was impossible.

(To be continued)

Sound and Audio Frequency Amplification

(Continued from page 840)

the detector plate current flows, with a so-called by-pass condenser of about .002 mfd. which allows the high frequency current to pass almost unhindered. But, and this is generally disregarded, this by-pass condenser also allows a considerable part of the higher audio frequencies to pass around the primary of the transformer, and these frequencies would suffer in the amplifying process, if the step-up of the transformer after the detector were uniform over all frequencies, because at these frequencies less current is available, part of the high frequencies flowing over the condenser. The choice of the particular transformer in this place was then made, because as far as the author is aware, it is the only one available which gives a step-up curve that can compensate for this loss of high frequencies due to the effect of the by-pass condenser.

In Fig. 5 an endeavor is made to explain the reason for the excellent performance of this particular transformer, when used after the detector. Curve A gives the actual step-up curve of the transformer, and it shows that the step-up increases with frequency. Curve B pictures the effect of the by-pass condenser, which, as is seen, decreases the current available in the primary for amplification at high frequencies, while curve C shows how curves A and B more or less compensate each other, as this same curve C is an approximation to the amplification actually obtained by the use of this transformer used after the detecting tube.

(This is the second of three articles on sound and amplification of which the third one will appear in the next issue, dealing with resistance and choke coil amplifiers.—Ed.)

Remote Control

(Continued from page 816)

The resistance (R1) is one of the big secrets of this method of using remote control. It should have a value of about 15 to 25 ohms and its purpose is to allow enough current to pass through the circuit when (S) is closed and (K) is opened to operate the relay (R), but not to operate the sounder in instrument (X). Therefore, you cannot possibly apply the plate voltage to the tube until after the filament is lighted. This is a distinct advantage, particularly with high-powered tubes or rather tubes of over 5 watts capacity. Even with the latter, this precaution should always be observed, as it will materially lengthen the life of the tube.

The action of this system is as follows: When (S) is closed, the signal lamp (L) informs the operator that he can start working. At the same time current from battery (B) actuates relay (R) through the resistance (R1) and lights the filament of the tube. Now when key (K) is depressed, relay (R) still remains closed, but the magnets of the sounder in (X) are actuated and the key (K1) is closed. This of course completes the circuit through the primary of the plate transformer and actuates the entire transmitter. When the operator is through working, the signal lamp (L) serves to remind him that the current is still on inasmuch as it remains lit until switch (S) is opened.

If you observe the various precautions mentioned throughout the above paragraphs, you should have no trouble in making your remote control apparatus work efficiently.


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