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The EXPERIMENTER

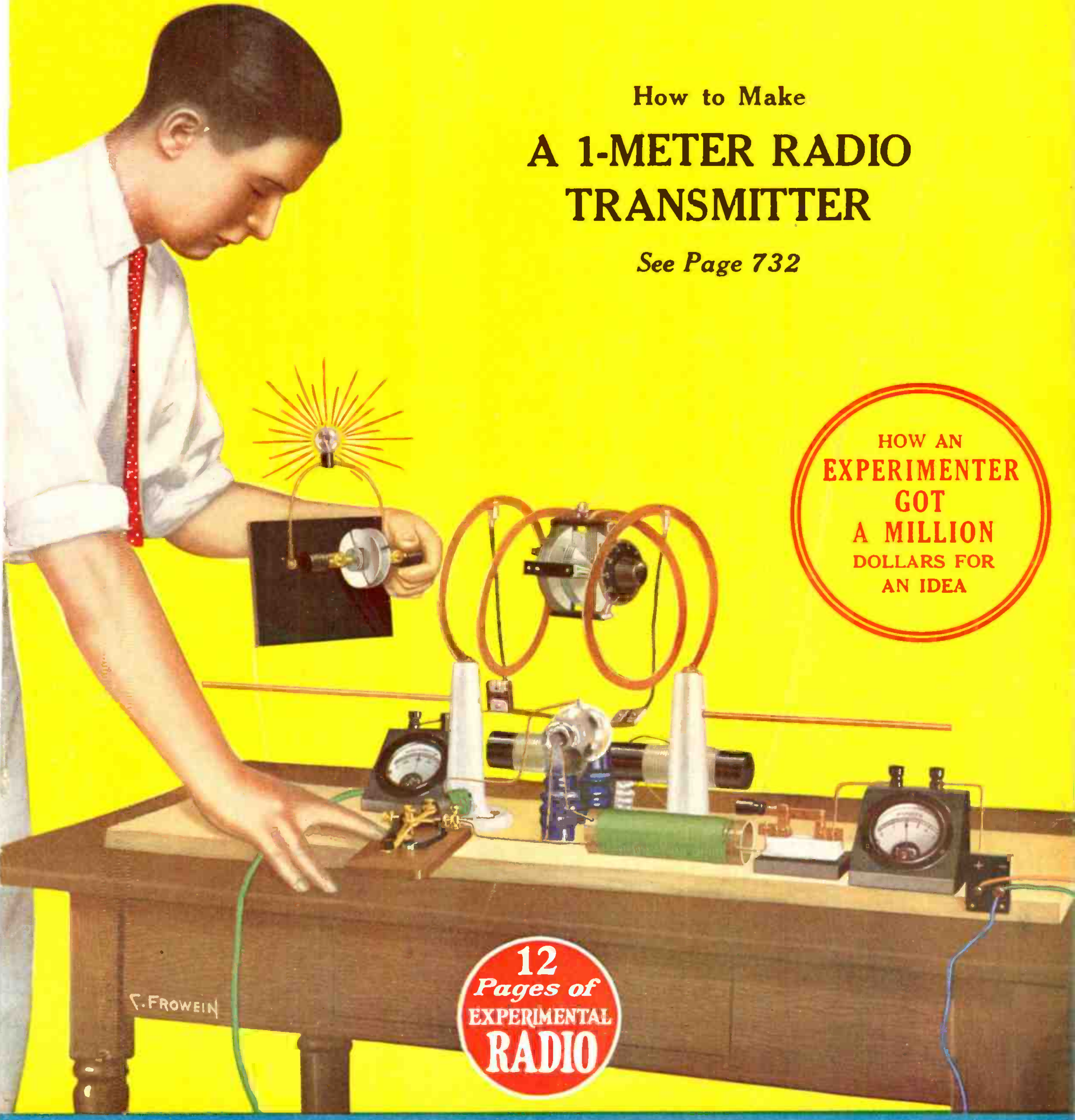
Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

How to Make

A 1-METER RADIO TRANSMITTER

See Page 732



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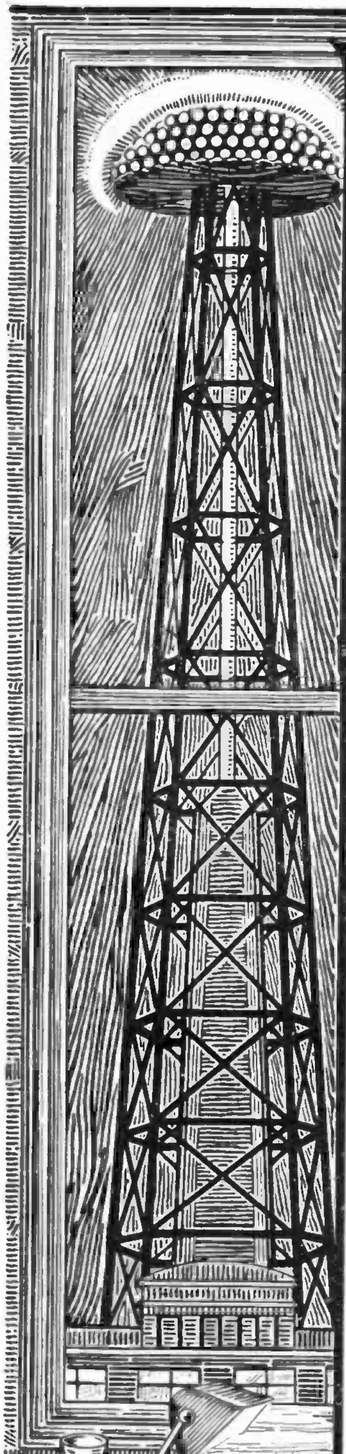

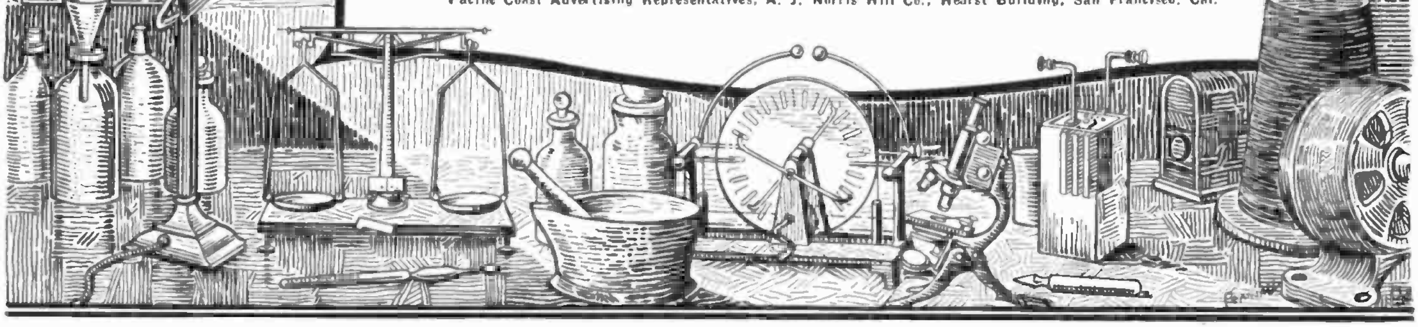

The EXPERIMENTER

Vol. 4 — No. 11

Contents

FOR SEPTEMBER

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9-25

Volume 4
No. 11

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

September
1925

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

A Million Dollars for An Idea

By Hugo Gernsback

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

ELSEWHERE in this issue we are publishing an intensely interesting document, that every experimenter should read and reread as often as he finds time to do so. It shows how it paid one young man to do a little original thinking, a little original experimenting, and how, finally, one of our great industrial corporations thought it wise to pay him a fortune for an idea so ridiculously simple that the event staggers the imagination.

As the writer has mentioned many, many times in his writings, it is not the invention involving a complicated and far-fetched idea that always counts. Rather, it is the simple thing which, if it is in demand and is good, usually wins out. This has shown itself to be true a great many times in the past. Notable examples of simplicity are the safety pin, the metal bottle-cap, the pencil eraser, the fountain pen, the magazine pencil, and dozens of others, all of which have made fortunes for their exploiters.

The Spencer Thermostatic control described elsewhere in this issue is no exception to the list. Spencer, when a youth, noticed a boiler door, part of which snapped in and out under the influence of the heat, acting like the bottom of an oil can, which snaps in under the influence of pressure applied and springs back when released. There was nothing new to the principle, as it had been observed hundreds and thousands of times. Millions of mechanics have operated oil cans with spring bottoms for many years, but not one of them stopped to think what it was all about. Spencer applied his analytical, as well as thinking, mind to the problem and found that here indeed was a device that would hold great promise if properly worked out.

He also knew that there was a big market for electrical contacting make-and-break devices, that under a certain variation in heat would become operative. While all of this sounds simple, it took the experimenter many months of patient labor to find out all about the snapping contact, and while the final product looks simple, nevertheless a good deal of experimental work had to be done in order to get the desired results. Here again the experimenter emerged triumphant, and we now have to thank Mr. Spencer for a really wonderful electrical device of great simplicity that becomes operative under practically any desired degree of heat change, by which the contact can be either made or broken as desired for different purposes.

All this sounds very crude and easy, yet evidently it is not so, because, if it were, the device would have been in use long ere this. It will be noticed that in this series of experiments there are a number of features which we should contemplate thoughtfully.

First, there was a principle, well known by everyone—namely, the snapping bottom of an oil can.

Second, there was the same principle, where the pressure of the hand or thumb was replaced by heat.

Third, there was the original idea of putting to use one or both of the two familiar principles, by applying them to electrical devices for heat regulation, for which there was a great need. Not everyone knew that under the action of heat any oil can bottom would snap into a different position. Some few probably had noticed this, but paid no attention to it. It will therefore be seen that there are three important points in the problem which had to be correlated before the experiment became a success.

The same thing is probably true of most inventions and most experiments that have proven successful. There are hundreds and thousands of simple and well-known phenomena all around us that every one of us notices day in and day out. How these phenomena or principles will act if heat, cold, light, sound, electrical current, or other agencies are brought to bear upon them may make all the difference in the world. This is also well known, but comparatively few people pay much attention to such things.

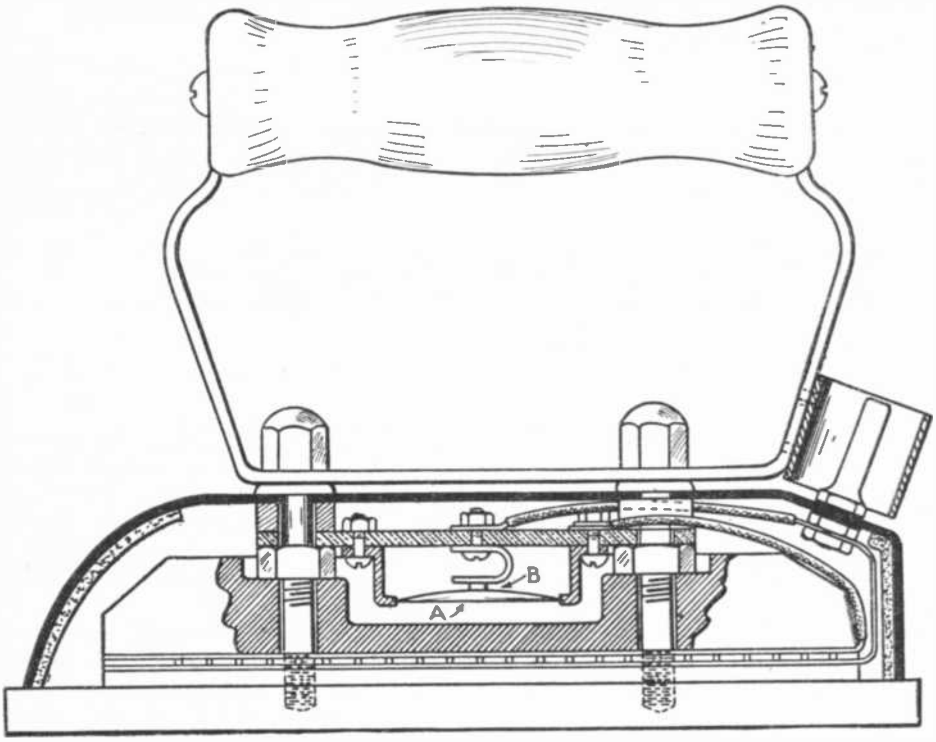
How many people ever take into consideration the expansion and contraction of practically every material we know under the influence of heat and cold? Everyone knows that, with few exceptions, all metals expand a good deal under the influence of heat, and contract under the influence of cold, but how many experimenters ever stop to think that this property can be used in dozens of different ways, some one of which may be worth a million dollars or more if there is a great use for it?

There is a surprisingly large number of appliances and instruments made in which the makers never have paid the slightest attention to the contraction and expansion of materials, although its influence upon the device may be tremendous. Take, for instance, the ordinary loud speaker, as used for radio purposes. The casing is usually of some metal, and the thin diaphragm, measuring from .007 to .01 inch think, is also metal. Now then, in loud speakers, as we all know, we find that a difference of .002 inch more or less between pole pieces and diaphragm makes a tremendous difference in the quality of operation of a loud speaker. Yet, temperature differences are enough to count more than this .002 of an inch, so that on a hot day the loud speaker will work entirely differently from what it does on a cold day. Some manufacturers have tried to get around this trouble by making the loud speaker adjustable, usually by moving the pole pieces up or down, so that the user can find the best point, but how many people have ever thought of having the compensation right in the diaphragm itself, so that no regulation would be necessary if the temperature changes? Here is an idea that might be worked out with good results by any first-class experimenter.

As Spencer found out in his thermostat, two different pieces of metal, when welded or attached together, will curve surprisingly under the influence of heat and cold, but how many people know that when the compound metal strip begins to curve a tremendous amount of force is also let loose? The inventive experimenter could find many ways of utilizing this force.

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

A Million-Dollar Invention



This electric flat-iron is provided with a Spencer disc thermostat for which the inventor received $1,000,000. The convex disc (A) is made of bi-metal, which disc under the influence of heat will assume a concave shape at a predetermined temperature. The change is very sudden and results in the breaking of the contact at (B). The rapid break eliminates all arcing.

The Phenomenon

A mill in the Maine forests was equipped with a "fire tube" boiler with a large smoke-stack. At the bottom of this stack was a right-angled elbow which had a large circular disc-shaped cover on hinges, for access for cleaning out the boiler, etc. At ordinary room temperatures, this disc was always convex or "bulging out" in shape. When the fire was burning brightly, however, it would suddenly snap, for some unexplained reason, to the concave or "bulging in" position, and would snap back again when the fire became low. This snapping operation gave warning that the fire needed attention and served as an alarm clock.

Of 10,000 people that might observe this event, about 1,000 will comment on it. Of this 1,000 about 100 will be curious enough to inquire into the cause of this action. Of this 100 about ten will, by correct analysis, discover the principle of the action. And of this ten about one will apply that principle to new uses. This one is the inventor.

All inventions of this sort, that is to say, such as are suggested by some observed phenomenon must pass through these four stages: 1. observation of the event; 2. analysis of causes; 3. disassociation of the basic principle from the circumstances of the particular phenomenon under observation; 4. the synthesis, that is, the application of the basic principle to new uses. It is true that the inventor is seldom aware of these four steps in invention, but he succeeds because his mind has been disciplined to apply this four-fold process unconsciously. The reader will find it an interesting discipline to analyze by this method the inventive process through which the invention discussed in this article or other interesting inventions have passed.

That the application of this method is not merely a stimulating mental exercise but also a profitable occupation is demonstrated by the case of Mr. John A. Spencer, who, while still a young man, finds himself today a millionaire by virtue of a very simple, very elementary, but, nevertheless, very useful invention.

The Story of the Invention

Something happened in this wood-working mill in the backwoods of Maine. John, 15 years old, worked there and saw millions of clothespins turned out. Clothespins are not in themselves recognized as stimulants of the imagination, but young Spencer's imagination was so active that it needed no stimulus. It absorbed everything of interest, and in after years John A. Spencer became a wealthy over night, because of this active imagination.

He was one of the few who absorbed into his mind and memory the snapping action of the man-hole cover. The fact that the noise gave warning of the state of the fire was also observed by him. The action was an absolute temperature alarm, or a fire control. The motion of the disc took no part in operating the chimney damper, so it was not a thermostat. It took an inventor to develop a thermostat from it, to recognize in it a way to overcome the difficulties incident to the construction of an electric make-and-break regulator of heat and current, and to dispose of the troubles, especially of the arcing, by going back to the observations of his boyhood days.

Years afterward Mr. Spencer was working on thermostats. His memory being as acute as his observation he recalled the phenomenon of the old boiler cover and started, on that basis, a line of experimental work which ultimately led to the disc type thermostat. The utter simplicity of this highly efficient thermostat the reader will note in the illustrations. The very high value attached to this device is evidenced by the fact that the Westinghouse Electric and Manufacturing Company promptly offered $1,000,000 for Mr. Spencer's invention.

It was in 1923 that his patent was issued covering a quick-make and quick-break thermostat in which the temperature-control element was itself the moving part without the use of levers, springs, or other subsidiary parts. This patent covers, among other controls, a disc type thermostat which does away with the necessity of complications so common to ordinary thermostats, and permits the thermostat itself to break without the use of a relay, power units as high as 3,500 watts, either on alternating or direct current.

The Analysis

To cause a movement of the disc which we described above, a force is obviously necessary. What was the nature of the force and where was it applied?

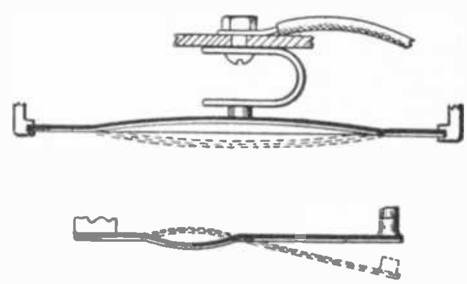
What were the outstanding external circumstances which accompanied or immediately preceded the motion of the disc? The rise in temperature of the boiler strikes us at first thought as the most important event preceding the action of the disc. We know that heat is capable of setting up stresses in solids. These stresses are in the nature of ordinary mechanical forces and would account for the phenomenon under analysis if we understood exactly the direction and point of application of the forces.

Under the action of heat stresses, the metal disc tends to expand. Let us suppose that its expansion toward its edges is prevented and that further bulging outward is also impossible. The effect of increased temperature will then be to develop the stresses in the disc until these internal forces are great enough to strain the disc into a concave position. This action will be very sudden and its rapidity accounts for the snap, with which the disc changes from a convex into concave state. We might, therefore, conclude with reasonable certainty that the stresses induced in the disc by rise in temperature are the cause of its peculiar behavior.

The analysis then suggests the possibility of actuating metallic discs in this fashion by means of changes in temperature

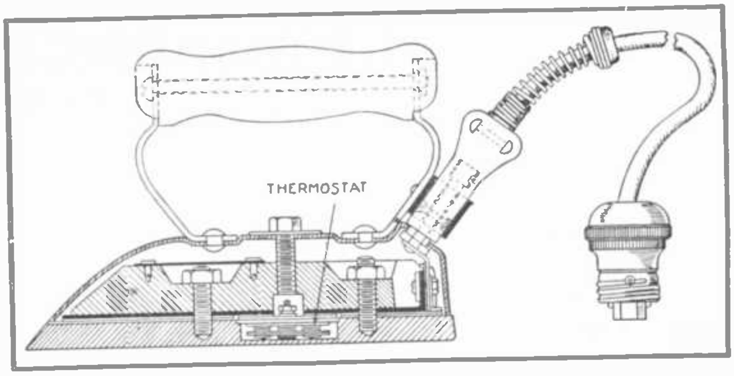
The Principle

Suppose, instead of a convex disc of a single metal, we employ two convex discs of



The upper figure shows the Spencer disc thermostat as it is applied to an electric flat-iron. The disc thermostat itself forms part of the electric circuit. The dotted lines indicate the high temperature position when the electrical contact is broken. The lower figure shows another form of the same device.

metals having different co-efficients of expansion brazed or welded together as shown in the illustration (Fig. 1). Then it will not be necessary to provide means for the prevention of expanding movement of the disc toward its periphery. For, suppose that at normal temperature, the two metals are so arranged that the inner one has the larger co-efficient of expansion. This means that for a given rise in temperature the inner disc will expand more than the outer. Now, obviously, the curvature of the outer disc being greater, it spreads over a larger area than the inner disc. Of course, this difference is extremely small, but sufficient to cause the action we desire.



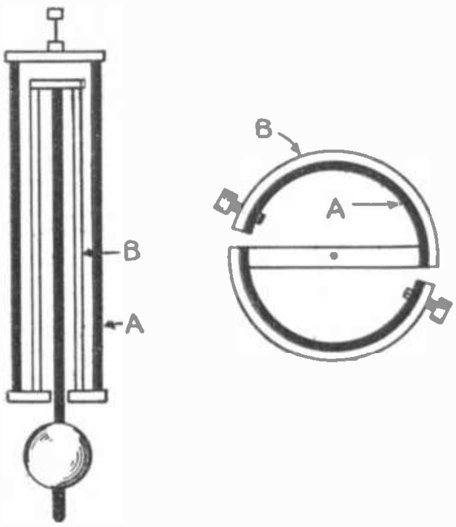
Another form of the Spencer disc thermostat embodied in an electric flat-iron. In this instance, three contacts are provided to render the breaking of heavy currents possible.

As the temperature rises, and the inner disc expands more rapidly than the outer, the former will tend to take an outer position in order to allow for its increased size. When this tendency becomes strong enough, the compound disc will snap over into a new position, as shown in the illustration.

Now, as the temperature falls again, the contraction of the metals is again unequal. The now outer metal contracts more rapidly than the inner and will tend to occupy a position in which it has a smaller surface. In other words, it will tend to resume its former (inner) position. The result is that when the normal temperature is reached the disc will suddenly snap back into its normal position.

The principle of compound metals used for controls of various sorts under the influence of changes in temperature is not at all new. It is, for instance, used to maintain a constant length of clock pendulums. The pendulum rod is made of two different metals, as illustrated below, with the result that the unequal expansions acting in opposite directions maintain the pendulum at a constant length.

The similarity between the present inven-



Some applications of bi-metals. The figure at the left indicates a compensated clock pendulum in which the metal (B) expands approximately twice as much as (A) and so maintains the pendulum length constant. The figure at the right shows a compensated chronometer balance wheel. Under the influence of an increase in temperature the loaded ends of the discontinuous wheel curve inwards and so counter-balance the expansion of the hair spring and the spokes.

tion and the compensating balance wheels of chronometers is even more striking. The rim of the balance wheel is made of two metals, say brass and steel, of unequal expansion, that with the less expansion being inside and the wheel is discontinuous, as shown in the figure. The outer rim expands more than the inner and the two loaded ends therefore curl inward with a rise of temperature. The loads are so adjusted that the mass is thrown inward by a sufficient amount to compensate for the weakening of the hair spring and the expansion of the spokes.

These are but a few of numerous examples which could be cited to show that the principle on which the Spencer disc thermostat is based was well known long before Mr. Spencer's time.

Mechanically, the principle on which this style thermostat works is similar to that of the bottom of an oil can. In an oil can the bottom is mechanically pushed from a convex to a concave position. When the push or strain is released the bottom snaps to the original or convex position. In each operation there is a quick "snap," due to the internal strains in the metal.

We have now derived from the behavior of the boiler cover a general principle for the operation of convex discs. We have found that if the bottom of an oil can, say, is made of bi-metal upon the application of heat the bi-metal would tend to alter its "bulge" or convexity until it came to the critical or "snap through" position, when it would suddenly snap to the concave position. Then, when it cooled off, it would snap back to its normal or convex position.

The Synthesis

Having abstracted the general principle underlying the behavior of a metallic manhole cover, which gave rise to this line of investigation, we proceed to the next step in the inventive process, that is, the invention proper—the synthesis of the general principle with new functions. In this, Mr. Spencer's ingenuity is notably displayed. He chose for the field of application of this principle one which long stood in need of just the device which Mr. Spencer originated. He selected, to begin with, the thermostatic control of electrical circuits. Being of reasonably heavy construction, the bi-metallic disc may form a part of the electrical circuit which it controls.

We illustrate here the application of the Spencer disc thermostat to an electric flat iron. The bi-metallic convex disc (A) controls the contact (B), the disc itself carrying the current. When the temperature within the iron reaches a predetermined value, the disc (A) snaps over and opens the contact (B). The speed with which the thermostat operates is so great that it is practically impossible to measure it. It is estimated that the time of the actual operation of the thermostat is approximately .00016 second. The speed at which the contacts move approximates that of a bullet issuing from the muzzle of a high-powered rifle.

With such speeds there can be no doubt about the positive action of the contact. Under normal temperature, the bi-metal disc exerts a pressure of approximately 50 pounds.

To illustrate the force which this disc can develop, a disc three inches in diameter was heated, reversed in shape, and inverted over a tack just started in a board. The disc, when cooled to its operating temperature, would drive the tack flush with the board with its positive snap.

It should be noted that this speed of action is an essential feature of the Spencer thermostat. Thermostatic cut-outs have been known before, but they were of a simple bar construction, whose action being very slow caused considerable damaging arcing at the break of a contact. This is obviously eliminated in the Spencer disc thermostat.

Such is the story and analysis of one of the most remarkable inventions of recent years. Remarkable not merely because the device is one of extensive usefulness, but because it illustrates that careful observation, that keen analysis, and that ready seizure of opportunity that characterizes the inventive mind. It is precisely these elements which THE EXPERIMENTER, through its editorials and other articles, tries to impress on its readers.

Other applications which undoubtedly will appear within a very short time are waffle irons, percolators, heaters, etc., in the domestic field, and glue pots, solder pots, water heaters, ovens, motor and generator protection, etc., in the industrial field.

A Historic Cell

THE cell here illustrated was built by the writer for the old D. S. Greeley Company, Dey Street, a well-known supply house at the time (January or February, 1893), and submitted for test against probably two hundred other batteries, to be used in the initial circuit for starting the World's Fair.

President Cleveland pressed the key and (as the D. S. Greeley Co. advertised extensively at the time) the Excita Dry battery did the rest.

While nothing definite is known of the construction of this cell, it is safe to assume that it is made along lines similar to that of present day cells. The cell here shown has been retained intact since that memorable Fair.

Through the courtesy of Mr. Louis Auerbacher, who was the store manager at the time mentioned, in 1893, this cell was loaned to the writer a few days ago who thought THE EXPERIMENTER readers might be interested in it.

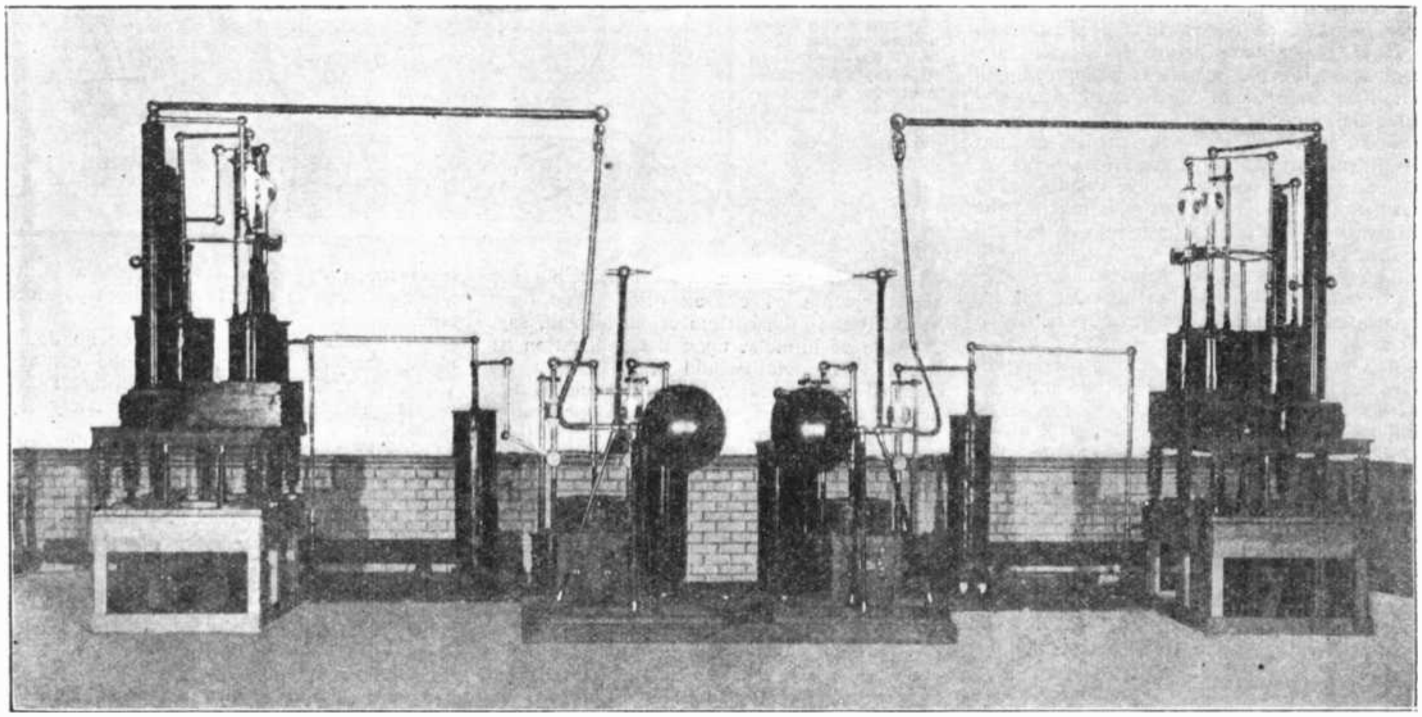
That this was one of the two original cells used in the circuit referred to can be proved through the oral testimony of a half dozen people that known to be living, including the contributor.

Contributed by B. Roche.

This old dry cell was used in the electrical circuit which gave the signal for the starting of the World's Fair in 1893.

The Bombardment of Atoms

By Jacques Boyer



An apparatus recently exhibited in Paris before the Academy of Sciences, capable of giving a discharge four feet in length by direct current. An alternating current is rectified and a potential of 600,000 volts is attained. It is hoped to go far higher than this and to disrupt atoms by the discharge.

USING a powerful X-ray cannon working at 600,000 volts, Prof. Jean Perrin of the Sorbonne hopes to discharge "projectiles" capable of demolishing the atomic nucleus.

Like the ancient alchemists, the physicists of today are actively working on the discovery of the law of the transmutation of matter, but instead of employing the empirical methods and the cabalistic formulas of their predecessors, they call upon national processes for exploring hitherto unknown atomic regions. They are approaching closer and closer to the besieging of the citadel which constitutes the atom. They are trying to get to the heart of this inviolate fortress, to reduce the central nucleus, bombarding it with rapid cathodic "projectiles" or electrons. These indefatigable pioneers hope sooner or later to succeed in disintegrating the atom. In any event, if they do not succeed in resolving the problem in the course of the methodical siege which they are carrying on, they will undoubtedly make unanticipated discoveries.

Up to the present time, however, the range of their electric "cannons" is limited by the defects of insulation, which prevent them from utilizing high potentials.

These classes of generators frequently used today in radiotherapy for the treatment of cancer, for example, are based on the following phenomenon discovered by Edison. As the great American electrician has shown, if a filament brought to incandescence is contained in a vacuum tube, and if there is an insulated metallic electrode there also (the plate), the electric current will circulate between this electrode and the filament, when the latter is at negative potential referred to the plate electrode. The transfer of electricity is done by the action of calorific ions, called thermions, emitted by the incandescent filament.

Among other radiologic or wireless apparatus based on this action, the kenotron is the best known. It consists essentially of a glass vacuum tube supplied with two diametrically opposite connections. Each of these contains two electrodes, one a filament of tungsten raised to incandescence by an auxiliary electric current; the other consisting of a concentric cylinder of molybdenum. If an alternating current is connected to the kenotron, one-half of the cycle will pass from the plate to the filament, the other half being rigorously cut off. Such a rectifier will furnish a direct current in small installments. In connecting in series, on a high tension alternating current circuit, a kenotron and a condenser, a current always in one direction will result.

Availing himself of these facts, and bringing very well developed improvements into models of rectifiers based on the preceding principles, some French constructors, Gaiffe-Gallot and Pilon, have augmented the range of their "atom-bombarding cannons." Prof. d'Arsonval, at one of the recent meetings of the Academy of Sciences at Paris, exhibited their new constant current generator which can produce a potential of 600,000 volts. Using this potential in the laboratory, for whose uses this "heavy artillery" was constructed, Prof. Perrin hopes to discharge cathode projectiles, able to demolish the first outworks of the entrenched camp where the atoms are in hiding.

The increase of potential is easily obtained by connecting to the terminals of a 300,000-volt generator two groups of 150,000 volts, all insulated from the earth by a platform carried on insulators.

So far the builders utilized only the potentials between two spheres of 50 centimeters (20 inches) diameter, which are seen in the photograph in the middle of their impressive installation, and are capable of discharging a spark 1.20 meters (about 4 feet) long. With this formidable apparatus, Prof. Perrin is going to undertake a series of researches on the positive nucleus of atoms. Starting with an element it will be enough to introduce a supplementary positive discharge, to give an elementary substance of higher rank in the scale of atomic values established by Moseley. Also this new X-ray cannon has not only a scientific interest of the first order, but it effects an advance of considerable practical importance. We may say that it permits us to foresee in a future time, more or less distant, the discovery of the philosopher's stone. If success is reached in augmenting the range of the marvelous engine, up to 10,000,000 volts, and if the energy, which is set free at the moment of the cessation of the positive charge on the nucleus, could be stored, we could supply factories and combine or decompose bodies almost without limit. Machinery would be driven at low expense. Our present crude methods would become an archaic myth, and the creation of gold would sooner or later become child's play. The noble metal would no longer govern the world.

Prof. Perrin, who is experimenting with cathode projectiles, to demolish the atom, somewhat in the line of Prof. Miethe's work. He hopes to exceed the above potential eventually.

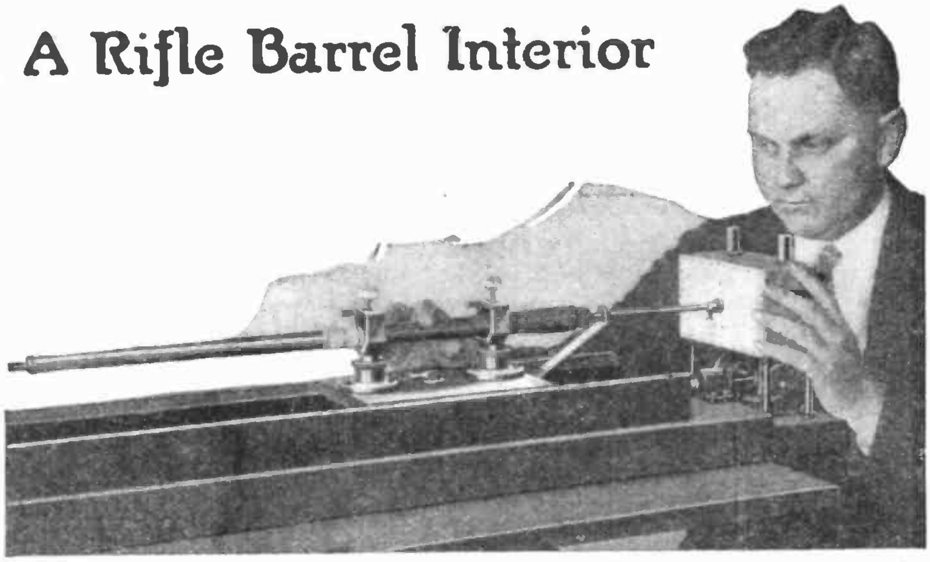
Photographing A Rifle Barrel Interior

IN order to study the progress of the erosion in the .30 caliber service rifle and machine gun barrels, a camera has been designed for photographing the interior surface of the barrel. The apparatus consists essentially of a periscope of unit magnification of such dimensions as to permit entry into the bore of the rifle.

A small electric lamp, also placed in the bore of the gun, provides the illumination. The periscope projects an image of a small portion of the bore on a strip of motion picture film. The barrel to be photographed is slowly drawn along the periscope and simultaneously the film is moved at such a rate that there is no relative motion between images projected by periscope and film.

If the barrel is drawn its entire length along the periscope, one obtains a picture on the film showing a strip of the interior of the bore of the same length as the barrel and including approximately one-sixth of the circumference. Six such pictures provide a photographic record of the entire surface of the bore upon which the detailed defects arising from the erosion can be clearly seen.

The instrument is also excellently adapted for a visual examination of the interior of the barrel. A microscope magnifying 20 or 30 diameters can be used to view the image in the focal plane and the different characteristics of the surface of the bore stand out clearly in good contrast. This camera is intended to be used to study the manner in which different steels resist erosion.



A very interesting apparatus which photographs the interior of a rifle barrel. By the use of a reeled tape film and shifting the gun barrel the entire length is photographed with a width of one-sixth of the circumference of the barrel. Six exposures cover the entire inner surface.

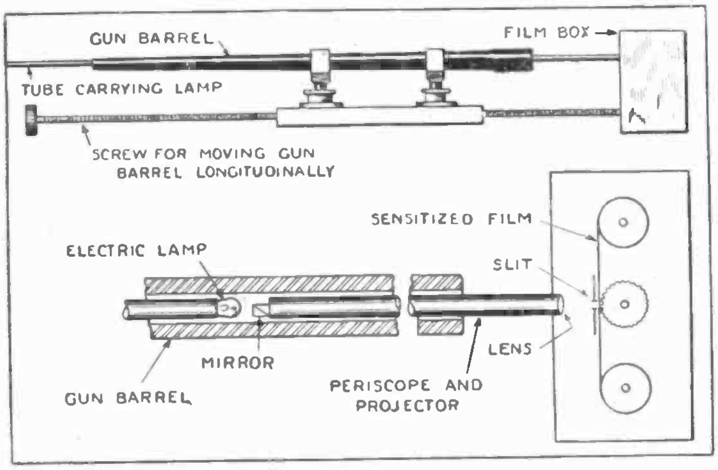


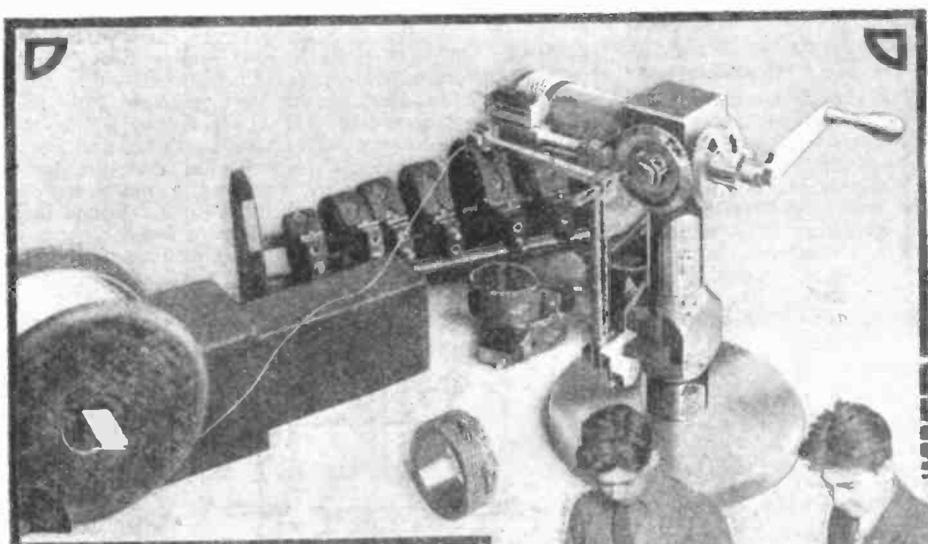
Diagram showing how the apparatus works; the barrel is moved in accordance with the speed of travel of the sensitized film. The electric lamp and periscope mirror are especially to be noted.

A Novel and Practical Coil Winder

HAVING need for a coil winder which would materially aid students in winding coils, a practical machine was evolved by Mr. George Heald, an instructor in machine shop practice at Seneca Vocational School, Buffalo, N. Y. Honeycomb coils can be wound in exceptionally quick time, in sizes ranging from a mere 15-turn coil to the large 1,500-turn coil.

Mounted on a heavy brass pedestal are two right-angle bevel gears in mesh, one of them being equipped with a small handle. An eccentric arm is driven backwards and forwards by means of a cam attached to the other gear. Fastened to the shaft which turns with the handle is a small drum upon which the bakelite coil form is placed when ready for a winding operation. A small roller held against the coil form by a spring action keeps the wire taut.

If it is desired to change the width of the coil to be wound, all that is necessary is a smaller or larger cam, which can be placed on by the mere tightening of a set screw. As can be seen in the accompanying photograph, a turn of the handle carries the wire through the zig-zag formation in which the coil is wound. Notice that the wire, as it passes from its spool, goes through what is known as a tension adjuster, which simply consists of four spools through which the wire is interwoven and then passes on through the winding machines. This arrangement keeps uniform tension on the wire and eliminates in large measure the chance of breaking it.

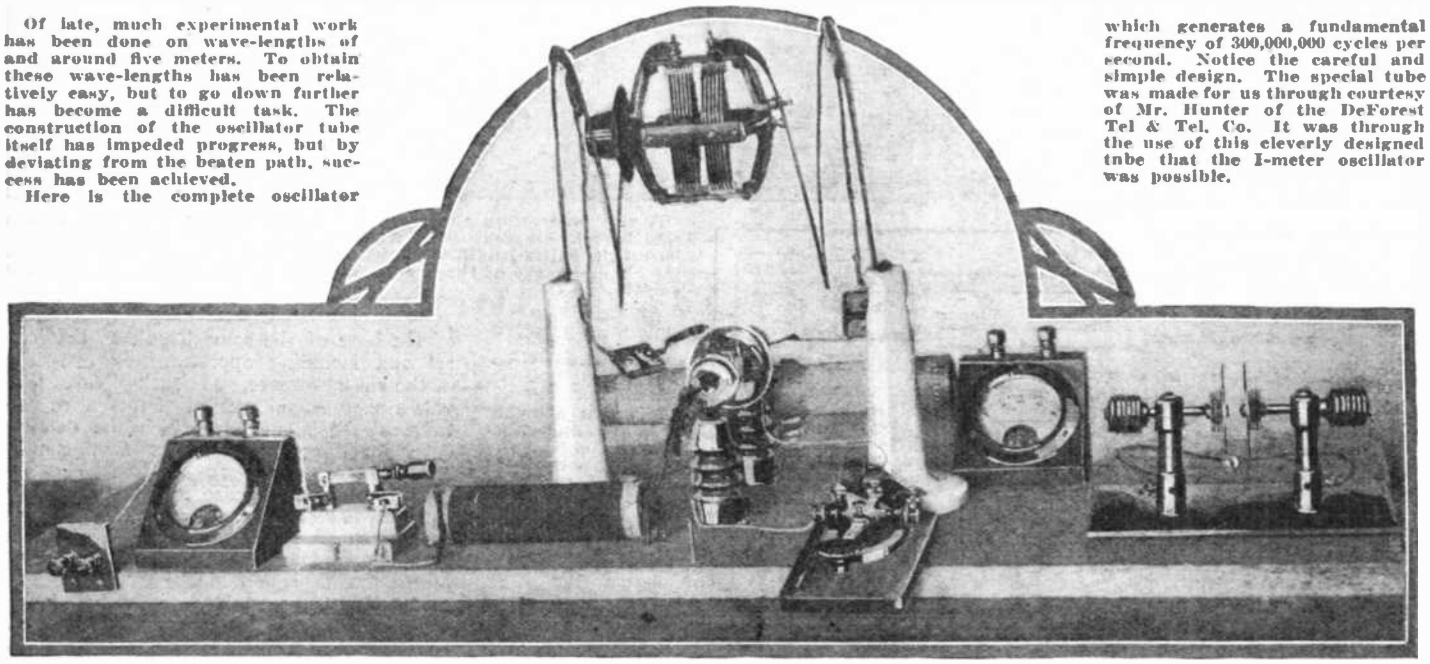



Students work in a Buffalo school. The young experimenters are winding honeycomb coils. The apparatus is very simple and gives excellent results.

EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

How to Make a 1-Meter Radio Transmitter



Of late, much experimental work has been done on wave-lengths of and around five meters. To obtain these wave-lengths has been relatively easy, but to go down further has become a difficult task. The construction of the oscillator tube itself has impeded progress, but by deviating from the beaten path, success has been achieved.

Here is the complete oscillator which generates a fundamental frequency of 300,000,000 cycles per second. Notice the careful and simple design. The special tube was made for us through courtesy of Mr. Hunter of the DeForest Tel & Tel. Co. It was through the use of this cleverly designed tube that the 1-meter oscillator was possible.

THE construction of a short-wave oscillator presents numerous minor difficulties which usually are overcome through originality on the part of the builder. Whether the oscillator is designed for 40 meters, 20, 10, or even 5 meters, some special circuit will give best results. No two hook-ups have the same characteristics and the radio frequency output of each varies with a given power input. For as low as 40 meters, the Colpitts oscillator will give excellent performance. Below 40 meters, the new Reinartz circuit has been shown to produce remarkable results.

To the one who has built a successful 5-meter oscillator or transmitter and who found it a relatively easy task, the 1-meter oscillator described in this article will offer opportunity for further adventure in exploring new territory.

As far as is known, the lowest wave-length as yet reached by means of a 3-element tube has been approximately ¼ of a meter. This was done by using a type UV-199 tube, and measuring its highest harmonic frequency when operating at 2 meters. In the case of which we speak, it was possible to record with certainty the fourth harmonic. Such a frequency as this, 1,200,000,000 cycles per second presents numerous difficulties in its generation.

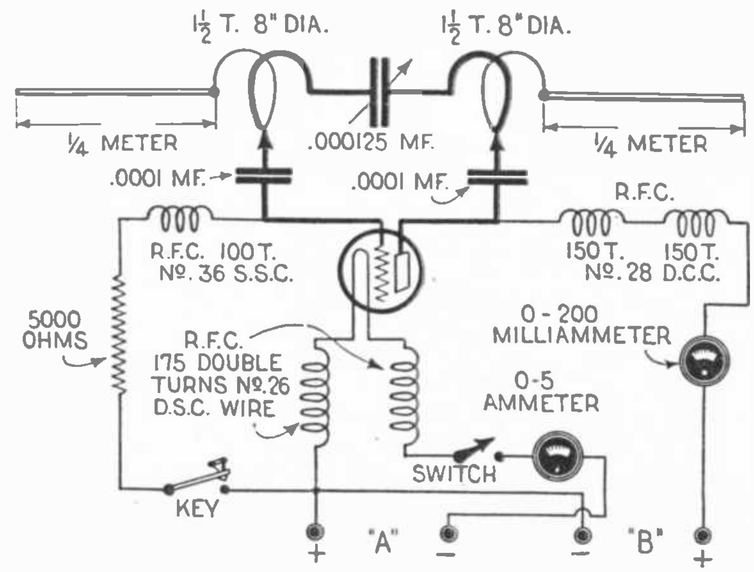
In the experiment we are about to describe it was decided not to depend upon the chance of picking up harmonic frequencies, but to build an oscillator which would have a fundamental period as low as possible. Thus, it would be possible to obtain and measure even higher frequencies and more closely approach the frequency of light. (The gap between the frequency of the shortest radio wave and that of light is 10,000 times the frequency of the former.) It was, therefore, decided to cast about for the best available materials to go into the Reinartz circuit. Great care was exercised in the selection of the accessories and a multiplicity of insulators, condensers and different kinds of wire were tried and tested before being allowed to remain as part and parcel of the oscillator. Although the greatest care was exercised, it must be admitted that it is a very difficult task to prevent the radio frequency energy from being dissipated to a large extent due to absorption losses.

Considerations

The very first concern was the tube itself. What was wanted was one having a very low inter-electrode capacity, the characteristics of a powerful oscillator, and the ability to withstand high voltages. A high powered tube was not essential, since it was desired for laboratory experimental work only and not for communication purposes. Unable to find one which would serve the purpose, a special tube was constructed having the following characteristics:

Filament voltage	8 volts
Filament current	2 amps
Plate voltage	1000 volts
Plate current	100 mils
Grid-plate capacity	3 mmfd.
Power output (approx.).	10 watts

The inductance was then considered. Would it be best to employ two or three turns of copper ribbon, wound in a small diameter, or to wind a single turn in a larger diameter? Rather than follow precedent by taking others' advice, a series of experiments soon proved that the larger diameter wire produced a much stronger field and gave better results. Round brass and copper tubing, square bus-bar, stranded phosphor-bronze and aluminum wire were tried in succession, but the best results were obtained by utilizing edge-wise wound copper strip from a discarded oscillation trans-



The circuit diagram of the ultra-short wave oscillator. It will be recognized as the latest development of John L. Reinartz with a few slight modifications. The oscillatory circuit itself is outlined heavily. The use of the antenna and counterpoise is optional.

former. One and a half turns for the grid inductance and the same for plate inductance will allow a variation in range from one to fifteen meters when used with a condenser having a capacity of .000125 mfd.

The coupling condenser, which is interposed between grid and plate inductances, has much to do with the energy output and frequency of the oscillator. Dozens of condensers were tried—high capacity, low capacity, "mud end plate," low loss, square law, straight-line frequency and straight-line wave-length, grounded rotor, isolated frame and, in fact, every conceivable size, shape and manner of condenser available. The facilities of Radio News laboratory offered a remarkable storehouse of apparatus, instruments and materials, and sufficient inspiration was instilled so that the *simple* procedure of testing an endless number of condensers and taking measurements was made possible.

Insulation—the best was none too good. In order to keep the oscillatory circuit away from all objects, even the wooden baseboard, glazed porcelain insulators of the stand-off type were used. The oscillator tube itself was suspended high on top of two of these and in order to prevent vibration with consequent effects on the frequency of the oscillator, cotton padding was inserted between the tube and the insulators. A couple of rubber bands passed around both furnished a firm mounting.

Materials

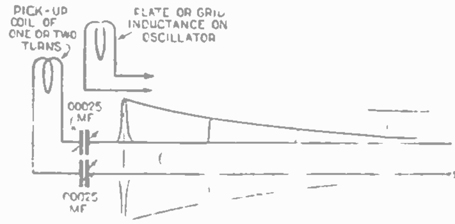
It will be necessary to procure the materials as outlined in the following list:

3 turns of 8-inch diameter edgewise-wound copper strip.
1 .000125 mfd. Bruno condenser.
2 .0001 mfd. Dubilier fixed condensers.
1 0 to 200 milliameter.
1 5,000 ohm Crescent grid leak.
1 0 to 5 ammeter.
1 single-pole, single-throw knife switch.
1 standard telegraph key.
2 glazed porcelain aerial insulators.
2 glazed porcelain stand-off insulators.
1 baseboard.

The special tube and the motor generator which delivered the thousand volts to the plate circuit may be available to some experimenters. Others not having these materials should have recourse to the use of the type UV-199 tube with its base removed and should use upward of 300 volts of "B" battery potential.

The radio frequency chokes can be made by the experimenter. The correct values for the various chokes are given herewith. The radio frequency choke coil which is used in the plate circuit consists of 150 turns of No. 28 D.C.C, together with a similar number of turns spaced three inches further away on the tube having a diameter of 1¼ inches. It is supported by a pin which keeps it at least two inches above the surface of the baseboard, and is mounted out of the field of the oscillatory circuit. The grid choke is much smaller and is of as much importance, if not more, than the plate choke. It is made by winding, evenly, 100 turns of No. 36 S.S.C. wire on a short length of glass tubing ¾ of an inch in diameter. It is connected in series with the grid leak. The radio frequency chokes for the filament of the tube are made into a single unit by winding 175 double turns of No. 26 D.S.C. wire on a cardboard tubing 1¼ inches in diameter.

As regards the grid condenser and plate stopping condenser, the lower their value the better. In this case, two .0001 mfd. mica condensers were used. Although it was necessary to test several of them before being put to use, the high voltage is likely to break down their insulation and great care must be taken to use good condensers.



The Lecher wire system of measuring wave-length.

Nothing more need be said concerning the wiring of the oscillator except that it is a prime requisite to keep the leads as short as is possible and as is consistent with a neat layout. No wire smaller than No. 22 should be used for making connections, although copper ribbon is to be preferred.

Operation

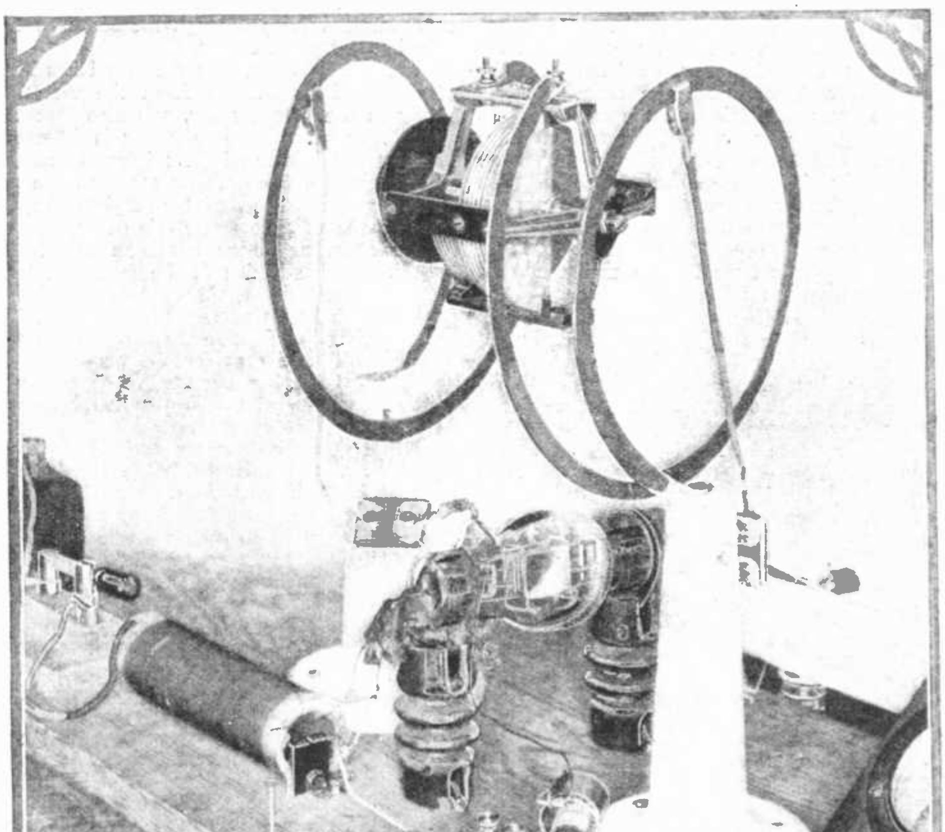
Having carefully collected, assembled and wired up all the necessary parts, the filament of the tube is lit and the filament ammeter noted to see whether the tube is drawing the normal amount of current. The motor-generator is then started up and the 1,000 volts of the plate circuit are applied to the tube. If the telegraph key is then pressed, a reading of from 75 to 150 mils should be the value recorded by the plate milliammeter.

The simplest way to test for oscillations is to note carefully the reading of the plate milliammeter when the tuning condenser capacity is a maximum and when it is a minimum. More than likely, it is possible that, without further adjustment, the tube will oscillate over only a part of the condenser capacity and will thus read higher when not oscillating. If the meter drops to a lower scale reading while tuning the condenser, one can be reasonably sure that the tube is oscillating.

A more positive way is to construct a simple resonator or wave-meter. In this case, it will be necessary to procure a small flashlight lamp and a low value variable condenser. As seen in the photo, an old zinc spark-gap fitted with aluminum plates was used and afforded an excellent vernier condenser. A single turn inductance at the center of which is soldered a flashlight lamp constitutes the wave-meter. Of course, by bringing the wave-meter in proximity to the oscillator inductance, it is possible to pick up the radiated energy. Not only the fundamental, but even one or two harmonic frequencies can be picked up in this manner. Instead of using a small flashlight lamp, a current-squared meter having a range of 0 to 100 will give much better results and will allow picking up as many as 8 or 10 harmonics.

It is interesting to note that although the successive harmonics are appreciably weaker, the odd numbered ones are stronger than the preceding even ones. Just why this should be has never been explained satisfactorily. The use of a straight-line frequency condenser will greatly aid in taking note of the harmonics, since a slight capacity change means a great frequency variation. Although it is a simple matter to pick up the fundamental and its harmonics, we do not have the

(*Continued on page* 748)



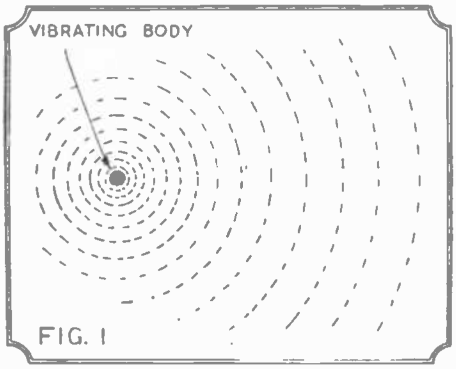
Close-up view of the oscillator. The tube is supported by glazed porcelain insulators and vibration is prevented by carefully packing cotton around it. Note the grid leak and grid radio frequency choke coil behind the telegraph key. The inductance is varied by means of clips.

Sound and Audio Frequency Amplification

By Theodore H. Nakken*

MORE and more, as the the quality of broadcasting programs improves, the critical radio listener judges the performance of radio receivers on quality of reproduction. We may safely predict that this attitude will become more and more pronounced.

While it remains true as ever that the reception of distance always gives a thrill of accomplishment, the demand for quality grows more and more insistent. Distance reception alone cannot satisfy the buying public.



A vibrating body creates a series of condensations and rarefactions in the air around it.

It is for this reason that quality in production is made the subject of intensive study, both by progressive manufacturers and serious radio experimenters. On all sides we see evidence of this tendency. This study centers specifically on amplifying apparatus and the reproducer itself, the loud speaker.

It is intended in this series of articles to deal with sound in general, and the means available to attain quality sound production. An endeavor will be made to keep the articles as simple as possible, still trying to analyze the reasons underlying this work. At the same time, we will give constructional data on different amplifiers that will give the best quality attainable at the present time.

* * *

To approach the subject at a proper angle, we will first of all consider sound itself, which then will enable us to establish the demands which have to be satisfied by an amplifier, in order to give perfect reproduction.

We are all familiar with the fact that most bodies will vibrate when they are agitated in some way or other, *i.e.* if they are struck. There are a few materials that will not do so, an example being sponge rubber, which is nearly deadbeat, as it is called, and substances like putty.

But the majority of bodies and substances will vibrate when agitated; in some cases, we do so on purpose as when we play musical instruments, talk, sing or whistle; but most of us would be only too grateful if no vibrations were caused by street cars, elevated cars, riveting machinery, etc.

Now what happens when we have caused a body to vibrate?

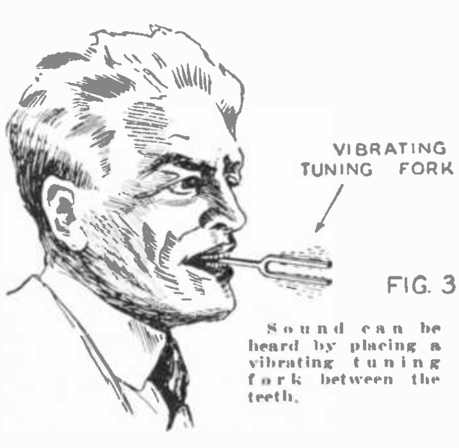
We know the body is completely surrounded by air, the same air we breathe, which we feel in the form of wind. This air is a mixture of gases, and gases have one most remarkable property: perfect elasticity. By this is meant that a gas always is able to regain its original volume, no matter how it is treated, whether it is compressed or expanded. Completely elastic air, then, surrounds the vibrating body: and thus every vibration of the latter is imparted to the air particles directly adjacent to it.

But as these particles are perfectly elastic, they transmit the vibration imparted to them by the vibrating body at once, and without any change whatsoever, to their next door neighbors, other air particles. And these in turn repeat the same process, and in this way the original vibrations are, so to say, instantaneously transmitted into ever widening layers of air, ever expanding and probably never ending. But as the transmission takes place in all directions, the consecutive layers of air grow larger and larger, so that the intensity of the vibrations of the individual air particles decreases till we cannot detect them any more.

Let us now assume that the vibrating body is a piano string. When we strike the key, we impart a smart blow to the corresponding string, and it starts to vibrate. We may now say that it gives a series of successive impulses to the surrounding air particles, which in turn transmit these impulses to adjoining layers, etc. Every vibration of the string is accompanied by a certain loss of energy, so that after a time, the string comes again to rest.

When we are at a small distance from the string, the vibrations created in the surrounding air will have progressed, after a definite interval of time, to the place where we are standing. At that moment, the air particles adjoining our eardrum will be agitated and reproduce the successive impulses from the string on the eardrum. In this way, the eardrum itself will start to vibrate and transmit its vibrations over an extremely delicate mechanism, which need not be discussed here, to our aural nerves. These nerves will thus feel vibrations, and we describe this sensation by the word "hearing." The sound we hear is then the same as the vibrations felt.

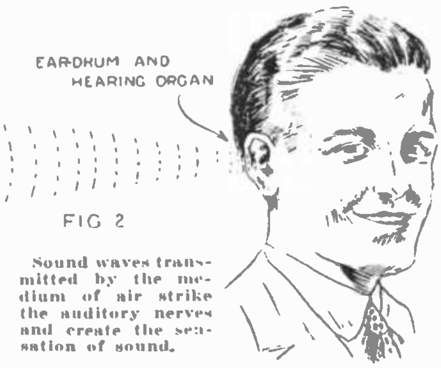
That this is true, we can easily prove to ourselves by the following experiment: If we take a tuning fork and after striking it place the handle against our front teeth we hear the sound very strongly. Another very easy way of observing this is to take a spoon or fork, which is tied to a string. We now take this string between the front teeth and let the string and spoon hang freely. When we now rap the spoon with a stick, we will hear a sound like the striking of a large clock.



Sound can be heard by placing a vibrating tuning fork between the teeth.

The explanation is in both cases that the vibrations are concentrated upon the teeth and by them transferred to the bony structure of the skull. This transmits them in concentrated form to the aural nerve centers, and because the vibrations are localized, the sound sensation is very strong. Yet one cannot very well say that this is hearing in the true sense of the word.

It is interesting to know that this principle has been put to practical use for those people, whose aural nerves are not damaged, but who have some defect in the ear mechanism. Often such deaf people can hear, or rather feel sound perfectly, by taking a kind of small sounding board with a handle, and placing this handle against or between their front teeth. By so doing they expose a comparatively large surface to the vibrations of the air, and transmit these vibrations in concentrated form through the bones of the skull to the nerve center.



Sound waves transmitted by the medium of air strike the auditory nerves and create the sensation of sound.

We can thus say, that the sound has been transmitted by the air from the vibrating body to the listeners ear, and also that the sound, or vibration in the ear is in every respect a duplicate of the original vibration. In serving as transmitting medium, the air has not changed any of the original properties of the vibrations: outside of serving as the carrier, its action has been completely neutral, which is due to the fact that it is a perfect elastic medium. We also know that the source is some vibrating body, imparting its vibrations to the surrounding air.

We will now consider the properties of vibrating bodies, and therefore of sound, a little closer, so as to form a better mental picture of what happens.

Different bodies possess entirely different properties, and this difference is also apparent in their vibrations. One body will vibrate at a very low frequency rate, it will be ponderous, so to speak, while the other one will vibrate at a very high rate. But all of them will show one common property: They very rarely will vibrate at only one single rate. Careful and painstaking experiments by one of the world's greatest scientists, Clerk Maxwell, have proved conclusively that almost any body will vibrate at different frequencies, as the number of vibrations per second is called. The lowest of these frequencies is called its natural or fundamental frequency, and it is this vibration which determines the so-called pitch of the sound observed when feeling or hearing the vibrations from that body. This pitch, or height, determines the place of the sound in the musical scale. In addition to this fundamental frequency the body vibrates at several more frequencies which are all multiples of the fundamental. So when we make a tuning fork, which vibrates at a fundamental frequency of 1,000 vibrations a second, it will also vibrate at frequencies of 2,000, 3,000, 4,000, 5,000, 6,000, etc. Hence the air will transmit from such a tuning fork not only the fundamental frequency, but all the other ones, which are called harmonics or overtones. It will faithfully preserve all

(Continued on page 774-B)

*Research Engineer, Radiall Co.

Conducting an Amateur Station

By L. W. Hatry, 1 OX

PART I

FOR years the amateur has offered the public a free message service to all parts of this country. Of late, it has been extended to foreign countries and will eventually cover the globe. It has been well used, and undoubtedly is growing. This amateur service is not in competition with the commercial services; the amateur, in the main, gets the type of message that otherwise would have been trusted to the mails. The amateur service is becoming recognized as a staple, a part of our daily life.

This message service provides a definitely genuine purpose for the owner of a radio station if he is sincere in his hobby. It is performing a service to humanity in leading to inter-citizen communication the world over.

A RELAY STATION

A relay station, as the name suggests, is one that will accept messages to forward them on their way to, or to their destination. If the relay station is located in the place marked as destination, its owner will deliver the message to the addressee.

A *good* relay station consists of two things: the works and the man behind them, the operator.

The man should make it a point to be versed in operating procedure, prompt, friendly and dependable; qualities not difficult to attain. If he is up on procedure, time and effort are conserved and he will be respected as a capable operator, which is the best and most favorable ad. that he can get—it will create dependable friends on the air. If he is prompt in message relaying or delivery, he gains friends both in other radiomen and in the laymen, for whom and to whom the messages are delivered. By being friendly, he makes certain that there will always be a welcoming fist when he gets on the air. And, by being dependable he makes certain of *the* thing, his place on the air. He knows then that no matter what comes to bat he will be very likely called upon to be one of the batters—they know he'll do his bit.

The works are less important. Put a good man in any kind of radio-shack and he will get something out of it. Nevertheless, it is desirable to have the station in facile operating condition, if only for the convenience and comfort of its owner. It needs, too, every facility that the owner can achieve for active operation. It should always be ready at the throwing of a switch, and can generally be kept that way or put that way after changes. This applies to the times it is to be depended upon, to the schedules.

If at all possible, the station should have regular working periods. Let us say, as an example, two days a week with specified time periods during which there is certainty that the station will be on the air. As much other work as the operator could get in could be done, of course; but he ought to have schedules with certainty. The station should stick to one wave in a particular wave-band. It should not change, there is no need. This wave will become its landmark and something for those stations which are operated by air-acquaintances to look for, easy to find and rely upon. But—let me say again with additional emphasis—above all comes the requirement of a receiver and transmitter always in operating condition at times designated on the operating schedule.

OPERATING PROCEDURE

Operating procedure is the methods used in calling and handling of traffic. To be versed in the proper thing to do and the "how" to do it, is the hall-mark of a good operator.

CALLING

The best place for observing good calling procedure is the commercial wave-lengths on about 600 meters. Although we amateurs are playing a different game, we certainly can learn from the men who pride themselves on being operators above all, if only for business reasons. It will be noticed that they confine themselves often to a three-one system: e.g., *KTI KTI KTI de KUX ar.* (*ar.* by the way, means that a particular transmission is ended, or can be used to terminate a message, thought, etc.) This is in calling, and is generally answered by a one-one acknowledgment ending with a laconic *k:* e.g., *KUX de KTI k.* We cannot get away with such a minimum of key exercise in our sharply tuned sphere, but the bushel basket of calls that most of the fellows unload in trying to raise someone is needless.

A sensible and approved procedure is to use a double three-three system: e.g., *5KK 5KK 5KK u 2KK 2KK 2KK 5KK 5KK 5KK u 2KK 2KK 2KK ar.* This is followed by a short period of listening-in. As it would take less than thirty seconds for a reply to this call to be made, that length of time is long enough to wait before repeating the call. This repetition of calling is done as often as the need of communication with a particular station demands—or, until someone other than the one called answers.

A second procedure, from a practical viewpoint, is good. It consists of a six-three used *once*. This allows a long call with a short sign. It should be used in a manner similar to the foregoing. Either way eliminates the giving of a long and QRMing call. And, after several years of operation, anyone will feel certain that the long calls indulged in regularly are not only not necessary, but are both tiring and bothersome to others. Besides, such action makes the performer an object of ridicule and one to avoid.

The calling of *CQ* should be confined to a similar system. The generally approved *CQ* call is a triple three-three: e.g., *CQ CQ CQ u 2KK 2KK 2KK CQ CQ CQ u 2KK 2KK 2KK CQ CQ CQ u 2KK 2KK 2KK ar.* Because, in general, the thing to be put across is what is being called, it is much preferred to sign one's own call only twice. After a person's attention is attracted, his every fibre is focused on learning who the caller is; thus there is no need for a long sign.

ANSWERING A CALL

In acknowledging a call, if the station calling has or has not stated whether it has messages (traffic, abbr. tfc.), the answer should consist of a double three-three. If previous communication justifies a certainty of the reception of the answer with dependable QRK, it can be limited to much less, say, simply a three-two. This answer should include complete information. The information consists of indication of willingness to relay, readiness for copying the message if there is such and a mention of the signal strength of the station that called; e.g., *2KK 2KK 2KK u 5KK 5KK 5KK 2KK 2KK 2KK u 5KK 5KK 5KK QSA QSR QRV k.* Or, as a matter of courtesy—and a good precedent, well established—one might start the remarks with a salutation of some sort, such as *ge om*—good evening old man, or *hello om.* More than this should be avoided, for the man who called might have been in a hurry and, as a mere matter of consideration for the other one, his time should not be wasted. If, on the contrary, the calling station is weak, possibly too weak to make copying easy, warn him. If impossible to copy with any certainty, by all means refuse an attempt at a message unless urgency demands trial. Possibly, however, the signal strength justifies a trial and the transmission of each word twice might prove successful. Mention these things; e.g., *QRZ om tri QSR QRV QSZ k.* (your signals are weak, old man, let's try, will forward message, am ready, send each word twice, go ahead).

TAKING CARE OF THE ANSWER

While calling a station, it is easy to incorporate in the call the signal signifying that one has a message, or messages, going his way. This can be indicated by the use of one of two abbreviations; *QTC*, the international abbreviation meaning "I have something for you," or *msg* (plural, msgs) which is in general use to mean "I have a message for you," incorporated in the call—*5KK 5KK 5KK u 2KK 2KK 2KK QTC ar.* or *5KK 5KK 5KK u 2KK 2KK 2KK msg ar.* The commercial operators use one of these two, or else another that is just as prevalent, perhaps more so. They use a single number to indicate both that they have messages and the quantity of them; e.g., *KSK de KPI 2.* *KSK* knows from that, that *KPI* has two messages for him. The system is certainly short and snappy in a profession where brevity and snap are required.

After the station called has answered with the "go ahead," there are certain courtesies that ought to be observed in addition to the business of sending messages. These, too, take up but little time. He should be given an idea as to the strength of his signals and the character of his note. This action may be considered as self-defense, for it will be asked for anyhow, as well as courtesy. Consider the audibility scale given below which is in more or less general use:

R1—Weak signals barely readable.
R2—Weak signals easily readable.
R3—Signals readable and fair strength.
R4—Good, clear, but easily interfered with.
R5—Fairly strong signals.
R6—Strong signals, not bothered by average QRN.
R7—Very strong and dependable strength.
R8—Extra strong signals, audible several feet from phones.
R9—Tremendous signal strength.

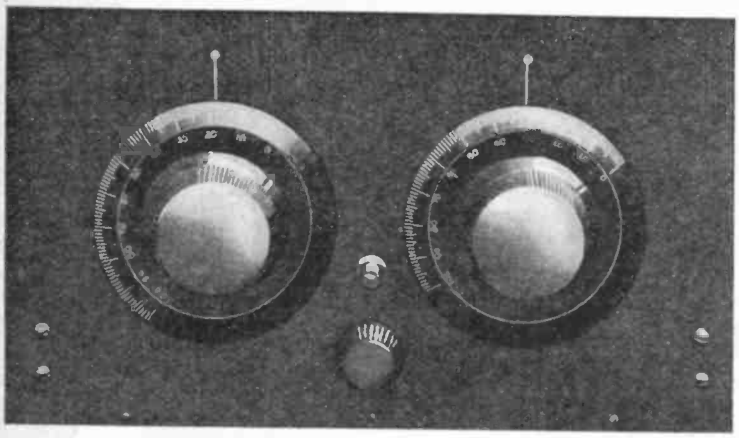
If he is being received well, using the international abbreviation for that, add the "*r*" signal that denotes how well; e.g., *QRK r5.*

In referring to the tone of the received signal, the international abbreviation QSB is in use. Its correct meaning is, "How is my tone?" Used this way, it is followed by an abbreviation indicating the character of the note; viz.:

(Continued on page 774-B)

An All-Wave Short-Wave Receiver

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



Left: A panel view of the short-wave receiver showing the extreme simplicity of the layout. The dial markers were scratched into the panel and filled with white lead.

SO MUCH interest has been shown in the writer's series of articles which appeared under the title of "Getting On the Air" that it has been decided to continue to present information and details on short-wave work from time to time, as important phases of the subject arise or may be requested by readers. Recently, several requests have been received by those interested in amateur reception asking for full information on the construction of a receiver that will be more general in use than the one published in the April issue of THE EXPERIMENTER. The writer, using accumulated data, has constructed a receiver that he is sure will fulfill all the requirements for a set capable of tuning in all of the short waves used by amateurs and which, furthermore, can, with a few changes, be adapted to broadcast reception as well.

The set that has been designed and constructed and that is illustrated in the photographs herewith is one employing a rather unusual circuit. At first glance it appears to be a combination of several types, and that is just exactly what it is. A feed-back arrangement is used for regeneration and oscillation, but the control of this part of the circuit is not the usual movable tickler coil. The coil is, of course, present in the set, but is fixed in its relation to the secondary. The regeneration, or oscillation, is controlled by means of a variable by-pass condenser and the results are astonishing. Instead of the usual home-made, rickety, flimsy, movable tickler coil with its troublesome pigtails and unstable operation, all we have to do to control the set is to rotate a smooth-running and easily operated variable condenser. In this way, many of the defects of the standard three-circuit coupler are overcome. When the writer finished the set illustrated, a great surprise was in store. When everything had been correctly adjusted, it was found that the oscillation control was the smoothest of any set that he had ever operated. By rotating the variable feed-back condenser, the circuit could be brought up to the oscillation point and would go into oscillation with a smoothness that was astonishing. Only a soft hiss was heard in the phones when the circuit started to oscillate and after a C.W. signal was tuned in with the tuning condenser it could be brought up to its maximum volume, with relative ease. All of this action, of course, depends upon the correct adjustment of one or two of the parts. In the first place, a variable grid leak must be used in order to get the very best of results. Of course, if you have two or three dozen fixed grid leaks on hand, of various rated capacities, you could probably find one of them that will suit the purposes of this set. However, it is far better to use a good standard type of variable grid leak, such as the one illustrated. With different tubes, you will have to change the value of this device and, therefore, a continuously variable leak comes in handy. Inasmuch as it it not often used, it was located on the baseboard. This was done not only for the reason mentioned, but also so that the lead from the combination grid leak and condenser to the grid binding post on the socket will be as short as possible. This is another important point to remember. If this lead is long, the set will be hard to control and unstable in operation. Therefore, make it as short as is physically possible.

The distance between the tickler coil and the secondary coil must also be determined by experiment. The position shown in the photographs is approximately correct for the particular coils that the writer used. A small variation of this distance may mean the difference between an unstable and a stable one. The third point to be carefully watched in the operation of this set is the capacity of the tiny antenna coupling condenser. This device is built of two small sheets of aluminum with active areas about ½-inch square. The space between them is approximately ¼ of an inch and must be varied until the best signal strength with good control is obtained. It can be varied merely by pressing the top sheet down and bending it a little so that it stays closer to the bottom sheet.

Let us next consider the construction of the coils. The one which is the combination primary and secondary should be of the low-loss type. An excellent method of constructing coils of this nature can be seen in the various photographs of the set and in the close-up of the coil in Fig. 5. This only applies to the secondary coil. The tickler need not be wound in this fashion and was wound on a standard basket-weave form for convenience sake. It was then tied together and used as shown.

The complete method of constructing the low-loss secondary coil was as follows: Double cotton-covered No. 12 wire was used, although this may be slightly smaller. The form for making up the coil was first made as shown in Fig. 6. A tube 4 inches in diameter and of arbitrary length was slotted for 3½ inches with four slots, each ¼ of an inch wide and spaced evenly around the circumference. The heavy wire was then wound on a 3-inch form, being careful to straighten the wire out as the winding is being done. Wind 3 or 4 more turns of wire than you will need on your finished coil. Upon releasing this wire, after it is wound on the 3-inch form, it will spring out slightly and will form a spiral about 3½ inches in diameter. This can now be worked over the 4-inch form, and will be found to hug that form closely. By following this procedure, the usual difficulty experienced in holding the turns in place on the 4-inch form will be eliminated. Put as many turns of wire on the form as you will need for the particular band that you have to cover, consulting the table of turns below. Now cut up some strips of fairly heavy celluloid, 3/16 of an inch wide and about ½-inch longer than the length of the coil. Four strips will be necessary and the material from a draftsman's discarded triangle will be found excellent. Clamp the four strips in a vise, allowing the edges to project about half of their width. Hold three hacksaw blades together and cut slots through half the width of the strips. The number of slots necessary will be determined by the number of turns on the coil and their distance apart should be equal to the thickness of the wire used. Now take these prepared strips of celluloid and hold one of them under and against the wire wound on the form, using one slot for this purpose. Work the wire into the notches cut in the strip until you have every turn in its correct position. Fasten them with collodion or amyl acetate. In case you find trouble in holding the strip to the wire with this material, dissolve a small quantity of celluloid in the liquid. This will make it heavier and of a consistency that will surely serve the purpose. After all four strips are securely fastened in place, allow the coil to dry for several hours, whereupon it can be slipped off the form and the ends shaped for mounting. In the particular coil that is illustrated, which was designed for 40-meter work, the coils happened to be wound in the wrong direction and, therefore, the leads had to be crossed, as shown in Fig. 5. Inasmuch as the ends were cut too short, an additional length had to be soldered on, as shown. Probably, however, the reader can profit by the writer's mistakes and wind the coils correctly the first time.

(Continued on page 745)

The circuit diagram given at the right shows the connections for the short-wave receiver, with an experimental connection indicated. Try both ways of connecting feed-back condenser C2.

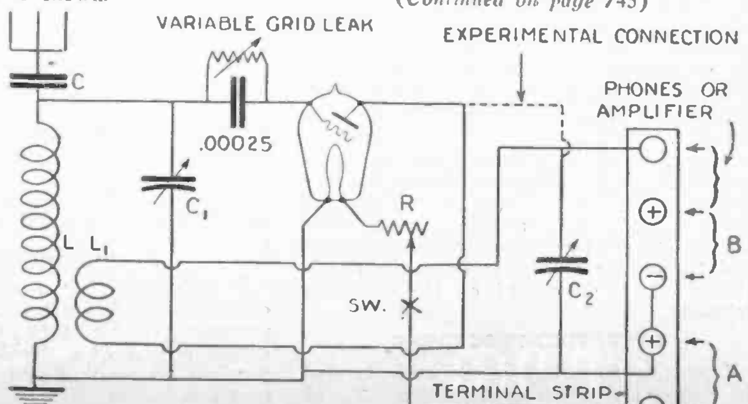
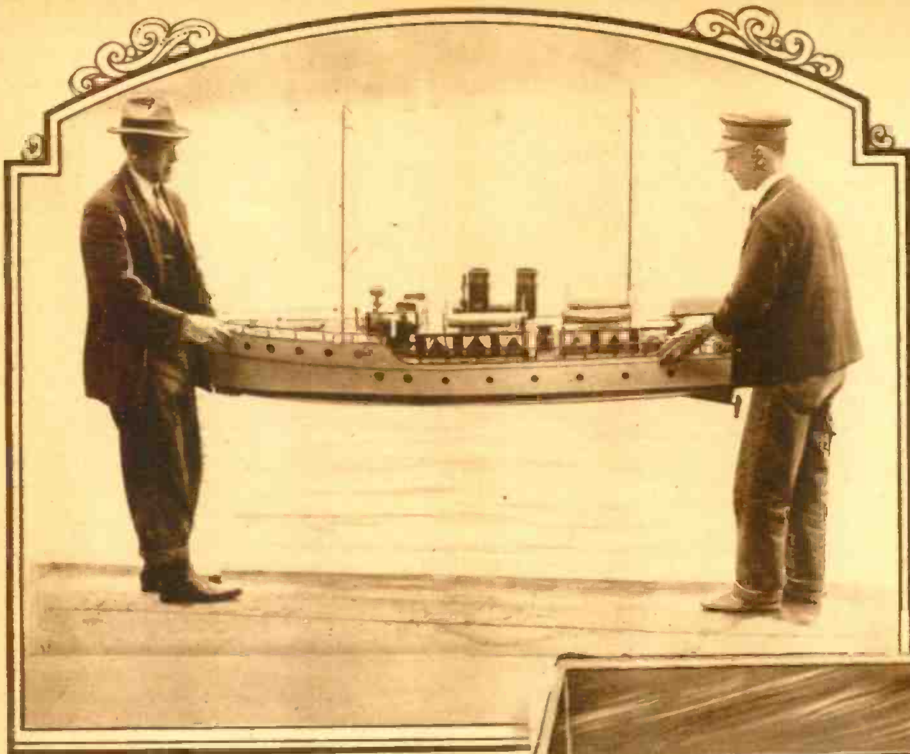
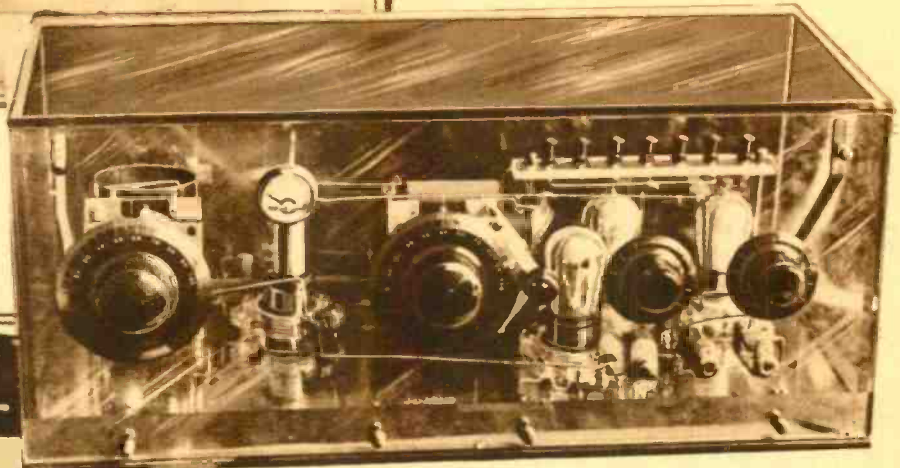


FIG. 4

What Experimenters Are Doing



What electricity and ingenuity can do is shown by the model yacht at the left, which is equipped with radio, electric lights and all modern appliances. It cost its builder, C. B. Hollis, of 32 Reeve Place, Brooklyn, $1,500. It is 40 inches long and is driven by dry batteries. It is designed according to the best principles of marine architecture and makes very good speed.



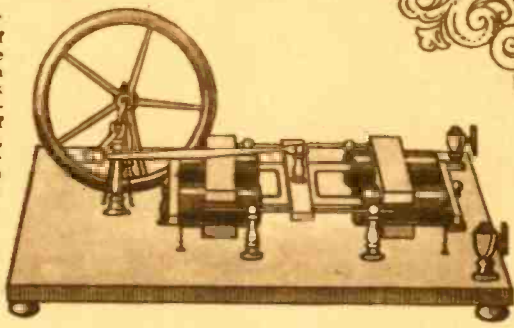
When a jeweler becomes a radio enthusiast he indulges in such a luxurious radio set as that shown above. This one built by Joseph Affanato, a Boston jeweler, has all metal parts heavily gold plated. The glittering apparatus rests on a plate glass mirror and is enclosed in glass panels.

An automatic timer shown below helps the distance runners of the University of Wisconsin to judge their speed. The timer is electrically operated and rings a bell at predetermined intervals of time during which the runner is expected to cover one lap on the track. It was designed by coach Tom Jones.

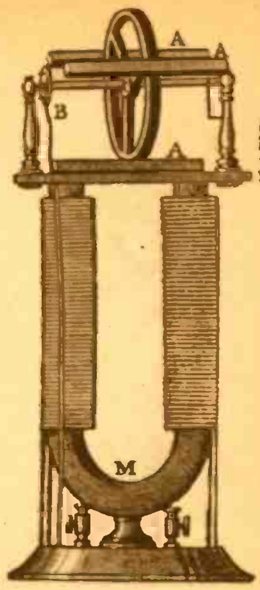
The students of Wellesley College have built the 50-watt broadcast set shown at the right. Miss Jane Wiggin, of Pittsburgh, Pa., and Miss Lucy Begeman, instructor, are shown experimenting with it.

Old Time Electric Motors

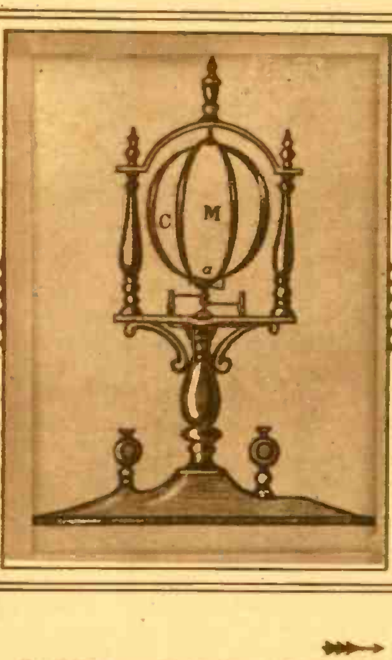
The interesting set of motors shown in these illustrations are taken from a very famous book which is now a great curiosity, Davis' Manual of Magnetism. Daniel Davis, Jr., was a mathematical instrument maker of Boston and in 1842 published the book now quite celebrated

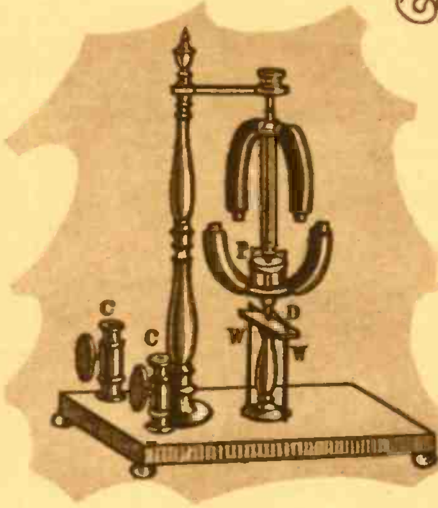


On the left is seen a reciprocating motor. One idea of the times was to make motors on the lines of the ordinary steam engine. The motor shown on the right departs from the reciprocating principle; the wheel carries bars which are attracted at proper times. The action of attraction is regulated by an ordinary commutator as the wheel rotates.

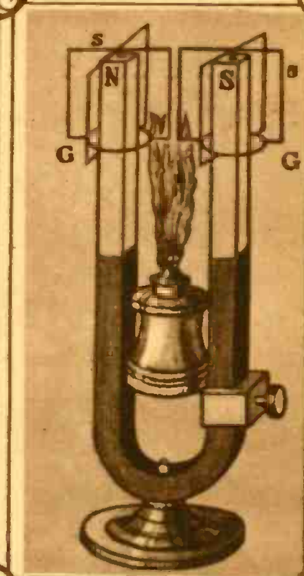


This is quite a curious apparatus; the circle M is of steel and is a magnet; the coil C is a coil of wire and at the base of the shaft will be seen the commutator. It is a curiosity only as it will develop extremely small power.





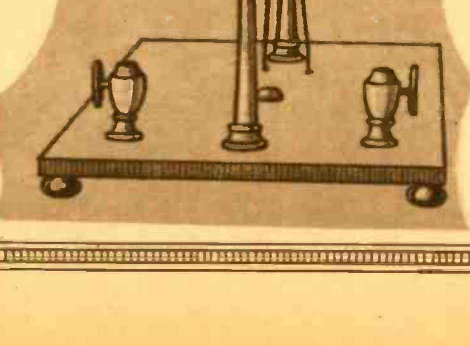
Above is shown a very familiar type of motor, or at least one that used to be so, somewhat on the lines of what was called a revolving armature. It has its coils, pole changers, as Davis called the appliance which we call the commutator, and undoubtedly would produce a very high speed. This was one of the characteristics of many motors of old times, while of low power they were of quite high speed. It has virtually two electromagnets. The upper one, as well as the lower one, rotate in opposite directions. It would be very interesting to reproduce such a machine as this and the double rotation idea might be carried out advantageously for some purposes.



Here we have the familiar thermo-electric motor with an alcohol lamp mounted between the legs of the magnet, which heats the wire frames delicately poised, one for each of the magnet poles. We have several times had occasion to illustrate interesting varieties of thermo-electric motors in our columns.

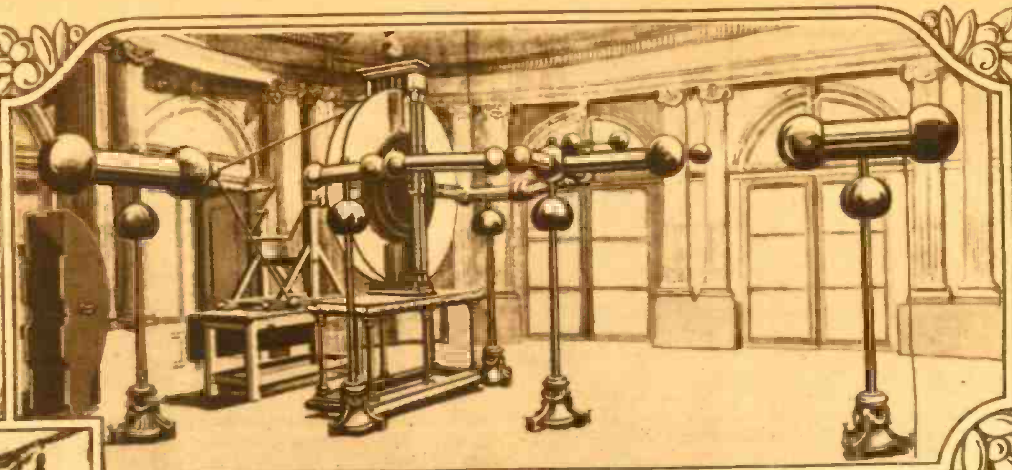
The frames are generally made of silver and platinum; but German silver, in combination with brass or silver, will develop a stronger current in the frames.

In this apparatus current is supplied through a commutator to the bar electromagnet so as to reverse its poles as it rotates. The field is the field of the earth. The author states that the polarity of the bar is to be reversed when in the course of the revolution it reaches the line of the magnetic dip. The shaft of the bar is carried by two wheels at each side to reduce friction.



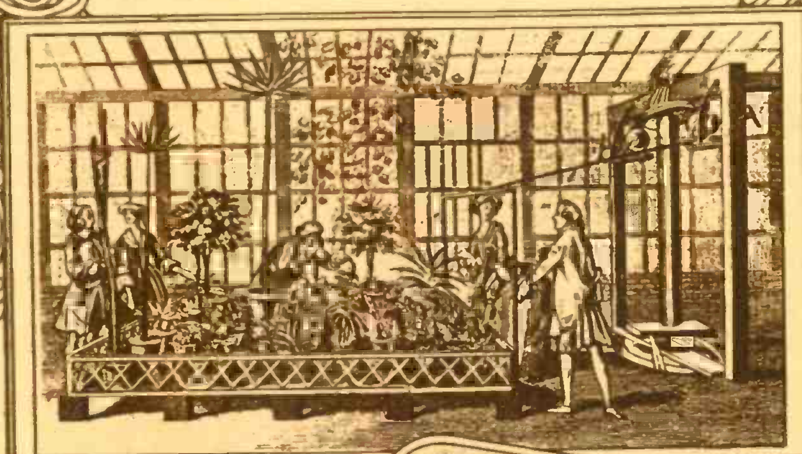
Odd Electric Machines

A large static machine shown at the right was constructed for demonstration purposes at the French court of the 18th century. The illustration is reproduced from Martin van Marum's book on Electrical Machines.

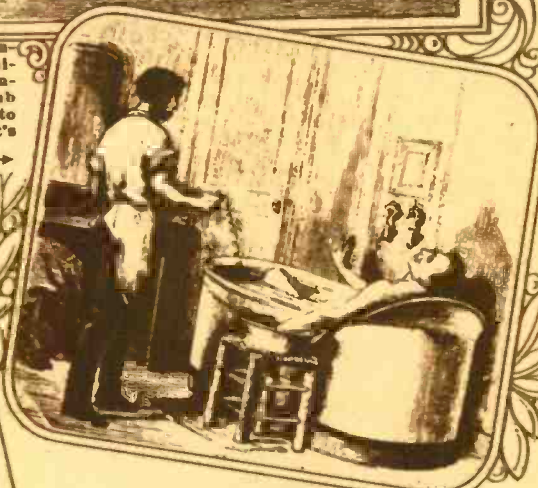


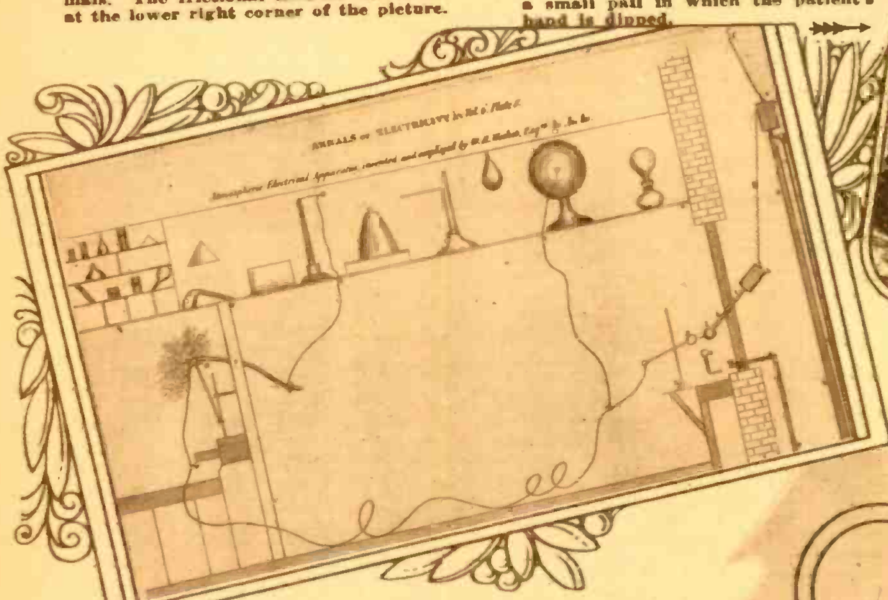
The Abbe Nollet, whom we have mentioned before in the columns of THE EXPERIMENTER, constructed this quaint apparatus to investigate the effects of electricity on plants and animals. The frictional machine is shown at the lower right corner of the picture.

In the apparatus illustrated below, a hydraulic motor was employed to drive two frictional electrical machines which supplied electricity to the flower stand mounted on insulators. The apparatus was built in 1755.



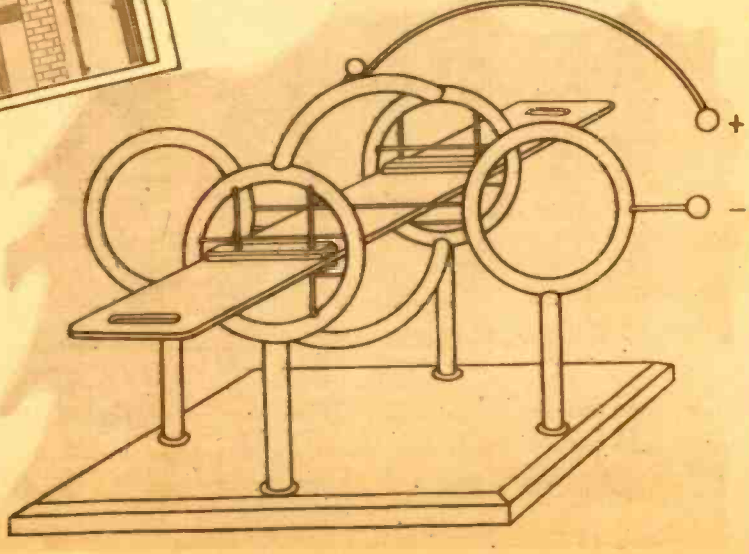
An electric bath of the 18th century is shown at right. One terminal of the Galvanic battery is connected to the salt solution in the tub while the other terminal connects to a small pail in which the patient's hand is dipped.





An apparatus for the study of atmospheric electricity. The lead-in wire is connected to the pump at the left and to various apparatus on a shelf. A spark discharge is represented at the handle of the pump. The picture is reproduced from Sturgeon's Annals of Electricity of nearly 100 years ago.

In this curious static machine, devised by Vander Weyde in the latter part of the 19th century, electricity is generated by the reciprocal motion of the glass strip passing under the friction cushions and through the center of the rings



The Latest Progress In Talking Movies

By Dr. Bacher

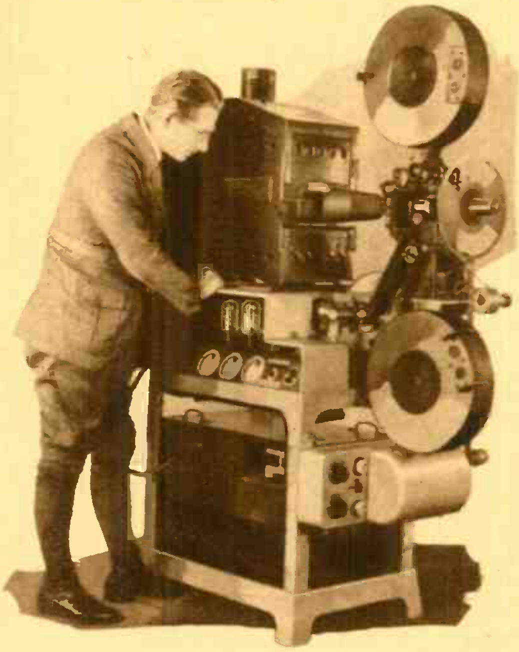
TO synchronize movement and sound successfully, both must be recorded by one operation, and whilst a gramophone-like receiver coupled to the camera might produce a true negative, a reproduction of both cannot be made to harmonize. Various inventors decided, therefore, that the tune must be recorded on the film itself and tried to convert the acoustic waves into variations of light, which they photographed alongside the pictures. No doubt, an inseparable uniting of movement with sound is obtained, and the idea appears simple enough, but the inventors of the system, Joseph Massolle, Hans Vogt and Dr. Engl, three German engineers, spent years in perfecting their apparatus.

The writer had an opportunity to witness a demonstration and it seemed to outclass anything hitherto presented. The purity of sound, be it the spoken word, song, music of any sort and of any instrument, a small or a large body of orchestral performers, noises of any class are reproduced; no distortion occurs. It is surprising to observe persons moving on the screen with word and song coming straight from their lips.

A telephone receiver, capable of reproducing without distortion the longest and the shortest waves, was the first necessity. To accomplish this they constructed the "Cathodophone" (Fig. 2). It is based on the emission of electrons, but differing from the radio tube, the Cathodophone employs ions, *i. e.*, air molecules electrically charged by electrons, to produce the current. The ions are the conductive medium from negative cathode to a positive electrode; both are in the open air and consequently the ions are influenced by the impulse of sound waves and in turn vary the flow of the electric emanation.

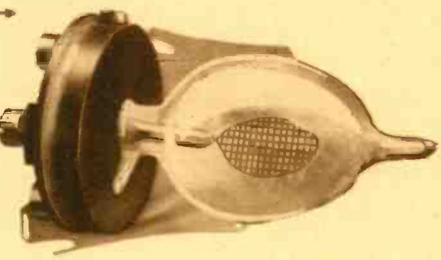
(*Continued on page 777*)

The talking motion picture projection apparatus. Note the amplifying tubes in the center. The movie apparatus and the sound reproducer are kept in perfect synchronism.

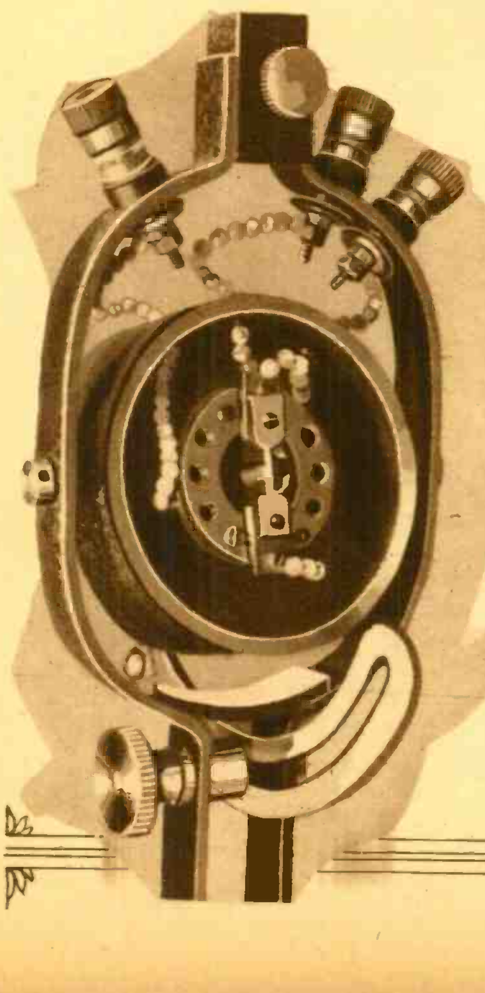


A strip of film showing the speech band on the left. The latter is merely a thin division of the strip and is of varying transparency.

A photo electric cell shown at the right is used in the apparatus for reproducing the speech sounds.

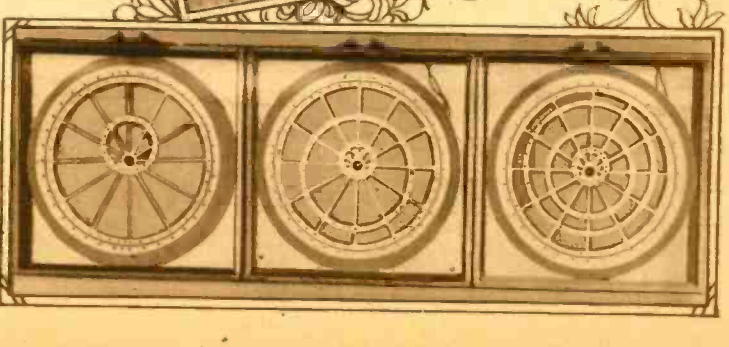


The cathodophone shown below is a novel apparatus in which sound waves act directly on an electron current when so modulated. Its diagram of connections is shown elsewhere in this article.



The speech recorder or cathodophone in use is shown at the right of the picture.

Below are shown the three disc hornless loud speakers used with the talking motion picture. The peculiar framework is used to eliminate zonal vibrations of the diaphragm.

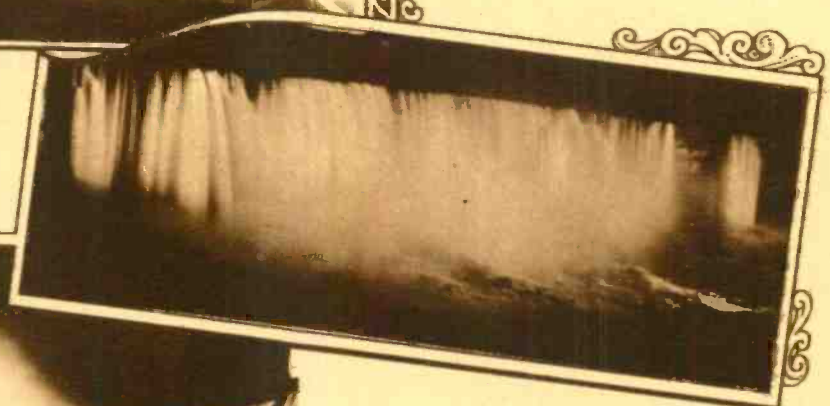


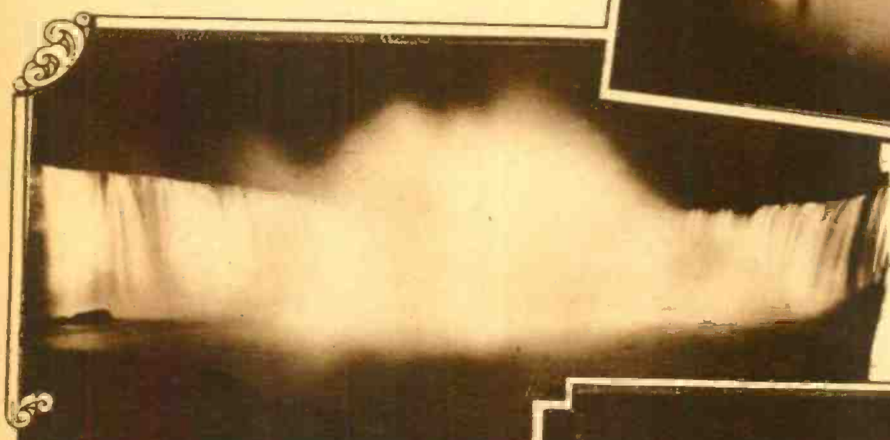
Illumination of Niagara Falls

The great battery of 24 searchlights which were turned upon Niagara Falls last May in the presence of over 65,000 spectators. The illumination of the Falls of some years ago we have already described, but the work of this year far surpasses what was done then. We all hear of the millions of horsepower that go over the brink at Niagara. Here one and one-third billions of candlepower are directed on the falling waters and on the rising clouds of mist and spray, producing the beautiful effects shown in our reproduction of the photograph.

A view of the effect from the neighborhood of the lighting station; a long range vision of the illuminated Falls.

On the right is a view of the American falls as illuminated. The peculiar striated effect will be noticed; the apparently local cloud of mist in the center, rising from the river below, is more strikingly shown in the picture below.





The Horseshoe Falls in which the great cloud of vapor is more accentuated than in the American Falls.

Distant view from a low horizon.

The cities of Niagara Falls on the American side and Ontario in Canada, the Park Commission, the Power Company, and the General Electric Company have made the lighting a reality. When it is realized that each of the searchlights is 36 inches in diameter, the extraordinary scope of the work will be appreciated.

on him, subject to his consent, as the most important link we should have with the outside world. I went straight to him and explained the scheme without reserve. He agreed to help.

I placed a large sum of money to his credit, and gave him lists of the plant and stores he was to purchase for us, lists which the chief and myself had gone over thoroughly until we knew we had missed nothing. Lippencott anticipated no difficulty in meeting our requirements and agreed to scatter the orders so that any trace would be difficult to find in the future.

At the plateau we had, for example, to drill for oil, which entailed the purchase of drills and casing, with the necessary power, and a small refining plant. Then we had the gas to tap, the Chief having become certain that a sealed reservoir lay behind the wall of the cave in which we had taken the sample, and this meant the buying of rock drills and piping. For utilizing the water of the fall we needed hydraulic mains, turbines and dynamos. Plant for the machine-shop was the next consideration, with small motors for the lathes and so forth. We had to have cement for bedding down the engines. And, finally, we needed agricultural implements, seeds, potatoes, so that we could cultivate enough land to supply vegetables for the crews of the airships when they should arrive at the plateau.

To the task of collecting all this mass of material, Lippencott applied himself with a devotion and energy which even his lackadaisical demeanor could not disguise, and he was the means of putting two of our best officers in our way.

David Lippincott and Steve Curtis—Two Important Additions to the Party

"Seton," he drawled at me, "I have a young brother who could do with having the edge of a pretty large deviltry rubbed off. Could you find a place for him in your crew?"

"Let me have a look at him, Lippencott," I replied. "You can understand that I must make no mistakes in my men?"

"Sure," said Lippencott, and stretched a lazy hand for the telephone. "Dave," he said when he had the connection, "just look in here for a moment. I want you to meet Commander Seton. Contrive not to be arrested for speed on your way here."

"Speed fiend, is he?"

"And then some," said Lippencott. "But Dave's no hog. He's a wizard at the wheel, and so far hasn't killed even a chicken. Drove a French ambulance because he was too young for the army."

David Lippencott was a slim, dark young fellow, with deep-set eyes, perhaps a little too close together for frankness, but his mouth was large and good-natured. He had the same appearance of languor as his brother, but a glance was sufficient to show that his quality of muscle was of the stringy, untiring kind. I liked him at first sight.

"Yes, Commander Seton," he said, when after an hour or two of his company I put the thing to him, "I'd like to join you. But I'd like you to give a friend of mine, Steve Curtis, a chance of joining, too."

"Good man, is he?"

"You bet—and can keep his mouth shut, too."

"You'll like Steve," his brother affirmed.

Thus, before I had been in New Orleans two days, I had enlisted the services of three good men, including Travers Lippencott, our master of supply.

Steven Curtis was a fair-haired sturdy young American, short and wide shouldered, with a voice, I discovered, that might have charmed the heart out of a brass Buddha. He wrote his own verses and composed his own tunes, and sung them to an accompaniment on the guitar. He also could whistle as I have never heard man whistle in my life. These gifts, it will be understood, were valuable assets where it was contemplated to keep men away from civilization for some years. In addition, Steve was like young Lippencott, given over heart and soul to internal-combustion engines.

My visit to New Orleans saved me much time, for there through Lippencott I heard of a small river vessel being offered for sale. She was old, but in good condition, a motor-ship with twin engines of the Diesel type. She had started life as a steamer on the waterway on whose banks she was built—the Clyde—and had afterwards been converted to internal-combustion engines. Under thirty meters in length, not too broad of beam, and drawing slightly over two meters loaded, she was just the kind of vessel that I had hoped to purchase in Britain and bring over the Atlantic on a false bottom. I bought her, through my master of supply, and gave orders to have her altered for carrying cargo.

"Sleepy Sam Smithers"

As Lippencott and I turned ashore from our inspection of the little vessel, and paused by the gangway in talk, a strange figure seated on a bollard close by came gradually into our consciousness. The figure was strange because it was foreign to the atmosphere of the place. A very stout man it was who, regardless of the heat of the day, wore a thick blue pilot jacket.

He was smoking a rakish and slim clay pipe, beautifully colored, and with a rugged thick hand on either knee he was gazing at the ship and us with an air of placid contentment. Now and again, by a slow movement, the pipe would be removed to permit of expectoration over the quayside, the hand would return to the knee, and the bovine gaze would come back to the little steamer and to us.

There was something so familiar about the placid stolidity of the mountainous figure and the contrasted fragility of the slender clay pipe that for a moment I thought I was dreaming. I crossed over to the bollard and stood in front of the man. Then with the same placidity the amazingly unprehensile clump of fingers of one hand were stretched out to come slowly to the peak of the cap, and the huge figure slowly rose. A deep husky voice rumbled up from vast depths.

"Commander Seton, sir," it rolled. "Gi'e ye a good day, sir."

"Bless my heart and soul!" I exclaimed. "It's Smithers!"

"Aye, aye, sir! Smithers it is, sir—as wus with you, sir, on the cruiser *Dorset*. Happy to see ye so 'earty, sir!"

"You're pretty bobbish yourself, I should think?"

"Aye, sir. Tol'rable bobbish, thankee kindly, sir."

"And what are you doing in New Orleans, Smithers?"

He hoisted back his big shoulders, and brought his ox-like eyes into a fixed stare at me.

"Like this, sir," he rumbled. "I was second-class warrant shipwright on the *Orleans* arter the wawer. I j'ined 'er, sir, arter you got to flyin' like. An' w'en they retires me—as in the course o' natur' they was bounter do—not 'avin' any womenkind like, an' thinkin' wi' my weight as settlin' down would make me 'eavier, I makes up my mind, jest for somethin' ter do, like, ter go round an' visit all the places as the ships I been on wus named from."

He paused for a breath, and to take another hitch, as it were, on his wall-eyed gaze.

"The *R'y'l George*," he explained, "wus easy. They's a little pub down Barkin' way o' the name. I 'ad a bit o' trouble ter find the *Minotaur*, but I comes on another pub o' that name outside Davenport. I finds *Arethusa*, *Good 'Ope*, the *Lion*, *Intrepid*, *Marlborough*, wi' difficulty more or less, but I finds them—pubs mostly. Cur'ous fact in natur', sir, as so many of 'Is Madgesty's ships should be called arter pubs, ain't it, sir?"

"Extraordinary!" I agreed, for I wanted to hear the end of this peculiar Odyssey.

"*Dorset* wus easy. I just goes down ter Weymouth an' 'as a quart at the Anchor, for the sake o' ol times, so to speak. The *Téméraire* wus bothersome, but I gets down ter Demerarar as bein' as near as I could find. *Orleans* brings me 'ere—though I done the French one, too, to make sure, but she was a new ship, an' I'm goin' ter do the *Amazon*, sir, 'n' then I'll be finished."

(*Continued on page* 782)

"He charged an electroscope until the two leaves were held out at right angles to the stem. He put the piece of rock over the cap of the instrument and the leaves fell at once."

The Ark of the Covenant

By Victor MacClure

"I sprang for the cap of the inset pipe and threw my weight on the lever. Slowly the cap went over, though it took me all my time, as the phrase is, and every muscle in my body was protesting at the strain."

[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 stronge 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, and eventually the Captain goes with them to the treasure safe and finds that it has been 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, taking with them the charming Miss Torrance, the niece of Lord Almeric, who is also of the party. As the Parnassic reaches port, investigations into her robbery are in order.

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 where similar raids have been perpetrated.

The 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 leaving police machines far behind, 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, for the first one has several successors, 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. Meanwhile it seems that Miss Torrance has been pleading the cause of the Merlin at the White House and all goes smoothly.

In spite of delay due to carburetor trouble the search is prosecuted and at last the enemy is sighted. Eager to attack, a gas defense by the enemy threatens. The gas begins its work upon the Merlin's crew.

The Merlin is gassed by the raider. 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 and the Merlin, after her fight with the airship, has a rest. 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.

CHAPTER TWO

The Formation of the League

Higgins came with me in the canoe for the first stage of my journey Europewards, and when he had put me on land for my solitary trek down the Negro he left me, to return to the plateau. I had little difficulty, if it took me some time, in reaching Manaos, where I found a passage to New Orleans.

My purpose in making for this American port was simple, for there I had a friend on whose discretion and help I could implicitly rely. This was a Southerner, an American gentleman of the finest type, and one of those who in the early part of the European War had found a way into the British flying service. We had worked together in the service, and I knew my man for a close-mouthed, shrewd and capable fellow who none the less permitted deep languor and slow, drawling speech to belie a mind well above the average for alertness and keen business instinct.

Lippencott, for that was his name, was a trader in New Orleans, and I had decided

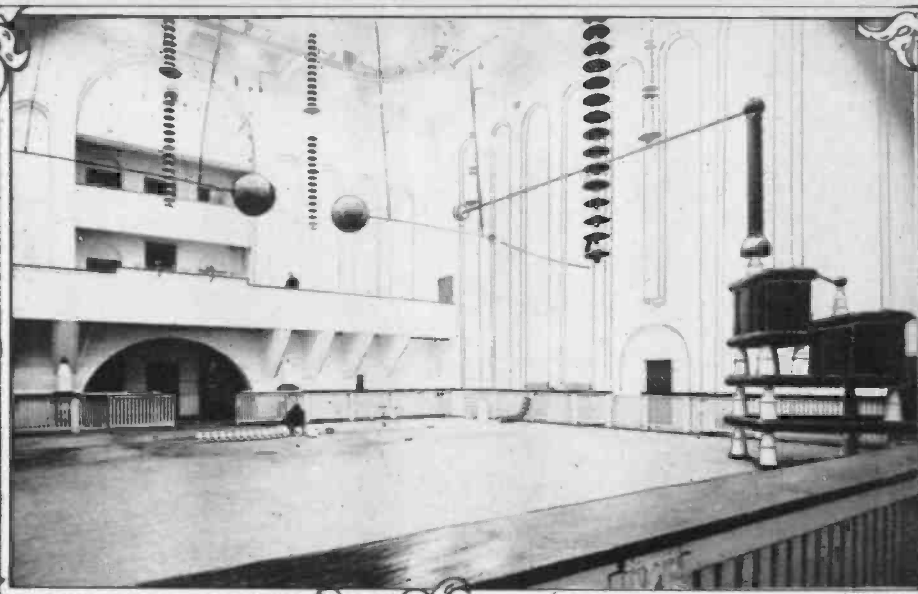
Examining Insulators at One Million Volt Tension

By Dr. Albert Neuburger

ONE million volts! Is it possible to imagine what it means when an electric circuit is under such a tension—when such a pressure is employed to drive the electricity through the wires?

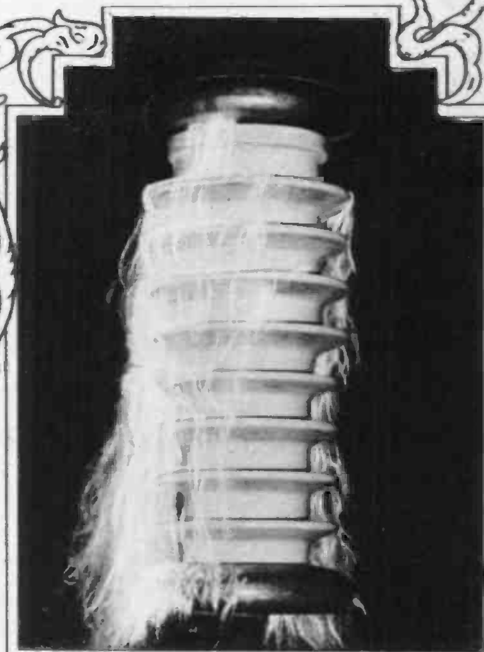
The centralization of the power plant offers great advantages, but it also demands technical arrangements of a hitherto unknown sort and dimension. When the first important plants were constructed, the current of which was taken longer distances than ever before, the potential was raised to 50,000 and later to 100,000 volts. Then—it is not so very long ago, either—vivid discussions arose among the experts whether such an increase of tension was controllable at all. How should the current be prevented from escaping into the ground, how were discharges to be prevented from setting buildings on fire? All these fears have proved to be groundless.

(Continued on page 776)

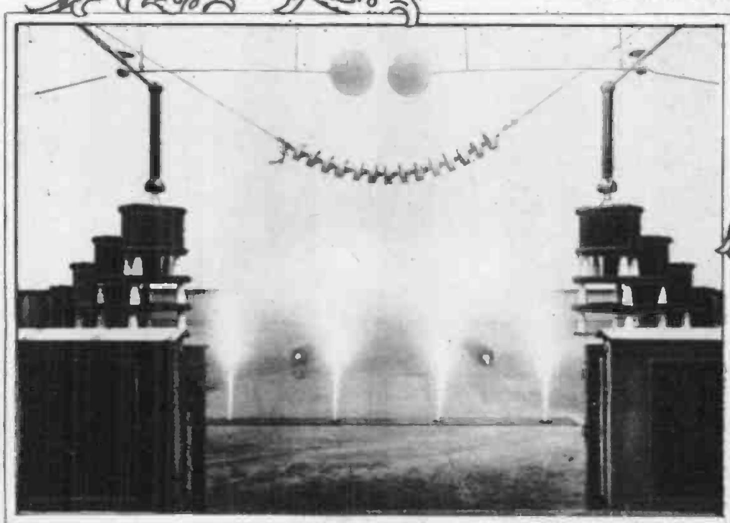


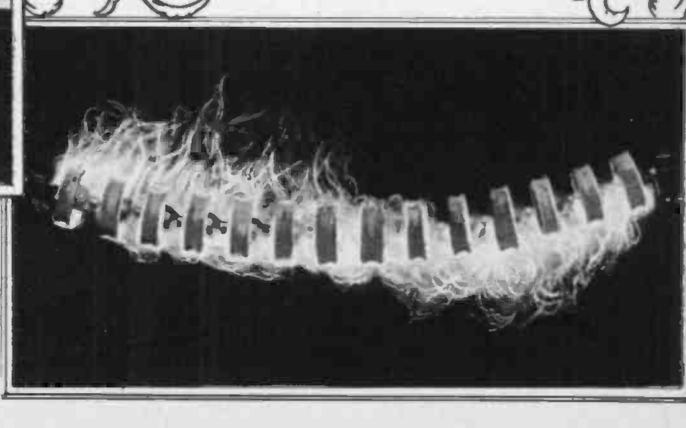
View of the floor and gallery of the great 1,000,000 volt laboratory in Friedburg, Germany. The balconies are for the observers and are arranged to protect them from danger.

Electrodes for the high potential discharges. Note the great chain insulators. The laboratory is arranged for the operators to work at a distance from the dangerous discharges.



A great discharge or a flash-over across a stack of insulators. These beautiful phenomena are attended by noises which are anything but agreeable.





Above: Set of insulators suspended bridge-fashion between electrodes for testing, and on the right is shown a flash-over discharge across such a set.

An All-Wave Short-Wave Receiver

(*Continued from page* 736)

The mounting for the two inductances consists of a square of hard rubber, bakelite, radion or celeron, supported from the baseboard by four battery nuts and equipped with five binding posts. Two of these hold the tickler coil; two, the secondary inductance, and one, the upper plate of the antenna coupling condenser. The antenna is also connected to this latter binding post and the ground to the same post as the opposite end of the coil.

When the writer built this set, only one single section Bruno condenser was at hand and later one of the two-section types was pressed into use. However, only one of the units is used for the oscillation control and, therefore, you can use any condenser with a maximum capacity of .00025 mf. that you may have at hand. The tuning condenser, however, is much smaller in size so that the range will be spread over a greater

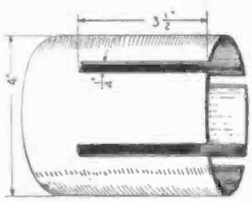


FIG 6

Left: The form used for winding the low-loss coils used in this tuner.

space on the dial. A standard 11-plate condenser was taken apart and reduced to 5 plates by the mere process of tearing out the surplus plates. The result can easily be seen in the photograph in Fig. 3.

In case the reader desires to adapt a set of this nature to broadcast reception, it is not advisable to use the capacity coupled antenna scheme shown. In fact, an inductively coupled primary should be incorporated and may consist of four or five turns of No. 16 D.C.C. wire, wound in the same low-loss style as the secondary. This will prevent radiation, which would cause trouble if the capacity coupled antenna system were used on broadcast wave-lengths. For this work, the circuit described and the method of regeneration control used will be found to be very good. The control of volume, as the condenser C2 might be called, gives very good results. A signal can be brought up to its maximum strength and held at that point without the usual distortion that takes place when a tickler coil is brought up to full regeneration or suddenly spills over into oscillation.

The following sizes of coils will cover the amateur bands very effectively:

Wave-length.	Secondary turns.	Tickler turns.
6	1	2
15	3	3
30	7	3
50	9	3
125	18	4
220	25	6

For the broadcast band the type of coil described will be rather bulky, although it can be used. In such an event, use 45 turns of No. 20 D.C.C. wire in the secondary, 10 in the tickler and a .0005 tuning condenser with a .0005 feed-back condenser.

In the above table, the lowest range that can be reached with the smallest coil or the one-turn coil is much lower than you will ever need. The maximum wave-length to which this will tune is approximately 10 meters. From there on up to the 25-turn coil you will be able to cover every band of wave-lengths used by amateurs today.

Do not forget, however, if you wish to adapt this set to broadcast reception that you must use a loose-coupled primary. Failure to do this will make you most unpopular with your neighbors, inasmuch as a set of this type with a capacity coupled antenna circuit will radiate terrifically. If you so desire, a little ingenuity will enable you to fix up a switch or plug arrangement whereby you can quickly change your set from short-wave to broadcast-wave reception. In fact, it is entirely possible, and some amateurs prefer, to make this set inductively coupled over its entire range. Some do not like the capacity coupled antenna system and, therefore, a separate primary can be used for all waves. In such an event, use the primary mentioned above for broadcast reception and a 3-turn coil for short-wave reception. We are sure that a set of this nature will furnish all your expectations for a short-wave set and will give you all the satisfaction that is possible.

When you start tuning down around the 20- and 40-meter wave-length bands, you will find that the tuning is extremely sharp. In fact, you will be able to do much better work if you incorporated an external vernier on the panel of the set. The cheap types using a rubber wheel in frictional contact with the dial are perfectly satisfactory and give excellent results. Possibly one will say that they do not look as good as standard vernier dials, but on the other hand they work just as well, so why worry about looks?

In tuning this set, place the oscillation control dial at a point where the set is in quiet oscillation. You can test for this point by listening for the "pluck" that will be heard if you touch your finger to the grid binding post of the socket when the set is in oscillation. You will find that the oscillation control dial need only be varied over a space

Fig. 5

Above: One of the low-loss coils showing the supporting strips and leads.

of possibly ten degrees on either side of this point, and it should be varied simultaneously with the tuning dial as you cover the entire range of the set. After you have worked the set for a short time you will acquire the knack of tuning it correctly, as it is very simple to handle. Because of the type of oscillation control that is used in this set, varying such control has little if any effect on the tuning of the set. Therefore, you can log this tuner quite accurately and can check your transmitter with it.

Considering the fact that there are quite a few foreign amateurs on the air using 20 and 40 meters, the one who constructs this tuner will find himself amply rewarded for his labors. Certainly one cannot help feeling thrilled by the signals from some far-distant country!

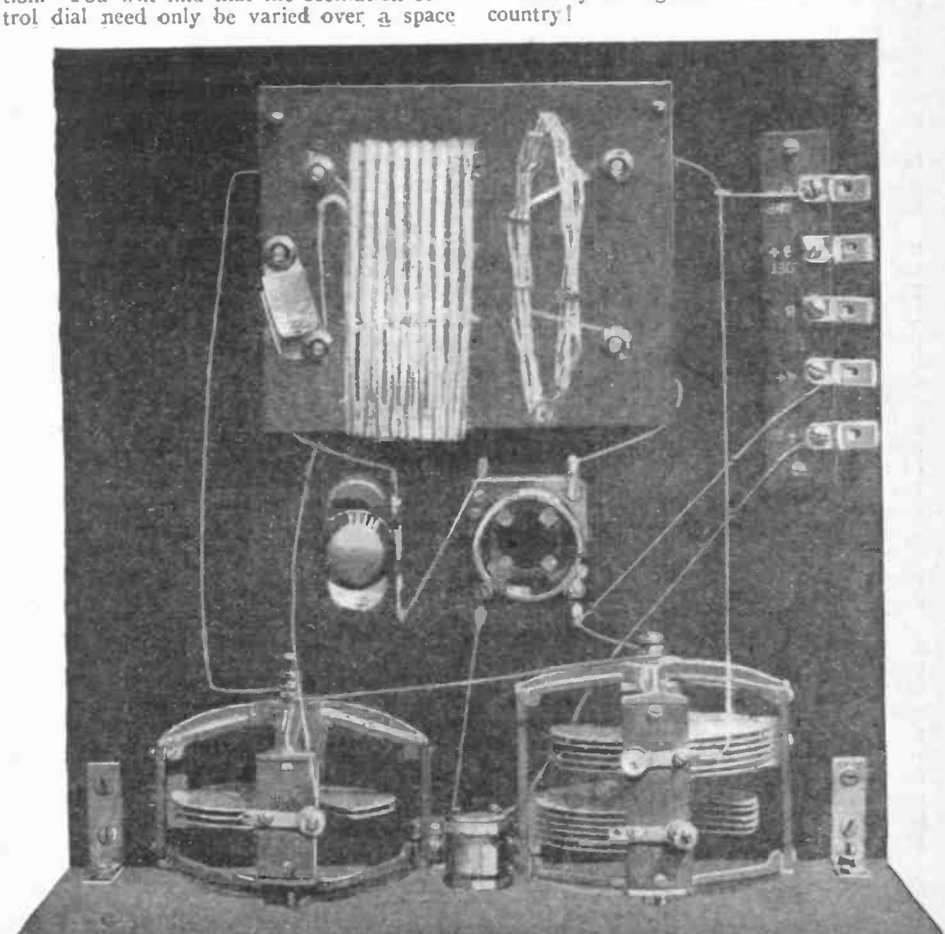
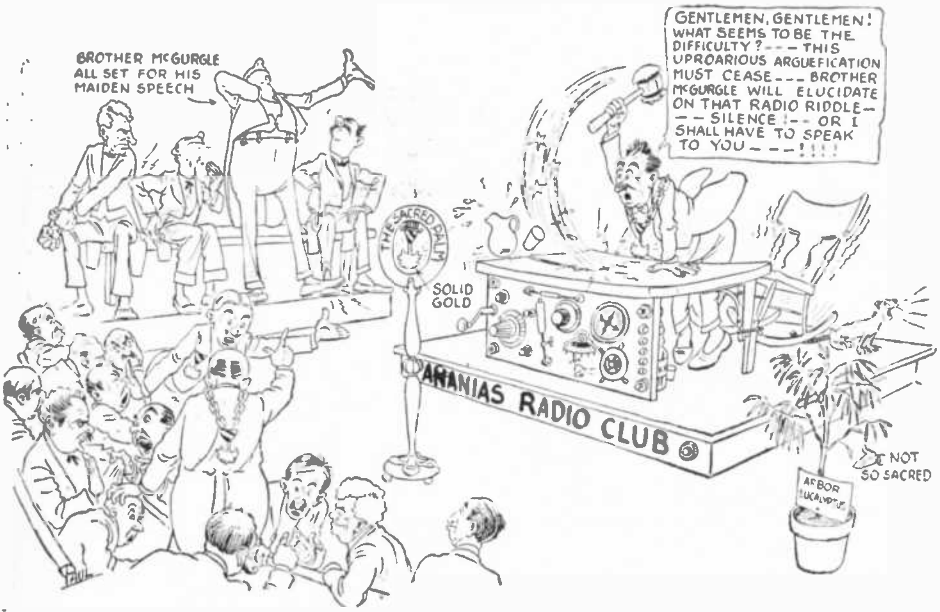


Fig. 3

The top view of this highly efficient receiving set showing the layout of the various instruments and the straight connections between them.

The Sacred Palm

By Robert Hertzberg



The auspicious occasion on which the Palm of the Prodigious Prevaricator is awarded always brings to life the scanty-haired and fossilized old gentlemen of the Ananias Radio Club.

"GENTLEMEN, gentlemen, pray be seated," pleaded the evening-clothed man on the platform at the end of the room, as he vigorously rapped his gavel on the table. "Gentlemen, please take your seats. It is time this meeting commenced. There is important business on hand."

The tumult in the smoke-fogged room gradually quieted, and the little groups in the corners broke up as the men filed into the rows of chairs that faced the raised platform.

"In the name of the Ananias Radio Club," briskly declared the man with the gavel, when the last straggler had finally stretched his legs, "I call this meeting to order."

Followed in quick succession the usual trivialties of parliamentary procedure. Then the president arose. He carefully smoothed his rebellious shirtfront, turned half way to his right to smile benevolently at four dinner-coated men fidgeting uncomfortably in small chairs, and then started to speak, slowly and grandly.

"Gentlemen," he said, and he swept the gathering with an inclusive gaze, "we are assembled here this evening for the purpose of awarding our annual and eagerly sought-for medal, our far-famed P. P. P., our sacred Palm of the Prodigious Prevaricator."

Murmurs of "Yes, yes," "Go on, spill the rest" and "We know all about that," drifted disturbingly across the platform.

"You will recall, gentlemen," proceeded the president, unperturbed, "that our 1924 medal went to Mr. Eustace B. Blatherskite, for receiving Honolulu on his home-made one-tube radio set. This year it appears that the marvelous radio is again to be honored, for, gentlemen, all four candidates are radio members of the club. Allow me to introduce them: Mr. Claudius J. Grimp, Mr. Archibald Blister, Mr. Herman Q. McGurgle and Mr. Horace B. Whimple."

Each of the respective gentlemen jumped to his feet as his name was announced, smiled mirthlessly at the small sea of faces in front of him, and then sank quickly back in his seat.

A buzz of speculation arose from the club members. The man who won the 1922 palm for killing a deer at 535 yards with a .38 caliber automatic and the man who took the 1923 prize for purchasing a ticket for the opening of the "Follies" at the box office on the very evening of the event, snorted contemptuously and exchanged superior smiles. They started to say something to each other, but Mr. President silenced everyone with sharp raps of the gavel—on the table, of course.

"As has always been our custom, "we will let the P. P. P. candidates tell their own stories. We will hold the open vote later. Mr. Grimp will be the first to present his qualifications."

A light patter of applause, insidiously ironic in its slow tempo, greeted Mr. Grimp as he arose. He mumbled the standard preliminaries in the direction of Mr. Chairman, coughed a bit, and then essayed speech:

"On the evening of February 18, 1925," he began, "I was experimenting with my super-flex. The set had always given me excellent service, but lately it had been acting queerly. I examined the batteries and found them to be all right. I decided to switch the bulbs around, thinking this might do some good. I removed the first bulb, with the set going, and prepared to exchange it for the second, but, gentlemen, I never got that far, for the instant I lifted the bulb out of the socket, station WIMP, to which I was listening, came through the horn twice as loud as it ever did.

"I thought this might be a temporary phenomenon, and remained immovable with the bulb in my left hand, but the music continued. I then pushed the tube back in place, and the music died to half of what it was. I again removed the bulb and presto! WIMP was again twice as loud."

Mr. Grimp stopped, turned, and sat down abruptly. A deathly silence prevailed over the audience, but was broken in two or three moments by a low babel. Cries of "Piker!" "Cheap skate!" "Is that all?" made themselves audible. Mr. Chairman banged for order.

"Gentlemen, gentlemen," he boomed, reprovingly. "Reserve your comments for afterward. The time is getting short. We will now hear from Mr. Blister."

An attentive silence greeted Mr. Blister, a perfectly ordinary man.

"On the evening of January 13, 1925, I was entertaining some friends with a radio concert. I tuned in various stations with the aid of the earphones before plugging in the horn, as is my usual practice. One of my guests had picked up the loud speaker and was examining the name plate under a wall light. I was at the set at the time, and hearing a particularly good number, I turned around to rescue the horn. I removed the earphone plug from the set, but left the phones on my head as I walked across the room. As I passed a china closet, I stopped suddenly. Gentlemen, I was hearing the very selection I had just tuned in! I held the phone plug straight up in the air, and so help me, Hannah! fellow members, *I heard that music!* It was only when I was near the closet that I could do so; if I walked away the music would stop."

A thunder of applause drowned out anything else Mr. Blister might have had to say. He blinked for a second at the audience and then resignedly reclaimed his chair. Shouts of "Bravo! Bravo!" resounded through the hall, and even the pistol expert and the "Follies" patron joined in the commotion. Finally Mr. Blister, realizing that the demonstration was a friendly one, got on his feet, bowed graciously and sat down a second time, a glint of satisfaction in his eyes.

Only after smashing the water pitcher and hitting the secretary on the thumb did Mr. President restore peace. He screamed, "Order, Order!" and finally got it after five minutes of expostulation.

"Mr. McGurgle will now take the floor," he announced shortly and sat back to mop his brow.

Mr. McGurgle, a meek looking little fellow, had been watching the proceedings apprehensively, and when he now spoke he was extremely nervous.

"My experience is a very modest one," he squeaked apologetically. The crowd, now in good humor, listened attentively. "One evening when I got home from the office I found that the batteries of my set had been entirely disconnected. My wife told me the maid had just pulled them all out when cleaning my room.

"I untangled the mess and finally got the set working. However, I was a little uncertain about the polarity of the "B" battery wires, so while the set was pouring forth music, I deftly unhooked the plus and minus wires and quickly reversed them. Gentlemen, you may believe it or not, but my set kept right on working as if nothing had been done to it!"

Mr. McGurgle had raised his voice as he finished this sentence and he now sat down, apparently exhausted by his brief exertion. The club remained quiet and did not change its attentive attitude. It was only after a few minutes that they realized that Mr. McGurgle had said his say. Then heads turned to each other in interrogation, and questions were asked. "What's he talking about, anyway?" "Is that all he has to say?" "Isn't that thrilling?" "How'd he get voted in as a candidate by the Board of Governors?" etc.

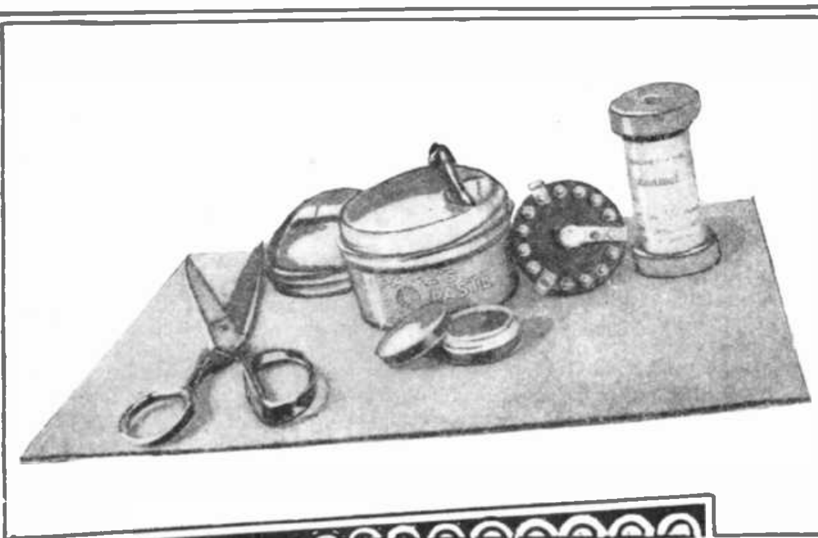
"Gentlemen," addressed the President, between blows of the gavel on the uncomplaining table. "I am afraid you do not appreciate the technical significance of this accomplishment. However, it is not my place to defend candidates. We will now listen to Mr. Whimple."

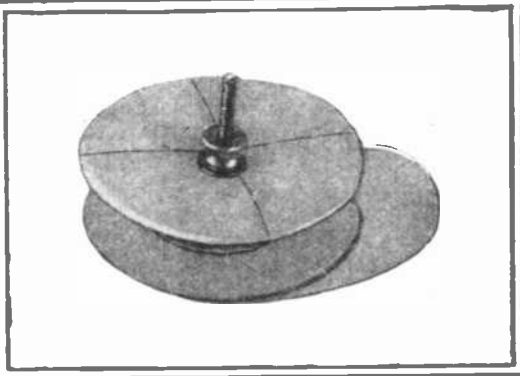
Mr. Whimple eyed the gathering sharply as he shook the wrinkles out of his trouser knees. He was an executive-looking man,

(Continued on page 774-A)

A Successful Three-Stage Amplifier

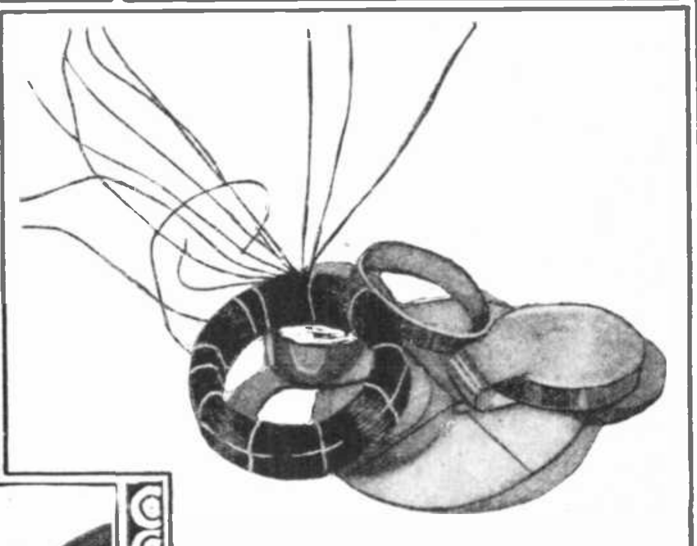
By Herbert E. Hayden



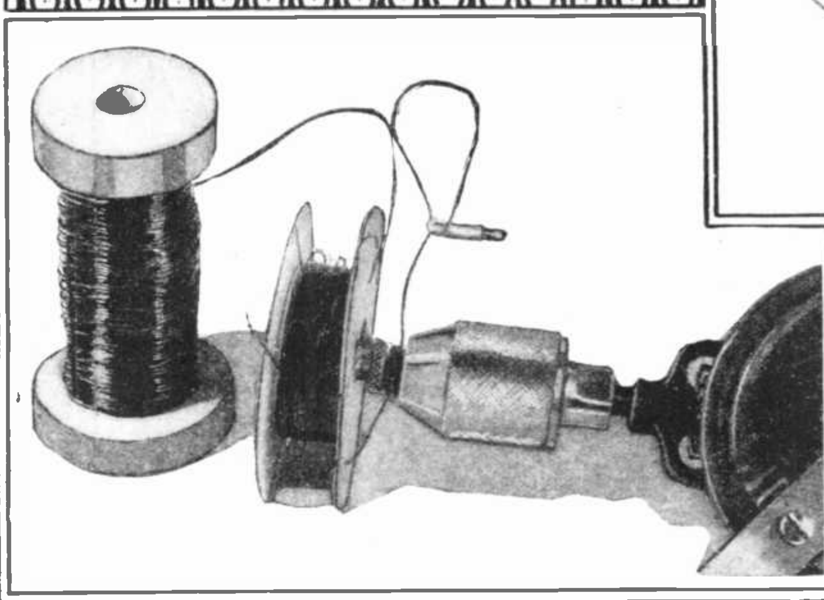


To the top and bottom of the pill box are pasted two discs of cardboard 3 inches in diameter. A long machine screw and battery nut are fastened through the center and allow the winding form to be placed in the chuck of a hand drill. After the winding operation has been completed, the form is discarded.

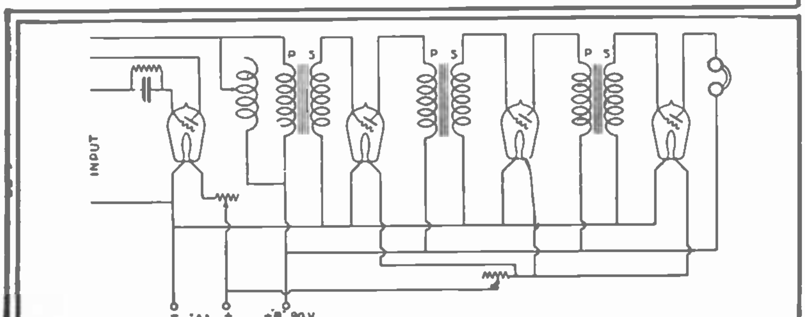
More than two stages of transformer-coupled audio frequency amplification added to any radio receiver have never been used. The main reason for this has been the excessive distortion and unearthly howling that has resulted. By introducing into the input of the first transformer what is known as a variable impedance, it becomes possible to regulate the fluctuating audio frequency currents. A pill box, a 15-point inductance switch, a pot of paste, and a pair of scissors together with one-quarter pound of No. 28 enameled copper wire and a sheet of cardboard are needed.

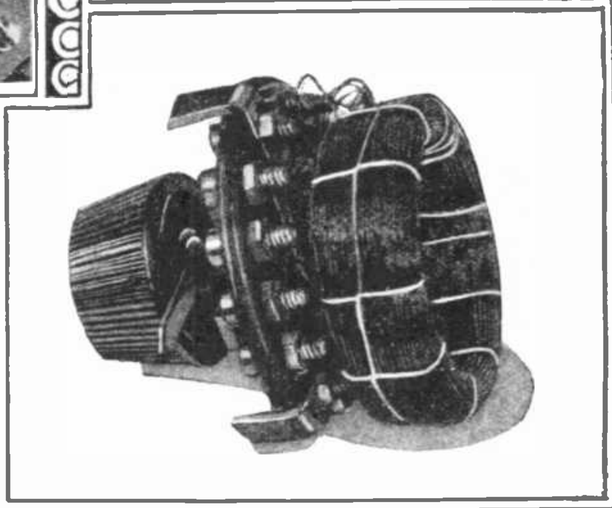


The completed coil and the discarded winding form. Immediately after finishing the winding and taking off the last tap, the coil is tightly bound with a strong string so as to prevent the wires from loosening. If desired, the coil may be dipped into molten paraffin for several minutes and then will remain impervious to moisture. You will be surprised at the wonderful volume and clarity control that it affords.



Here we see the winding jig with the coil about half way completed. Taps are taken off at every 20 turns, there being 300 turns in all. It will be very easy to keep count of the number of turns since the step-up ratio between the driving handle and the chuck facilitates the work. The taps should be carefully soldered and taped. In order to eliminate the possibility of making a mistake, the taps should be numbered successively and be connected to their respective switch points.





The completed variable impedance ready for use. At the left, we note in the diagram the input of which may be the familiar three-circuit tuner, the connections for the device. The degree of control cannot be emphasized too strongly, but even as an experiment, the device is worth making.

Piano as Loud Speaker

By Wallace R. Turner

READING about a physical law stating that a piano string or a tuning fork sets another string or fork of the same frequency into sympathetic vibration when it is struck, led me to experiment, by placing the phones upon the hammers of our upright piano, a half-inch from the strings, to see if a station miles away broadcasting a piano recital wouldn't set the strings of our piano into vibration, thus amplifying the music.

I found that the strings would not vibrate in sympathy with those in the studio, but I discovered that the sounding board of the piano amplified the music coming from the phones sufficiently to be heard all over the house. The music was found to be reproduced faithfully, which cannot be said of many loud speakers on the market.

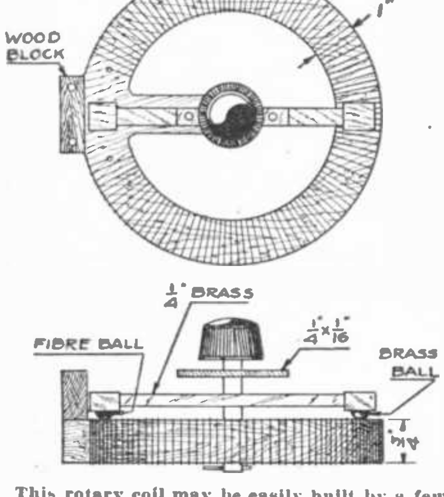
This discovery will prove to be a boon to those who possess a piano and a powerful radio set, but who either do not like the conventional loud speaker, or cannot afford one. The procedure for using the piano as a reproducer is as follows: If the piano is of the upright type, the music rack is opened wide, and left in that position, and the phones (without removing the headband) are placed on top of the keys, one-half inch from the strings, and facing the sounding board. Two or more pairs of phones can be used to better advantage, by placing them at equal intervals along the tops of the keys. If the piano is of the grand type, the phones are merely laid on top of the strings with a ring of felt or other shock-absorbing material between to keep the strings from rattling.

By keeping the piano closed and concealing the wires, one could lead a friend into believing that spirits are playing the piano. Not only does the piano reproduce piano music, but it reproduces other musical instruments and speech equally as well.

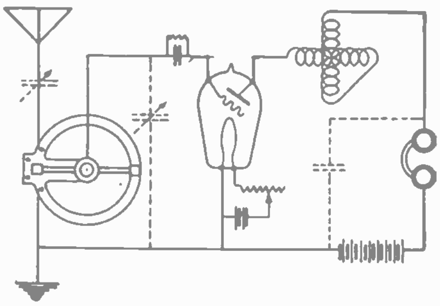
A Rotary Tuning Coil

ONE of the most unsightly pieces of radio apparatus is doubtless the tapped coil. The many taps and switch arms that are used on the average homemade set can be eliminated very effectively by the use of the rotary tuning coil as illustrated below.

The instrument described is very easily constructed by cutting a circle four inches in diameter from a piece of heavy cardboard. An inner circle is cut out, leaving a rim one inch across as indicated below. The rim is wound in toroidal fashion with No. 24 S.C.C. wire.



This rotary coil may be easily built by a few minutes' careful study of the illustration.



The above drawing shows you how to place this rotary tuning coil in the circuit.

The arms are of ¼-inch square brass. Sliders, mounted on the ends of the long arms, are kept in place by set screws. The insulation is removed on the top of the coil where the arms make contact.

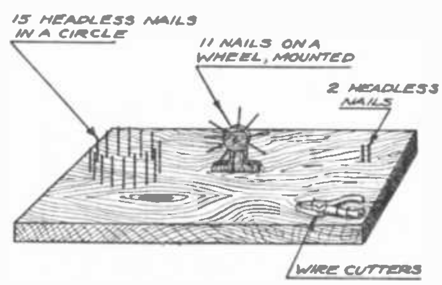
—Contributed by Wm. E. Gilbertson.

Coil Winding Board

HERE is a little device which I have found very useful in aiding me in winding coils quickly.

It is bothersome to hammer nails into a board, sometimes getting them out of alignment, every time one desires to wind a basket weave coil.

Procure a board of soft wood, about 18 inches long, 6 inches wide and approximately 1 inch thick. Next, take a good sized, round saucer or bowl, about 4 inches in diameter, and draw a circle on one end of the board, using the circumference of the bowl or saucer for drawing the circle. Now take about nineteen 5-penny nails, cut the heads off and file the rough edges smooth. Larger nails and larger shafts make larger coils. Drive these nails evenly along the circle. This completes the winding form of the basket weave coil.



This coil winding board eliminates the troublesome remaking of forms of practically all types of coils. The 15 nails at the left of the board are for basketweave coils; the 11 nails on the rotary base are for the spider-web or stagger-wound coils. The two headless nails make an effective bus bar bender while the pliers held to the board by staples are for cutting.

The next step will be to make a wooden spider-web coil form. As this has been described so many times in past issues of The Experimenter, it is not necessary to repeat the process. After the spider-web has been wound on the form, it may be secured by passing a thread in and out of the apertures, tying the two ends together. By the use of this coil winding board it will not be necessary to cut out new forms for each spider-web coil, for the process may be repeated as often as desired.

The board may be made a bit more elaborate by arranging a system of all convenient size wire on rolls and mounting them at the back of the board. This will save time and make it far more adaptable to wind large numbers of coils.

—Contributed by Cyril A. Bast.

Transmitting with a Crysta

By Neil Thompson

SINCE the average radio fan has no expensive apparatus to work with, the parts used in this experiment consisted of a crystal set and a three-tube regenerative set. In this experiment the crystal was used as a transmitter, voice being received with very good volume in the tube set. The transmission was made either by direct wire or a form of wired wireless.

The crystal set, which acted as the transmitter, consisted of a Baldwin loud speaker unit, a home-made 3,000-meter tuning coil and a standard crystal detector. When the electric light line is used to connect the sets, it is necessary that a fixed condenser be placed in the aerial lead of the set. This was necessary as a protection for the set as well as the fuses in the house. The tube set is a standard single circuit regenerator. The condenser was used here also in the aerial lead.

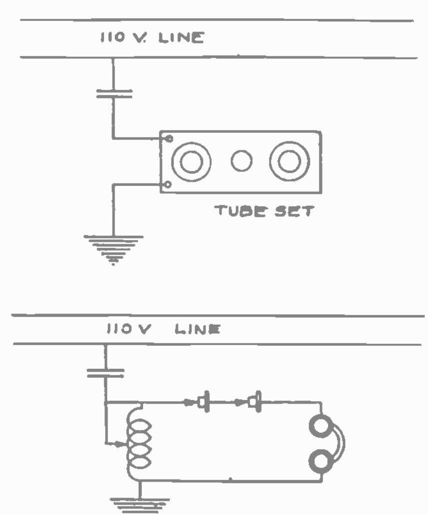
The connection to the light line is through a standard socket and plug. The wire from the plug was connected to a fixed condenser, thence to the set. This was followed out in both the transmitter and receiver. When the experiment was started, the tube set was made to oscillate. The crystal set was then adjusted to the wave by the oscillation of the tube.

The headphones of the crystal set were spoken into and were picked up by the tube receiver. The speech was picked up very loudly owing to the sensitivity of the receiving set.

When instead of the electric light line direct wire connection was used, the signals were stronger. However, in either case the signal strength was unusually loud. The two accompanying diagrams explain thoroughly how the set is wired.

There certainly must be some energy radiated by the crystal. No doubt, this energy is very small, but due to the fact that the two 110-volt lines ran parallel and very close together, from my home to the home of my friend, this energy was enough to cause a transmission from one wire to the other.

This simple experiment, I believe, should lead to bigger things in the way of crystal transmission, and I feel that there is really something in this idea that should be carried further.



You may be able to spend many pleasant hours, speaking with your friends, using this system of crystal transmission, utilizing the 110-volt line for "aerial." It was found that two crystals in series resulted in a more powerful transmission. This wrinkle presents meat for the radio experimenter.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE ELECTRON TUBE

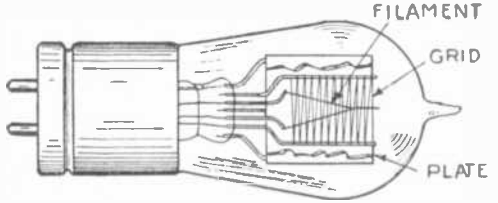
(*Action of the Grid*)

IN RADIO Data Sheets 3-2 to 3-5, inclusive, we have learned something of the phenomena going on inside an electron tube. The tube, as we have considered it so far, has had only two electrodes in it, that is, a filament and a plate. The electrons are emitted from the incandescent filament and are collected by the plate, which has a sufficiently high positive charge on it to attract the electrons.

In using these tubes in radio circuits, it is necessary to be able to control the number of electrons which pass to the plate from the filament, without having to continually adjust the potential of the plate or the temperature of the filament. For this purpose, a third electrode, which is placed between the filament and plate, is inserted into the tube. This third electrode is called the "grid," and consists of any kind of metallic surface which has openings in it through which the electrons may pass.

The idea of the grid is to *control*, or regulate, the number of electrons passing through it, and not to collect them. For this reason, the meshes, or openings, in the grid through which the electrons pass must be of appreciable size.

Now, how does the grid work? It will be remembered, as explained in Data Sheet 3-3, that there is present in the space between the filament and plate a "space charge,"



which is set up by the electrons themselves as they travel through this space. Furthermore, we must remember that the electron has a negative charge, so that any electrode placed in its path will attract it, if positive, and repel it, if negative.

So, if for any reason, the grid should happen to be negatively charged, some of the electrons emitted by the filament will be repelled by the grid and made to go back into the filament. At the same time, the negative grid adds to the negative space-charge, and altogether it becomes more difficult for the electrons to reach the plate.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE SIMPLE SINGLE WIRE ANTENNA

IN RADIO Data Sheet 10-2 we have classified the various forms of circuits in a simple manner, and in this Data Sheet we will consider the first source of excitation of a radio receiver mentioned in the list. This is the excitation by means of the ordinary outdoor antenna. The simple inverted "L" or "T" antenna is more generally used than any other type of antenna and for this reason we will consider it rather carefully.

It consists of a horizontal portion, parallel to the earth, or nearly so, and a vertical portion, which is generally called the "lead-in" or "down-lead."

We have seen in Radio Data Sheet 1-30 that the wavelength to which a circuit is tuned depends upon the values of the capacity and inductance in that circuit. This is true of the antenna circuit as well as of any other tuned circuit, for, in spite of the fact that an aperiodic (or untuned) primary is often used, the antenna circuit is tuned just the same. It is tuned indirectly, that is, through the mutual inductance between the primary and the secondary windings of the tuning coil, the secondary of which is tuned by a variable condenser. The circuit is shown in Data Sheet 10-4. This will be considered in detail later on, but, for the present, the experimenter does not want to think of the antenna system as untuned, in spite of the fact that it is called an "untuned" primary circuit.

Both the horizontal and the vertical portions of the antenna have a certain capacity and inductance. The capacity of these portions is greater than the actual capacity of the wire itself, for there is the effect of the proximity of the earth to consider. In fact, the capacity of a grounded system like the antenna circuit may be much higher than the capacity of an equivalent length of wire isolated in space.

It may be of interest here to point out the fact that no good is accomplished by running antenna wires back and forth along the roof. The writer has known of some cases where the natural period of the antenna was not great enough and the available space in which to build the antenna was not large, so the wires were run back and forth along the roof-top several times. Little, if any, good came from doing this. The student must understand that, in general, whatever is done to increase the inductance of a simple antenna will decrease the capacity and vice versa. This rule does not hold in all cases, but is a good principle to go by for ordinary purposes.

The EXPERIMENTER Radio Data Sheets

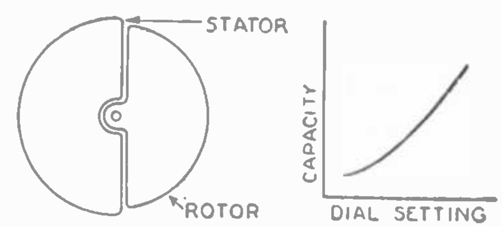
By Sylvan Harris

VARIOUS FORMS OF VARIABLE AIR CONDENSERS

THERE is no doubt that nearly everyone is aware of the extensive advertising that is going on in connection with marketing of the various types of variable air condensers. The oscillatory or tuned circuits in radio receivers contain all three elements, *viz.*, resistance, capacity and inductance, in one form or another. It is generally advisable to reduce the resistance (or "losses," as it is sometimes termed) to as small a value as possible, so that for many practical purposes it need not be considered. The inductance in the circuit is obtained from a coil of one form or another and generally has a nearly constant value. The tuning of the circuits is done mostly by means of variable air condensers, so it will be well for the experimenter to become acquainted with the three types that are in general use.

Condensers may be classified according to both mechanical and electrical features. In this Data Sheet we will consider only the electrical features, and of these features will confine ourselves to those which take into consideration the shape of the condenser plates.

The simplest form variable air condenser is the straight-line capacity type. This type has semi-circular plates. The reason why it is called "straight-line capacity" type is that



when the capacity of the condenser is plotted in a graph (as in the figure) against the setting of the condenser dial, the calibration is a straight line over its major portion.

It is evident that this should be so, since the capacity of any plate condenser is in exact proportion to the overlapping area of the plates, and the overlapping area is exactly proportional to the angle through which the movable plates are turned. In other words, equal changes of the angle (or dial setting) will produce equal changes of capacity in the condenser. Hence the calibration curve is a straight line.

CUT ALONG PERFORATED LINES

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

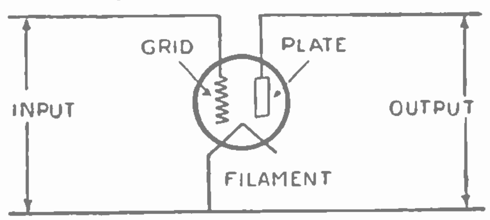
THE ELECTRON TUBE

(Action of the Grid—Continued)

SUPPOSE, now, that the grid happens to become positively charged. The positive charge will now attract the electrons coming from the filament and will, at the same time, tend to reduce the space charge. As a consequence, the number of electrons which reach the plate will be greater than when the grid is absent, or when it is negatively charged, so that the output current of the tube will be greater.

It happens, however, that when the grid becomes positively charged, it also absorbs some of the electrons, just as the plate does. Under ordinary conditions, however, since the positive charge on the grid is generally small, the tendency to absorb the electrons is likewise small. Moreover, on account of the wide openings in the grid, very few of the electrons actually strike it, but pass through those openings and thence to the plate.

It must be remembered that we are interested in the current in the plate circuit. We are not interested in current in the grid circuit. In the grid circuit we are only interested in the potential, at least for the present.



So, whatever electrons are absorbed by the grid may be regarded as having been robbed from the plate, and when this happens, it is evident that the current to the plate will not be as great as it ought to be. A flow of current to the grid represents a loss of electrical energy, and many things may happen as a result of the grid current which will cause the radio receiver to act in an unsatisfactory manner. This introduces the idea of the "C" battery or "grid-bias."

The radio energy coming in from the antenna circuit is sent into the tube *via* the filament and grid. This radio energy places a high frequency potential on the grid which is continually changing from positive to negative and back again, many thousands of times a second. Each time a change of polarity is effected, a corresponding change will take place in the current in the plate circuit.

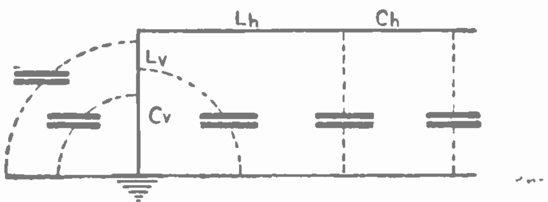
THE EXPERIMENTER, September, 1925. 3-7

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE SIMPLE SINGLE WIRE ANTENNA [Continued]

THE simple antenna circuit is shown diagrammatically in the illustration below. Each part of the wire is supposed to have a certain capacity with respect to the earth. These small capacities are represented by the small condensers shown in broken lines.



The capacity of the lead-in is regarded as in parallel with the capacity of the horizontal or flat top portion and, consequently, if we represent the capacity of the horizontal portion by Ch and that of the vertical portion by Cv, then the total capacity Ca of the antenna is

$$Ca = Ch + Cv$$

and Ca is the total capacity of the unloaded antenna, that is, its capacity when there is no coil or condenser attached to it in any way. The loaded antenna will be considered at another time.

The inductance of the antenna, however, does not follow such a simple law as the capacity does. The theory of the matter is very complicated, but for most practical purposes the results will be sufficiently accurate if we take the sum of the two separate inductances and divide by 3, thus

$$La = \frac{Lh + Lv}{3}$$

The reason for dividing by 3 is not generally known, but it is required on account of the fact that the current at any instant flowing in the antenna circuit is not uniformly distributed throughout the length of the antenna.

After obtaining the total inductance and capacity of the antenna, it is a simple matter to multiply them together to obtain the oscillation constant, as explained in Radio Data Sheet 1-30, and from this to obtain the fundamental wavelength or frequency from the table of oscillation constants given in Radio Data Sheet 1-31.

THE EXPERIMENTER, September, 1925. 2-21

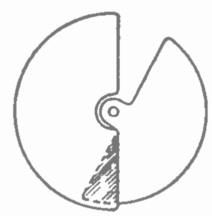
The EXPERIMENTER Radio Data Sheets

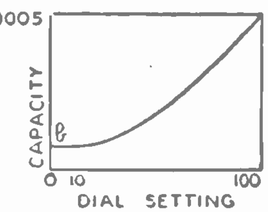
By Sylvan Harris

VARIOUS FORMS OF VARIABLE AIR CONDENSERS [Continued]

IN THE figure shown in Radio Data Sheet 5-10 it will be noted that the curve at the bottom end is not linear, that is, it is not straight. It bends over toward the horizontal somewhat. The reason for this is that the condenser has a certain capacity even when the plates are entirely *out of mesh*. This small capacity is called the "minimum capacity" of the condenser, as opposed to the "maximum" capacity, which the condenser has when the plates are entirely *in mesh*.

The minimum capacity exists because a condenser of small capacity is formed by the edges of the plates and other metallic parts of the condenser. Furthermore, it will be noted from the figure below that the plates do not begin to mesh over the whole radius of the plates until they are moved in somewhat. The angle through which they must be moved before they can be said to mesh properly is shown by the shaded area in the figure, and may be as great as 10 divisions on a dial which has 100 divisions in





its semi-circumference. As a result, the curve will not be straight for the first 10 divisions on the dial, because of the overlapping area of the plates.

It is possible for the experimenter to construct an approximate calibration curve for any circular plate condenser if he knows its maximum and minimum capacities. All he has to do is to mark a point on a piece of graph paper indicating that the capacity at 100 on the dial is the maximum capacity. For instance, in the figure, the point "a" shows the maximum capacity to be 0.0005 microfarad. Then draw a straight line, cutting the bottom of the graph paper at about 10 on the dial. Next place a point at zero on the dial (point "b"), giving the minimum capacity. Draw a curve from this point ("b"), starting horizontally and gradually turning upward until it becomes tangent to the straight line. The resulting curve will then be a very rough calibration curve of the condenser.

THE EXPERIMENTER, September, 1925. 5-11

CUT ALONG PERFORATED LINES

Uses of Paraffins at Home

By Dr. E. Bade

1. Fuse 10 grams of sodium or potassium acetate over a small flame. 2. The fused and cooled acetate is mixed with 3 grams of sodium hydroxide and 10 grams of calcium oxide (quick lime). Mix thoroughly. 3. Place the mixture in a large test tube and heat the mixture, collecting the gas evolved over water. 4. A rust preventive solution is prepared with benzol, kerosene and paraffin wax. 5. An anti-match strike surface is produced by rubbing with vaseline. Save your walls and paint.

THE simplest carbon series in organic chemistry is known as the paraffin group and it contains gases, liquids and solids, many of which are members of vital interest to all walks of life. There are a number of reasons why this is so; one, and probably the most emphatic, is, that they are so common and easily obtained, while the other is based upon their comparative inertness. This latter factor is both an advantage and a disadvantage.

The mineral oil wells, which are found in many parts of the world in large quantities, make up this series which are obtained from sand or conglomerate known as "sand rock" by boring and pumping. The origin of such oil deposits has not, as yet, been established, although many interesting theories have been advanced to account for their presence. One calls attention to the fact that aluminum carbide gives methane, or march gas, the simplest of the paraffins, by the action of water, and, therefore, presupposes that underground deposits of such carbide, acted on by steam, may have resulted in the formation of the rock oil. Others claim that their presence is due to the decomposition of the remains of marine life under pressure and this view is supported by other experiments whereby a quantity of paraffins have been obtained by heating the blubber of fish under pressure.

The simplest paraffin is marsh gas, or methane, and it occurs in oil wells, bogs and swamps, coal mines, where it is known as fire damp, etc. It also is produced by decomposition under water by means of certain bacteria, and this is a special process of fermentation. Then, too, methane forms about 35 per cent. of the gas produced by the distillation of bituminous coal for the production of illuminating gas.

There are many ways in which methane can be prepared in the laboratory. The most common method uses soda lime and fused potassium or sodium acetate, which are heated together, whereby the acetate gives up its methyl group. Fuse about 10 grams of sodium acetate and cool. Grind together equal quantities of this fused mass with about 10 grams of quicklime and 8 grams of sodium hydroxide. Place the mixture in a large test tube, stopper and pass a bent glass tube through the stopper to the end of which a rubber tube is connected with its other end under water. Heat the test tube strongly and collect the gas. It will be methane, the simplest of all the paraffins. The gas is collected over water.

Fill a small bottle or large test tube full of water, carefully invert over the pneumatic trough so that no water is spilled. No air should be in the tubes when they are inverted. Let the gas bubble into the inverted tube or vessel; this will displace the water and the pure gas is thus easily collected. After the first test tube full has been collected, collect more gas in a small flask in the same way. Place a match near the open end of the test tube; a slight explosion will result. This is due to the mixture of air and gas, the air coming from the gas generator. The gas also burns with a luminous flame, due to impurities present, which can be removed. Into the flask containing the collected gas pour a few cc. of conc. sulphuric acid. Do this very quickly and stopper as rapidly as possible, for no air should be allowed to mix with the gas. Rinse the flask with the acid. Then add a few cc. of fuming sulphuric acid and repeat the rinsing after quickly stoppering again. Let the closed flask remain for about an

(*Continued on page 777*)

Combustible Gas and Vapor Detection

By E. F. Bacon

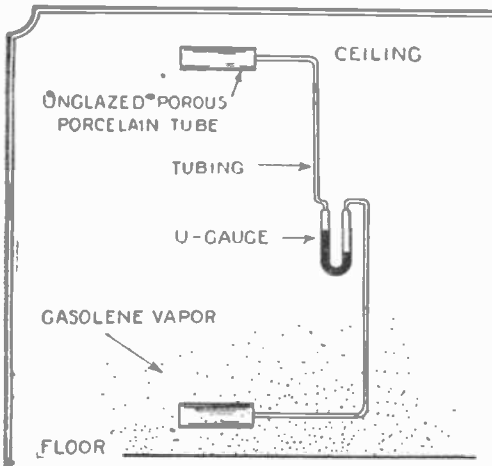


FIG. 1

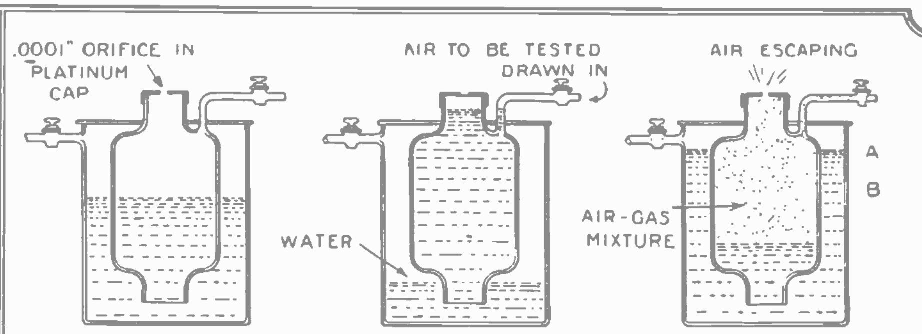


FIG. 2

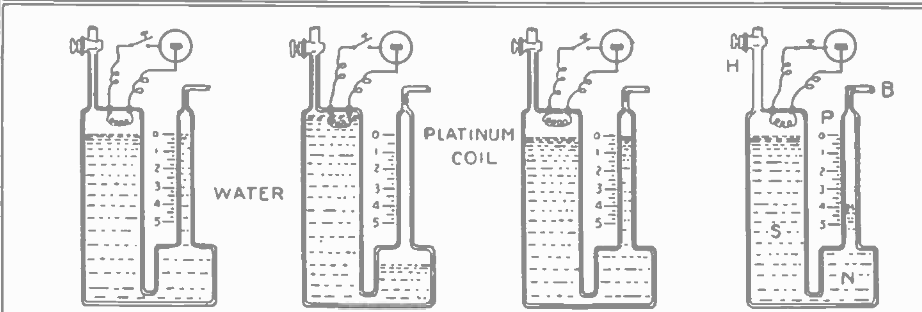


FIG. 4

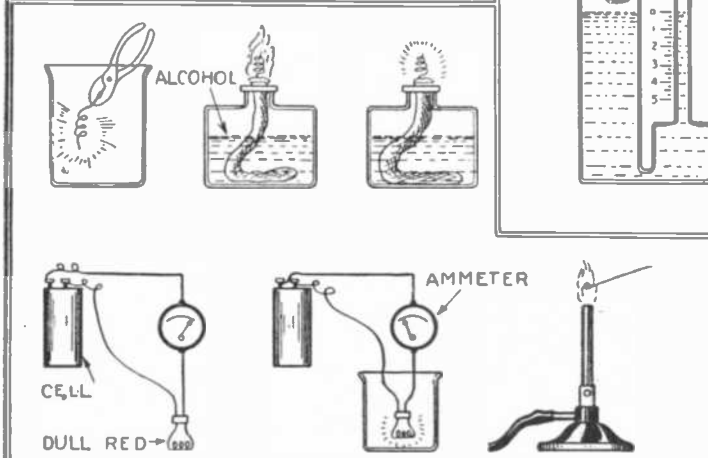


FIG. 3

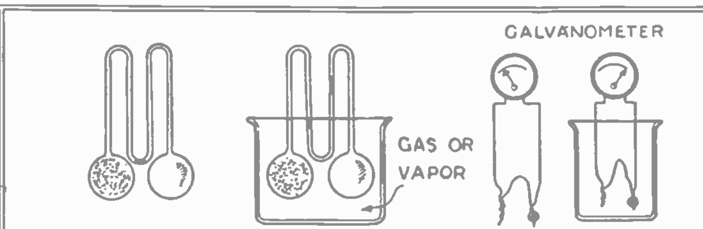


FIG. 3-A

Fig. 1. Unglazed porcelain vessels are placed one at the ceiling and one on the floor. There is a difference in pressure in two limbs of a U gauge, if one is in air and the other in gas or gasolene. Fig. 2. Effusion of gas or contaminated air through a small orifice under pressure indicates the specific gravity by the time it takes to escape detecting contamination. Fig. 3. By catalytic action platinum produces slow combustion as of alcoholic vapor in air. Immersion in a mixture of alcoholic vapor and air heats the wire and affects the current going through it. Finely divided platinum will light a Bunsen burner. Fig. 3a. A bulb coated with finely divided platinum if immersed in a mixture of air and combustible vapor or gas is heated if placed in a combustible mixture and moves a little column of mercury in a connecting tube, or the same principle may be made to operate a thermo-electric couple producing a current shown on right. Fig. 4. By heating the coil as shown, if combustible gas is present mixed with air it will be burned up and reduction in volume will indicate its presence. The water should be alkaline.

A GREAT many fires and explosions can be directly traced to the accumulation in closed spaces of combustible gases or vapors.

The only common means of detecting these gases and vapors is by the sense of smell. Carbon monoxide, for instance, the deadly gas present in automobile exhaust gases, is practically odorless, and for this reason, impossible to detect without suitable apparatus. In view of this widespread danger to life and property, it is pertinent to consider the characteristics of these gases and vapors, especially those characteristics which could be most easily used as a means of detection. Two such distinctive characteristics are density and combustibility, and many instruments can be conceived which use either of these qualities as the activating medium. The several schemes outlined below and shown are laboratory methods of measuring the density or the combustibility of gases. Anyone with an inventive mind should be able to incorporate one of these principles into a simple, practical instrument for gas detection.

Fig. 1 shows the method of detecting a heavy vapor, such as gasoline vapor, by means of two porous porcelain chambers, connected to a U-gauge or other differential pressure gauge. The gasoline vapor diffuses through the chamber near the floor, and causes an increase in pressure which is indicated on the gauge. This type of instrument could also be used in detecting gases which concentrate near the ceiling. The use of two chambers compensates for temperature changes.

The method of determining density which is illustrated in Fig. 2 is a common laboratory procedure. The time for any two gases to escape under the same conditions of temperature and pressure has a relation to their densities. Two gases, S and S_1, take time t and t_1 to pass through the orifice. The density varies with the square of the times.

If air is taken as 1, then density of the gas tested can be easily determined.

The remaining diagrams illustrate the possibilities of employing the combustibility characteristic of the gases and vapors. The catalytic action of platinum, palladium and rhodium on combustible gases and vapors is of great value for their action. These metals, under certain conditions, greatly accelerate the combustion of gases, especially those which contain hydrogen or hydrocarbons. Fine wires of these metals, when heated to a dull red, and then exposed to a combustible mixture, will glow brightly, due to the burning of the gas by flameless combustion on the surface of the wire. When finely powdered forms of the metals are used, such as the so-called black or sponge, the metal when exposed at ordinary temperatures to an explosive mixture of hydrogen and air will glow brightly. A pellet composed of platinum and rhodium black will ignite a stream of illuminating gas. The preparation of this black or sponge is a simple process which is outlined in any standard book on chemistry.

While this catalytic action at room temperatures is most noticeable on hydrogen and illuminating gas, the black is slightly heated by alcohol and gasoline vapors. In the case of these latter vapors, the catalyzing action soon becomes sluggish and fails. For this reason most satisfactory results can be obtained by the use of the metal in the form of wire heated to a dull red. Fig 3 illustrates a few experiments on the catalytic effect obtained with these metals in combustible mixtures.

Fig. 4 shows a method of determining the per cent. of combustible gas present in the air by measuring the shrinkage of volume after burning the combustible element. The products of combustion, principally CO_2 and water vapor, have a smaller volume than the combustible gases.

Fig. 5 represents an apparatus which detects combustible gas by indicating the pressure drop across orifice plates before and after burning the combustible elements with

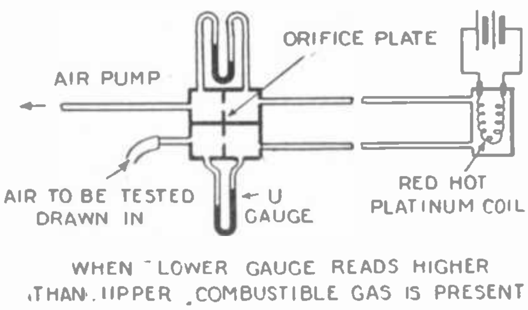


FIG. 5

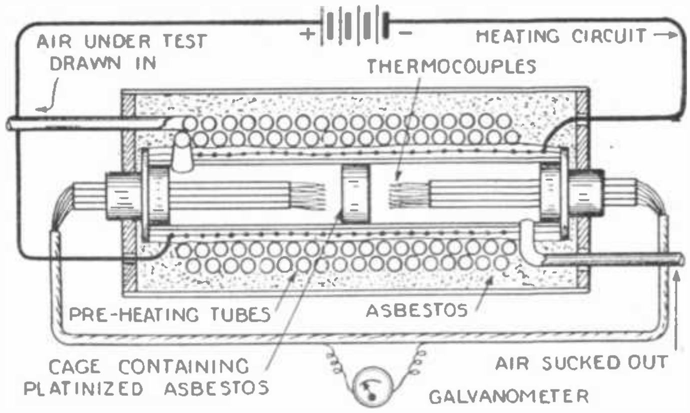


FIG. 6

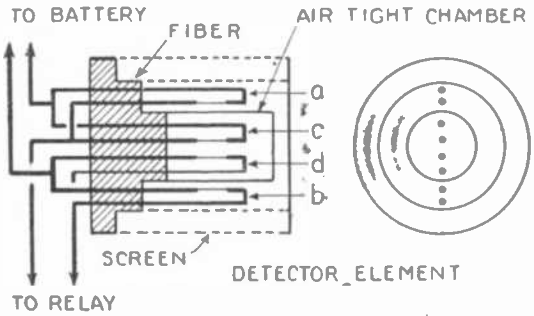


FIG. 7

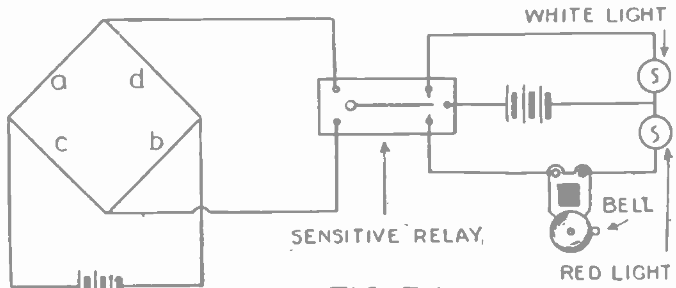


FIG. 7-A

Fig. 5. If air under test contains gas, its volume will be reduced and the difference of pressure on two sides of the diaphragm will indicate its presence. Fig. 6. Here platinized asbestos acting on a gas mixture affects its temperature so as to affect a thermo-couple or battery and indicates the presence of gas. Fig. 7. An apparently complicated set of connections which act as a Wheatstone bridge. Two arms are exposed to pure air and two to the air to be tested; all four arms are kept at a low red heat, and the presence of gas throws the bridge out of balance and operates a relay, the diagram of connections being shown on the right.

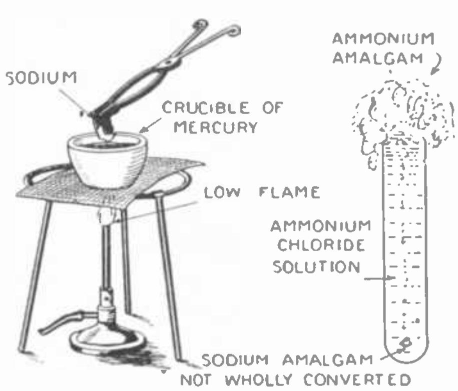
oxygen of the air. An increase in pressure at the lower gauge and a decrease at the upper shows gas to be present.

In the apparatus shown in Fig. 6 the air to be tested is heated to 300° C. (572° F.) and passed through a cage containing platinized asbestos. The platinum causes flameless combustion, and a higher temperature results in the air which has passed through the cage. Differential thermo-couples measure this rise in temperature which is proportional to the amount of gas present in the air.

Fig. 7 shows a method of utilizing the change in resistance which accompanies the rise in temperature of heated platinum wires when they are exposed to combustible gases or vapors. This instrument is essentially a Wheatstone Bridge, the arms of which are fine platinum or palladium wires. A battery is connected across two corners of the bridge and a relay galvanometer across the other two. Sufficient current is passed through the bridge to heat the arms to a dull red heat. If now, two opposite arms of the bridge are exposed to pure air, and the other two to the air-gas mixture, the bridge becomes unbalanced by the catalytic action of the hot platinum on the combustible vapors. The vapors are burned upon the surface of the wires with flameless combustion, thereby heating the two wires exposed to the vapors, and increasing their resistance. This unbalanced condition of the bridge causes the relay galvanometer to close a circuit containing alarm devices, such as a red light, or an electric bell. The two wires which are protected from the gases are encased in a thin copper cylinder.

Ammonium Amalgam

By J. Harold Byers



Amalgam of sodium acting on an amonium chloride solution is supposed to produce an ammonium amalgam, a most interesting demonstration.

AMMONIUM amalgam, NH_4—Hg, is an alloy of the ammonium radical with mercury. It may be made from sodium amalgam and concentrated ammonium chloride (sal ammoniac) solution.

First prepare the sodium amalgam by adding sodium to about 10 times its volume of mercury which has been heated to 70 to 100 degrees C. (158° to 212° F.) Having carefully removed the oil from the sodium with blotting paper, plunge it quickly into the mercury.

Take precautions to protect yourself against flying bits of mercury, as the reaction is violent.

When cool, drop the sodium amalgam into ammonium chloride solution. An astonishing increase in volume will be noted. The metal will rise to the surface and froth over the mouth of the test tube, due to liberation of hydrogen and ammonia gas from unstable ammonium.

Since only metals alloy with mercury, ammonium must act like and represent a metal, although it is not known to exist alone. It differs from ammonia gas only by one atom of hydrogen. Ammonium amalgam is the probable means by which the chemical experimenter will eventually effect the isolation of hypothetical metallic ammonium.

Experiment in Deflagration

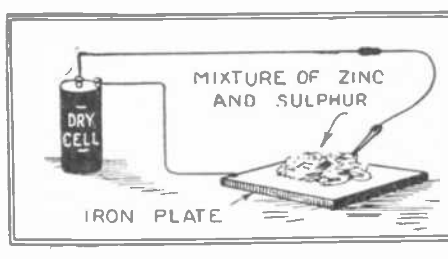
PROCURE a tin can cover. Place on it a mixture of two measures of zinc dust and two measures of sulphur.

Run two wires from a dry cell, one to the tin can cover; on the other attach a needle. Rub the needle around in the mixture until it ignites, and, presto! it will go off with a flash, followed by a lot of smoke.

Be careful to keep the hands and face away; do not touch the remains while the combustion is still active.

In this and in the preceding experiments it is well to hold a pane of glass in front of the face.

Contributed by HAROLD YOUNG.

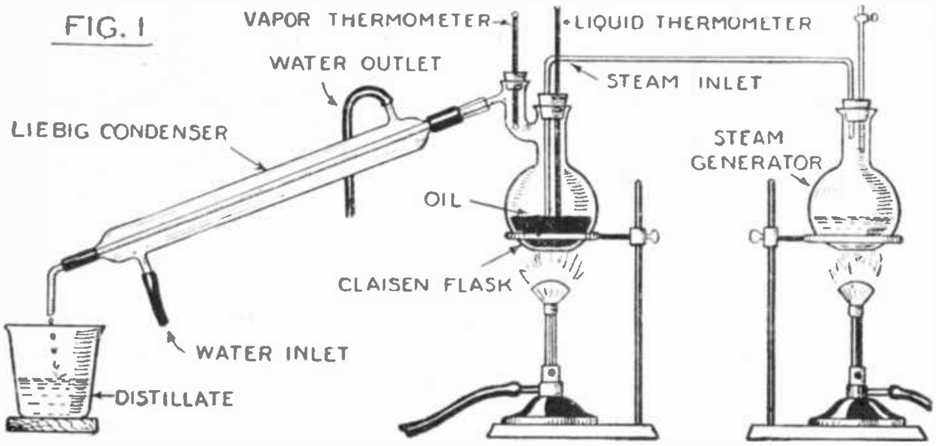


Deflagrating a mixture of zinc and sulphur with a spark directly produced from a battery without any spark coil being required.

Experimental Cracking Of Oils

By W. A. Sperry

FIG. 1



Petroleum is rectified not only by fractional distillation, but also by processes of cracking, which cause chemical decomposition. Above is shown a simple apparatus for studying the subject in the laboratory, using familiar apparatus. Note the two thermometers, one for the liquid and one for the vapor.

THE so-called "cracking" of oils is a term used to denote the breaking up of the hydro-carbon molecule. It is generally applied only to those processes which make use of this decomposition for the production of light, valuable gasolenes and naphthas from heavier, more complex mineral oils. The refining industry considers any means of accomplishing the above reaction a cracking process, and this includes the use of heat, pressure, chemicals and electricity.

At the present time there are two broad systems employed commercially for cracking, aside from chemical methods; these are known as cracking in the *vapor phase* and cracking in the *liquid phase*, but the former holds out so many difficulties to the commercial refiner that it has been largely relegated to the production of gas from oil. Cracking in the liquid phase is the principle on which practically all the successful modern cracking processes operate, and their reproduction in the laboratory is easily executed. A somewhat fuller explanation is necessary before attempting the experiments submitted below, and this should be carefully read and digested.

Petroleum refining is a treatment consisting of fractional distillation, chemical processing, filtering and compounding, while there are often supplementary cracking processes involved between these operations. The oils used as cracking stock are distillates or "cuts" taken off after the naphthas, gasolenes and kerosenes naturally contained in the crude petroleum have distilled over and are called "gas oil," "fuel distillate," etc.

There are two elements in cracking that are important and should always be considered. They are: temperature and the time during which the molecule is subjected to that temperature. In accord with Boyle's law, the pressure and temperature are functions of each other, so that as the pressure is increased the time element is decreased. Every petroleum hydro-carbon has a characteristic temperature at which decomposition takes place; for the gas-oil and fuel-oil distillates mentioned above this temperature is between 280° C. and 315° C. (536° F. to 599° F.) Heavy oils crack with comparative ease, while the lighter cuts require extreme temperature and pressure. Commercially, therefore, the cuts above the kerosene fraction are seldom cracked.

Theoretically, the cracking reactions are but vaguely understood. The following formula is advanced* in explanation of them:

$$2CnH_2n + {}_2 = 2C\ (n\text{-}m)H_2(n\text{-}m) + mC\ H_4 + mC$$

Applying this to Pentadecane ($C_{14}H_{32}$):

$$2C_{15}H_{32} = 2C_8H_{16} + 7CH_4 + 7C$$

Pentadecane, Octane Methane Carbon

The application of this formula in experimental work helps in the determination of the constituents of a cracked oil.

* * * * *

The apparatus needed for experimental cracking in the laboratory is quite simple, and comprises only standard equipment. A fractional distillation set is built up as in Fig. 1. and will suffice for cracking under ordinary pressure or with the use of chemicals. If the Liebig condenser or the rather rare Classen flask cannot be obtained, the arrangement shown in Fig. 2 will work practically as well. This is easily set up from materials not hard to get; the condenser is made from a length of glass tubing, pipe, or even rubber garden hose, and has its ends plugged by rubber stoppers provided with holes for the condenser tube, and water inlet and outlet. It is imperative, however, to have at least one thermometer, preferably Centigrade, of either half or total immersion, in order to adequately control temperature. If only one is available, it should be so arranged as to record the vapor temperature, and then to read the liquid temperature it must be forced down into the solution. Besides the outlets for thermometers and vapor, the flask should be provided with a gas or steam inlet.

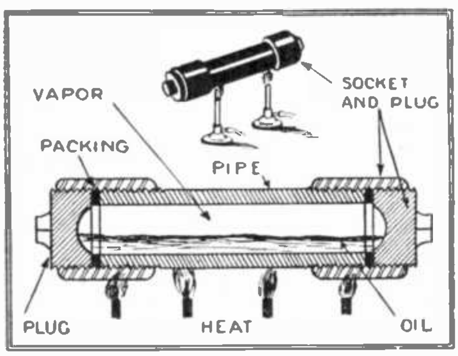
Before attempting to do any cracking it is best to use the apparatus as a simple still, not only to test it but also to familiarize oneself with its manipulation. Pour about 250 ccs. of crude oil, if you have it, into the flask and proceed to raise the temperature gradually to about 210° C. (410° F.) The first distillate that comes over is crude benzine (gasoline and naphtha). When the temperature of the oil has reached 104° C. (219.2° F.), it is wise to introduce steam or some inert gas into the still; this not only brings over the distillate at a lower temperature, but also sweetens and deodorizes it. Incidentally, in working with oils, one must expect to be assaulted by unpleasant odors most of the time. After the mercury in the thermometer has remained at 210° C. (410° F.) for a few minutes, raise the vapor temperature to approximately 300° C. (572° F.), when the next fraction (kerosene or water-white distillate) will come over. Leave the steam generator connected, as the steam will prevent cracking and consequent discoloration of the product. The next cut is distillate oil or gas oil and the distillation is continued under higher temperature and increased pressure for some time, but as the experimenter will doubtless have no method of ascertaining the specific gravity of the residium, at this point the experiment must cease.

The process so far has paralleled typical refining practice, save that in the industry, cuts are controlled by Baumé gravity instead of entirely by temperature. The residue in the flask will vary according to the source of the crude, possibly there will be a wax base, or it may consist of asphaltic material or "coke." From this residuum, lubricating oils and paraffin wax are made, dependent, however, on the percentage of original wax in the crude.

Now for cracking. For stock, practically any oils one has may be used. Moreover, in the process which I shall describe, ordinary cylinder oil, universally obtainable, is utilized for this demonstration. A quantity of this is put into the flask and the steam inlet closed, at the same time making sure that all other connections are tightly fitted. Since a fairly high pressure is necessary, the condenser tube is also closed. A suggestion which decidedly hastens the reaction is the idea of building a "pressure cracking bomb" from pipe fittings, which is capable of withstanding a markedly higher degree of pressure than the flask. Heat is applied until 400° C. (752° F.) is reached, when cracking will begin. Thirty minutes at this temperature should suffice to bring about partial decomposition, so that there will then be light products in the flask, which will distill over upon lowering the temperature and opening the condenser tube. These products are synthetic gasolenes and naphthas, and this is the process by which a large part of the present artificial gasolene is made, only the pressure in the commercial still is well up to 200 atmospheres, which, of course, cannot be accomplished by our apparatus, although the pressure in our bomb at the end of an hour may be as much as 100 atmospheres. To make up for this deficiency, a longer time is required, so that at 400° C. (752° F.) at least three to five hours are needed.

If the experimenter has saved the cuts taken from the distillation experiment, he may further duplicate refinery processes by placing some of the gas-oil or some of the water-white distillate in the flask or bomb, proceeding as in the above experiment. The results will yield considerable gasolene and other distillate, having densities ranging all the way from far above the original stock gravity to those having low densities representing high-grade naphthas.

By means of the Cross process of cracking, a synthetic crude oil is produced, which is then fed back and mixed with the natural crude. To do this in the laboratory, use the same flask but disconnect the condenser tube and construct a reaction chamber from a



A high pressure iron cell or still for operating at higher temperatures to crack petroleum products.

*Cross: Bulletin 16, Kansas City Testing Laboratory.

section of iron pipe, as in Fig. 3. The stock is gas-oil or kerosene distillate and is heated in the flask to a temperature of 480° C. (896° F.), at which point it is transferred to the reaction chamber by shoving the tube (a) down into the oil so that the vapor pressure will force the oil out into the pipe. Here the cracking reaction takes place with the disposition of carbon in the chamber. Upon opening the cooled pipe, an artificial crude oil resembling the source crude will be found. This may be distilled or cracked again at pleasure.

Here's something peculiar. Since paraffin wax is a derivative of petroleum, it is easily possible to crack the same and thus to manufacture an excellent quality of gasolene! To do this follow the procedure of the first method outlined above.

There are several chemicals which have the property of decomposing, by catalysis, hydro-carbons heated in their presence. Aluminum chloride has proven the best and most active reagent, but other metallic chlorides exhibit the same catalytic action. The anhydrous chloride is mixed with the stock which, is then heated to about 260° C. (536° F.); at this stage the solution probably will volatize and it is needful to keep the temperature just below this point. Decomposition takes place, yielding octane, heptane and hexane as constituents of the resultant light oils, whose recovery is accomplished in the usual manner, with, however, the omission of further chemical processing.

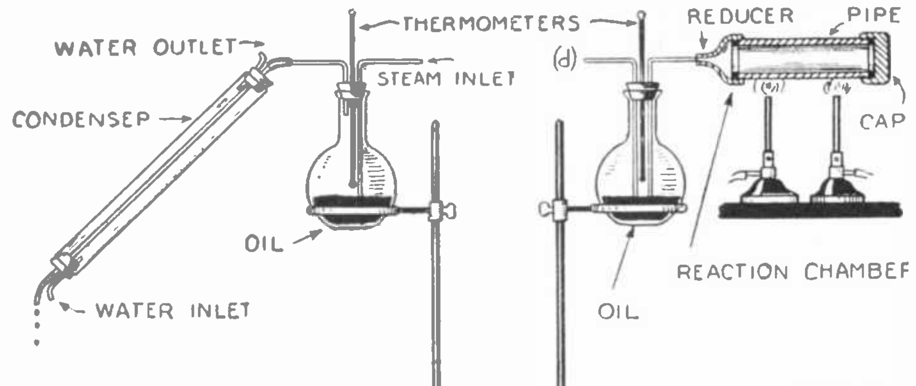


FIG. 2 FIG. 3

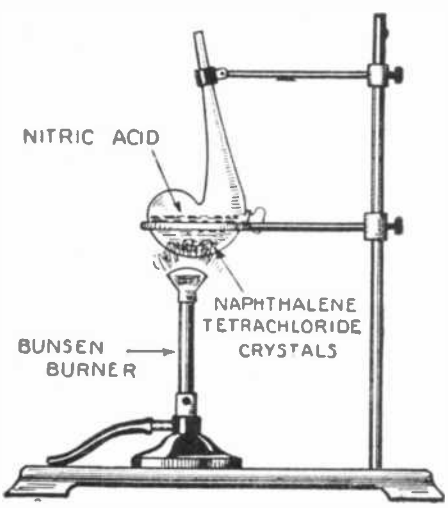
Fig. 2 shows a simplified construction, dispensing with one of the thermometers, of what is shown as a more elaborate apparatus in Fig. 1. Fig. 3 shows the use of the high temperature still, for the heavier products.

The question of where to secure the necessary oils with which to perform these experiments may prove troublesome, as it did to the writer. Many service stations keep on display, racks of samples of the different crudes, distillates, etc., from which its gasolene is make, and it is highly probable that the earnest experimenter can obtain one of these, or part of one. Of course, there are always kerosene, cylinder oil and many kinds of lubricating oils that may be utilized.

Thus far, only petroleum products have been mentioned in connection with cracking. It is possible, however, to crack animal oils, such as lard, butter, etc., and, as a result, a batch of more or less complex, volatile oils is obtained, and by following the suggestion given for cracking petroleum oils the experimenter may be able to obtain these products and duplicate the operation of the great oil refinery.

Preparation of Fluorescein

TO make fluorescein powder, mix 4 gm. of naphthalene, or moth balls, as such are sometimes called, with 8 gm. of potassium chlorate. Put this in a beaker and add *slowly* 38 c.c. of hydrochloric acid,



Treating napthalene tetrachloride with nitric acid, a step in the production of the beautiful fluorescein, a minute quantity of which develops high fluorescence in water.

sp. gr. about 1.18. Operate either out of doors or under a hood, on account of chlorine gas generation.

Naphthalene tetrachloride is formed and sinks to the bottom of the beaker as crystals. Wash with water and add slowly to 35 c.c. of nitric acid, sp. gr. about 1.42, and boil in a retort with the neck upright. When the crystals are dissolved, evaporate the acid and distill the residue; phthalic anhydride passes over. Recrystallize from water and add from 5 parts to 7 parts resorcinol. Heat in a test tube to about 200° C. (392° F.) or until the mass fuses and boils, then cool. Fluorescein is formed.

Dissolve the fluorescein in a solution of sodium hydroxide, also in a solution of potassium hydroxide. Notice that while they are different, the two solutions show a wonderful fluorescence, one color by reflected light; another color by transmitted light.

Put about 1/8 grain of the fluorescein in a test tube and add about 2 drops of bromine (prepared according to any standard textbook). When the reaction is over, drive off the bromine if in excess, by a gentle heat. Put 5 c.c. of this solution in a test tube and boil, adding potassium carbonate from time to time until the beautiful tint is properly intensified. The exquisite colors and fluorescence are due to the potassium salt of eosin (tetra-bromo-fluorescein) which is sometimes used as a dye. Add some gum arabic to the solution and use it as ink. Drop a few drops in a test tube of water and notice the delicate pink of the early dawn.

Contributed by Edward Mackey.

Simple Laboratory Burners

IN chemical experiments where an alcohol lamp or Bunsen burner are needed, inexpensive ones may be made which will do the work.

For the alcohol lamp an ink bottle serves as the container. A strip of tin bent into a shape as a metal tube ¼ inch in internal diameter and 1 inch long will make the holder for the wick which is made of string doubled up a number of times. A glance at Fig. 1 will show the arrangement of parts with (A)

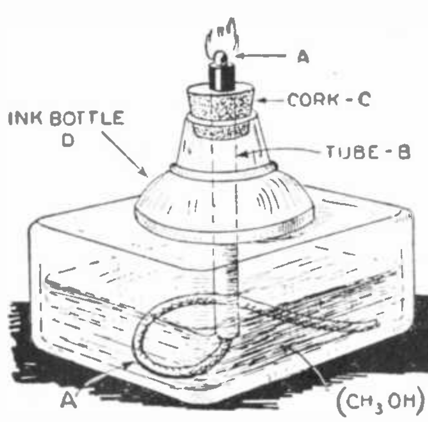


FIG. 1

An alcohol lamp for the laboratory extemporized from an ink bottle.

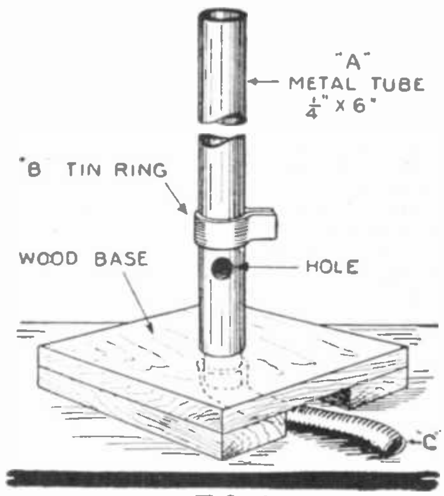


FIG. 2

A simple Bunsen burner made of the most primitive materials with adjustment for the air mixture.

the wick, (B) the tube, (C) the cork and (D) the ink bottle.

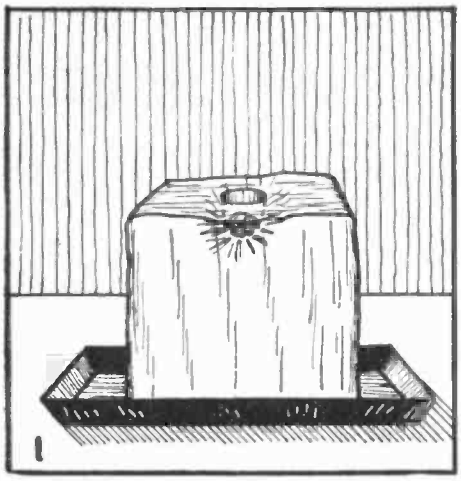
The Bunsen burner is made of a real metal tube about ¼ inch inside diameter and 6 inches long. A small hole a short distance from the bottom is drilled through the tube.

A tin ring wide enough to cover the hole just drilled, fitting snugly yet so it will slip up and down on the tube, is needed to regulate the air supply. A wooden base may be constructed as is shown. In Fig. 2 (A) is the metal tube, (B) the tin slide ring, and (C) the rubber tube leading to the gas supply. In lighting this burner it is rather important to cover the air aperture with the sliding ring first. Then after lighting it you must gradually give more air until the desired non-luminous flame appears.

—Contributed by Carl W. Fischer.

Six Interesting Chemical Experiments

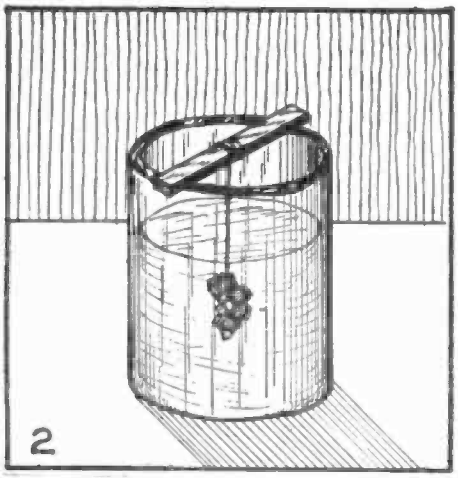
By Milton L. Keyes



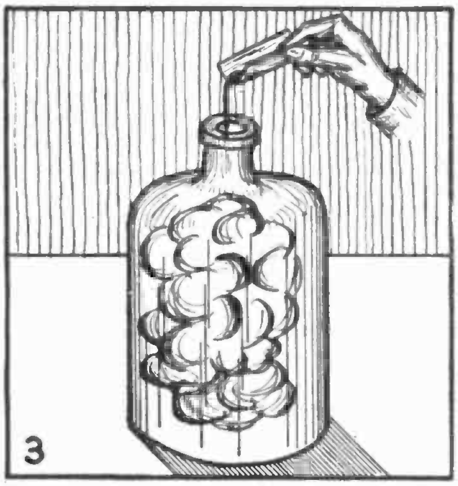
Fire on ice with metallic potassium.

MAKE a small, deep cavity in a piece of ice and into it drop a small piece of potassium. Immediately a flame, tinged with purple, appears. A sharp explosion follows, so it is imperative to stand at a distance. The flame is produced by the burning of hydrogen, which has been pushed out of the water molecules by the potassium, and the color is due to the metal vapor.

To make "rock candy" dissolve enough sugar in hot water to give a saturated solution. Suspend a string in this solution and crystals will form on the string. When the crystals cease growing, suspend them in a fresh solution and they will again grow.



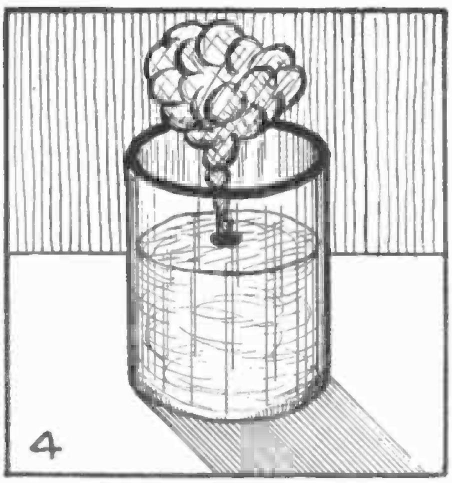
Making rock candy in the laboratory.



Spontaneous combustion of metals in chlorine.

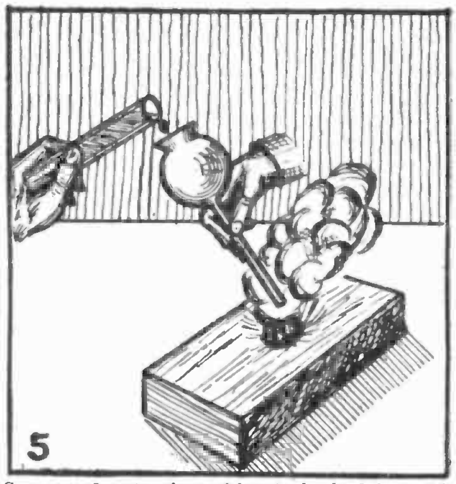
Put a small piece of potassium chlorate in a test tube, cover with a few drops of hydrochloric acid and warm gently. Collect some of the chlorine gas given off in a jar and throw into the jar a small quantity of iron powder. A shower of brilliant sparks is produced as the two elements combine. Also try powdered antimony.

The reaction is exothermic; that is, it generates heat and causes the incandescence of the iron particles.



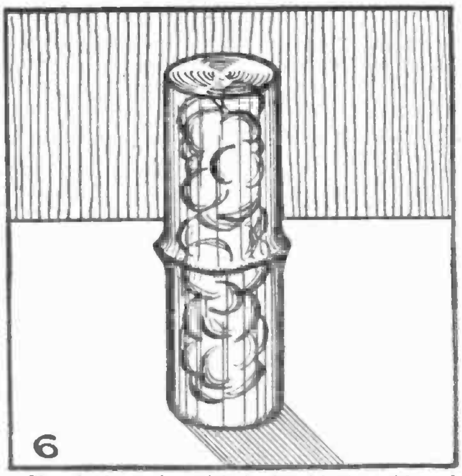
Flames from water with floating potassium.

Into a glass tumbler a third full of water drop a piece of potassium. This causes hydrogen to be given off which is set on fire by the heat from the chemical action. The flame is tinged with a bright violet as above.



Suger and potassium chlorate ignited by acid.

In a clean porcelain mortar pulverize a small quantity of potassium chlorate. Avoid heavy pressure in doing so. Place the powder on a paper and mix with an equal amount of dry sugar which has been crushed to powder. Do not rub the two materials together, as they are liable to explode. Place the mixture on a stone and let fall upon it a drop of sulphuric acid. Immediately a violet colored flame appears. This is due to the vapor of the potassium salt.



Chemical smoke with hydrochloric acid and ammonia.

Rinse one tumbler with ammonium hydroxide and the other with hydrochloric acid. Cover one with paper and bring it to the mouth of the other. The white solid formed is ammonium chloride.

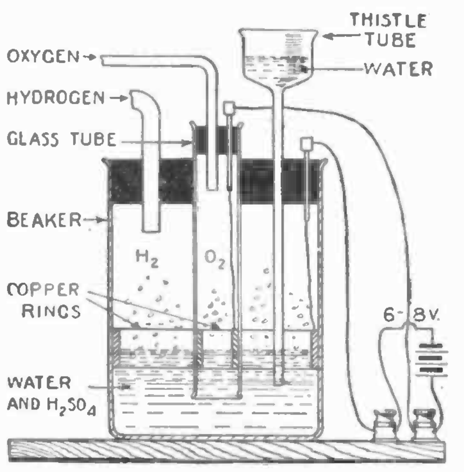
Making Oxygen and Hydrogen by Electrolysis

By Lester S. Thomas

THE accompanying illustration shows how oxygen and hydrogen can be made in large quantities in the laboratory by electrolysis.

The main part of the generator consists of a large beaker or a wide mouthed bottle fitted with a cork to prevent the escape of gas. Since twice as large a volume of hydrogen is made as of oxygen, the hydrogen must be made in this part of the generator. An iron ring, fastened tightly in the beaker about half way from the bottom, serves as the negative electrode. The ring *must* be above the bottom of the glass tube in which oxygen is generated to prevent a mixture of gases which would explode when used.

The oxygen generator is made of a piece of glass tubing inserted in a hole in the cork, which may be an inverted test tube with the bottom cut off and a one-holed cork with a delivery tube fastened in the end.



The bottom of this tube should be about one and one-half inches below the level of the liquid. An iron ring is also used here as the positive electrode. Rubber covered wire should be used to connect the electrodes to a battery.

A very neat arrangement for producing oxygen and hydrogen gas by electrolysis is shown here. By adding water as fast as the solution is expended the apparatus can be used indefinitely.

The electrodes should be covered with the liquid at all times. A thistle tube in the large cork serves to introduce a solution of sodium hydroxide or water and its lower end should be under water. A delivery tube is also provided in the large cork to collect the hydrogen. All corks should fit tightly and should be shellacked. The solution is made by adding caustic lye to water until it will easily pass a current. A battery of from 6 to 8 volts is used.

Vacuum As Insulator

By G. Lagerquist

MOST people that think of vacuum in connection with electricity have the idea that it is a good conductor of electric current. This assumption is maintained even among a great number of engineers. And they are right if by vacuum we mean the best evacuation that could be attained twenty years ago or let us say the degree of vacuum we have in a Crookes tube.

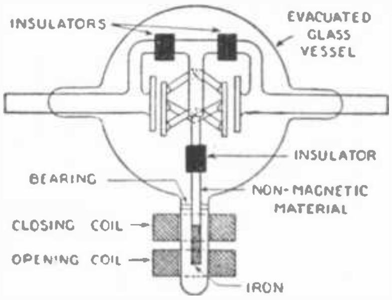


FIG. I

The figure illustrates a circuit breaker whose contacts are placed in a vacuum. The disadvantages arising from the use of oil in circuit breakers is here eliminated. At the same time adequate provision is made for preventing excess. ·e temperature rise of the electrodes while the circuit is broken under heavy load.

What is vacuum then? Vacuum is gas at any pressure below the atmospheric. All gases except neon and argon are pretty good insulators at atmospheric pressure and higher; but when the pressure is lowered, the resistance drops and reaches a minimum at about one-tenth of a millimeter of mercury column. When lowered still more, the resistance starts to increase again and will undoubtedly reach infinity at absolute vacuum. Absolute vacuum nobody has yet been able to attain, only pressures as low as one billionth part of a bar or about 8 ten million millionths (8×10^{-14}) of a millimeter mercury column. The one means of passing electric current through vacuum of this degree is by heating either one or both of the electrodes to the temperature at which they emit electrons. By means of these electrons the current can pass through the evacuated space.

We now may ask how the insulating qualities of vacuum can be utilized.

Everyone now-a-days knows about the vacuum tubes and so much has been written about them that I will not waste any words on that subject. I will show the reader other and probably not less important possibilities for the use of vacuum space.

In the generation and distribution of electricity, so-called oil circuit breakers are used partly to switch off and sectionalize parts of the system and partly to protect generators and transformers. It happens occasionally that such a breaker explodes when efforts are made to break a heavy current. When this occurs, burning oil is thrown around and ignites everything. Many a substation has burned down as a result of an oil switch failure.

Several years ago I started to figure out how to avoid these failures, which are such a danger both for the operator and for the equipment in generating stations and in substations. I considered all kinds of substitutes for the oil and at last I came to think of vacuum. I made the most careful calculations in order to find out whether or not the contact surfaces of the switch would heat up enough to emit a considerable amount of electrons while opening it. According to my calculations the switch could be opened so fast that even under very heavy currents the temperature would hardly go up to 400° C. (752° F.) and copper does not emit any great amount of electrons before it is at a white heat. Fig. 1 shows the vacuum switch. Calculations made me think of what a wonderful condenser there could be built with vacuum as dielectric. I started in on new calculations and designed three different types. Fig. 2 shows a type that can be built in small cylindrical units of increasing diameter and placed concentrically and outside of each other to any convenient size. Fig. 3 shows a later design which I thought could be built at once in large units. When designing these condensers I had in mind a 110,000-volt power system in which they could be used with great advantage for power-factor correction. The space between the condenser plates need not exceed one millimeter for this high voltage, but the condenser has to be so designed that the glass walls do not intersect the electrostatic field. If they do, they will have to be very thick or they will be pierced through by sparks and the vacuum will be lost, and if they are heavy enough to withstand this they will heat up due to so-called electrostatic hysteresis. Fig. 4 shows a design which it was thought could be built entirely of copper except for one terminal outlet and an evacuating opening.

Many different uses can be found for high voltage static condensers. The power-factor correction, of course, ought to be the main one, but another place where a vacuum condenser could be of advantage is where carrier current telephone waves are impressed on a power line. The condensers now used for this purpose are very expensive and very clumsy looking affairs. In the high voltage testing and research laboratory the vacuum condenser will surely be accepted with acclamation because the cost does not increase with the voltage as is the case with paper, mica, glass, porcelain and oil insulated condensers.

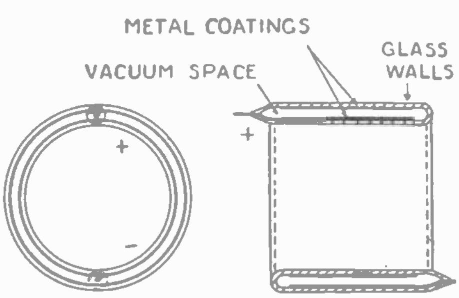
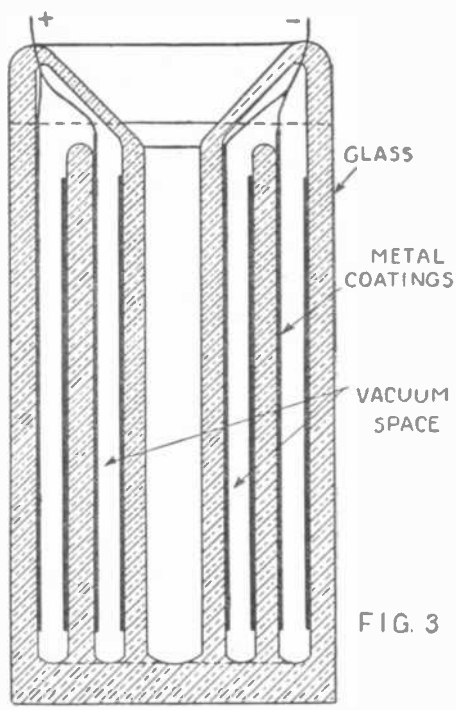


FIG. 2

Vacuum has not been employed as much as it deserves in condensers. In that shown above, two pieces of glass tubing are sealed together with metal coatings between them. The narrow cylindrical chamber so formed is then exhausted.



The multiple plate condenser illustrated above makes use of vacuum (that is to say, pure ether) as its dielectric. The walls of the condenser are made of glass. The experimenter after a little practice in glass blowing should find no difficulty in building such condensers.

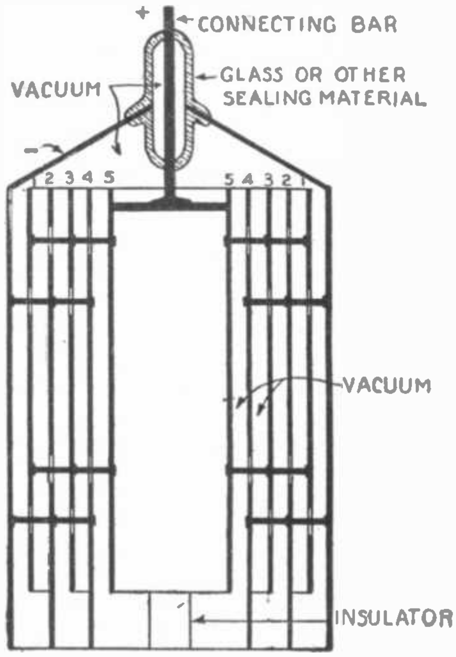


FIG. 4

Another form of vacuum condenser. The glass walls are here eliminated, the external copper cylinder being made air-tight. As indicated, alternate copper cylinders are connected to each other. The only glass part required is the terminal support. This, however, may be made of some other insulating material.

High Capacity Chromic Acid Battery

By C. A. Oldroyd

JUDGING by recent numbers of the EXPERIMENTER, compact "block" type batteries have again come into fashion. Many years ago, when the storage battery was in its infancy, such "block" batteries were the only means of generating heavy currents, if a dynamo was not available, and the latter were then few and far between.

From the experimenter's point of view, the "block" batteries have many advantages: they are small and compact and require but little room for storage. In addition, they can be built far more cheaply than the standard types of batteries.

Before describing the construction of the new battery, we might do well to glance back and review the stages through which the chromic acid battery passed during its development.

The high potential of over two volts in a cell attracted the research workers' attention at quite an early date, and many attempts were made to improve this powerful battery. Although even a comparatively small chromic acid battery can supply a current of over twenty amperes, it dropped out of use more or less, as far as commercial purposes were concerned, on account of lack of constancy. After a few minutes the original twenty amperes would fall to fifteen, to ten, and then to a more or less steady four or even less . . . the battery had become polarized!

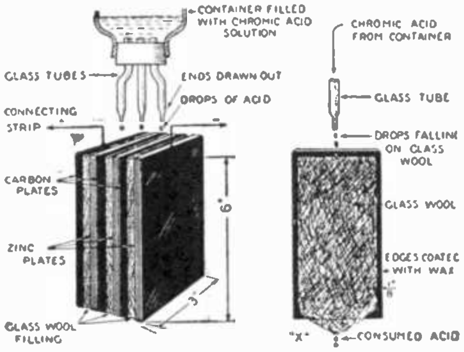


FIG. 1 FIG. 2

The illustrations show the construction of the chromic acid battery. The battery is made up of alternate layer of zinc and carbon plates separated by a thin layer of glass wool.

Every avenue was traversed to find a means of preventing polarization, and many new designs were the result. Air was blown into the battery jars to keep the acid moving, small lead pumps circulated the acid constantly, and many other ingenious contrivances saw the light of day. Unfortunately, the battery and accessories became more and more complicated and expensive.

To show what the large chromic acid batteries of over forty years ago were capable of, two instances may be given. A large bank in Paris, then the home of electrical research, decided to install electric lighting. A dynamo was out of the question, as a gas engine would have been too noisy, and a steam installation needed far more space than could be spared.

So a huge chromic acid battery was decided on; the jars were over three feet high and capable of supplying a steady current for hours on end. The battery was located in the cellar, where also the storage tanks for the acid were placed. A small pump circulated the acid through the numerous battery jars; after the acid had passed through two or three times it was strengthened and used a few times more. Finally it was discarded.

The installation proved a great success, although the cost of running this plant was very high.

The other case that comes to the writer's mind is even more interesting in this age of aviation, for it concerns one of the very first dirigible balloons or airships that ever sailed through the air under their own power.

In 1882, M. Tissandier, of Paris, constructed what we would today call a very small airship capable of lifting a total weight of about a ton and a quarter. The propeller of this ship was driven by a Siemen's electric motor, then quite a novelty! It weighed just under a hundred pounds and gave approximately one and a third horsepower.

Current was supplied by a battery of two dozen cells, needless to say of the chromic acid type. Charged with acid, the batteries weighed close on five hundred pounds, an immense figure for the small airships of that time. Using fresh solution for every ascent, the batteries were able to keep the motor going at full speed for two and a half hours. Propelled by this small motor, the airship attained a speed of about seven miles per hour.

And just as the chromic acid battery appeared to become the battery of the future, rivals appeared: the Bunsen type with its porous cup, later the storage battery, and finally the power driven dynamo. The chromic acid battery disappeared from the maker's lists, and only a few experimenters used it for their work. Very little progress has been made since that time with this battery, although many believe that it may yet re-appear in a new guise and score heavily over the batteries we are generally using just now.

"Well, granted all that," the reader may say, "when are we going to hear some more about that new type of battery?" The answer is "Right now," but the writer hopes that the reader will not consider the prologue a waste of time, for it has shown that once research workers and experimenters alike were more or less dependent on the good old chromic acid battery.

As you may have guessed, the battery now to be described is of the "block" type (Fig. 1). The set is built up as follows: First comes a carbon plate, then a layer of absorbent material, next a zinc plate. This is followed by the carbon plate of the next cell, then comes the absorbent layer, and so on, until the last zinc plate is reached.

For clearness' sake a battery of only three cells is shown, but quite large sets can be built up in the manner indicated here. Owing to the high voltage of the chromic acid battery, which is twice that of a Daniel cell, fewer cells are needed for a specific voltage than with other types.

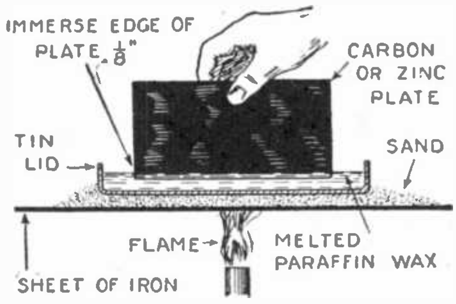


FIG. 3

To prevent electrical leakage around the edges of the electrodes, the plates are dipped into paraffin as shown. The edges are in this way given a thin coating of insulating paraffin.

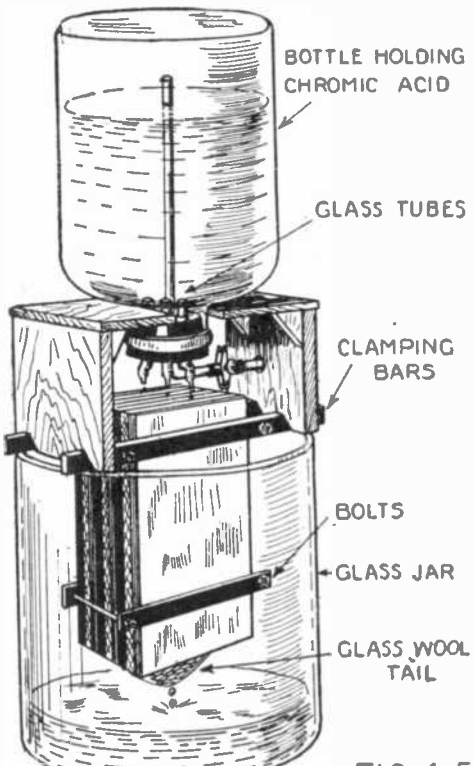


FIG. 4-5

A view of the assembled chromic acid battery. Note how the electrodes are held between clamps. The chromic acid which forms an electrolyte in the battery is supplied by small feeder tubes.

The three-cell set shown in the illustration has a voltage of six, for twelve volts a six-cell battery would be needed. The latter should be ample for the ordinary needs of the experimenter.

The novelty of this battery lies to a great extent in the nature of the absorbent material, as glass wool is used for this. Glass wool is finely spun glass, and is commercially used for the manufacture of non-spillable storage cells for pocket lamps; it can be obtained from electrical dealers.

Its price will seem high, as it is sold by weight, but a quarter of a pound costs only a few cents and will be more than ample for even a large battery. This glass wool is "teased" and placed in an even layer between the plates; the thickness of the layer should be about a quarter of an inch at least, as the latter is compressed when the plates are clamped together.

Two sets of clamping bars press the plates against each other, as shown in Figs. 4 and 5. The upper clamps are longer than the lower ones, as they also support the battery as it hangs in the glass jar.

Only sufficient pressure to hold the plates in position should be used when clamping up, to prevent the glass wool being compressed too much. After the set is assembled, the glass wool is tucked in at the edges so as to be about 1/8-inch from the edge of the plate. The lower side of the glass wool layer is then drawn out to form a "tail," as shown at "X" in Fig. 2. This allows the used acid to drain off in one point only.

The completed set is then hung from the longer clamping strips in a wide glass jar (Figs. 4 and 5). The acid is contained in a glass bottle placed inverted over the cells. Its neck rests on a small board; into the latter a slot is cut so that the acid container can be easily placed in position and withdrawn.

Through the cork pass as many thin glass tubes as cells are used, in our case three. The center tube is straight, the others are slightly bent so that the openings are immediately over the glass wool layers. The ends of the tubes are drawn out to fine points, about the diameter of a fountain pen filler; the actual diameter of these tubes need not cause the constructor any trouble, as long as they are not too fine.

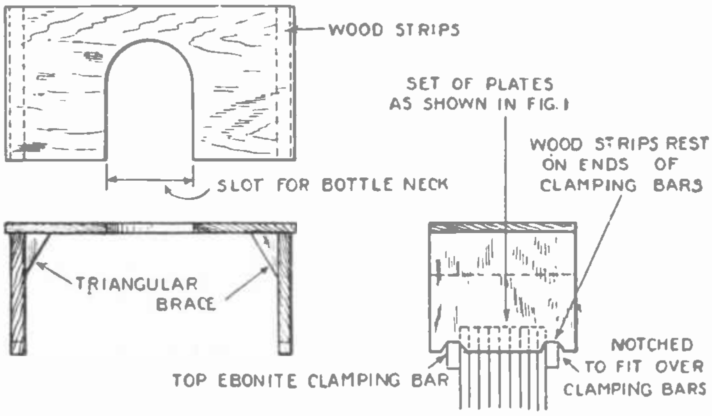


FIG. 6 FIG. 7

Fig. 6 and 7 show various details of construction of this battery. They should be studied in connection with the preceding illustrations to get a clear idea of the settting up.

Finally some wood strips are screwed to the slotted board supporting the acid storage jar; the lower edges of these strips rest on the upper clamps and can be notched to fit securely.

To make our battery work, we set it up as shown in Fig. 4, after the storage jar has been charged with chromic acid solution. Then we invert the jar and turn the glass tubes in their holes in the cork until they are just above the glass wool layers. To supply air to the jar, a bent glass tube is also passed through the cork; this reaches nearly to the upper end of the acid jar; the outside end is bent over and a short length of rubber tube is slipped over it. If we fit a pinch-cock over the free rubber tube, we can adjust the air supply within fine limits.

The acid will now trickle out of the ends of the glass tubes and saturate the glass wool; it will spread through the whole layer in an even stream, and finally reappear at the bottom "tail" (X), whence it will fall into the large jar which surrounds the cells.

If the flow is carefully adjusted, the acid will be spent by the time it has passed through the cell, and the accumulated acid in the large jar can then be thrown away. The heavier the load, the greater must be the flow of acid; for average work drop should follow drop without more than a perceptible interval

It will be seen that such a battery is very economical, as only a minimum of acid is used. Storage jars for used acid are no longer required, and the action can be interrupted at any time by closing the pinch-cock on the air tube. The upper jar serves also as a storage jar for the fresh acid when the battery is not in use; it is then simply taken off and inverted, so that the bottle now stands on its base and the tubes are pointing upwards.

After use, the cells are cleaned by filling the large jar which surrounds them with clean water, renewing the water several times, then the glass wool will be clean and the assembled set can be stored to dry.

If the cells are carefully washed in this way, they need not be taken to pieces every time they have been used, and the greatest drawback of the "block" type of battery is overcome.

If a large number of cells is used, it will be found difficult to arrange for the great number of feed tubes for the acid. In this case a perforated lead pipe, one end of which has been closed, can be placed horizontally over the tops of the cells. From the holes in this pipe, the acid will flow into the glass wool layers. The other end of the pipe is, of course, connected to a large jar containing the acid.

It will sometimes be found, particularly when the battery has to supply a great deal of current and the flow of acid is heavy, that the acid will leak around the upright edges of the carbon and zinc plates, from one cell to another. This must be prevented, or else the current will fall off, for the cells will be partly short-circuited.

The simplest means of curing this is shown in Fig. 3. Before assembling the cells, the carbon and zinc plates are immersed, at their sides, for about 1/8-inch in a bath of melted paraffin wax, and then put up to allow the paraffin wax to harden. This should be done on every side of the carbon and zinc plates. As paraffin repels aqueous fluids, no leakage will take place around the sides, from cell to cell, if the plates are treated as described above.

The wax is melted in a suitable tin lid, the latter resting on a layer of sand to distribute the heat evenly. This wax layer must be carefully scraped away at the back of the carbon and zinc plates, where they join when assembled, in order to enable the plates to make good contact with each other.

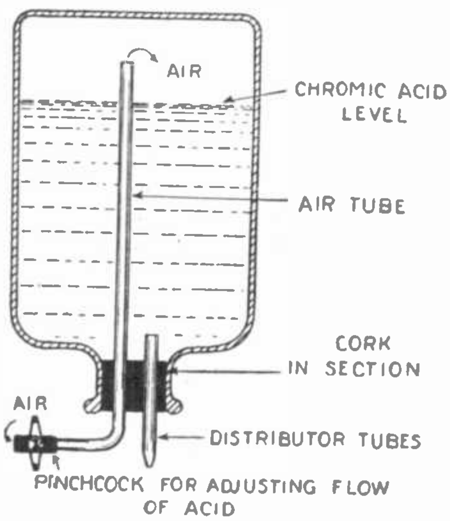
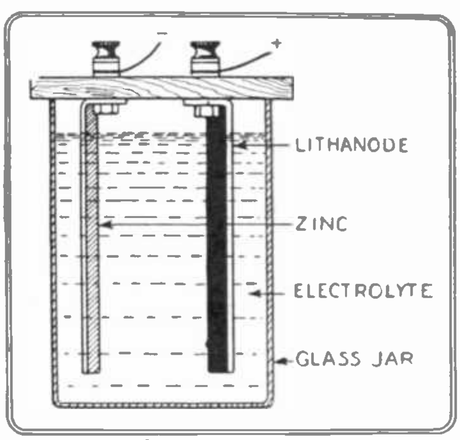


FIG. 8.

The electrolyte bottle arranged to supply the exciting solution drop by drop to the battery; by adjustment of the opening of the air inlet the rate of feed is regulated.

The Kingsland Cell

THE Kingsland cell employs for its depolarizer lithanode (stony anode). This is a composition devised by Mr. Desmond Fitzgerald, and consists of a mixture of oxides of lead with glycerine, ammonium sulphate or dilute sulphuric acid.



A battery using lithanode for the positive plate; it can be recharged over and over again.

The composition is placed in moulds of the size desired and the mass is then subjected to great pressure in a hydraulic press. The compressed plates are transferred to a drying room and when perfectly set and hardened are immersed in a solution of chloride of lime (calcium hypochlorite), which converts the surface into lead peroxide.

Finally, the peroxidization is carried to the highest possible point by electrolysis in a bath of magnesium sulphate. Some of the best plates contain as much as 10 per cent. of lead peroxide. The lithanode plate thus prepared is said to be the only one which does not disintegrate when placed in an electrolyzing fluid.

When used in the Kingsland cell against a zinc plate acted on by dilute sulphuric acid, sp. gr. 1.170, the EMF is 2.5, and this remains constant for a long time. As the cell is sealed, this form is convenient for testing purposes, as it may be recharged when exhausted by passing .5 ampere through it from lithanode to the zinc.

Contributed by DAVID TERRIERE.

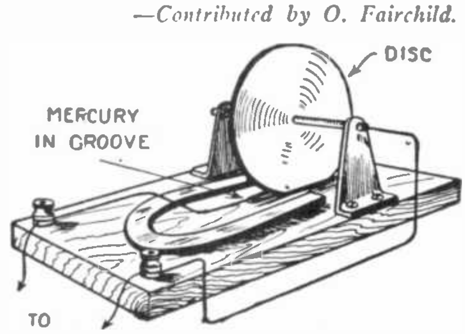
Simple Mercury Motor

ONE of the simplest motors to construct is the "mercury motor." The materials needed are a base of hardwood 4 inches by 2 inches; a brass plate 2 inches across; a horseshoe magnet, and some mercury.

Cut a small groove an inch long and 1/4-inch across and fill it with mercury; make two uprights for the bearings of iron; punch a hole through the disk and put a needle through it.

When a direct current circuit is connected to the posts, the disk rotates relative to the poles of the magnet. To reverse, turn the magnet over or use a reversing switch and reverse the current.

—*Contributed by O. Fairchild.*



A version of a well-known motor; a radial current through the disc causes it to rotate.

Low Tension Magneto Grinding Set

By William L. Jones

MOST workshops are dead without a motor. There is hardly a job that does not take twice the time by hand that it would take with machinery.

The following is a description of a home-made electric grinding-set driven by an old low tension magneto. It has been giving constant service for the past year, running on the average of about six hours a day. The motor has also been used for many other purposes, such as driving a fan blower, etc.

Fig. 1 gives the general view in side elevation showing how the structure is fastened to its base; the different parts are described by the wording on the diagrams.

Fig. 2 shows an end view of the relation of armature, field and pole pieces, and below the main figure is shown the commutator, which is in two sections of brass tubing, and the brushes.

Fig. 3 gives the construction of the armature, which is to be studied out in connection with the cross-section shown in Fig. 2. The winding should be between 3½ and 5 ounces of No. 19 to 22 wire. The motor is made from an old low tension magneto or an old telephone magneto; in the latter case the fine wire on the armature is removed and the wire mentioned above, single or double covered, is substituted therefor.

A wooden cylinder shown in Figs. 4 and 5 is driven on with a very tight fit and cemented on the end of the shaft. Brass tubing shown in Fig. 6 is sawed into two pieces longitudinally; this is cemented or screwed to the hollow wooden cylinder, and the ends of the armature winding are connected, one to each section of the tube. This gives the commutator connection. A thick solution of shellac will be found a satisfactory cement. The position of the armature and commutator section in relation to each other is shown in Fig. 2.

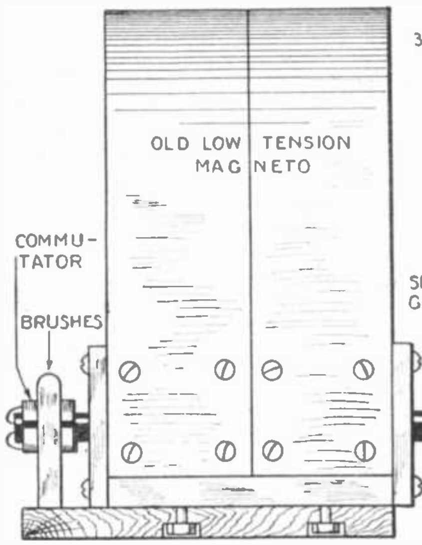
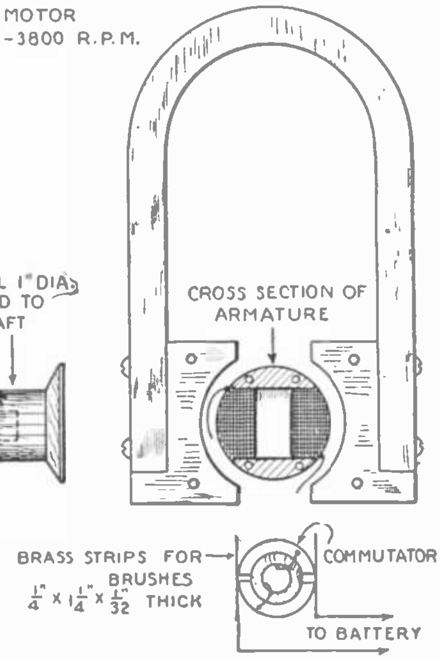


FIG. 1



END VIEW SHOWING CONNECTION WITH COMMUTATOR

FIG. 2

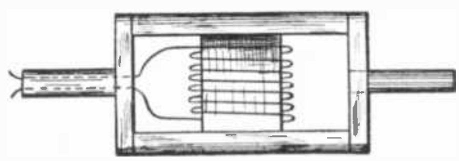


FIG. 3 ARMATURE - SHOWING HOW WIRE IS WOUND, AND PASSED THROUGH SHAFT.

Fig. 1. Side elevation of the magnetos. Note particularly the spool for the belt.
Fig. 2. End view showing relations of field, armature, commutator and brushes.
Fig. 3. The scheme of winding the armature, a bi-polar one, more or less of the old shuttle variety.

In the motor used in the writer's shop the magnet came from an old telephone magneto, wound with 5 ounces of single covered magnet wire. It is simplicity itself; in order to start it, the electricity is switched on and a slight twist is given by the fingers to the armature, when it will run by the hour. No fly-wheel is required.

The armature wires come through the hollow end of the shaft and are soldered to the commutator segments as shown in the lower diagram of Fig. 2. The bearings for the aramature shaft are two plates of ¾-inch brass, ½ inch thick, with holes as shown in Fig. 7. The oil hole must not be forgotten.

Figs. 8 and 9 show the layout for the grinding and sanding wheel mounting. It is wonderful how much can be done with a sand-wheel as compared with the slow work of the detached sheet of sandpaper. The edge and the face of the wheel can both be used; it must be remembered that the action of sandpaper is a cutting not a grinding action, so that hard pressure is not required. It is well not to have the emery wheel of large diameter; it is shown on the left end of the shaft in Fig. 8.

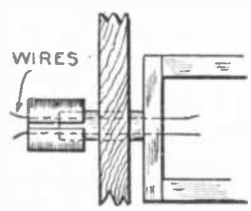


FIG. 4 SHOWING HOW COMMUTATOR IS MOUNTED ON SHAFT

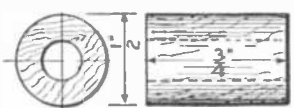


FIG. 5

CONSTRUCTION OF COMMUTATOR

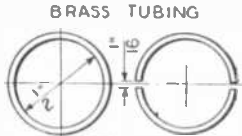


FIG. 6

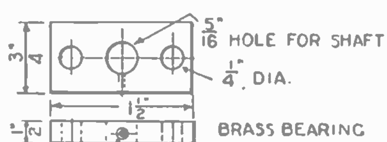


FIG. 7

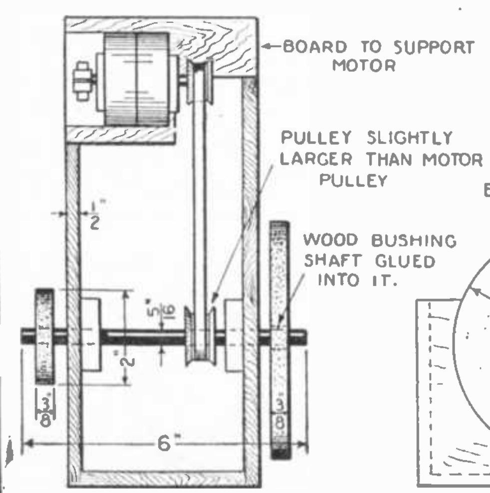


FIG. 8 PLAN VIEW

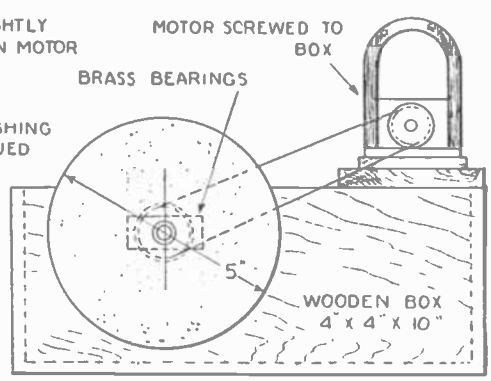


FIG. 9 SIDE VIEW

Fig. 4. The two-piece commutator; the two sections of tube cemented or screwed to a hollow wooden shaft, the latter is shown in Fig. 5. Fig. 6 shows the tubing before and after sawing into two pieces. Fig. 7 is the bearing for the shaft. Fig. 8 and 9 are plan and side views of the complete appliance for grinding and sanding.

Generator for Static Electricity

By C. A. Oldroyd

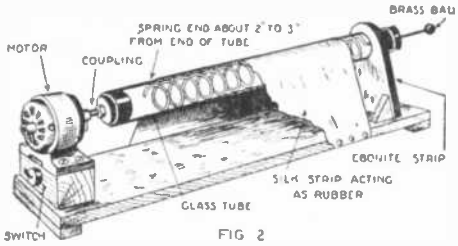


FIG 2

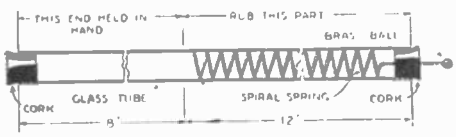


FIG 1

A very odd version of the old-time frictional electric machine which gives good results and is of the simplest construction. Fig. 1 shows a section of the tube and Fig. 2 is a view of the apparatus.

FOR simplicity and efficiency, as well as for workmanlike appearance, the novel static electricity generator shown cannot be excelled. It can be constructed in less than five minutes, if the necessary materials are at hand, and its output is at least equal to that of an amateur-built static machine with a rotating glass disc.

The illustration shows the machine in section; the body of this generator is formed by a glass tube having an external diameter of from ¾ inch to 1 inch, and a length of about 20 inches. A copper or brass spiral spring is next required; its external diameter should be such that it just fits into the glass tube. One end of the spring is straightened out, as shown on the right; the remaining coils are then opened out by pulling at the end, so that the adjoining turns are about one-half inch apart.

A brass wire, spring tempered, is best for this purpose; one end is slightly annealed by holding it over a Bunsen flame, and the first two or three turns can then be readily straightened out. The end of this straight part is threaded for a brass ball.

We can now assemble our generator. The glass tube is well cleaned and dried in front of a fire or in any other warm spot. To give the best efficiency, both inside and outside of tube must be kept perfectly dry.

One end, the left one in the illustration, is permanently closed by a well-fitting cork stopper; after insertion, the stopper can be cut off flush with the tube end. Insert the spiral spring into the glass tube so that it extends for a length of approximately 12 inches. The other end of the tube is closed by a second cork stopper provided with a hole through which the straight end of the spring passes. It is well to paint over the faces of the corks with a touch of shellac varnish, or with sealing wax to ensure an airtight joint.

If the brass ball is now screwed on the threaded end of the straightened end of the spring, our generator is complete. It is used in the following fashion:

The section under which the spiral spring lies is rubbed well with a piece of silk or flannel, holding the tube in the left hard at the handle end (the left 8 inches, see illustration), after a few seconds rubbing strong sparks can be drawn from the brass ball.

The working principle of this generator is as follows: The rubbing produces an electric charge on the outside of the tube, this charge *induces* a second one in the metal spring. As the tube is held by an insulating handle, the external charge, on the outside of the tube, cannot be dissipated. In turn, this will induce new charges in the spring, and quite a number of sparks can be obtained without further rubbing.

All static electricity apparatus work best when slightly warmed, and the least film of moisture tends to reduce the charge in the outside of the tube. Bear this in mind when using the new generator, and warm it well before a fire or near a radiator.

As the ends of the tube are closed by cork stoppers, which have been fitted after the interior of the tube has been warmed, the interior part will maintain its perfect insulation for long periods.

The size of tube mentioned at the beginning serves well for average experiments which do not require much electricity; if large Leyden jars are to be charged, and for experiments making a great demand on the capacity of the generator, much larger tubes can be used, say about 25 inches long and of about 2 inches diameter. Instead of the glass tube, ebonite tubes can be employed, resulting in an almost unbreakable generator.

If a small fan motor or a similar small motor is available, we can easily convert our hand operated generator into a power driven one. The arrangement is very simple and shown in Fig. 2. On the left, the end of the glass tube is attached to the motor spindle by a simple coupling, details of which will be given later.

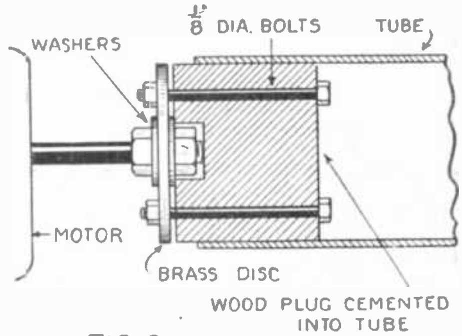


FIG. 3

Attachment of the shaft to the tubes in the tubular frictional electric machine.

In a power driven generator, the spiral spring can extend for nearly the whole length of the glass tube, except for the last two or three inches from the coupling end with its metal parts.

(*Continued on page 775*)

Hedgehog Transformer

By William French

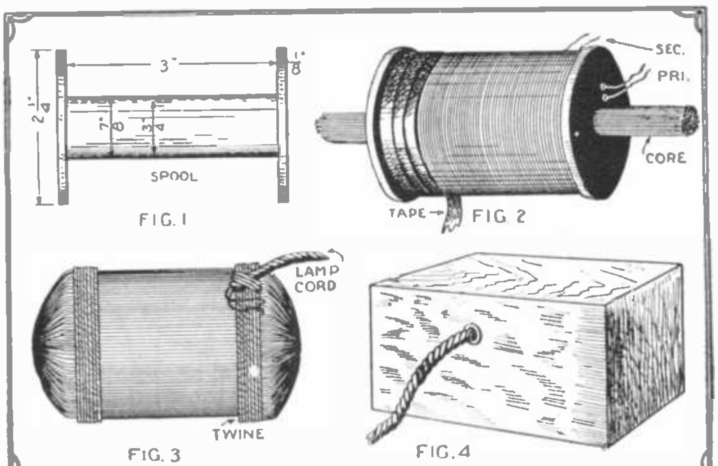


FIG. 1 FIG 2 FIG. 3 FIG. 4

How to make the well known hedgehog transformer. If properly constructed in accordance with the description here given it makes a neat piece of apparatus and the disposition of the ends of the core wire is characteristic of its type.

THE following instructions for making a transformer, if carried out, will produce a very efficient piece of apparatus, which will serve for short telegraph lines, miniature lamps, small electric motors, Christmas tree lamps and other things.

It is a piece of apparatus that requires no attention at all and uses up very little power. It is a type of apparatus known as a "hedgehog" transformer, consisting of two coils of insulated copper wire wound one on top of the other on a spool through which passes a bundle of soft bare iron wires.

The dimensions of a suitable spool upon which to wind the coils are given in Fig. 1. The spool is best made in the lathe by turning it out of a solid piece of hardwood, but a good one can be made by gluing two wooden heads on a tube of pasteboard or else by winding several layers of stiff paper around a ¾-inch rod and gluing them together.

For lighting circuits of about 110 volts, 60 cycles, the primary coil should be wound with 4,800 turns of No. 28 double cotton-covered wire, which will weigh about one pound. Wind the wire in smooth, even layers, like thread on a spool, passing the ends through holes in one head.

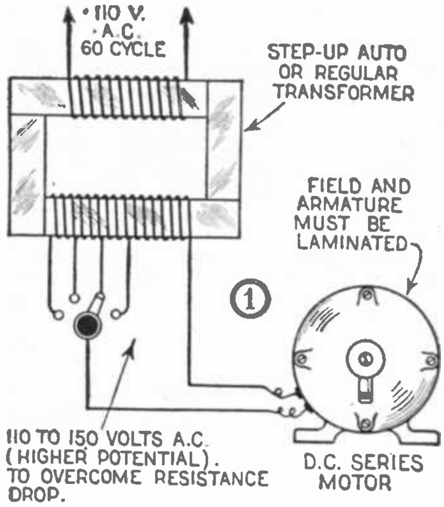
The secondary coil is to be wound on top of the primary coil, the latter being first covered with two layers of tape. For 8 volts there will be needed in the secondary 600 turns of No. 18 double cotton-covered wire, of which 1½ to 2 pounds will be required. This is most conveniently put on in eight layers of 50 turns each, which allows taps to be brought out at intermediate layers for lower voltage.

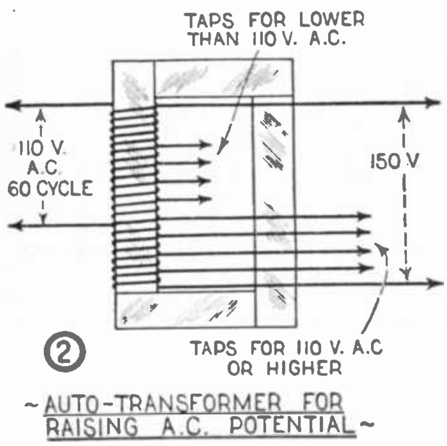
Fig. 2 shows the primary with its two fine wire terminals projecting from the head, and the secondary coil on top with three connections.

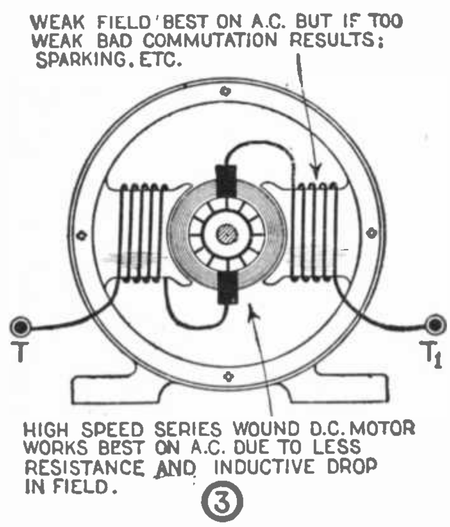
For the core of the transformer about ¾ pound of No. 20, or finer, soft annealed iron wire is required, cut in pieces about 11 inches long and carefully straightened. The ¾-inch hole through the coils is then packed with as many of the wires as it will hold. This, with the necessary insulation of the secondary coil, is shown in Fig. 2.

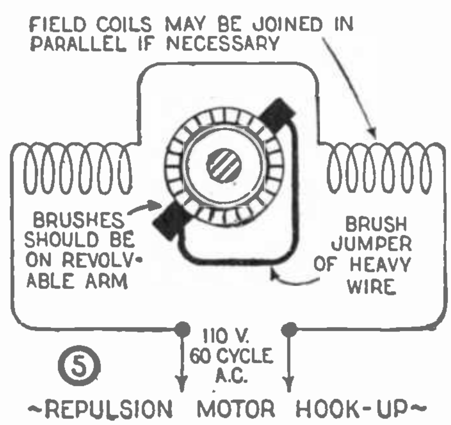
(*Continued on page 776*)

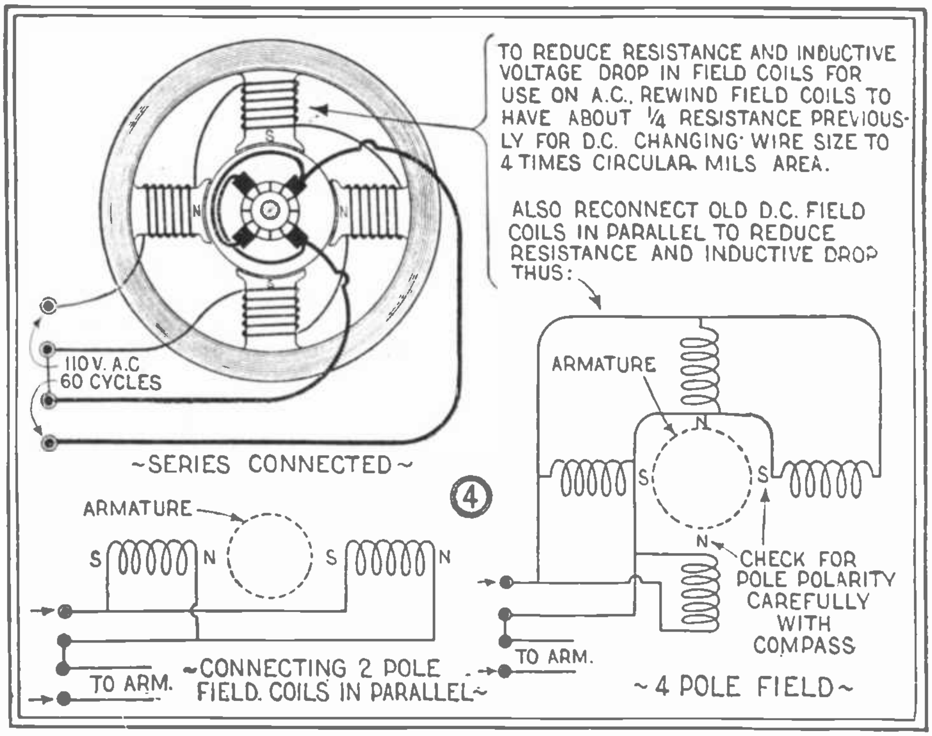
Operating D.C. Motors on A.C.

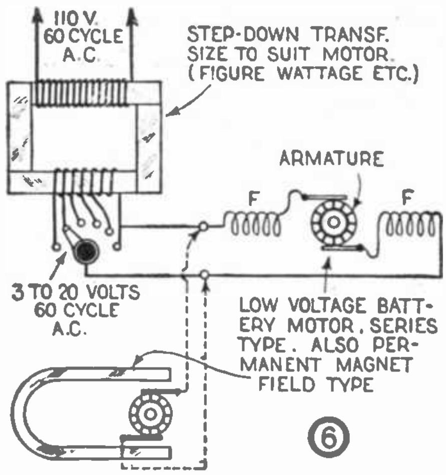












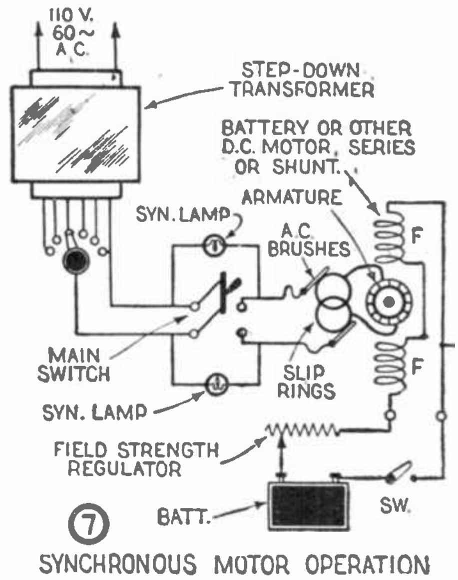


Fig. 1 shows use of step-up transformer to increase the applied A.C. potential in order to overcome the high resistance drop found in some D.C. motors of the series type. These relations are more fully discussed in the text.

Fig. 2 illustrates how auto transformer is designed for increasing the voltage of the line.

Fig. 3 brings out the salient fact that a high speed series wound D.C. motor is the best suited to operation on A.C.

In the diagram Fig. 4 directions are given for changing the resistance of a D.C. motor so as to render it suitable for operation on A.C. The field windings frequently have to be connected in parallel, as shown, in order to reduce the impedance.

Fig. 5 shows the simplest type of repulsion type motor where the fields are excited on A.C. while the armature brushes are short-circuited.

Fig. 6 shows how toy battery motors can be operated from 110-volt A.C. circuit by means of a step-down transformer, such as those sold for operating toy railways.

In Fig. 7 we see how a D.C. motor has two slip rings mounted on the shaft and connected to diammetrically opposite commutator segments in a two-pole machine. In this fashion a synchronous motor may be divided.

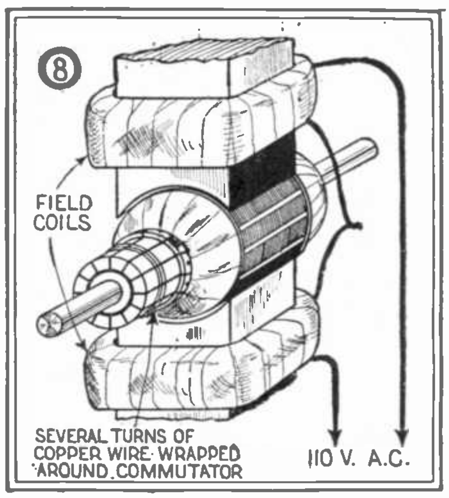
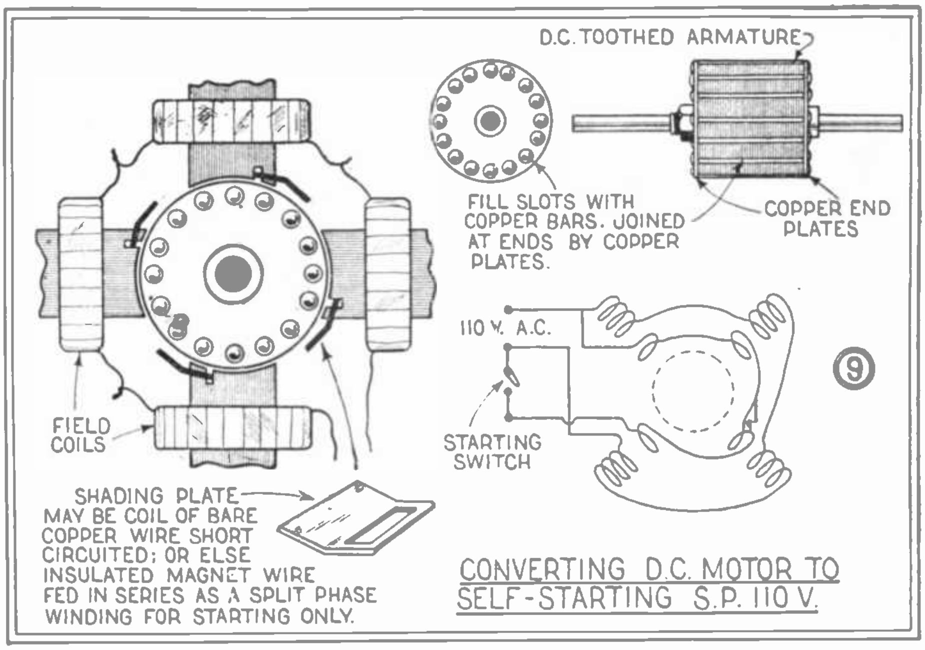


Fig. 8 shows a simple induction motor, the armature of which has to be spun until synchronous speed is reached. A piece of bare copper wire is wrapped several times around the commutator and twisted tightly in place; or for a permanent job it may be soldered to the bars.

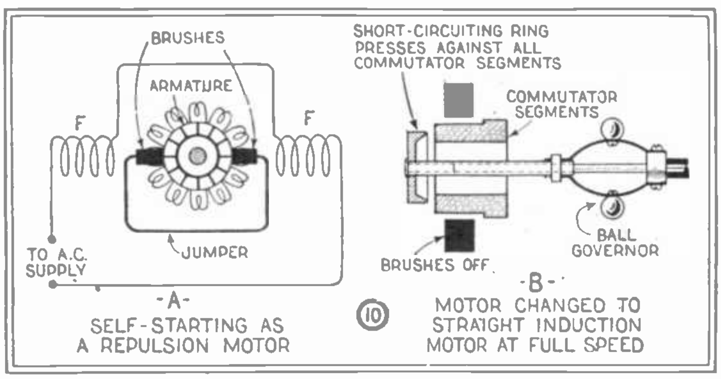
Operating D.C. Motors on A.C.

By H. Winfield Secor
Associate Member, American Institute of Electrical Engineers.

Hints on How to Operate Fractional Horse-power Direct Current Motors on Alternating Current Circuits.



The simplest form of self-starting single phase A.C. motor is shown in Fig. 9 above. It will usually be found that the armature doesn't have a sufficient number of slots, and that more slots will have to be provided.



For the experimenter interested in operating D.C. motors on A.C., there is a great deal of novelty and merit in the motor shown schematically at the left, Fig. 10. The experimenter can easily try out these motors in his home laboratory and will learn a great deal thereby.

IT IS often desired to operate fractional horse-power direct current motors on alternating current circuits, usually of 110 volts potential and 60 cycles frequency. In general, the best type of D.C. motor for this purpose is a series wound type, *i. e.*, having the armature and field windings connected in series when used on direct current; it was recently pointed out in the Journal of the A. I. E. E. that almost any D.C. series motor will run on alternating current, provided sufficient voltage is applied to the terminals.

One of the main problems in operating many D.C. series motors on A.C. is that the field has too great a resistance and inductance to permit sufficient current to flow through the armature to give any worthwhile speed and torque. The frequent result is that a D.C. motor operated on A.C. shows poor speed and torque. The inductive voltage drop across the windings of the motor increases with increase of frequency, and vice versa; and, hence, with a given motor, the higher the frequency of the A.C. applied, the less will be the value of the voltage reaching the armature of the motor. The inductive drop in the field can be compensated for in a fashion by changing the number of turns and the size of the wire on the windings, and using the minimum number of field turns, but this procedure is limited as commutation becomes unsatisfactory, when the field is weakened to any great extent.

It is clear from the above considerations that the high-speed D.C. motor is more satisfactory for operation on A.C. than those designed for lower speeds. In any case, the motor to be operated on A.C. should have both armature and field built up of iron sheets, *i. e.*, laminated. So-called universal A.C. and D.C. motors have their windings carefully balanced out so as to operate on either form of current, and their speeds are usually nearly alike on either current. It is also noticeable that these motors, as aforementioned, are usually of quite high speed.

Raising A. C. Voltage Applied to Motor

The applied A.C. potential may be raised above 110 volts, the usual potential available, either by means of a step-up 2-coil transformer, as shown in Fig. 1, or by means of an auto-transformer, as shown in Fig. 2. Care should be taken to see that the motor does not over-heat, and it is well to have the A.C. potential variable, either by means of taps on the transformer winding, or else by means of an adjustable choke coil placed in series with the line to the motor. Such a variable choke coil or impedance may comprise a small coil wound with several layers of insulated magnet wire (No. 14 to 16 B. & S. gauge) having a laminated iron core, which can be slid in and out of the coil.

Fig. 3 illustrates the features mentioned above, and refers to the desirability of using a high-speed D.C. motor with as weak a field as possible if it is to operate on alternating current.

Reducing Resistance and Inductance of Field

D.C. motors, when connected to A.C. of similar potential frequently will not even turn over, owing to the high resistance and inductive voltage drop in the field coils. The armature usually has a sufficiently low resistance to render it satisfactory for A.C. service, provided we reduce in some way the high resistance and inductance of the field windings. As shown in Fig. 4, a 4-pole series wound D.C. motor may have the field coils reconnected in parallel, which will reduce the resistance sufficiently to allow the motor to operate satisfactorily on A.C. The terminals of the whole field winding are connected in series with the armature, of course, as indicated in Fig. 4. The parallel connection for a 2-pole field is also shown in that diagram.

Replusion Motors

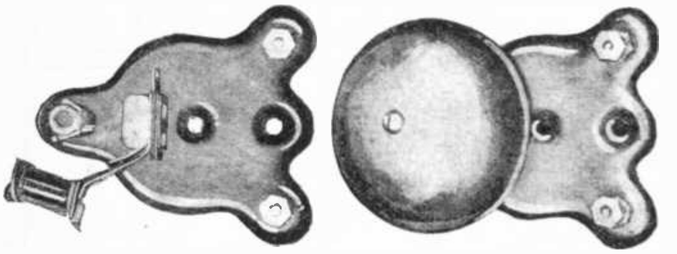
The repulsion type of A.C. motor hook-up is shown in Fig. 5. Here the commutator brushes, which should be mounted on an arm so as to be moved around the commutator to determine the best point of commutation with the least sparking, are connected together by a jumper of heavy copper wire. The field coils may be tried in series, but if sufficient current does not pass to permit the motor speed to pick up sufficiently, they may be connected in parallel to reduce the resistance. In all of these experiments, it is best to have an adjustable choke coil or rheostat in series with the main line, and to make a test on the motor for a half hour or so, to see that it does not unduly overheat. In any case, the motor should not become too hot for the hand to be borne on it comfortably. The repulsion type motor is self-starting, as is the series type D.C. motor when operated on A.C. The simple squirrel cage induction motor is not self-starting, unless some means, such as starting coils or shading plates, are used to enable it to start.

Low Voltage D.C. Motors on 110 Volts D.C.

Fig. 6 shows the use of a step-down or toy transformer for operating a low voltage motor, such as those intended for battery circuits. This applies to the toy electric railways so much in vogue today. The motor is series wound, and rated at 6 to 8 volts usually. The other day a friend asked if he could operate a 6-volt 1/6-h.p. series wound D.C. motor on A.C. He seemed to think it was out of the question, but all that is necessary is to see that the transformer is big enough to supply the necessary current required by the motor. Step-down transformers of small size are used, as shown in Fig. 6, for operating a number of D.C. appliances nowadays, including electric door bells, induction coils, sounders, relays, etc.

For experimental work, the circuit shown in Fig. 7 is often valuable. This shows how to operate a low voltage battery motor from a step-down transformer in synchronous fashion, *i. e.*, where the speed of the motor will be constant and in step with the alternations of the supply circuit. Two slip rings

(*Continued on page 774*)



Elevation of an electric bell whose clapper carries the electro-magnet itself. This hits the bell and gives the sound.

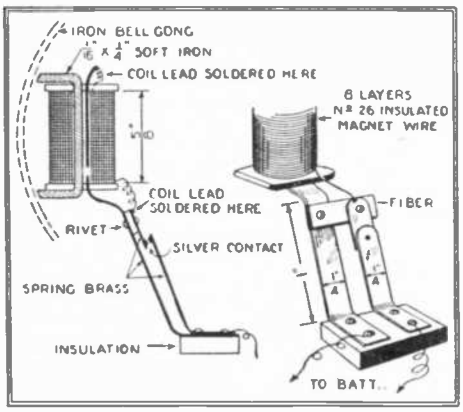
Building a Small Electric Bell

By H. Winfield Secor

A SIMPLE and cheap electric bell or buzzer can be constructed as shown in the illustrations. The gong of the bell should be of soft iron or mild steel, as it forms part of the magnetic circuit for the actuating mechanism of the bell.

The single magnet coil used, wound with about eight layers of No. 26 insulated magnet wire, enameled or cotton covered, has a U-shaped soft iron core made of $\frac{1}{16}$" by $\frac{1}{4}$" strap iron. One terminal of the magnet winding is secured to the short contact spring, as shown, while the longer contact spring connects with one of the terminal posts of the bell. The brass or phosphor bronze spring (A) supporting the magnet has the second terminal of the magnet coil soldered to it at its upper end, as the diagram shows, while the lower end of this magnet-supporting spring is connected to the second terminal post.

When battery current is applied to the bell terminals, the electro-magnet is attracted toward the gong, striking it a blow which gives forth a sound. At the same instant the circuit is opened by the separation of the two silver contacts mounted on the springs in the manner shown. This action is repeated rapidly, causing the bell to give forth the usual vibratory or musical note. By adjusting the bell gong, so that the vibrating magnet cannot strike it, a buzzer sound will result or the same sound effect may be secured by pasting a piece of thin paper around the inside of the gong, so that the magnet cannot strike it.



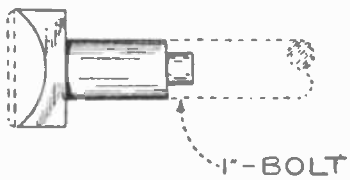
Details of construction of the electro-magnetic clapper or hammer of the bell just described.

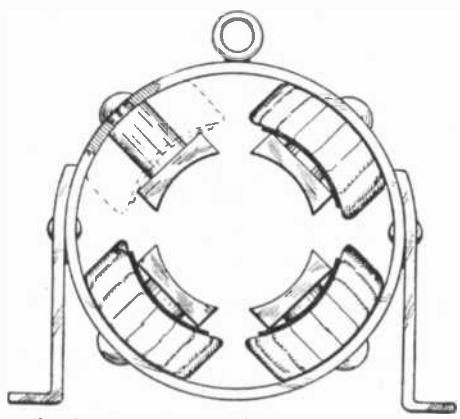
Field for Small Motor

THE field magnet shown in the illustration is very simple to construct and offers very little impedance to the magnetic circuit. The circular part or yoke is made of a section of six-inch pipe which is about two inches long. The legs are made of strap iron riveted to the sides of the yoke as shown.

Each of the poles and pole pieces are in one piece and are made of the head end of one-inch machine bolts. The heads of the bolts are filed with a half-round file so as to form a concave surface which will conform with the curved surface of the armature. A shoulder is filed on the opposite end of the pole as shown. The reduced portion is passed through a hole of corresponding size in the yoke and riveted down.

The field coils are form-wound and placed on the pole core before the poles are riveted into the frame. The coils should be well insulated with tape before being put in place and wound in the way to produce poles of the proper polarity, that is, alternate north and south poles.





Simple construction of the field of a small motor, using a section of 6-inch iron pipe for the yoke. This line of construction is of special interest to amateurs.

Experiment with Lamp Bulb

By J. Alston Bridges

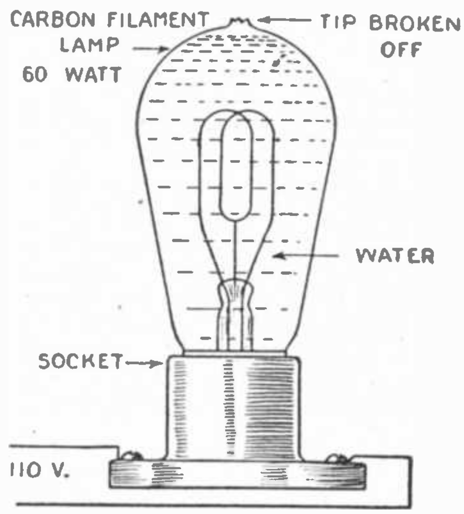
ON exceptionally interesting experiment can be performed with an ordinary 60-watt, carbon filament electric light.

The bulb is immersed in a bowl of *distilled* water and the tip snipped off with a pair of pliers. The water will rush in and fill the bulb. It should be inspected afterwards to be sure that the filament is intact.

The bulb, now full of water, is screwed into a socket in a vertical position and connected to the supply as shown in the illustration.

When the current is turned on a drumming sound will be heard. This sound is caused by the sudden condensation of the steam produced in the immediate vicinity of the filament by the cold water in the bulb.

It will be seen at the start of the experiment that there is a small space at the top of the bulb. This space will gradually fill



A curious experiment with a lamp bulb, heating the filament while the bulb is full of water. The top has been broken or filed off under water. The air pressure fills it with water.

up as the water becomes warmer and warmer. This shows that water expands on being warmed. As the water warms up connection currents can be seen, similar to those produced by pouring acid into water.

The filament of the bulb vibrates quite energetically during the experiment, and, in mine, drew itself over to the glass until at the end it was touching the side of the bulb. Why this is so I do not know. It worked the same with A.C. or D.C. current.

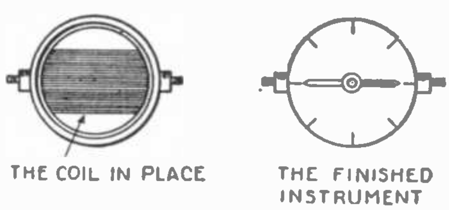
When the water commences to boil, the filament becomes covered with bubbles of steam. Whenever these bubbles become large enough so that the water cannot cool the wire very much, the wire turns red. Sometimes half the filament will become bright red. This makes a very interesting spectacle.

A Pill Box Galvanometer

THIS simple and novel galvanometer was constructed from a pill box, a little wire, about No. 30, and a dime store compass.

I wound the wire around a circular piece of cardboard and slipped it into the bottom of the pill box. I then put a small binding post on each side of the box and fastened the ends of the coil to them. I then put the compass in the box and the instrument was complete.

Contributed by John Pierce.



Exceedingly simple galvanometer, contained in a common pill box. This is the last word in extemporized apparatus.

Simple High Frequency Experiments

A HIGH tension transformer, ½ k.w., 400 volts to 6000-volt secondary, is required. The following list gives the rest: A high tension condenser composed of 60 glass plates 5 x 7-inch with tinfoil interleaved. Spark gap with ¾-inch faces. Twelve feet of copper ribbon ¾-inch wide by 1/32-inch thick wound in a compact circle 8-inch in diameter. Forty to sixty feet of No. 14 gauge wire fairly heavily insulated, wound in a compact circle 8-inch in diameter.

The transformer is operated from 110-volt 60-cycle circuit and should be tapped so that the current can be regulated. The secondary current is connected to the condenser in parallel. The spark gap is connected in

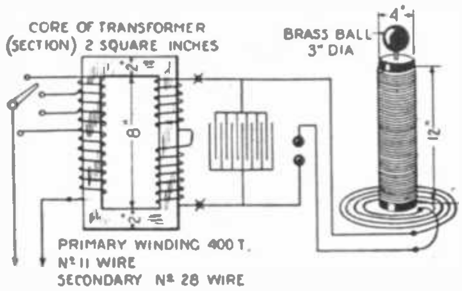
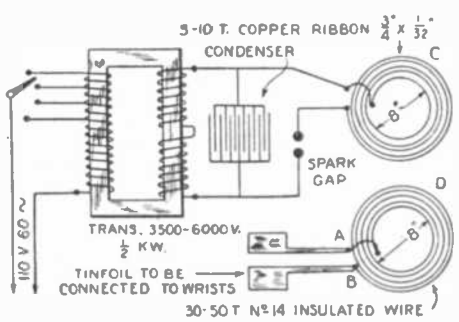


Diagram of connections for a simple high frequency apparatus. The primary of the transformer is tapped so that the secondary potential can be varied.

series to the oscillation transformer which is composed of heavy wire. The sixty feet of No. 14 wire is placed about ½-inch above and directly over the other coil of wire. The experimenter gets strips of tinfoil about three inches wide and two feet long and connects these to his wrists, making sure that the tinfoil makes good connection with the skin, or a burn may result. He then connects the terminals of the second coil to his wrists by a No. 14 wire.

Now for the stunt. Turn on the transformer, adjust the spark gap to about 1/16-inch spark, get a 110-volt 40- to 60-watt light and touch the terminals of the light with your finger tips, and lo, and behold, it lights to about one-half the power which it generally gives on the 110 volts. The effect is very mysterious when the spark gap is muffled and the wires from the wrists are concealed. The diagrams and circuits are shown here.

No shock is felt while conducting these experiments on account of the high frequency of the current, and the "skin effect," which means that the current travels on the surface only. A hollow copper tube would be just as good a conductor of electricity as a solid rod. In this case the current travels on the surface of the skin and



This form of the high frequency apparatus is especially adapted for demonstration. With the tin foils connected to the wrists, incandescent bulbs may be lighted by bringing them in contact with the hands.

goes to the finger tips where it lights the electric globe with about one-half its usual intensity.

Instead of lighting the bulb by passing the current through only part of the body we can pass the current over the whole body by taking two electric bulbs 40- to 60-watt size, holding on one brass contact piece of each lamp and touching the other contact piece to the terminals A and B. Then both bulbs in the experiment light quite brightly. apparatus, when the coils are about ½-inch apart, if the spark gap is properly adjusted and the condenser is of right capacity. The

A 100-watt light can be lighted with this lamp if connected to A and B.

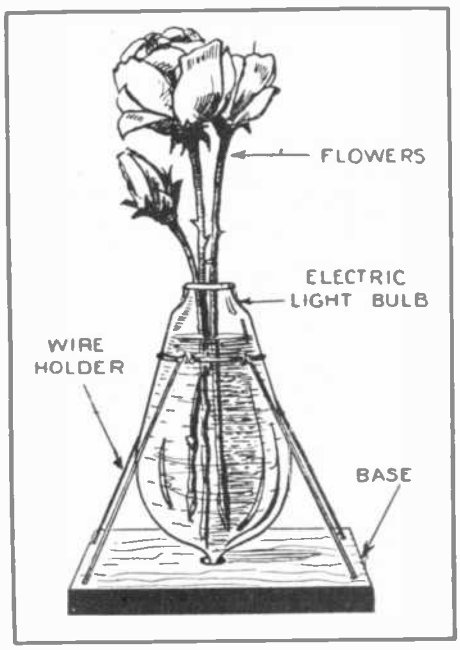
To make an efficient Tesla apparatus the only article that is needed is a cardboard tube 4 inches diameter and 14 inches long, wound with No. 30 S.C.C. wire closely wound. This coil is then placed in the center of coil C. The wire from the end of the Tesla coil is then connected to the inner turn of the copper ribbon. Sparks 4 to 8 inches long can be obtained from this coil.

—Contributed by E. A. Thompson.

Flower Vase from Old Bulbs

INSTEAD of throwing away those old electric light bulbs that have burned out, we describe a novel way in which they can be turned into very attractive bud or flower vases.

Remove the brass ferrule very carefully until the sealed end is uncovered. Then with a quick tap with a metal tool knock off the tip and thus destroy the vacuum. With a glass cutter cut off this narrow end, remove the filament holder and enlarge the opening sufficiently to allow the insertion of two or



A novel use for discarded incandescent bulbs is here illustrated. The bulb with the base removed provides an unusual flower vase.

three rose stems. Then heat this cut edge in an alcohol flame until hot enough to be moulded into a round edge as suggested in the illustration. This can be done with a thin strip of glass held in one hand while the end of the bulb is being heated.

The base can be made of a small, square piece of wood with a small hole bored in the center. The bulb is turned tip end down in the hole and then a four-legged wire frame is formed to encircle the bulb near the top with the ends of the legs thrust into four holes in the base. This makes a neat holder, although any other suitable way of retaining and supporting it will answer that pleases the fancy.

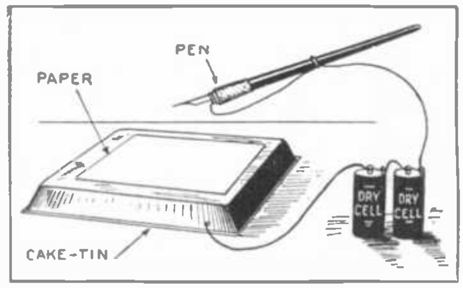
Cover the frame with fancy paper if desired and fill the bulb with water. Two or three pretty roses inserted in this vase will prove very attractive.

Contributed by L. B. Robbins.

Writing With Electricity

DID you know that you could write with electricity? It doesn't sound reasonable, but it can be done nevertheless.

First, get a large tin cakepan and turn it bottom up on the desk. Drill a small hole in one edge, solder in a short length of wire and lead it to the negative or zinc plate binding post of one or two dry cells connected in seies as shown. Connect a second wire to the carbon binding post of the other cells, the two being connected in series, and attach the free end to a steel pen



With the steel pen connected to the positive electrode of a battery, and a sheet soaked in potassium iodide connected to the negative terminal, electric writing can be done.

by pushing it between the pen shank and the inside of the pen holder.

Buy a few crystals of potassium iodide and dissolve them in warm water. Then soak a piece of clean, white paper in the solution and spread it on the pan while wet. Write with the dry pen on the paper while the connections are on the battery and the writing will show up in brown letters on the paper.

Contributed by L. B. Robbins.

2-Inch Throw Knife Switch

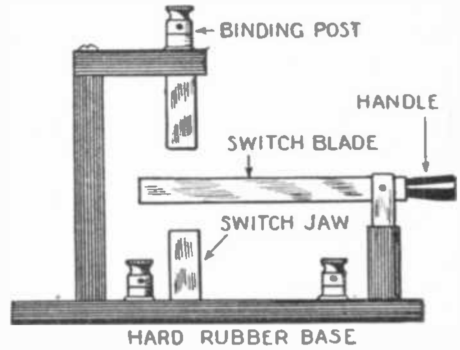
IN most double throw switches the switch handle has to move through a semi-circle. The switch shown here is designed to eliminate most of this swing.

The base and the upright that carry the switch jaws are made of hard rubber. The uprights are bolted to the base. The dimensions of this base and the uprights depend on the size of switch used.

A double throw switch is taken apart, and the two jaws are placed in the position shown, and connected to binding posts. The switch blade and the jaw, which the switch blade swings on, are taken apart and a hole of the correct size to receive a rivet is drilled near the handle-end of the blade. The blade and its pivoted support or jaw are riveted together, mounted as shown, and connected to the other binding post.

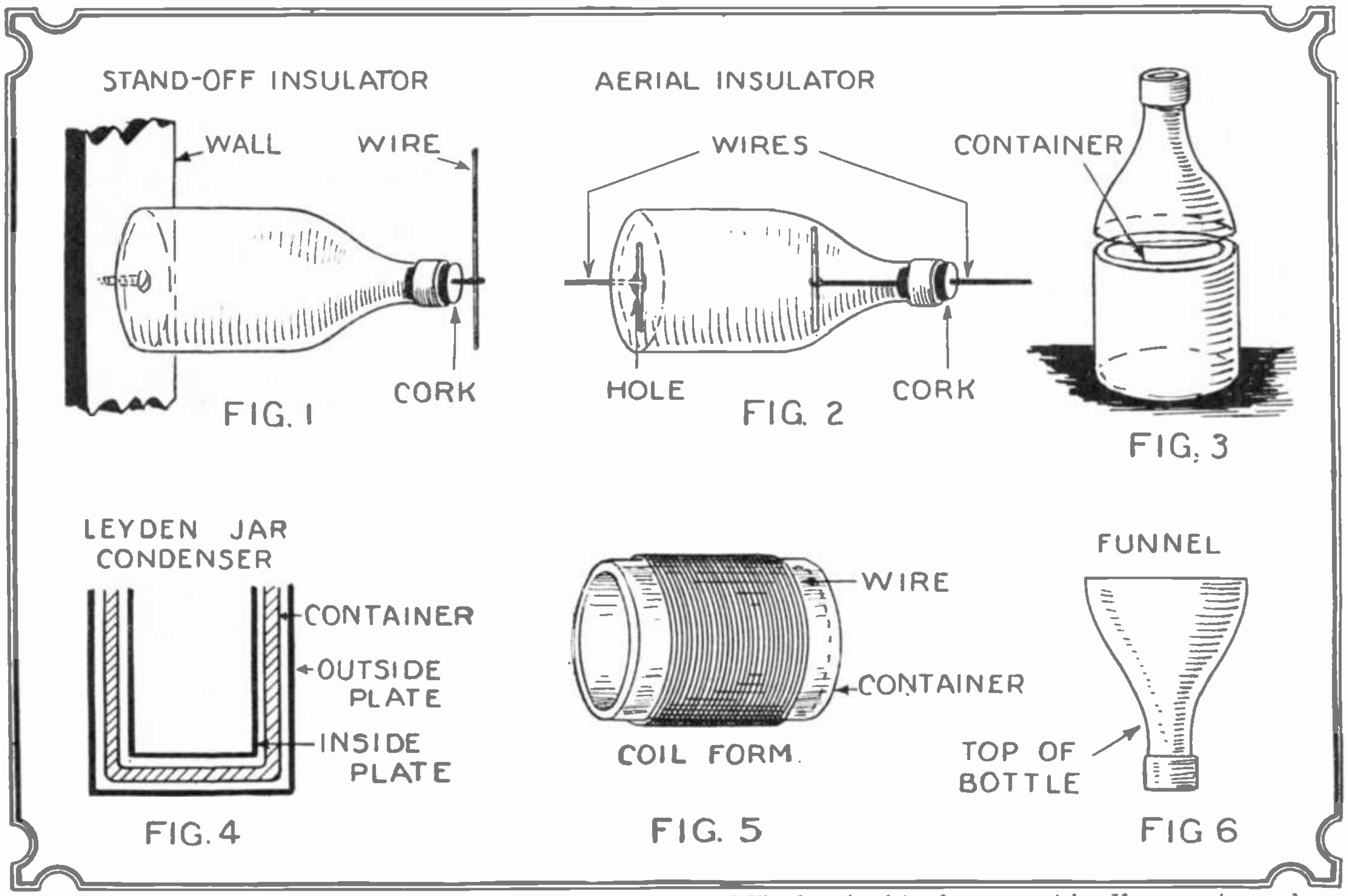
While this switch is harder to "throw" than the other type, because of the decreased leverage of the blade, the handle of this switch does not have to swing in so large an arc, as it does in the other type.

—Contributed by Roger Anthes.



Modification of a switch so that a small motion produces the same effect as a movement through an arc of 180 degrees does in the ordinary type of throw switch.

Service from Bottles



What can be done with bottles? Fig. 1 shows a stand-off insulator and Fig. 2 an insulator for your aerials. If you want a condenser you can make the container as shown in Fig. 3, building up the condenser as shown in Fig. 4, while Fig. 5 shows the section of a bottle used to wind the coil on. The discarded top of Fig. 3 can be used for a funnel.

THERE are many uses for old bottles, but an ingenious and mechanical experimenter will ever find many more adaptations.

In Fig. 1 there is a stand-off insulator. This will find its place in many a radio amateur's shack for aerial and high tension insulators.

In Fig. 2 is shown an aerial insulator. You will notice in Figs. 1 and 2 that there is a hole in the bottom of the bottle. This hole can be drilled with a broken file held in and rotated by a carpenter's brace. This insulation is very desirable because if we have a long bottle, the length of the insulator will be great, thus making leakage from the aerial very slight. Use a solution of camphor or turpentine for the drilling.

Now if we cut the top of the bottle off we have a container. There are several ways to cut a round glass bottle, but I shall mention two good ones. The first requires a red hot, taut wire which is pressed against the bottle where the cut is to be made. Then dip it in water.

The second requires a piece of cord long enough to go around the bottle once. This is dipped into alcohol and tied around the bottle at the spot where the bottle is to be split. Then the cord is lighted with a match and allowed to burn. When we see that the flame is about to go out, we dip the whole bottle into a pail of cold water, and presto, the bottle will be cracked at that spot. The beginner should make several trials on scrap material before attempting to use a good bottle.

We may use the container of Fig. 3 as a Leyden jar condenser as shown in Fig. 4. Thin sheet copper or brass may be used for the plates or coatings. In Fig. 5 is shown another very useful article, a glass coil form. This will make your coils low-loss and be much better than the regular forms in many ways.

Those fans who like to utilize whatever they can lay their hands on will find that the tops which they cut off the bottles with narrow necks make fine funnels. This is shown in Fig. 6. The sharp edges of cut bottles can be removed by rubbing with a file or whetstone. The latter is probably preferable. Do not try to round them in a flame.

Contributed by Harry H. Farb.

Inexpensive Flasks

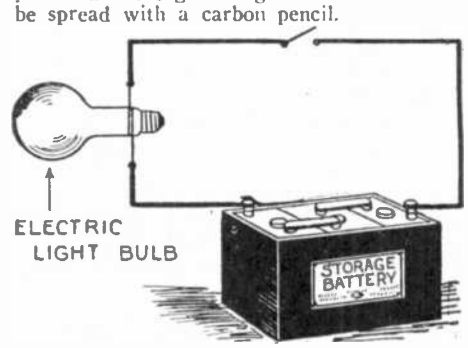
By Harry R. Lubcke

MANY experimenters know that an electric light bulb will make a good flask. However, the difficulty in securing a clean, smooth cut in separating the base from the bulb causes many to give up in despair. By following the procedure outlined below it is possible to make a very satisfactory job.

The "nitrogen" filled bulbs with a nearly round shaped bottom, or what is to be the bottom, and a long stem or neck, are, of course, the best for a Florence flask. The tipless type is to be preferred since it gives a stronger base for heating. The cutting is done electrically. A piece of resistance wire of about No. 22 B. & S. gauge and nine inches long is secured. Such wire can be taken from an old electric heater coil. This is attached to pieces of copper wire which run to a six-volt storage battery as shown in Fig. 1. About 7½ inches of resistance wire between the connection with the copper pieces will give a red heat on six volts.

The resistance wire is wrapped around the neck of the bulb where the cut is to be made, care being taken that the two ends do not touch, so that the loop around the glass will not be shorted. If the wire is put in place when heated by the current it will bend more readily. The current is allowed to flow for about one minute, after which time the neck of the bulb is plunged into cold water. This sudden change of temperature will cause the bulb to crack evenly where the wire was located. The base and lead-in wires can now be pulled out.

Round off the sharp edge by "fire polishing," holding it in a gas stove or Bunsen flame until the flame is colored intensely yellow and the glass begins to melt. It can be spread with a carbon pencil.



Using a resistance wire heated by a storage battery for cutting off the neck of an electric light bulb. Will cut bottles as above.

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

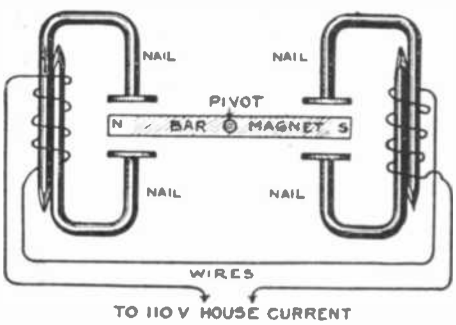
First Prize, $25	Second Prize, $15	Third Prize, $10	Honorable Mention
Edwin Crosby, 649 4th Avenue, Troy, N. Y.	H. J. Russel, 23 Institute Road, Worcester, Mass.	G. V. Kimmel, 925 S. 22nd Street, South Bend, Ind.	Ralph Townsley, Emison, Indiana

First Prize
Home Made Buzzer

BEND four nails of a convenient size, each into a sort of U-shape, with the head of the nail on the short leg, which is to be one-half the length of the larger leg; arrange with two coils as in the diagram.

If used on a 110-volt circuit the coils must be wound with a great deal of No. 30 B. and S. gauge wire, but if used with a step-down transformer, less wire of larger gauge may be used.

The armature is a small bar magnet with a hole drilled in the center or supported in some other suitable way so as to allow easy vibration. A small nail through the hole as an axis will answer.



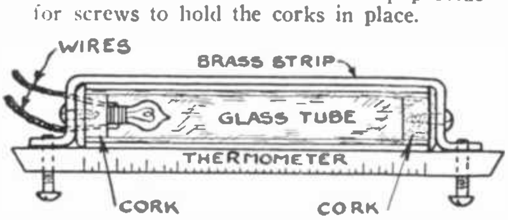
An extemporized buzzer using bent wire nails for the magnet cores.

When the buzzer is arranged as shown in the diagram, the alternating current sets up a changing magnetic field in the electromagnets, driving the armature back and forth on each side of its axis, producing a strong vibration.

Second Prize
Illuminated Thermometer

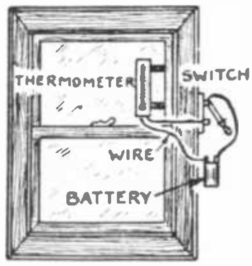
BUY a glass outdoor thermometer; ground glass if possible. Bend a piece of ½-inch brass to the shape as shown in AA, with holes to attach it as required.

Cut a piece of glass tubing (cost about 5c) with cork in each end about ¼ inch shorter than the inside of the bent brass strip. Two holes in the end of the brass strip provide for screws to hold the corks in place.



A system of illuminating a thermometer for use outside of a window. By touching a button a light is turned on to show the temperature on the scale.

Buy a battery and lamp (10c each); solder insulated wire to bottom and side of lamp base. Run wires through bottom cork to the battery inside the house. A switch is put in the line where convenient. I made one by screwing a round head brass screw for one contact, attaching one wire to it, and the other part was a 2-inch long thin strip tempered brass to touch against the screw head when pressed.



The general arrangement of switch, battery, light and thermometer. The thermometer is supposed to be fixed in position outside the window.

I have had such a device for several years and have also constructed some for gifts for friends. The only upkeep expense is a 10c battery occasionally.

$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

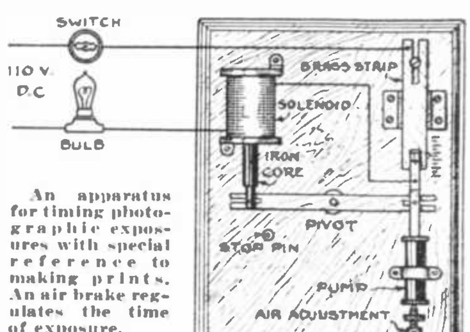
This department desires particularly to publish new and original ideas on how to make things electrical, new electrical wrinkles and ideas that are of benefit to the user of electricity, be he a householder, business man, or in a factory.

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.

The tube with lamp may be placed behind a glass-scale thermometer or alongside a wooden scale one.

Third Prize
Photographic Timer



An apparatus for timing photographic exposures with special reference to making prints. An air brake regulates the time of exposure.

THIS simple timing device is an original idea of my own. It can be used to time photographic prints, or by connecting any electrical device (in place of the bulb as illustrated) the exact time of operation can be governed.

(A) is a small solenoid, with a soft iron core. The core is slotted at one end and a small hole drilled there for a pin. (B) is a heavy brass strip, slotted at each end, and a hole drilled near the center for a pivot.

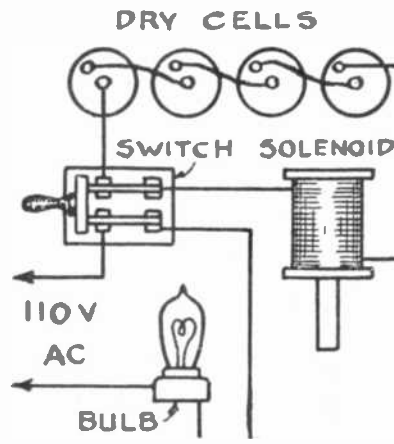


Diagram of the connections for the photographic timer. The solenoid attracts its armature, but its speed of action is restrained, by what may be termed an air dash pot.

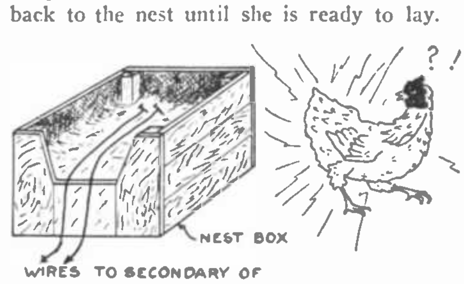
(C) is a small bicycle pump, which is cut off three inches from the top and a small brass plate soldered on; this plate should have a small pin hole. It is used as a dash-pot; the compressed air slows down the action of the solenoid. The piston of the pump is cut the right length and slotted and a hole is bored for a pin. (E) is a small brass strip, which is soldered to the piston of the pump and not to strip (B). (F) is a brass strip slotted at one end for the screw (G). (H) is the guide for the strip (F). (J) is a switch.

A set screw with a needle point regulates the air compress, but most of the adjusting should be done with the strip (F).

If the city current is not direct, dry cells must be used to operate the solenoid, as illustrated. The coil is excited and the bulb lights at the same time.

Honorable Mention
Electricity for Sitting Hens

ABOUT this time of year on most farms it is desirable to stop hens from sitting. This is nothing more than three or four dry cells, a Ford coil and a few feet of bare wire. Simply turn on the coil current to see things happen. The fun is worth all the time and trouble and the hen won't come back to the nest until she is ready to lay.



An electrical apparatus for discouraging hens from sitting and by this discouragement it is supposed that they will be induced to lay eggs.

What Our Readers Think

Electrolytic Hydrogen for Power

Editor, THE EXPERIMENTER:

While reading THE EXPERIMENTER for July I noticed an article entitled "Power Generation in the Future," which stated that the use of hydrogen, which had been separated from water by electrolysis, would probably be a factor in future power generation.

Isn't the production of hydrogen by electrolysis rather an expensive process? According to my calculations it takes a very large power to liberate hydrogen from water. A small amount of this gas would probably, however, be quite sufficient in quantity to operate an explosion engine. I would like your opinion.

I would also be pleased to have your opinion on the use of acetylene in an explosion engine.

Yours truly,
ELMER R. CAMPBELL.

Taunton, Mass.

(The idea of the power plant is to utilize wind-power and only to maintain a reserve of hydrogen to take care of calm days. The author is a Cambridge (England) University man, and although his idea is extravagant from our point of view it is interesting as an attempt at a glance into the future. A great deal has happened in the last fifty years, and the end is not yet.

We would not advise you to use acetylene in an explosion engine. The gas is endothermic and is liable to explode by breaking up into its constituents hydrogen and carbon. If it did this in the engine cylinder it would tend to interfere with its regular cycle. It has been used to facilitate starting automobile engines, but met with little success.—EDITOR.)

Electronic Cells

Editor, THE EXPERIMENTER:

I noticed your article on the "Electronic Cell" in the June issue of THE EXPERIMENTER. It is really a very revolutionary application of radio-activity and may lead to revolutionary changes in generation of electricity if it advances as fast as generation by magnetic fields has.

I wonder if the electronic cell battery would ever need recharging? The polarization drop ought to be practically nil since the radio-active electrolyte is active for some hundred or more thousand years.

If it never needs recharging it appears to be a big step toward the ultimate goal of practically utilizing atomic force.

Your magazine is just about ideal for live-wire tradesmen and experimenters in all science fields.

Yours truly,
RAYMOND WAGNER.

(The electronic battery is decidedly in the experiment stage and it is not possible to make any predictions concerning its possibilities. One thing is certain, the electric battery whether primary or storage needs much change to give it the standing it should have. The storage battery is too heavy and too expensive; the primary battery uses too expensive "fuel," namely zinc, and too expensive a source of "oxygen," namely the electrolyte or battery solution.—EDITOR.)

Wants Articles for the Beginners

Editor, EXPERIMENTER:

I have just finished reading "THE EXPERIMENTER." On page thirty-six was a voting coupon which I was asked to cut out and mail to you. As I keep all my magazines (*Radio News* and *Science and Invention*) I do not like to cut this magazine up and so I am writing instead.

You asked for my opinion of the magazine and what I would like to see in it. First it does not come up to *Science and Invention* or *Radio News* in size or material. It is too advanced, for me anyway. I refer to the articles such as "Little Known Methods of Producing Oscillations, Hearing Muscular Action, and Simple Telegraphone."

I should like to see a monthly page for the beginner. Radio owes its popularity, in my opinion, to the ease with which it is learned. It is easy to learn because most radio articles are written for beginners.

Science and Invention has the majority of its contents put in pictures which are very easy to understand.

THE EXPERIMENTER would increase its circulation greatly if it had monthly articles for the beginner. Since it is called "THE EXPERIMENTER" why not have a simple monthly experiment which the beginner could do?

I enclose one which I think would prove a good one to start with. It proves a common statement and is very interesting.

I hope you will see fit to publish this experiment and continue to have a page for the beginner.

Yours truly,
Worcester, Mass. ERNEST CARPENTER.

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

Highly Pleased With "The Experimenter"

Editor, THE EXPERIMENTER:

Just a line to let you know how a highly pleased reader of THE EXPERIMENTER feels. I bought the first issue of THE EXPERIMENTER and it has taken its place along with SCIENCE AND INVENTION on my laboratory bench. You are to be congratulated upon the change. "Practical Electrics" I didn't care for at all, but the new magazine is a *Wow!*

I have a small chemistry laboratory of about sixty reagents, so of course I would like to see more of Dr. Ernest Bade's and Raymond B. Wailes' stuff. In the February issue, J. Edmund Woods and Earle R. Caley's articles were enjoyed. More!

The radio department is great, for those that like it.

There is only one drawback to your publication (I think) and that is: Your articles on the future. I think you let your imagination run a little too wild. Your drawings and your captions seem to be a little too positive. You tell all about how to do it without giving any details.

This is a pretty long "word," but I wanted you to know that THE EXPERIMENTER fills a long felt want in the heart of the American experimenter.

Long may she wave!

F. E. UPCHURCH.
An S. & I. Reporter.

Atlanta, Ga.

(You will find the details you seek for in the text of the articles. We wish we could be sure that our readers depended more on the text of the articles and less on the captions. We give our best efforts to securing good material and some very remarkable articles have already appeared on our pages and more are coming.—EDITOR.)

A Question of Magnetic Poles

Editor, THE EXPERIMENTER:

The question has often arisen, where is the North and where is the South Magnetic Pole. According to E. E. Weber, map maker, the North Magnetic Pole is situated near the North Geographical Pole. Taking Amundson's voyage to the South Pole into consideration, the above statement is false.

When he, Amundson, reached the South Pole, his compass needle deviated so that his south end pointed down, showing the presence of a North Magnetic Pole. Therefore, the South Magnetic Pole must be in the vicinity of the North Geographical Pole. Moreover, a south-seeking pole is sometimes called north, showing that the north side of a compass needle is attracted by a South Pole (Magnetic).

Yours sincerely,
RAYMOND A. LISISQUEN.

(There is no doubt that the correct name for the north pole of the magnet is the "north seeking pole." But the short names "North Pole" and "South Pole" have won acceptance and it is too late to change now.—EDITOR.)

Danger in the Chemical Motor

Editor, THE EXPERIMENTER:

At present I am not a subscriber to THE EXPERIMENTER, but I chanced to note with interest mixed with some apprehension the illustration on the cover of the June issue of that magazine as it appeared in an advertisement in *Radio News.*

This illustration is of a "Chemical Flask Motor" which operates due to the vaporization of some volatile liquid, the pressure thus produced forcing an excess of the liquid over into the other side of the motor, and thus causing it to rotate. I have not read the article describing the construction of this motor, but unless the article is at variance with the illustration, the presence of a bottle marked "ether" would indicate the use of that dangerously inflammable liquid in the motor. Any sane person having any knowledge of the properties of ether would hardly use it in thin-walled glass bulbs which were to be heated by a direct flame as in the illustration.

The possibility of a leak or of breakage of some part of the apparatus is too great under such conditions to warrant suggesting such an experiment where it might be performed by some unskilled technician, with genuine danger to his person and to those who might be near. In my opinion, the use of chloroform, which is uninflammable, and yet sufficiently volatile for the experiment, would have been much saner and wiser. Of course, if the use of some non-inflammable liquid was specified in the article proper, the above criticism does not apply, and in that case, I would beg your pardon for the criticism.

Sincerely,
HERMAN P. ROTH.

Olivet, Mich.

Private Laboratories

Editor, THE EXPERIMENTER:

Having purchased a lot in this locality, I am preparing to erect a combined dwelling shop and laboratory. The laboratory work is to involve physics, chemistry, etc.

It has occurred to me that if neighbors consider this dangerous I may have to move. I wonder if there is anything you can tell me in regard to my rights in this matter, and if so, would be pleased to receive an early reply.

Respectfully,
G. M. L.

(There is no danger of the neighbors forcing you to move. Your laboratory as you speak of it, will be no more dangerous than any dwelling house. When you have insured you will automatically get the views of the underwriters on the subject of laboratories. There are laboratories all over the country and no one should object.—EDITOR.)

An Appreciation

Editor, THE EXPERIMENTER:

I am but one in a great army of experimenters and am trying to learn all I can about the theory and practice of electricity and radio. Your magazine has been a very great help to me in these matters. The July, 1925, number was exceedingly good.

Those articles by radio amateurs 2ABM, 2DK, 2FZ and 3MO were excellent and the one by Leon Adelman called "Circuit Analysis," is also to be highly commended. Here's to the continued success of your publication.

Very truly yours,
JOHN O'DONNELL.

Pittsburgh, Pa.

Binding the Data Sheets

Editor, THE EXPERIMENTER:

I wish to make a little contribution in the line of a suggestion. To keep the radio data sheets or any others from being torn at the holes I suggest making gummed reinforcements as follows: Get some gummed strips of paper such as grocers use to fasten paper bags and stick two pieces together one on top of the other so that one side is plain and the other gummed.

Then make punches from two brass tubes ½ inch and ⅛ inch diameter by filing the ends to a knife edge. With a compass make as many ½ inch circles or washers as possible and make ⅛ inch circles in the centers. First use the ⅛ inch punch and then the ½ inch punch. Stick these on either side of the data sheets where the filing holes are.

Hoping for the future success of the EXPERIMENTER, I am,

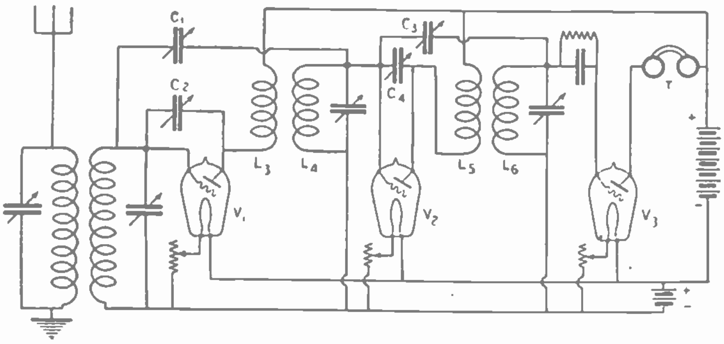
Yours truly,
SIMON CHERRY,

Montreal, Canada.

(We are glad to publish this suggestion. There is no doubt that reinforcements are desirable, although other arrangements could be devised.—EDITOR.)

Latest Electrical Patents

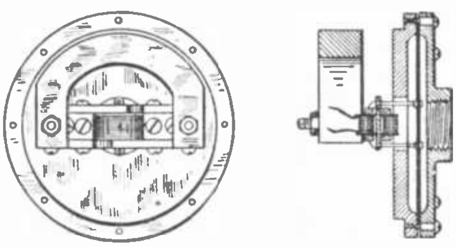
Amplifying System



This new system of radio frequency amplification has been patented by John Scott-Taggart, the eminent engineer. An auxiliary condenser is used to enhance the inherent tube capacity while at the same time another one is used to neutralize the tendency to oscillate. The inter-electrode capacity of the tube is so very small that the proper neutralization cannot be effectively made when using small neutralizing condensers. The capacity is increased by means of one of the condensers and then counterbalanced by a second one. Greater stability is thus insured and higher amplification is obtainable. The neutralization is not affected by changes in wave-length, and when the condensers are once adjusted it will be found that stable operation is as good on long wave-lengths as it is on short. C2 and C4 are the neutralizing condensers, while C1 and C3 are the counter-balancing ones.

Patent No. 1,521,580 issued to John Scott-Taggart, Ilford, England.

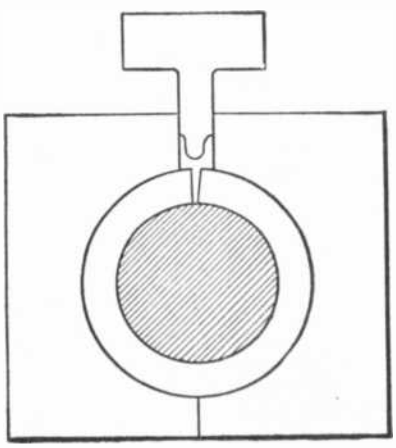
Loud Speaker



In this loud speaker, friction due to armature bearings and fulcrum points usually employed to support the armature are eliminated. It is claimed that considerable tone improvement is obtained in this way.

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

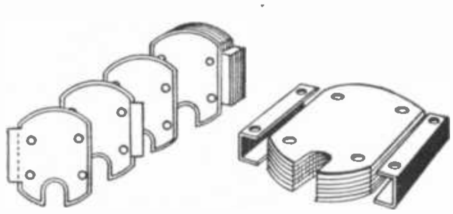
Electric Welding



In electric welding a groove is often plowed out to start the operation. Here a coupling is made by shaping a piece of iron into a cylinder and then by driving a die down into the gap a proper shape is given to the gap to facilitate welding, a thin edge being produced at the bottom for the operation to start at.

Patent No. 1,531,824 issued to Chas. S. Smith, Milwaukee, Wisc.

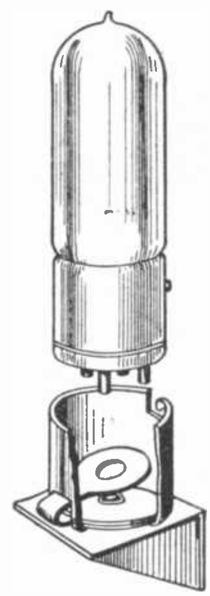
New Mica Condenser



In this condenser each plate of mica is coated on one side with black oxide of lead or graphite and then electroplated on this side only with copper. In this way a more compact assembly of the strips is made possible.

Patent No. 1,533,334 issued to H. O. Russell, et al, Dayton, Ohio.

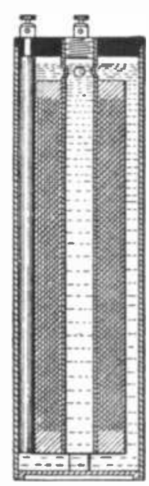
Vacuum-Tube Holder



The object of this invention is to secure a vacuum tube in its socket by the use of a bayonet joint. To make it doubly secure there is a spring in the bottom of the socket which pushes the tube upward to secure the grip.

Patent No. 1,533,209, issued to John W. Badu, New York, N. Y.

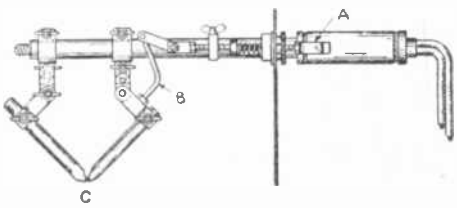
Electric Condenser



This condenser, the invention of the distinguished electrician, Elihu Thomson, is made by rolling up sheets of metal and of dielectric into a cylinder placing them in a case which then can be charged with oil.

Patent No. 1,536,948, issued to Elihu Thomson, Swampscott, Mass.

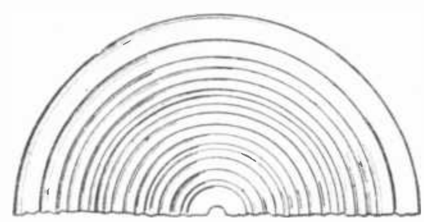
Electric-Arc Welding and Preheating Handle



This is a handle for operating two diagonally placed carbons for arc preheating and welding. The numerous joints give opportunity for various adjustments and at B and at A there is a finger piece for opening the arc C.

Patent No. 1,533,874, issued to Henry W. Livermore, East Orange, N. J.

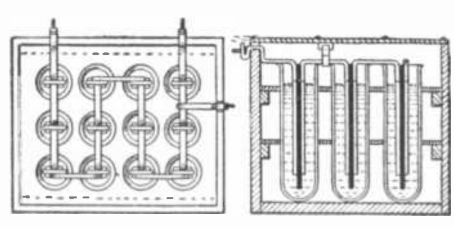
Telephone Diaphragm



The telephone diaphragm illustrated is corrugated in concentric circles. The lengths of the radii of the circles are prime with each other numerically, so that each corrugation overcomes in great measure the resonance due to the circles adjoining it.

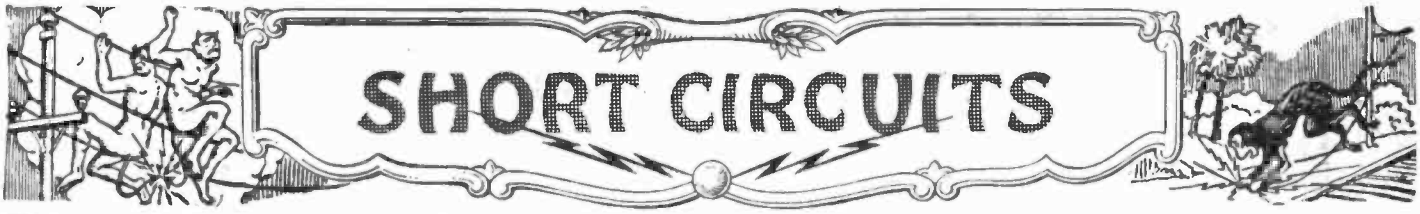
Patent No. 1,522,758, issued to Phillips Thomas, Pittsburgh, Pa.

Combined Storage Battery and Rectifier



The above patent covers the combined storage battery and rectifier for charging by rectifier connected in series with the battery and cut out of circuit when the battery is to be used. It is particularly adapted for use as a "B" battery in radio.

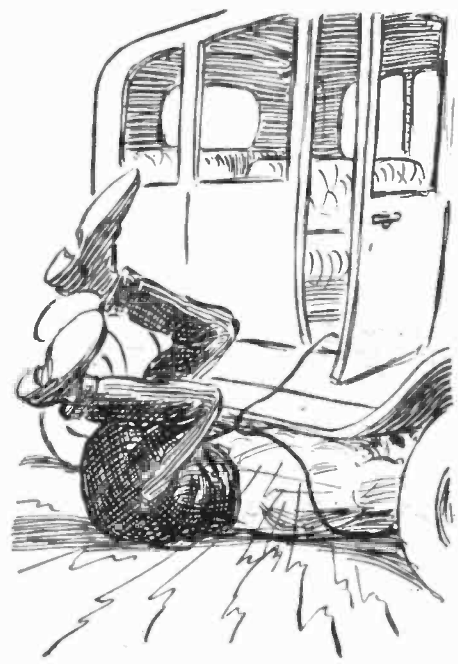
Patent No. 1,533,906, issued to William Threm, Cincinnati, Ohio.



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

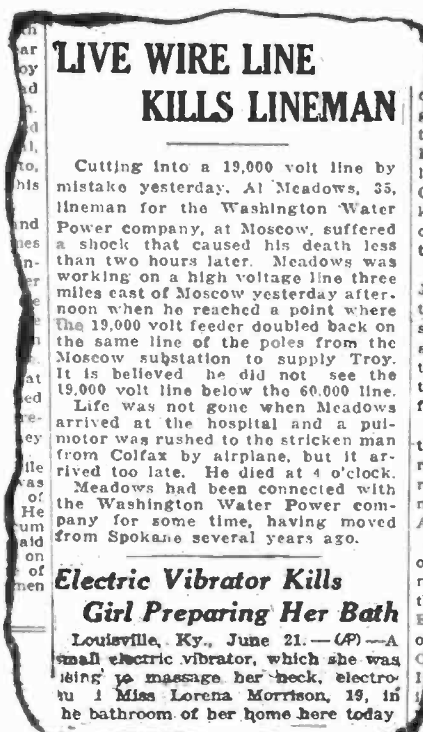
Here lie the remains
Of Miss Lizzy McDubb.
She massaged her neck
With one hand in the tub.
—Harry Sand.

Here rests in peace
Poor Harry MacLawter.
He stuck his soldering iron
In a pail of water.
—Ron. Symms.



Entombed 'neath this spot
Lies Willem Van Camp.
He hunted for trouble with
An uninsulated lamp.
—Harry West.

Beneath this sod
Is little Jimmie Durkt.
He put his finger in the socket
To see how it worked.
—Ron. Symms.



LIVE WIRE LINE KILLS LINEMAN

Cutting into a 19,000 volt line by mistake yesterday, Al Meadows, 35, lineman for the Washington Water Power company, at Moscow, suffered a shock that caused his death less than two hours later. Meadows was working on a high voltage line three miles east of Moscow yesterday afternoon when he reached a point where the 19,000 volt feeder doubled back on the same line of the poles from the Moscow substation to supply Troy. It is believed he did not see the 19,000 volt line below the 60,000 line.

Life was not gone when Meadows arrived at the hospital and a pulmotor was rushed to the stricken man from Colfax by airplane, but it arrived too late. He died at 4 o'clock.

Meadows had been connected with the Washington Water Power company for some time, having moved from Spokane several years ago.

Electric Vibrator Kills Girl Preparing Her Bath

Louisville, Ky., June 21.—(AP)—A small electric vibrator, which she was using to massage her neck, electrocuted Miss Lorena Morrison, 19, in the bathroom of her home here today

A scholarly death
Died operator Mitch,
He pointed his pencil
At an electric switch.
—Leo R. Lieder.

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.

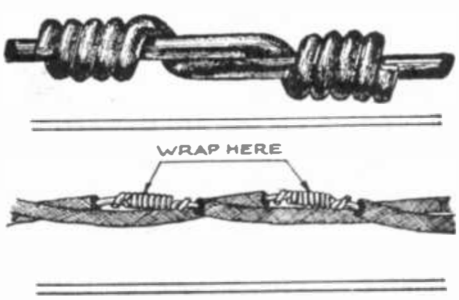
Kindly oblige us by making your letter as short as possible.

Conventional Splicing

(530) James R. Morgan, Des Moines, Iowa, asks:

Q. 1. What is the standard practice used by wiremen in splicing twisted cable?

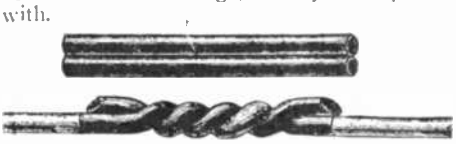
A. 1. The method in use the world over is that known as "staggering joints." The familiar Western Union connections are employed in splicing the ends of the wires. The following procedure is used:



The upper figure shows the American connection or joint. If the straight portion of the wire lying between the two twisted portions were also tightly twisted it would be the Western Union connection. The lower figure shows how to connect flexible wire for lamps and so forth so as to avoid short circuiting and arcing.

The ends of one of the cables are cut so that one wire is three inches longer than the other. The insulation on both is then removed for a space of 2½ inches. The other cable is treated in a similar manner and the standard Western Union splice made. Thus, there remains a space of about two inches of untouched insulation between both joints, which prevents accidental short circuit. After the connections are thoroughly soldered they are well taped and in such a manner that the joints are almost unnoticeable.

What are known as McIntyre sleeves are used to some extent in different parts of the country instead of the ordinary standard splice and soldering practice. The sleeve consists of two copper tubes having a slightly larger diameter than the wires which are to be connected. By inserting the ends of the wires into the tubes, which are practically welded together, and then twisting them two or three times about each other an excellent joint is secured. Soldering may be used with advantage, or may be dispensed with.



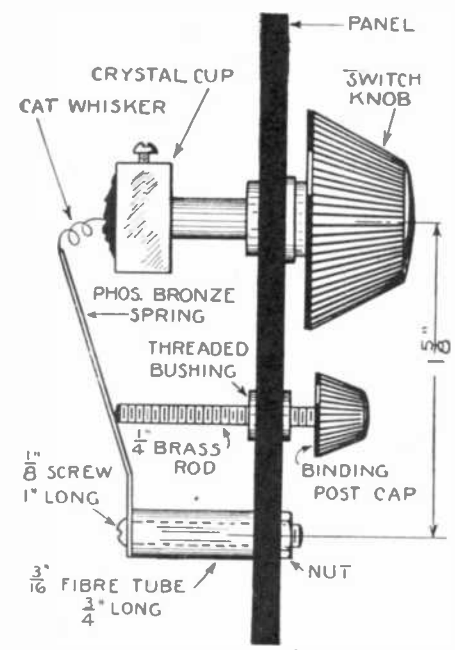
The McIntyre sleeve; the straight ends of the wires are inserted in the tubes which are then twisted as shown in the lower figure, making a very secure joint and one of high conductivity.

Crystal Detector

(531) Leon P. Peck, Bronx, New York, asks:

Q. 1. Kindly give me constructional details on a back-panel-mounted crystal detector. I want this so that it will be protected from dust and mechanical injury.

A. 1. The crystal cup is soldered to a short length of brass rod, to which is fastened a knob, and which rod projects through a bushing in the panel. A short length of spring bronze, or even spring tempered brass is fastened, as is shown in the diagram, and to one end is soldered a small catwhisker of phosphor bronze wire. Regulating the pressure on the crystal is done by a short threaded rod with a binding post head soldered on it passing through the panel immediately underneath the larger knob. The arrangement provides for extremely delicate adjustment and is quite convenient in operation.



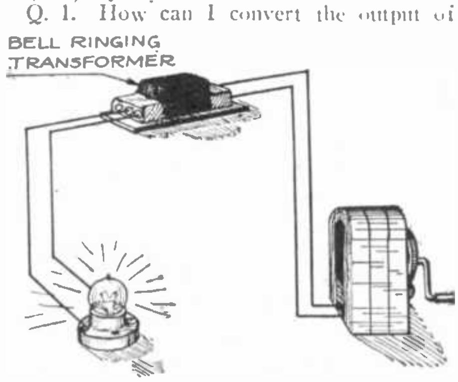
A very neat arrangement for a catwhisker crystal detector operated by the familiar switch knob in front of the panel and adjustable by a binding post cap below the switch knob.

Bell Ringer

(532) Jerry Bass, Oshkosh, Wis., asks:

Q. 1. How can I convert the output of a bell ringing generator so as to light 6-volt automobile lamps?

A. 1. The simplest method by far is to use a small step-down bell ringing transformer. The average voltage generated by the bell ringer is approximately 110 volts, and secondary of the transformer will thus deliver approximately the necessary voltage.



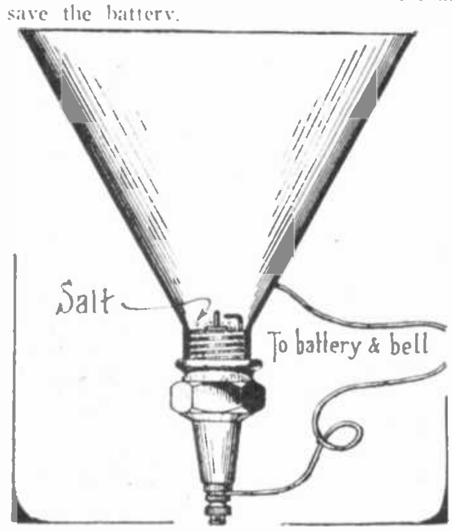
Operating a bell-ringing generator giving the usual high voltage; by means of a transformer the voltage is lowered so that it can light a low voltage lamp.

Rain Alarm

(533) Jackson Stewart, Glen Cove, L. I., inquires:

Q. 1. Is it possible to make a successful rain alarm and which will warn one immediately after it commences to rain. I have seen many described in various journals, but it usually takes too long for them to function.

A. 1. The accompanying diagram shows how utterly simple it is to make a rain alarm which will work effectively as soon as rain begins to fall. A spark plug fitted with a funnel is fastened to a piece of board projecting from the window sill. A few grains of salt are placed around the electrodes and then the device is wired in series with a 6-volt battery and electric bell. As soon as rain water trickles down the side of the funnel it dissolves the salt which, upon solution in the rain water, ionizes and the saline solution becomes a fairly good conductor. If a small switch is included in the circuit, it will be possible to shut off the alarm when it has been answered and thus save the battery.



A rain alarm. It operates by the moistening of salt by the rain, a spark plug being used to give the terminals. A metal funnel is connected to the one wire.

High Voltage Experiments

(534) A. R. Ibbotson, Souris, Man., writes:

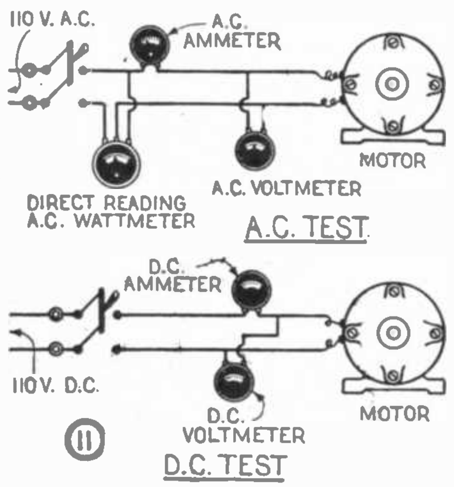
Q. 1. I am particularly interested in your article by Lester Reukema on high voltage experiments. Please give me page reference for the second instalment.

A. 1. You will find this in the May issue of THE EXPERIMENTER, page 494 with additional illustrations and diagrams.

Operating D.C. Motors on A.C.

(*Continued from page* 765)

are connected to diametrically opposite commutator segments, as shown, and synchronizing lamps connected across the main switch. These lamps should be of similar voltage rating to that of the motor. Full details on how to synchronize can be found in any A.C. textbook. The field coils are excited or polarized by means of battery current, which may be varied through a rheostat. For this



The connection of volt and ammeter, as well as direct reading wattmeter, are shown in the diagram above, both for testing D.C. as well as A.C. motors. Some laboratories are equipped with a direct reading power-factor meter.

sort of work a shunt motor may be used, as well as a series motor. Some means must be provided to speed up the armature of the machine until synchronous speed is reached, and as soon as the main switch is closed the accelerating means may be dispensed with. The accelerating device may be another motor belted to the synchronous machine, or it may be spun by means of a belt and a pulley provided with a handle.

Inductance Motor from D.C. Machine

Fig. 8 shows a simple method for converting a D.C. motor into an induction motor simply by wrapping a few turns of bare copper wire around the commutator bars, thus short-circuiting all of the armature coils. The field coils are connected to the A.C. supply, preferably through a controlling impedance coil or rheostat, or, failing this, a lamp bank. This induction motor is not self-starting and the armature has to be spun by pulling on the belt, or otherwise, until it reaches a synchronous speed. The connections of the field coils may be changed until best results are obtained.

Self-Starting A.C. Motor from D.C. Machine

To make a squirrel cage induction motor self-starting, one or two tricks are usually resorted to, *viz.*, either to provide copper shading plates placed in the leading field pole tips, as shown in Fig. 9, or else to use starting coils in place of them, opening the starting winding as soon as the motor has reached synchronous speed. It is a simple matter to make a squirrel cage rotor out of a D.C. armature by filling the slots with copper bars and soldering these at either end of the rotor to copper discs in the manner shown. Usually, however, it is best to have more rotor inductors than can be got into the average D.C. armature. Those interested in this particular phase of the work may refer to books on A.C. motors, or to an article by the writer, entitled "How to Build a 1/16-h.p. A.C. Motor," in the October, 1921, issue of SCIENCE AND INVENTION, page 531.

Combination Repulsion—Inductance Motors

For the electrical experimenter working on the problem of how to operate a D.C. motor on A.C., Fig. 10 may provide an interesting field of thought. Here we see two diagrams, (A) showing a motor of the D.C. type starting as a repulsion motor with short-circuited commutator brushes. After the motor has reached synchronous speed, a centrifugal ball governor device causes the brushes to rise from the commutator and pulls a copper or brass short-circuiting ring against all the commutator bars simultaneously. This, as will be seen, converts the armature into a sort of squirrel cage rotor. The motor is thus operating as an induction motor.

This unique principle has been used for many years on well-known A.C. single-phase motors. For small motors in experimental work, the action can be simplified by not having the ball governor lift the brushes from the commutator, but simply by causing such governor to open a switch in the jumper circuit connected across the brushes. Of course, as with all the previous motors described, the main field frame through which the field flux passes from one pole to another, including the field poles, must be of laminated sheet-iron. The field coils are connected, of course, to the A.C. supply, and the number of turns, as well as the connections of the field coils, may be changed until best results are obtained. All this sort of work is very enlightening to the embryo electrician, and he will never regret the hours spent in studying and experimenting with motors in their relation to A.C. and D.C. circuits, as it is difficult to absorb the necessary practical knowledge of actual results obtained from the theory given in textbooks. Keep a record of all tests, as they will prove of incalculable value in later years.

Testing Motors on A.C. and D.C.

In Fig. 11 is shown a method of connecting an A.C. ammeter and voltmeter, as well as a direct reading A.C. wattmeter, to a motor, in order to determine the watts consumed, and the power factor of a machine. The connection of the D.C. ammeter and voltmeter is also shown for making a test on D.C. circuits.

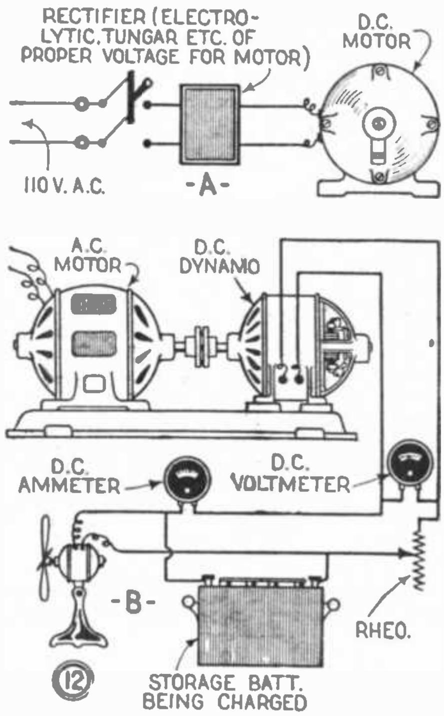
After obtaining readings from the A.C. instruments, the following factors can be computed. The *apparent watts* consumed by the motor is found by multiplying the amperes by the volts indicated on the ammeter and voltmeter, respectively. The *true watts* expended in the circuit and for which we pay real money is volts *times* amperes *times* power factor. The *power factor* is found by dividing the true watts, indicated on a direct reading wattmeter, by the apparent watts. The power factor is about 80 per cent. for motors.

In making changes in the windings on a machine intended for use on A.C., it is well to keep in mind that the heating effect is sensibly the same for A.C. or D.C. Therefore, it is permissable to allow the same cross-sectional area for copper wire used in windings as for D.C. machines, *viz.*, 1,000 circular mils per ampere for non-moving coils and 600 circular mils per ampere for moving coils, such as armatures, etc.

Use of Rectifiers

Small D.C. motors can be operated from a rectifier, preferably of the electrolytic or vacuum tube type. Of course, the rectifier must be designed to have a sufficient output in volts and amperes (or watts) to take care of the motor in question. The current from vibrating rectifiers is of too pulsating a nature for operating motors satisfactorily, and in any case the rectifier should correct both halves of the cycle and not one half, or else the D.C. supplied will be too pulsating.

One means of operating D.C. motors from A.C. is to use a motor-generator set, as shown in Fig. 12-B. This may be an un-



In the diagram at A, a rectifier of some form is indicated for the purpose of operating a D.C. motor on A.C. Diagram B shows a reliable method of operating D.C. motors and other apparatus, including storage batteries to be charged, etc., by supplying these with direct current from a dynamo driven by an A.C. motor.

economical method of accomplishing the purpose in many instances, but in some cases it is the best method. An efficient and extremely satisfactory method of charging storage batteries is to use a small A.C. motor directly connected to a small D.C. dynamo in the manner shown. Arc lamps for motion picture projectors and for many other purposes are best operated on D.C. supplied in this way. As a hint to experimenters, we might mention that, for battery charging, a water motor may be substituted for the A.C. motor.

Notes on Electric Machines

There are three principal types of motor and dynamo, depending on the arrangement of the armature and the field windings. These types are series, shunt, and compound wound. The compound wound machine is a combination of the series and shunt wound. The series wound type gives the most constant speed when used as a motor and the most constant voltage when used as a generator, under changing loads, and is the most widely used.

Dynamos are divided into two clasess according to the nature of the current they deliver. Direct current dynamos deliver a direct current or one always flowing in one direction; one terminal being positive and the other negative. Any direct current dynamo may be used as a motor. Series and shunt wound motors turn in the same direction whether used as a dynamo or motor. By weakening its field, the speed of any motor is decreased and the torque increased.

Alternating current dynamos or alternators deliver an alternating current or one that periodically reverses its direction of flow, from positive to negative, and so on.

How to Make a 1-Meter Radio Transmitter

(*Continued from page 733*)

slightest conception of what the fundamental frequency may be. The Lecher wire system is, perhaps, the simplest and best method to be used.

Measuring the Frequency

Accurate knowledge of the frequency of the waves is of great importance, and they can, literally, be measured by a yard-stick or meter-stick.

All that is necessary is such an arrangement as shown in Fig. 2, which embodies a system of parallel wires spaced four or five inches apart, one end of each being left free, while the other ends are connected to two variable condensers and a small pick-up coil. Then, with the oscillator going, it is possible to pick up voltage nodes by means of the sensitive meter which is moved along the wire. The actual distance between successive nodes is one-half the wave-length.

This system has been described so many times that it is not at all necessary to go further into the details of standing waves, reflected waves and harmonic waves. Suffice to say that the experimenter will more than probably find numerous experiments to perform and measurements to take with this device.

Experiments

Of great significance and interest are the field measurements to be taken with the aid of the simple wave-meter. Unless the planes of both the oscillator coils and resonator coil are parallel, little or no energy will be picked up. If at exact right angles, even the most sensitive meter will give no reading. Again, if the resonator coil is brought in proximity, parallel to the oscillator inductance, but near to the supporting metallic screw on top of the glazed porcelain insulator, complete absorption will be manifest and for a radius of several inches around the screw it will be impossible to obtain a light in the lamp. On the other hand, even several inches further away, it might be possible to burn out the lamp, due to the excessive field strength.

It will be noted that with the inductance clips on various portions of the inductance, the tuning condenser will have little or no effect on the frequency but will have an enormous effect on the output. In fact, the radiation may fall to an extremely low value when the condenser capacity is made a minimum. We can readily account for this if we remember that the resistance of a condenser increases with the frequency and with a decrease in capacity value.

In experiments, the inductance clips have been so placed as to include the tuning condenser alone and leaving the inductance coils themselves to act as antenna and counterpoise, respectively. The inductance of the entire oscillatory circuit is made up only by the short leads between the grid and grid condenser, between the grid condenser and tuning condenser, between the tuning condenser and plate stopping condenser, and from the latter to the plate. It will at once be seen, therefore, that the values of the series condensers must naturally be low, but it also must be kept in mind that losses must be prevented, since the resistance of the circuit becomes so exceedingly high.

To further increase radiation, it has been found that short lengths of brass or copper tubing connected to the ends of the oscillator inductance, causing a greater load to be placed on the tube, give increased radiation and but slightly increase the wave-length.

Strange as it may seem, at certain points between the grid and plate inductances it is impossible to pick up any energy whatsoever, whereas, alongside of the coils, several 3½-volt battery lamps have been burnt out, due to the excessive energy radiated.

Experiments were carried on both during daytime and at night but no marked differences were noted.

While further experiments may bring to light some interesting facts concerning reflection, refraction and absorption of these extremely high frequency radio waves, we must content ourselves in acknowledging that we have made a big step forward in our attempt to differentiate between Maxwell's electromagnetic theory of light and Hertz's electromagnetic waves in the ether.

The Sacred Palm

(*Continued from page 746*)

tall and well-groomed, with a visage calculated to strike fear into the heart of any subordinate. He spoke deliberately and decisively, as if deciding an important business issue.

"There was no element of chance in my feat," said Mr. Whimple proudly. "This you will see as I go on. My story is this: Mrs. Whimple and I enjoy violin solos better than any other kind of radio music, but we are always annoyed by the fact that the piano accompaniment is invariably too loud for the soft playing of the violin. 'Horace, dear,' she said one evening, 'Can't you get rid of that piano music somehow? It spoils Mr. Ludlow's playing.' That set me thinking. The next day I went to the public library and consulted several books on sound and electricity. On my way home that evening I stepped into a radio store and bought several special radio instruments.

"After several nights of experimentation, I finally found what I was seeking. I invited Mrs. Whimple to listen to a demonstration of my new tone filter device. That night her favorite violinist was playing, and as usual the piano was too loud. So, what do you think I did? I switched in my filter, turned its knobs, and, gentlemen, I tuned out the piano music and left the violin playing as softly and as sweetly as a bird!"

The club members by this time were on their feet, shouting and applauding unrestrainedly. The din was terrific. Mr. President pounded on the table until the timbers began creaking, but it was only after Mr. Whimple took two bows that the excited club members resumed their chairs.

"Gentlemen, please, gentlemen". The president was hoarse. "It is growing late. Let us vote now. I will hold my hand over each candidate, and the strength of your applause will indicate your opinion of his story". The president walked over to Mr. Grimp, held his hand over his bald cranium, and looked questioningly at the club. "He removed his tubes from his set', he reminded them. A weak and lifeless patter dribbled across the hall. Mr. Grimp very definitely would not win the P.P.P.

Mr. Chairman had hardly reached Mr. Blister when another near-riot occurred. There was no need to remind the club that Mr. Blister had heard music with the phones disconnected.

Mr. McGurgle, poor soul, received nothing but a few scattered and impolite hisses. Mr. Whimple, however, was the recipient of another enthusiastic display of approbation.

"Messrs. Grimp and McGurgle, I am afraid, are eliminated", declared the president. "We will now vote again on Messrs. Blister and Whimple".

The two candidates received equal shares of vociferous acknowledgement, and it appeared as if the vote might result in a tie. However, Mr. Whimple's story was fresher in the audience's mind than his opponent's, so finally the president lead him to the platform.

"Mr. Whimple, in the name of the Ananias Radio Club," he said solemnly, belying his following words. "it gives me great pleasure to award to you this 14 carat solid gold palm, our sacred Palm of the Prodigious Prevaricator, for succeeding in tuning out the piano accompaniment to a violin solo. May the Lord keep you and guide you, amen".

"Did I hear a motion to adjourn? Gentlemen, the meeting is adjourned.

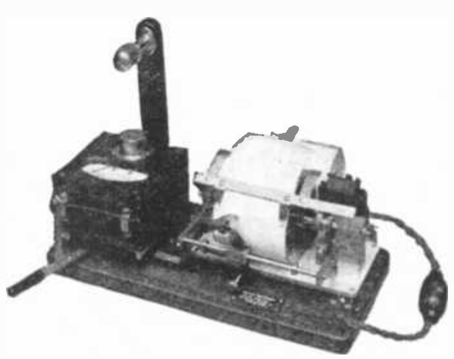
NOTE: Each of the four incidents has actually been attested to by unsuspecting beginners.—EDITOR.

Fading Recorder

EVERY owner of a radio receiver has noticed fading at some time or other. This is a factor which all who hope for dependable and continuous radio communication must contend with, and has been made the object of much study.

The illustration shows the instrument used by many of the observers in recent tests. The wire carrying the rectified output of a receiving set is connected to the galvanometer at the left; this galvanometer is an extremely sensitive instrument. A current of 14 millionths of an ampere is sufficient to give a full-scale deflection. The long line the pen has just drawn represents a change in current of about 5 millionths of an ampere.

This minute power, one of whose constituents is represented by this current, is not, of course, sufficient to actuate the recorder mechanism. The actual record is made by the operator, who moves the handle at the left back and forth with the galvanometer needle. The handle carries a pointer which is kept over the galvanometer needle. The lamp above the meter casts a shadow of the pointer on the meter dial. The pointer is moved so that its shadow always falls on the galvanometer needle.



The fading recorder which is operated by hand and motor working together. Photo courtesy of General Radio Co.

The pen connected to the handle moves back and forth across the paper, drawing a permanent record. The paper is carried by a drum, which revolves once in 20 minutes. The drum is driven by a small clock motor, which maintains its speed exactly uniform. Points on the roller prick the paper at two-minute intervals. The time at which the record is started is noted, and the time of any particular change is then indicated. A typical record may be seen on the roll.

Sound and Audio Frequency Amplification

(Continued from page 734)

these frequencies, and deliver them at the ear in their exact original proportion.

These harmonics now serve the purpose of giving what might be called distinction to the sound. They characterize the sound, they impart color, or, as it is generally called, they give the sound its distinctive timbre. This timbre is different for different bodies and substances, because the proportion in which these harmonics are present with the fundamental frequency is different. Without these harmonics and their infinite changeability, a violin would sound no different from a flute or an organ, no one instrument would have another distinctive or better sound than any other. With the harmonics, the various instruments are a mighty tool in the hands of the master and portray all emotions, as his mood dictates.

And always again the air is the faithful servant that brings to us all the finest graduations, the slightest variations, though remaining a neutrum all the time.

Yet, our picture would be incomplete when we imagine that the air particles bring to our ear each and every vibration separately. In reality the air vibrates in a way, which we might call a composite of all individual vibrations imparted to it. And it can do so with nearly an infinite number of vibrations, as when we are listening to an orchestra of many pieces, each of them vibrating independently in its fundamental and overtones. And the air particles deliver at our ear the composite or resultant vibration, and in turn our eardrum repeats merely this resultant vibration.

And now comes maybe the most wonderful part of our story of the magic called sound: we receive the composite wave or vibration, and in hearing, unerringly decompose this intricate vibration. And we follow the singing and sobbing of the violin in its tenderest

FIG. 4

Sound vibrations from a number of sources resolve themselves into a composite vibration which is again analyzed by the ear.

variations, we are thrilled by the triumphal tones of the cornet, and we wonder at the crystal clearness of the clarinets. While we know, little about the way this is accomplished, yet our knowledge is far from complete.

For most persons the range of frequencies from 16 to 20,000 fall within the range of hearing. But many people cannot hear the very lowest or the very highest tones. This is not detrimental in any way to the proper enjoyment of musical performances: The frequencies above 13,000 give mostly a very disagreeable sensation. In instrumental music the highest tone is below 8,000 vibrations a second. In fact, we rarely go above 6,000 vibrations a second. And in broadcasting, it is customary not to exceed a frequency of 5,000. In phonographic instruments even this number is scarcely attained, due to the physical limitations of this instrument. And it may safely be said that the phonograph of the future will have much in common with the radio reproducer, if it will not be in the nature of a glorified radio set. Even today we can have better reproduction by means of broadcast music than is possible of attainment in the phonograph.

After this somewhat lengthy discussion of sound—and the subject has only been touched upon very lightly—we may determine what we will want in an amplifier destined for pure reproduction. We will try to put the major requirements in a very simple way, as follows:

(a) It should be perfectly elastic; in other words it should function with equal facility on all frequencies.

(b) It should be perfectly neutral; in other words it should not subtract anything nor add anything to the original impulses it is supplied with. It should conserve proportions as present in these original impulses.

(c) It should amplify.

This is the first of three articles by Mr. Nakken, who will deal with quality radio reception, reviewing detectors, transformer coupled amplifiers in the second article, and resistance and choke coil amplifiers in the third article.—Ed.

Conducting An Amateur Station

(Continued from page 735)

ac—a steady throbbing or pulsating note of low frequency.
rac—a steady clear hum.
icw—a high toned screech or buzz.
dc—a pure or clear whistle.
fb—fine business—simply general praise.
ng—no good, general condemnation.

E.g., *QSB ac, QSBdc fb*. Assuming that necessity and general usage justify the warping of QSB from its correct meaning, we certainly have reason to accept the understood meaning in place of the actual definition.

The social rites having been properly performed, one is ready to go ahead with the transmission of the message.

HANDING OVER THE MESSAGE

Communication established ends the need for a long call. The communication should now begin with a two-two call, an OK and the courtesies as outlined. Then the double dash, or break, as it is often called, to indicate an abrupt change in thought: viz., —— . . . ——; after which the message follows, starting with the preamble. The preamble used in amateur work is simple. It consists of where from, number and date of origin. The message itself consists of whom to, text or body and the signature. Here's an example:

(call) (politeness)
5KK 5KK u 2KK 2KK r QRK r7 QSB rac
(preamble)
fb —— . . . —— *hr msg fm Hartford Conn*
(address)
10X Nr 10 Jan 15 to R Migurski 2345 Main
text)
St El Paso Tex —— . . . —— soup cheaper since forks in general use —— . . . —— sig Bill *ar hw k*.

The "*hw*" is not a necessity, it simply prevents the totally blunt and bare ending after the "sig." A *QSL* to this, if the message has been received correctly, can follow a simple form; e.g., *2KK 2KK u 5KK 5KK nr 10 r k*. After that, *2KK*, if he has more tfc, can continue with the next msg or start some conversation. But if the whole or part of the message has not been received correctly it must be repeated.

ASKING AND GIVING REPEATS

If the whole message has been missed, there is a Q signal to take care of asking for the repetition necessary, *QTA*. Had *5KK* missed entirely he would have come back at *2KK* like this: *2KK 2KK u 5KK 5KK nd om sri QTA pse k* (nothing doing om sorry please repeat the message).

If *5KK* had missed only part of the message, his procedure would be different. The question mark, . . — — . . is quite generally used to mean repeat. This in reference to a *part* of a radiogram or casual conversation. Or, another use for the "?" is in the case of failing to understand a call. Suppose *5KK* hearing *2KK* calling him missed *2KK's* signal. *5KK* would simply call . . — — . . . . — — . . *u 5KK 5KK pse k*, indicating that he desires the calling station to repeat the call. In obtaining a repeat of parts of a message, such as a dropped word, the word before the missing one is sent, a "?" and the word after the missing one; *e. g.*, assuming the two words "in general" in the message were missed—*2KK 2KK u 5KK 5KK forks* . . — — . . use —— . . . —— *rest r k*. Another method of asking for such a fractional repeat is best illustrated by an example: *2KK 2KK u 5KK 5KK? in ads after Migurski stop soup rest r k* (repeat in address words after Migurski, stop with soup, rest of message OK). This latter practice is more generally the amateur practice, while the former, because of its brevity, holds sway with most commercial operators.

SIGNING OFF

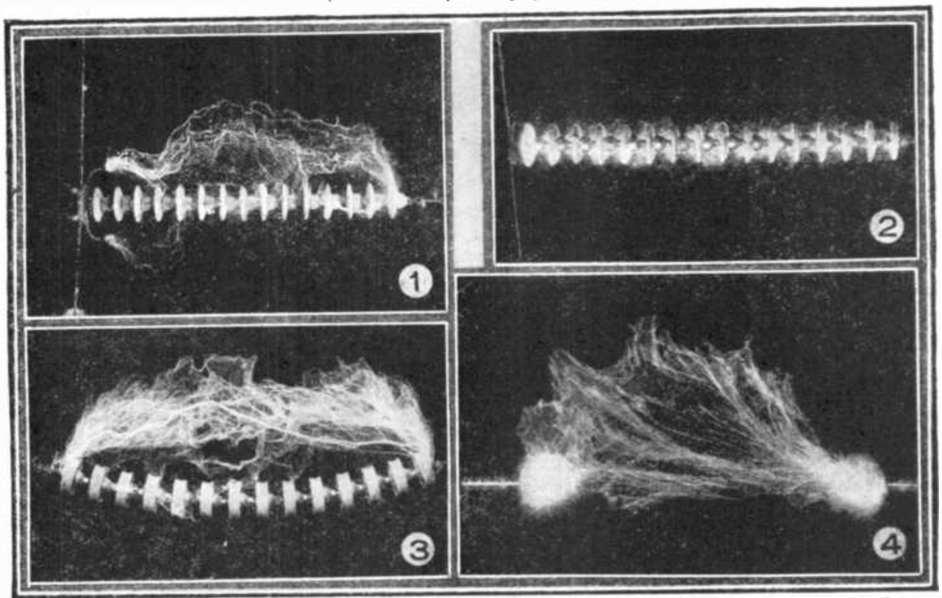
If all the talk is, to all intents, completed, stop. Don't bore the man you're working with, for you may want to connect with him again. Try not to use stereotyped endings. "*Cul and 73*" has been frayed to its fewest threads. *Cul* means "see you later" and it is used with no thought of its meaning. "73" means "best regards"; it is absurd to add an "*s*" or "*best.*" Simple enough to say "so long" and quit.

The closing signal is *SK*. It means that all communication is finished. It must not be confused with *ar*, the abbreviation signifying the end of a particular transmission, such as a call. *SK* should carry the significance that, since the person signing off is finished with one man, he is ready to tune about and try to locate someone else that might call him. After concluding a communication thus, one should tune carefully to see that no one else is calling him before using his transmitter again. In signing off finally, a three-three call preceeds the *sk*, so that those listening in may be warned that the signer is finished with one and ready for another station. If the operator has a personal "sine," it preceeds the *sk* just following the three-three close—this is not necessary in a one-man station. For example: *5KK u 2KK tnx om tts all gn 73 5KK 5KK 5KK u 2KK 2KK 2KK as sk*. An *sk* needs no acknowledgement. However, acknowledgement is often given without any sort of sign, *e. g.*, *r gn*. Laconic and brief, but certainly effective. Definitely, in any case, the *sk* should end things.

(To be continued)

Examining Insulators at One Million Volt Tension

(Continued from page 737)



Four examples of the work done in the famous insulator testing laboratory. Each one speaks for itself. The flash-overs in Fig. 1 and Fig. 3 over chain insulators, such as shown in Fig. 2, are specially interesting. Fig. 4 shows a gigantic high voltage discharge.

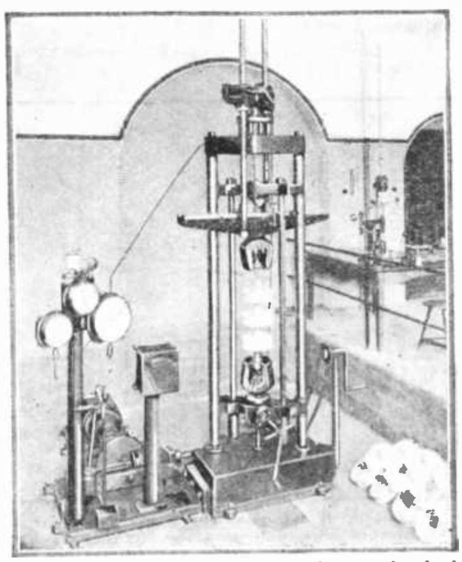
The potential of 100,000 volts is no rarity now. Cautiously 120,000 volts were tried and already one million volts are considered. As yet the electric energy has not been compressed to that amount—in a way concentrated—but technical science is prepared already for the tasks that are going to be given for it in the future. The first laboratories have been createcd, in which the electric power line insulators of our electric plants can be tested up to a million volts.

Everything depends in fact on these insulators, those familiar appliances made of porcelain. They prevent the current from escaping to the ground and avoid losses and dangers to life and property. They are comparable to a levee erected on the line of a river. Should this dam break in some place, the water submerges the land—ruining and spoiling all. The wire is to be considered the bed of the electric current, which must be insulated the better and safer as the tension of the circuit is higher.

If the supply of electricity is to fulfil all its present and future tasks, the insulation of the conductors must be up to the continually rising tension. For this reason Freiburg begins testing insulators at a million volts.

The laboratory built for this immense potential has the form of a large rectangular hall and is lighted artificially only. Special transformers make it possible to raise the tension of the circuit to a million volts. In regard to the danger offered by this tension, the side of the room in which the investigators work is guarded by a railing. The gallery for the staff of workers which lies between the walls and this parapet is closed by two doors. These only open when the high tension is switched off. As long as there is work going on under high tension, that is, as long as the transformers are fed by current, the investigators cannot leave the protecting room or area. One of the long walls has platforms for investigators as well, which contain the switchboard and all instruments necessary for the examination. Here also the investigator is in safety.

The insulators which are to be examined and which are often of gigantic dimensions, and the insulator chains, are slid on rails into the laboratory. In the same way they are brought to the investigators' platforms before and after the examination, where they can be examined without the investigators leaving their place. In the ceiling there are special constructions which make it possible to expose the insulators to artificial rain and artificial fog—that is, to all those accidents that open air conductors are subjected to. The rain can be changed in its directions towards the insulators—as in nature it also is driven from the vertical direction by the wind, and is sometimes more or less oblique in its relation to the conductors. Tremendous flashes of lightning cross the insulator chains with different effects, according to whether the discharge of the electric tension occurs in dry air, in rain or in fog. The noise of the artificial lightning is ear-splitting, but the electric force is harnessed and there is no danger, notwithstanding the high potential. Our electric plants will, however, profit by the experiences acquired here—however high the tension will be raised, which our plants will send into the land, the distribution will be safe.



The apparatus for testing the mechanical characteristics such as resistance to different strains, densile strength and the like, of the insulators, in connection with their electrical properties.

Generator for Static Electricity

(Continued from page 763)

On the right, the glass tube is supported by a simple insulating bearing consisting of a strip of ebonite or bakelite. The ebonite strip is secured to the wooden baseboard by a triangular or square piece of wood and some wood screws. In the upper part of the ebonite strip a clearance hole for the tube is cut, so that it can turn easily and with little friction.

The fan motor is shown on the left; it is raised 3 or 4 inches from the base by a wood block. The center of the motor spindle and the center of the hole in the ebonite strip must, of course, be exactly the same distance from the base, so that the tube can run true. The motor is controlled by a switch screwed to the end of the wood block supporting the motor. A small rheostat and fuse may also be included in the circuit.

The rubbing of the glass tube is executed in the following way: The motor drives the tube at high speed. Around the upper part of the tube a strip of silk or flannel is drawn, as shown in Fig. 2 and in Fig 3. The ends of the flannel or silk strip are fixed to the edge of the base, using drawing pins. This strip should be under slight tension, to lie against the glass tube; if desired, one end only may be fixed to the baseboard edge, while the other end is tacked to a small lath, as long as the silk strip. Two or three short spiral springs are attached to the lath at one end, and to the edge of the base at the other end. The springs will then automatically adjust the tension of the silk strip.

The coupling between motor spindle and tube end is of a very simple type, so that it can be easily made. The end of the glass tube is fitted with a well-fitting wood plug, which is cemented in with thick shellac varnish. Through this plug two holes are drilled for some small bolts, of about 1/8-inch or 3/16-inch diameter.

To the end of the motor spindle a metal disc is attached, clamped between two nuts. It has holes similar to those in the wood plug. After the end of the wood plug has been recessed for the nuts on the spindle end, the small bolts are pushed through the holes in plug and disc. If the outer nuts are tightened up, the disc will be firmly pressed against the face of the plug, and the drive from motor to tube will be transmitted most efficiently. Care must be taken to get the coupling fitted at the center of the tube.

If we now start our motor, we shall hear a terrible squeal, caused by the friction between tube and ebonite strip (right-hand bearing). This can be suppressed by lubricating the bearing with a small amount of graphite powder. Paraffin wax may be applied before to give it adherence. Now our machine will run silently, and continuous sparks can be drawn from the brass knob.

Do not run the motor too fast, as the rubbing silk strip will get very hot in any case. Adjust the motor to its lowest speed for a start and see how the machine stands it.

In all types of this generator, care must be taken that the coils of the spring used inside the glass tube touch the wall of the tube. If the spring is too small the induced electricity will be correspondingly weaker and the sparks shorter and less frequent.

An interesting feature of this generator is that the interior can be kept dry irrespective of humidity in the air and that the glass part is not readily breakable if of proper thickness, and if it should break can be easily replaced, while a hard rubber tube is unbreakable.

The Latest Progress in Talking Movies

(*Continued from page 741*)

The ordinary microphone cannot be used for this apparatus, because it distorts the sound, answering better for certain frequencies than for others. The Cathodophone, as the inventor calls it, is based on the following principles:

Incandescent metals, especially when they are coated with oxides of the alkaline earths, send out electrons when surrounded by a vacuum. They do not send them out under atmospheric pressure to any considerable distance. So each electron as set free from the incandescent body unites itself to a molecule of atmospheric gas, forming an ion.

These ions will flow from one pole to another with a certain rapidity, constituting an electric current called the ion or emission current. This current is affected by every change, even the slightest in the pressure of the atmosphere, and this pressure can be influenced by voice and music. Fig. 1 gives a schematic diagram of the Cathodophone.

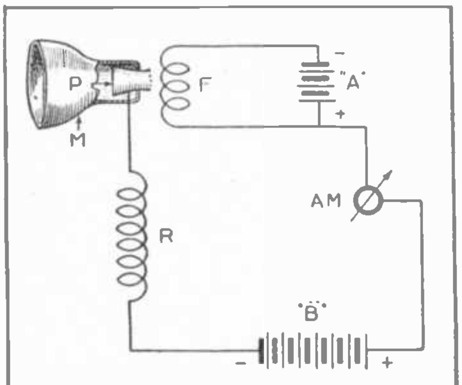


FIG. 1

The schematic diagram of the cathodophone showing the mouthpiece and the "A" and "B" battery.

F is a filament maintained at incandescence by the battery A B. To its left is seen the mouthpiece. P is the anode carried by the same. R is a resistance. Am is an ammeter. "B" is the anode or "B" battery, imparting the necessary potential to the anode. "A" is the filament battery or "A" battery. When the filament is heated and the anode potential connected up at a definite potential, the ionic current is produced and shows itself by a bluish lighting up in the vicinity of the electrode and by the movement of the ammeter index hand. Acoustic vibrations affect the pressure of the air in the space between anode and cathode, thereby varying the anode or plate current. These little variations are strengthened or amplified by vacuum tubes. As there is no diaphragm to effect a lag by its inertia, the Cathodophone is in the highest sense sensitive to the smallest changes even at high frequency.

An orchestral production with its many fundamentals and overtones is brought out true to nature, and a very slight sound will affect the instrument. The Cathodophone is designed for minute quantities of energy and its emanations have to be amplified 100,000 times in order adequately to influence a source of light.

The energy of current required to produce the light to project these undulations upon the film is about a hundred thousand times that of the Cathodophone and is obtained by means of the usual amplifying tube. The delicacy of this trembling ray of light required a *special type of lamp*, styled the "Ultra Frequency Lamp," a glass bulb filled with a rare gas, and the ignition of this gas gives the light.

In Fig. 3 the reproduction of portion of a film is shown, with an orchestra playing a tune; the narrow strip, the "Phonogram," accompanying the pictures, embodies the millions of vibrations of the music. Fig. 4 is the "Phono-Photo" camera at work. It must be mentioned that whilst the film remains stationary during exposure, the Cathodophone rays are intercepted at that point, but this infinitely small interval is imperceptible to the ear.

The next step was to reverse the process by *reconverting the oscillations of light into electric vibrations* first and *then into the original acoustic waves.* To do the first, a *photo-electric cell* is used, which is composed of a tiny plate of metallic potassium enclosed in a glass bulb with an inert gas. When this cell is exposed to light, electrons are driven off from the potassium, and as this stands in opposition to a positive electrode, the electrons will flow in proportion to the illumination. Fig. 6 gives an idea of the photo-electric cell and Fig. 7 shows the complete apparatus for reproduction which resembles very much an ordinary moving picture machine. The batteries are contained in the base and two tubes of the amplifier for loud speaker can be distinguished in the center portion.

The loud speaker is built on the electrostatic principle as the inventors found themselves unable to eliminate distortion sufficiently with the electro-magnetic system. Besides this only about 1 per cent. of the available electrical energy can be recovered as acoustic energy. The idea of adapting a two-plate condenser to this purpose with one plate to vibrate in proportion to the variations of the potential is not new; the acoustic effect, however, was too small to be of practical use. As a metallic diaphragm was too heavy for the desired size, mica of no more than 0.05 millimeters in thickness, made electrically conductive, was introduced. This diaphragm stands in opposition to a specially shaped metal plate with perforations so as to obtain a maximum volume of sound.

Distortion was not entirely eliminated by this method, but owing to the size of diaphragm a horn could be dispensed with and the distortion overcome by subdividing the surface of the diaphragm by eccentric rings. As a result, this arrangement showed no inclination to respond to certain tunes more than to others, due to the difference in width of the sections (see Fig. 8). Practice proved that it was not sufficient to depend on one type of statophone for increase of volume: it was found necessary to vary the distribution of these eccentric rings and to *compose units of statophones each differing from the other.* Fig. 8 shows one of these units. The portion at the right has more compartments and is arranged for reproduction of the high notes whilst the one to the left is for the deepest tones. By suitably arranging the sets of statophones an opportunity is afforded to tune the reproduction as desired, eliminating practically any notable distortion.

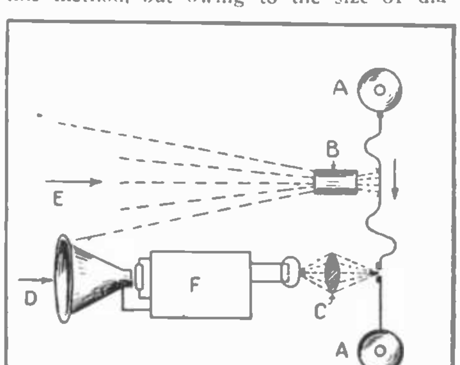


FIG. 9

A film is drawn past the projecting lens of the picture and then past the condensing lens of the cathodophone. The rays of light passing through B from the scenery, and those passing through C as affected by the voice, produce the two impressions on the film to be developed afterwards.

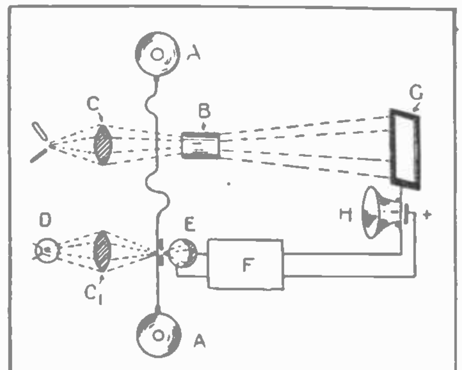


FIG. 10

Above, the picture is supposed to be projected on the screen, while below, the voice pictures, as they may be called, on the film produce the sound accompanying the play.

To conclude, this type of loud speaker would appear to lend itself to ordinary radio reproduction, but an electric potential of several hundred volts is required. Some firms are endeavoring to overcome this difficulty, and it is to be hoped that they will be successful, as the statophone promises to become the ideal loud speaker.

Hedgehog Transformer

(*Continued from page 763*)

The next step in the construction is the bending back of the ends of the iron wire, except for a small space where the ends of the coil wires protrude. The iron wire ends must be drawn down in place and bound with a wrapping of twine, as shown.

The terminals of the primary coil are so delicate that they are apt to be broken off, thus spoiling the entire apparatus. To guard against this mishap, it is advisable to bind a piece of flexible lamp cord to the cores as shown in Fig. 3, and afterward to connect the ends of the primary to this cord, preferably by soldering them, thus relieving them of all strain.

To protect the transformer fom dampness and mechanical injury, it is advisable to place it in a wooden box after heating the box slightly in an oven. Enough melted paraffin wax is poured in to cover the core and soldered connections. The lamp-cord is then led through a bushing, while the secondary is fastened to binding posts. The box is then covered and painted or stained. This can be seen in Fig. 4.

In bell ringing, 4 volts will be sufficient. For Christmas tree lighting with a dozen 3½-volt lamps, connect six lamps to one outside terminal and on intermediate tap; the other six lamps are connected from the tap to the other outside terminal.

If the primary leads are permanently connected to the 110-volt line it will not draw enough current to actuate the ordinary meter except when current is actually taken through the secondary leads.

The Experimenter's Bookshelf

Chemical History

CHEMISTRY TO THE TIME OF DALTON. 128 pages. Oxford University Press, London. Contents, list of illustrations and index.

This little treatise is to be credited to the University of Oxford and makes very good reading, bringing in the great workers in chemistry. It ends with what may be very justly called the daring conception of Dalton, when he made his great effort to place chemistry on the basis of atomic weights.

Some of his equivalents for the different elements are given and their wide divergence from the present accepted weights is largely due to the fact that Avogadro's supreme discovery of the volume of relations of molecules in the gaseous state had not yet been made.

The description of the work of the Englishman Priestley, much of which was done in Northumberland in Pennsylvania, and of the work of Lavoisier, victim of the French revolution, as Moseley was the victim of the World War, immediately precede the description of Dalton; these three chemists are the true founders of modern chemistry.

The book is the third of a series called Chapters in the History of Science, edited by Dr. Charles Singer, and more are to come. The present work is by Professor E. J. Holmyard of Clifton College, Bristol, and in the preface he makes his acknowledgments to Mrs. Singer for her assistance. The illustrations are highly to be commended, and we shall hope to review further books in this series.

Organic Chemistry for the School

OUTLINES OF ORGANIC CHEMISTRY. By F. J. Moore, Ph.D. xiv, 353. Index. John Wiley & Sons, Inc., 1924. $2.50.

Some years ago before it had reached the present development, organic chemistry to a certain extent was a confused subject and unfortunately even today there are many compounds especially in the human system and in the food which we consume whose satisfactory placing can hardly be obtained. But the great skeleton of the subject has been pretty well put together and today, organic chemistry has its scaffold or ramifying framework, which gives the touch and aspect of exact system to the greater part of the science. Four elements, carbon, hydrogen, nitrogen and oxygen plays so important a part in this science that they have been termed the four horsemen of chemistry. Then from these if the student starts by building up radicals and recognizing the fact that a radical in organic chemistry plays the part of an atom in inorganic, he will have clarified a great part of the subject. The present book seems to be built up very much on this line and it is interesting to see that the author has given a chapter to the really obscure chemistry of vital processes. It is unpleasant to find fault but the definition of an ester as an acid in which hydrogen has been replaced by a radical, is not quite pleasing, as a matter of wording, because an ester is distinctly not an acid. But we do warmly commend the book and only wish that there was more of it.

Rain From Electricity

This illustrated article shows high power and electrical apparatus used for producing rainfall. It is claimed to be successful, and it may doubtless be a forerunner of electrical weather control apparatus of the future.

Other Interesting Articles to Appear in September Issue of Science and Invention

Life Suspended In Ice
By H. Gernsback

The Next War
By H. Winfield Secor

Everyday Chemistry
By Raymond B. Wailes

Making Selenium Cells
By Raymond B. Wailes

Wrinkles, Recipes and Formulas
Edited by S. Gernsback

A Suitcase Portable Super-Heterodyne
By Sidney E. Finkelstein

Radio Constructor Series—Elaborately illustrated with progressive diagrams and photos for the layman—"The Browning-Drake Circuit"
By A. P. Peck

"B" Battery Eliminators—All kinds described and diagrammed.

One-Tube Portable Set De Luxe
By Herbert E. Hayden

Uses of Paraffins at Home

(Continued from page 753)

hour, then the pure gas can be experimented with. It will be found to burn with an almost non-luminous flame; it is colorless and has no odor. When mixed with air and ignited, it explodes.

A peculiar property of vaseline, a property for which it is seldom, if ever, used, is as an anti-match strike surface. It has been successfully used for this purpose under varying conditions. Some people have a bad habit of striking matches on the nearest convenient surface. Now, to prevent the formation of unsightly marks and streaks left after striking matches on painted or varnished surfaces, just apply a little vaseline with a flannel rag. Work the vaseline into the surface with pressure while vigorously rubbing. After the vaseline has been rubbed in, take a clean, dry piece of flannel and again rub the surface thoroughly. This will prevent matches from being struck on this surface. This is a nice little trick and I am sure many will find it useful.

The Ark of the Covenant

(Continued from page 739)

"And what then?" I asked.

"Then, sir," he said impressively—"then I'm goin' ter find a quiet retired spot w'ere I can just sit an' think—or mebbe not think at all if I like."

"Would you take a job that would give you a chance to sit and think from me?"

"Ah! I'd take *any* job from *you*, sir!"—very pointedly.

"Right. If you'll look after this steamer for me until I get back from England, I'll take you to the Amazon and find a quiet spot for you there."

So I secured Sleepy Sam Smithers, a very important cog in the mechanism for a time, as you shall learn, and I pictured with some amusement the delight of Higgins and Grumstock when they found their old shipmate joining them.

I now left the work in New Orleans in the hands of Lippencott, with his brother, Steve Curtis, and Smithers to help him, and set out for England, where I hoped to recruit another half-dozen men from among tried comrades.

II

Other Additions to the Crew

Almost the first person of my acquaintance whom I encountered in England was the young Marquis of Devonridge. He was coming down the steps of the Wanderers' Club as I ascended them.

"Hello, Jumbo!" he exclaimed, using the nickname my bulk has given me. "Got back from bug-stalking in the wild and woolly, have you? Got a good show of heads?"

"Fairish," I said. "Doing anything particular for the next three or four years, Pip?"

"I suppose the next three or four years will find me dodging the tax-gatherers, as usual. Why? Thinking of taking pity on a poor landowner?"

"I had thought of it, Pip. But I understood that you had sold all the Devonridge property?"

"Your understanding, my dear Jumbo," he replied, "has lost nothing of its limpid clarity. Except for a cottage or two given over to old servants, Devonridge is a barren title these days. If you're really game to take me out of this demagogue-ridden country, you may enlist my services for the next four years at the remarkable stipend of, say, ten shillings a week. That is to say, to wit, and *videlicet*: for five florins per week you may acquire a cook-secretary-chauffeur-gunbearer, warranted free from vice, clean about the house, faithful, willing, sober, industrious, surprisingly honest, and guaranteed to eat out of the hand! Do you go me, Jumbo?"

"I go you, Pip. Come and have lunch."

"Very good, sir."

And his lordship touched his hat obsequiously.

We had not much opportunity for talk during lunch. The Wanderers' was usually crowded, but after we had fed, Devonridge and I strolled down to his rooms at the foot of St. James's street, and there I outlined the scheme to him.

"My dear Jumbo," Devonridge said, when I had finished, "I'm on. *Ca va sans dire*—as the French always say in novels writ at Tooting. But I don't want you to take me on false pretences. The idea of stopping war conveys absolutely nothing to my young mind, except regret—if the scheme wins out—that we shall put a lot of honest lads belonging to my own class, and a Jew or so, out of a job. Natheless—did you mark the word, Jumbo?—*natheless*, I am with you, not out of any high-falutin' notions, but for the lark."

"There won't be much lark about it, Pip."

"Trust me to get some fun," he smiled. "But I'll hang on till you release me—and I'll do my best for my mob, you may be sure."

"I'll take you on those terms, Pip."

"Righto. And now I suppose you want more men?"

"My object in England."

"I can help you there," said Devonridge. "I know all the good men in London—and all the rotters, too."

Philip Bentinck-Scrope, Marquis of Devonridge in England and Baron Craigfeanteoch in Scotland, thus became my lieutenant while I remained in Britain. He was invaluable, for he enlisted the services of three young men of good family whom I knew by repute. They all had honorable records of service in the European War, two serving at sea and the other with the air force, and all of them had been wounded.

The last statement brings up an odd fact I was beginning to note. With the exception of the Master, the whole of the crew up to date had suffered from wounds taken on active service, and when I brought in three other men, two mechanics and an instrument-maker who had served on airships with me, the tally was not broken.

I need not enlarge on the characters of these men. Devonridge's three were of the gay and well-dressed, rather slangy type he represented, if I except one, a quiet big young man named Billy Haynes, who had Sleepy Sam Smither's ox-like stare and no great gift of speech. My two mechanics I knew to be capable and trustworthy men, quite ready to be plucky if occasion demanded it, but with the fine mechanic's logical habit of reasoned speech and movement. My third, the instrument-maker, was a little, slight man named Thetford, a perfect genius in the matter of the fine adjustments required by his trade. I knew him to be a man absorbed in his work, and a tireless worker.

In selecting these men, particular care had to be taken that they were without connections who would worry about their absence. With the exception of Thetford, who had a sister, none of the six could think of any relatives or friends who would be likely to get up a hue and cry for them if a reasonable yarn of exploration was spun. I arranged that money should be sent at regular intervals from New Orleans to Thetford's sister, and that he should write to her as if occupied in that city.

Within a fortnight of my arrival in England, I was on my way back to America with seven men.

Lippencott had wasted no time. The *Clutha* was ready for sea, and a good part of her cargo had been stowed. He had found papers to account for our voyage, and had created the Amazonas Exploration Company to account for our stores. We embarked young Lippencott, Steve Curtis and Sam Smithers, together with the English members of our crew, and under my command the good ship *Clutha* set out in fair weather for the Brazils.

We made Manaos without trouble, for apart from Thetford all my men were more than amateur sailors and engineers. I did some business at Manaos, connected with the buying out of a moribund trading company, and we proceeded on our voyage upstream. By this business we made a good acquisition. We were far from domestic and civilized markets.

At a place high up the Negro, where it was joined by the waters of another river, there stood an ancient wooden bungalow with storehouses attached, which had belonged to the moribund company. Some distance above the compound the placid flow of the Negro was broken by rapids, impassable for any craft whatever, and below the compound, some kilometers downstream, the tributary tumbled into the Negro over shallow rapids that seemed to put any navigation of it also out of the question. But to a point not very far distant from the back of the storehouse, a creek ran up from the second river. It was only a question of a short portage, therefore, to get the goods into flat-bottomed craft for navigating the tributary, and it was plain sailing—or as near plain sailing as was possible in such country—to tug barges right up *via* the Rio Innominata to the Plateau of the Scar. There were places, it is true, where we would have to get to work with spade and mattock to clear our passage, but on this point there was nothing that could not ultimately be overcome by willing hands. The trees lining the banks of the Negro's tributary and of the Innominata mostly branched over their waters, an arch of dense foliage which made the voyage one of half-light through the greater part of its length.

We berthed the *Clutha* by the bungalow and store, and with the aid of her new derricks began to unload the stores. In this work, Philip, Marquis of Devonridge, sweated like any laborer of blood untinged by blue, and the three other men about town, Messrs. Haynes, Fitzlan and Greyson, as also the two American boys, Lippencott and Curtis, took their coats off and worked with equal zest. They were willing and handy beyond my dearest hope. Brooks and Dane, the two mechanics, threw themselves into the work with the cool precision of men accustomed to handling machinery all their lives, and their eyes gleamed over the fine pieces of plant they saw among the cargo. Little Thetford installed himself as tallyman and checked the invoices, while Sam Smithers took his great bulk to wherever it was handiest and, I imagine, began to have hopes of decreasing his weight by the violence of his exercise.

Smithers' chief job after the unloading of the *Clutha* was the putting together of two flat-bottomed barges, for, as indicated earlier, Sam had been a shipwright in his day. Until that task was accomplished Sam was in charge of operations, and his work was excellent. We had brought two small power-boats on the deck of the *Clutha*, and these were transported to the creek behind the storehouse. It was a matter of weeks before we had the barges on the backwater and our stores—or part of them—loaded into them. We would have to make at least two journeys before the whole of the *Clutha's* cargo could be got up to the caves.

Sam Smithers was left behind in charge of the storehouse and the moored *Clutha*, and at last had acquired the job where he could just sit and think. The prospect of weeks of isolation did not daunt the stout warrant officer in the least, and I knew that in the unlikely event of visitors, no inquiries would get past his tremendous placidity and bovine lack of expression. Sleepy Sam was our last link with the outside world.

Our voyage to the plateau was toilsome and arduous to the point nearly of torture. There was now no question of portages, as with the canoe. Time and again we were held up until we could clear our passage. We might move a fallen tree that lay across the river, no simple task where the tough undergrowth and silted weeds of years impeded us, only to find a kilometer further on that a similar task awaited us. We carved and dug our way with saw and ax and spade. Our skins and clothing were scratched and rent by thorns. Insects bit us, bloodthirsty brutes that they were, until our faces were swollen out of recognition. But we kept on, ever with commendable cheerfulness where my crew was concerned, and we tugged our barges behind us all the way. And after weeks and weeks of toil, the nine ragamuffins that we had become sailed into the cavern of the plateau with perhaps a trifle more dignity than our appearances were warrant for.

III

The Cave and Its Lonely Garrison of Three Men

We found the garrison of three in good order. The Master—if it cannot be said he was in good health, for he never was that—at least was his self-contained and indomitable self. Grumstock and Higgins grinned cheerfully, and took pains to tell me that they had never been so hard driven in their lives, nor had they ever met anyone for whom they would sooner work than for the Master. That they had been working was evident. The living-room floor had been levelled, and big windows had been hewn to the face of the north cliff. Space enough had been provided for over fifty men, and clean, healthy barracks it made. The two seamen had become fair hunters, as witness the store of dried venison provided, which, with bacon from wild pig, had been cured under directions from the Chief.

The Master's laboratory now was well set out, and it only needed the instruments we had brought up and electric power to be as complete and up to date as any in the world.

The Chief welcomed his new adherents in a way that bound them to him at once. The tremendous personal magnetism of the man leaped out of its frail tenement to master them even as it charmed. He explained the possibilities of the cavern to them, and did not minimize the amount of work which would have to be done, but notwithstanding the starkness of his doctrine of labor he fired them with the romance of the scheme. If he promised to drive them hard, they welcomed the promise.

That night as we rested after the labor of our voyage to the plateau, Steve Curtis was not too weary to play his guitar and sing to us, or to whistle. It was a marvelous performance which enthralled my two seamen, Higgins and Grumstock, so that they were open of mouth and eye to an astonishing degree. The lilt of Steve's negro melodies was so haunting that the morning found every man humming or whistling at his work. A good sign, I thought.

The Chief looked in at the concert and stayed a little, then went back to his work. I found him in his laboratory before going to bed.

"Ah, Seton," he said. "I am glad you looked in. Your crew is distinctly promising. I like that boy Curtis with the guitar. He is an acquisition. And the rest seem good metal. I congratulate you—and myself."

"I'm glad you're pleased, sir."

"The little man—Thetford, is it?—he has skillful hands and intelligence——"

"That's our instrument-maker, sir. I think you'll find him useful in the laboratory."

"I am sure I shall, if I am any judge of men. Good-night, Seton. You have done well."

Next morning was devoted to unloading the barges. We landed the various pieces of plant as near their ultimate bases as we could; the oil-plant to its proper cave, the machines in their shop, the instruments by the laboratory.

When the unloading was done, the whole gang with the exception of the two mechanics, Brooks and Dane, and Thetford, went off under the charge of Devonridge to fetch up the remainder of the stores, while my men concentrated on fixing a temporary electric supply to the laboratory. The power for running the dynamo we got from a small petrol-engine, and both these we bedded on the solid rock with deep-set bolts and concrete. The accumulators and transformers for bringing the voltage up to the high figure required by the Chief for his work we laid down in a little cave near his laboratory.

This work occupied us two or three days, but we finished it to the Chief's satisfaction, who then took Thetford into the laboratory and became deeply absorbed.

Installing Machinery in the Caves

The measuring up of the caves and the setting out of the plans for the machine shop, the dynamos, and the turbines were our next task, but Brooks, Dane and myself had much of it finished, with several of the machine beds levelled and drilled for the bolts, before the barge party returned with the remainder of the *Clutha's* first cargo. Some of the plant now arrived was heavy, and we were obliged to cut down large trees and float them into the cave to make sheers for lifting it. We economized effort by lifting the heavy pieces right to their beds.

Our most difficult task was the setting of the mains for the turbines, but we managed it by constructing a strong flume of wood to divert the stream from its course a little, so that we could work dry-shod in its natural channel. By dint of hewing out portions of a side tunnel from the stream, we secured an excellent setting for the hydraulic mains, and these were conducted to where the turbines were conveniently placed at one end of the workshop floor.

We were fortunate in the matter of concrete. The rock of the cavern was free from clay, and had nothing in it to hinder the close and strong binding of the cement. The Chief selected our quarry for us after sampling the stone from several of the minor caves. Our stone-breakers were Billy Haynes and Devonridge, the latter insisting he was fully qualified for the job by being able to sing one song called "Stonecracker John." He sung the ditty as he did his work with such unremitting ardor that even the monosyllabic Haynes was moved to profane eloquence.

It was necessary that all the heavier work should be done before the company was broken up for a further voyage to civilization. We ran out of cement, for example, and certain of the plant had not been at New Orleans when the *Clutha* made her first trip. But months passed before we had the turbines in working order with the big dynamos sleeping beside them, or had all the machines laid out with their motors and switches.

Yet, when I looked along the cavern and saw the water gleaming under the blaze of powerful arcs, the array of machines under their covers, the waterfall harnessed to our use and the dynamos converting its power, I found it strange to realize that over a year had passed since I first paddled into the cavern. Much had been done in the time, and the days had flashed by on swift wings—all the more swift because the work had held us happily absorbed. I could say, with the Chief, that we had done well. But we had only made a start even then.

IV

In the Laboratory With the Chief

If the work done by the mechanical and laboring section of the crew could be fairly commended, the brain of the community had seldom slept. In the laboratory, with the help of the now enthusiastic Thetford, the Master had been working out many of our problems. In my spare time I had started to design an airship, and had made working drawings for its construction. To this the Chief bent very frequently his trained and fertile mind. He brooded over my drawings, correcting them here, adding to them there, and there was not a stroke of his pencil but outlined some amazing idea.

He would concentrate on his own problems, which were many and varied, and for relaxation he would walk out of his laboratory and make clear some difficulty of the working gang. Thetford worshipped him, and would slave with the tools of his trade far into the night on the models and instruments conceived by the Chief. A nod from the Master was sufficient to make any member of the crew call up the last ounce of energy for his service. But though the Chief drove us hard, it was always by his example and never by a word. And he drove himself harder than any.

There were times when we would not see him for days on end, when we would watch little Thetford creep to his bed exhausted night after night, and would know that the Chief had not sought sleep in all the hours. These periods were anxious for me and for all of us, for I knew with the others that the agony of the terrible burns on his tortured body robbed him of the slightest chance of rest. Our dread was that his spirit would break under the strain.

I remember one night when sixty hours had passed unbroken by sleep for the Chief. Eleven of us sat silent in the living-room, while Thetford sprawled exhausted on his bed, and we had not the heart even to play cards. We whispered among ourselves, praying in our hearts that our leader could relax and find rest. And suddenly he stood at the entrance to our cave.

His face was calm and placid, and his mild blue eyes, deep sunk though they were in his beautiful face, were full of something like a gentle wonder. He nodded to us with the strange little gravity which was his nearest approach to a smile, and he stepped into the chamber to cross to the sleeping Thetford.

"Thetford's asleep," he said. "Lucky Thetford! But he drives himself too hard, poor fellow. A good man!

"Who was it injured his hand today?" he asked, as he turned to us.

It was Greyson, who had his fingers crushed under a heavy weight, but he hid the damaged hand. I knew that the reticence would not suit the Chief, so I nodded in Greyson's direction.

"Greyson, was it?" said the Chief. "Let me see, Greyson. Yes," he said, as he examined the damaged fingers, "you have given yourself a bad crushing, Greyson. No bones broken, however."

In spite of his pluck Greyson shivered a little.

"Yes. It must be painful—and pain is hard to combat," the Chief murmured—he who could combat it so! "Come, let me dress it for you. I have a lotion——"

He crossed to the rough cabinet where we kept our small store of drugs and so on, and took out a bottle. Then with infinite tenderness he dressed the hand—with the five fingers left him to execute the mercy.

"I am rejoiced to tell you, gentlemen," he went on, "that I believe we can carry out our campaign without the shedding of blood, without taking life. I see your work, but you see nothing

(*Continued on page* 782)

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.

Selective Tuning

(15) M. Haylor, Arrochar, Staten Island, N. Y., has submitted several ideas for tuning out interfering stations. Two condensers are set on the same shaft, and the coils across the condensers are so regulated that they tune two meters above and below the desired stations. He asks our advice on the suggestion with reference to protection by patenting.

A. We have carefully checked over your ideas and would advise that they do not seem patentable. Placing two condensers on the same shaft is not a new idea, and the mere fact that you use two in the wave-trap does not seem to constitute a basis for a patent, inasmuch as four or five, or even more, condensers and coils have been employed for the same purpose heretofore. Experimentally, the device might prove very practical for your home set.

Design Patents

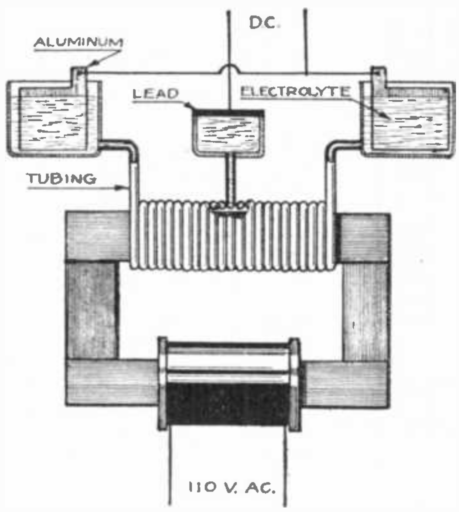
(16) A. Haywood, Munsing, Mich., asks whether or not he could get a design patent on a device the nature of which he desires to be kept secret.

A. It is not difficult at all to get a design patent on any particular device, and we doubt if you will experience any trouble in having your claims allowed. We do not believe, however, that your idea is of any practical value and doubt if you will reap any financial benefit from patenting the suggestion unless you are in a position to manufacture and market the device yourself.

Design patents, although very easily obtained, do not establish a very good protection to the inventor and, wherever possible, we would advise that a regular letters patent be taken out in preference to a design patent. This, of course, relates to mechanical devices and does not refer to those cases where the design is the important feature of the device.

It is a poor plan to try to protect by a patent, and to keep anything secret. The degree of protection given by a design patent for a mechanical device will be infinitesimal.

Electrolytic Rectifier



(17) Ned Alpert, Milwaukee, Wis., submits a drawing of an electrolytic rectifying circuit and asks whether or not it would work and if he should patent it.

A. Your idea for an electrolytic rectifier might possibly be made to operate, but we do not see any reason for the coil of copper tubing containing the electrolyte. This device is expensive to manufacture. It cannot possibly do anything more than an ordinary full-wave rectifier will do, and a vent will have to be placed in the tubing or in the top of the reservoirs containing the electrolyte, to permit the escape of gases which are generated in electrolytic rectifiers. We would not advise that you apply for a patent on the suggestion. You can rarely be sure that you can patent a device—you can apply for a patent on anything and may be awarded a patent, or more probably, not.

The Ark of the Covenant

(Continued from page 778)

of mine. I must tell you that I have discovered a gas which will cause sleep for a number of hours."

He went on to explain the anæsthetizing gas which was afterward to give us of the League such power. The men livened up to the interest of it, and he suddenly turned to Steve Curtis.

"You do not sing and play to-night, Steven," he said. "Why do you neglect your guitar?"

"Chief!" Steve choked in exclaiming. "You haven't slept for three nights. I—I—didn't like——"

"I don't think there is profit in watching me, Steven," the Chief reproved him gently. "You must not do it. Come, sing. It will not disturb Thetford. Sing the little song about the lonely cabin."

Steve reached for his guitar, and though he quavered over the first lines, he soon found his voice:

"Li'l ole cabin in de cawn-patch,
  Shingles all a-droppin' from de roof,
Looks lak eveh'body gone away
  Some place wheh dey's gone to stay.

"Lovin' ole Mammy, wheh is yu at?
  Kindes' ole Mammy, is yu daid an' gone?
Why did Ah leave ma home an' run away
  From de li'l ole cabin wheh Ah wus bawn?

"De's no smoke risin' from de kitchen flue,
  No light shinin' froo de do'.
Nobody home to welcome yu,
  But what's dat creakin' on de flo'?

"Lovin' ole Mammy an' ma Daddy, too,
  Is yu daid an' gone from me?
Oh, why did Ah up an' run away
  From de kindes' ole Mammy Ah will evah see?

"Empty an' sad—not even a houn'—
  Do' standin' open—done broke de latch—
Think Ah'll be goin' an' not stay aroun'
  De li'l ole cabin in de cawn-patch!"

"Excellent, Steven!" said the Chief. "You excel yourself. Don't ever lay your guitar aside because you think I have not slept. I like to hear it. I am grateful, indeed, when I hear it. Come, Seton. I have to show you something."

I followed to receive a gentle wigging for allowing the boys to be disturbed about him.

"Now, my dear fellow," said he, when the wigging was over. "I want to show you what I have found in the gas which you sampled for me some months ago. I have had many samples since. You understand how helium was discovered, I take it?"

I nodded.

"Then I need not explain the significance of the lines in the spectrum?"

"No, sir. I understand that roughly."

"Very well, then. I will show you the lines which are given by the gas from our cave."

Spectrum of a New Element. The Periodic Table Upset.

He had an elaborate arrangement of tubes and instruments set out on a low table, and a sort of magic lantern focussed on a white screen stretched over a wall of the cave. There came a crackle from one of the tubes and an intense, eery light. He touched my arm and pointed to the screen. There, projected on the white surface, was an elongated oblong of rainbow colors, broken by brighter and darker bars.

"Look at it well, my dear Seton," the Chief said quietly. "You see before you the spectrum of a new element—an element that may well upset the existing periodic table of the chemical elements. It is our gas, mixed with helium. The bright yellow bar to the extreme left is the characteristic D3 bar of helium. But this is new—quite new."

He touched a switch and the bright patch on the screen disappeared. He turned up the laboratory lights.

"I am now faced with the usual difficulty in a new science, of using old terms loosely to fit new ideas," he said. "The atom, as formerly understood, is gone. But let me put it loosely. Our new gas resembles helium absolutely in chemical nature in so far that it has no power of combining, and exists free, as single atoms, without having the ability to form any compound whatever. Since I judge its atomic weight—another misnomer, Seton—its atomic weight to be .145 of that of hydrogen, which, up to now, has been the lightest element known, you will understand what a revolution our discovery will cause in scientific calculation!"

CHAPTER THREE

I

The New Gas Aithon

The discovery by the Chief of the new element, which he named aithon, led me to think that the design of the airship as set out would have to be altered, but he declared that any drastic change would be unnecessary. I had designed the vessel to have its lift from helium. Our leader had proposed to manufacture that gas by passing electricity at an extremely high voltage through certain of the rarer metals—from the wolfram-type ores, I think—which he was positive abounded in the volcanic pipe we called the red scar. But the finding, first of the helium in the gas cave, and, second, his discovery of the new gas aithon in greater quantity than the helium itself, had laid open the possibility of an easier method of securing our lifting power.

We shelved all other work for the time being but the tapping of the reservoir from which the Chief believed that gas percolating into the upper cave was drawn. We could see that the gas in the cave had means of getting out above, but its lower fringe varied little day by day, which seemed to indicate that the escape overhead was continually being made good by fresh supplies.

The gas in itself was harmless. It was only its ousting of the necessary oxygen for breathing that made working in the cave an impossibility. We, therefore, took steps to fan the mixture of helium and aithon from the cave, and to keep a constant supply of oxygen—procured by the Chief from electrolysis of the cave water—circulating in it.

We brought up loads of concrete into the cave, sacrificing for the moment the stuff intended for damming the oil-reservoir cabin, and we bound it thoroughly to the thickness of a half a meter or more into the cave wall by steel bolts and dowels. When this concrete was set, we found that we had stopped the percolation of the gas into the cave, so that the fans and oxygen were no longer necessary.

Drilling for Aithon. Closing the Pipe Against the Gash Inrush

In the concrete wall we had bedded a capped pipe with a side stop-cock to a pressure gauge, and through the aperture, of which the hinged cap lay back with its bolts ready, we inserted our drill to the rock wall of the cave. For the drilling our power was derived from a small electric motor bolted to the cave floor, and was led to the drill by a flexible armored tube on the Bowden wire principle. Of this process of drilling I had but slight knowledge, as had the other members of the crew, but with the theory of the business which the Chief apparently had at his finger tips, and with the natural handiness of the seamen and mechanics, we made shift to achieve something of a job.

Toward the end of our drilling, the gas began to creep through past the drill, and we had to cap the pipe and lay off until we could make arrangements for clearing the cave. The Chief contrived to have two oxygen helmets made for his and my use in an emergency.

Drilling was resumed with the fans going and oxygen blowing into the cave, and it soon became apparent that we were nearing the inner side of the reservoir wall. From the amount of gas now streaming into the cave, the Chief anticipated an enormous pressure, so I had a long crowbar reeved through the ring of the cap in readiness.

It was well that we did so, for suddenly the drill broke through the rock, toppled with a thud first up against the concrete, and then was knocked back on its tripod over to the other side of the cave. The gas whistled out into the cave at enormous pressure, its force as strong as a typhoon.

Fortunately I am a very heavy man, or we might have had disaster. I was wearing the oxygen helmet, as was the Chief, so I sprang for the cap of the inset pipe and threw my weight on the lever. Slowly the cap went over, though it took me all my time, as the phrase is, and every muscle in my body was protesting at the strain. The Chief was by my side, and he slipped the hinged bolt back into its flange, then calmly stooped to pick up and hand me a spanner. I screwed the bolt tight and the rest was easy. There were two more bolts, but they only had to be slipped through their holes and screwed home. We had the cap on and the gas was harnessed.

We now had to turn our attention to one of the drillers who had been overcome. It was Brooks, knocked over by the thrown drill. The others had managed to scramble out of the cave. I picked him up in my arms and carried him into the clear air, where the Chief attended him. He quickly recovered, and though he was a sick man for the better part of the day, he made light of his experience, saying that not many people could boast of having been nearly drowned on dry land.

When the gas was clear of the cave, the Master and I went back to find what pressure we had, while a number of the men trooped after us. There was the faintest suspicion of a gleam in the Chief's mild eyes as he turned the handle of the stop-cock to the gauge. The hand of the dial trembled violently, then swung to forty atmospheres indicated, where it remained steady!

"Forty atmospheres!" the Master said quietly. "A great reservoir. Ah, Seton, it is almost sacrilege to tap it—the product of nature's slow processes through aeons of time!"

The Great Dirigible

And now a trip to the outer world became urgent. We were short of the stores and plant made necessary by our development of the cave's resources. Again, we had to complete the airship design in the light of the new gas. The Chief made tests of a sample drawn straight from the reservoir and found it to be almost pure aithon. The specific gravity of the mixture he declared to be close on five times less than that of hydrogen, so that with our design for a helium-lifted ship our margin for play was enormous.

In the original design, the total fixed weight worked out at about thirty-five thousand kilogrammes, with a disposable lift of under twenty thousand. The small proportion of disposable lift to total fixed weight was due to strengthening of the structure, and the sacrifice of carrying capacity to that end. It was not anticipated that we should have to carry heavy armament or bombs, or that sort of thing, or a very numerous crew.

With the advantages of the much lighter aithon, I urged the Master to permit a further stiffening of the structure, and he agreed. We thus avoided the weaknesses which have always characterized even the best of rigid dirigibles. The length and mould of the vessel we did not alter. She was designed to two hundred meters in length over all, twenty-three meters in diameter, with an extreme height of twenty-seven.

In cross section she was twelve-sided, and floated with one of the facets as a broad keel. This gave her a flat top and two vertical facets, one on either side. We joined the angles of these horizontal and vertical facets, each to the angle squarely opposite, with latticed girders of duralumin, so that the structure of the vessel was in fact a broad hollow girder of cross-shaped section through all her length. Her body was short and parallel, with long rounded bows and an extended tapering stern, the duodecagonal section being held throughout.

The cross-shaped section of the longitudinal girder permitted the running of a chamber, seven meters wide, from the point where her bows began to round to that where she began to taper to the stern, a length of ninety meters. On the main gangway, or keel, level, this chamber was divided off as follows, from fore to aft: first the room holding the control connections from the navigating cabin which was suspended below, the two being joined by a ladder; next two sleeping cabins side by side intended for the Chief and myself; behind these cabins, further aft, a bigger companionway ran down into the navigation room; next a space leading into an alleyway which had cubicles on either side to the number of fourteen, each cubicle taking two men and being provided with two low berths and two lockers; next came the engine room with the power for working the gas taps and so on, for raising and lowering a gondola to and from the main structure of the ship, and also for creating the enormously high voltage electricity necessary for some of the Chief's marvelous instruments; here also a stairway gave access to the observation top, and two doors led out to the amidships power units, one on either quarter; behind the engine room was a dining-saloon and lounge for the crew, with a stair down at its after end to the stern engines and control cabin. The galley and larder stood over this companionway.

Aft of the forward navigation cabin, two power units, port and starboard, were suspended. The engines here were 700 h.p. each, of the horizontally opposed cylinder type, with direct drive to the propellers. They weighed just over half as many kilogrammes as they had units of horsepower, and they were so arranged, each in its own little engine room, that the attendant mechanics could easily get at them.

The amidships engines thrust at the level of the main gangway, thus about four meters higher than the forward engines. They were also much wider apart, being about sixteen meters from crank to crank. These engines were of similar weight and horsepower to the forward units. The after control-cabin had two engines behind it, thrusting on the same lines as the forward ones. The whole of this after cabin swung horizontally on a pivot, engines included, on a strong column flanged on roller bearings, the idea being to hasten the turn of the ship by the side thrust of the propellers astern. The swing of the after cabin was electrically controlled from the forward one, but it was possible to work it from itself. The only thing not affected by the swing of the cabin was its binnacle, which was fixed to the stationary column on which the cabin pivoted, thus the lubber's mark of the gyrocompass always pointed to the real head of the ship. This old idea of steering was augmented by an ordinary rudder.

For the normal climb and descent we had the usual box-fins astern, but the genius of the Chief found us a much greater power in this direction. I anticipate the chronology of the story by telling of this feature at the moment, but it may be as well explained here as later.

We liquefied the aithon—at absolute zero—and carried a big reserve in steel containers. Owing to our immense lifting power we were able to have spring hoops for keeping our ballonets rigid, each being fitted with an automatic pressure valve. By an elaborate system of pipes, stop-cocks and valves, all electrically controlled from either navigating cabin, we were able to clear these ballonets of gas or air at will. When we wanted to rise quickly, we pumped the air from the forward ballonets, and forced into them the aithon expanded to gas by having been sprayed into a slightly heated chamber. Thus we upset the balance of the ship, and had the lifting power forward—helped, of course, by the thrust of the propellers. By turning a graduated dial in the cabin we were able gradually to fill the ballonets one after the other, or empty them, fore to aft, or aft to forward, as we chose. Thus, when we wanted a quick descent, we emptied the forward ballonets of gas and filled them with air, bringing the nose down.

By reason of these improvements, all made possible by the discovery of the aithon, we were capable of—and the structure permitted—quick manœuvre which would have buckled the ordinary dirigible at once.

Working Drawings Prepared, Drilling for Oil

It was my task now to set out working drawings of the improved airship. This was a matter of enormous labor for one pair of hands, involving as it did a mass of drawings and tracings to various scale from 1 mm. to 1cm., and full-size for certain details. Owing to the shortage of material, which could not be remedied until the drawings of the airship were ready to pass into the hands of Travers Lippencott at New Orleans, the crew had time on its hands, so I enlisted the services of Dave Lippencott and Fitzalan, who I found, in addition to being capable engineers, had some idea of mechanical drawing. They acted as tracers for me. They improved as they went on, and the time came when the close inspection of their efforts by the Chief, Thetford and myself, could find no errors either in drawing or in figuring.

While this work was in hand, the remainder of the crew began to try drilling for the oil with an electrically driven rotary drill. They succeeded in striking oil at a depth of one hundred and thirty-three meters, and, as with the gas on the opposite side of the main cavern, found an enormous pressure. It was a good quality of oil, pale sherry brown in color, and not at all the tar-colored, viscous stuff one expected to see. It had a paraffin basis, and readily ignited as it was, fresh from the earth.

The voyage to the outer world could no longer be postponed. The drawings of the airship were ready, and we needed the piping for gas and oil, and had to bring up the refinery plant.

Of the company, only the Chief, Thetford, Devonridge and Haynes—which last two were promising themselves some hunting in the slack time—and Grumstock were to remain behind. Grumstock came with us for the first part of the journey.

We found Sleepy Sam Smithers as placid and contented as ever, to the great glee of Higgins and Grumstock, who found much amusement in chaffing their old shipmate. In the months that Smithers had been solitary, not a single white man had he seen. He had captured and tamed a toucan, and the bird was his sole companion.

I had been rather anxious about Smithers, whether his resolution and phlegm would indeed be capable of sustaining that dreadful isolation, but I honestly believe even now that the stout shipwright really enjoyed his own company. His health was excellent, a remarkable thing in a man so short-necked. He had improved the storehouse greatly inside, but had carefully neglected all outward appearances. The place was desolate and overgrown to a forlornness that might have made the heart sink, and even the *Clutha* was hidden by creepers. But if Smithers had allowed her to hide herself naturally, he had looked after her, waging bitter war on the ants which might have eaten into her timbers, and keeping her engine room a picture of tidiness.

When the *Clutha* was ready for her trip downstream, Grumstock offered to bear Smithers company for a day or two before returning to the plateau.

"Well, Jack," said Smithers, "if you likes to muck in wi' Nosey an' me for a day or two, good an' well—you're welcome. But we ain't no debatin' sassiety, 'im an' me, I can tell you that."

Nosey, of course, was the toucan.

"Well, what do ye do with yourself all the time?" Grumstock demanded, with an irritated scratch of his head.

"Nosey an' me," said Smithers solemnly, "we've brort thinkin' ter wot ther papers calls a fine art.

"That bird," he went on with an impressive wave of his slim pipe—"that bird's a wonder,

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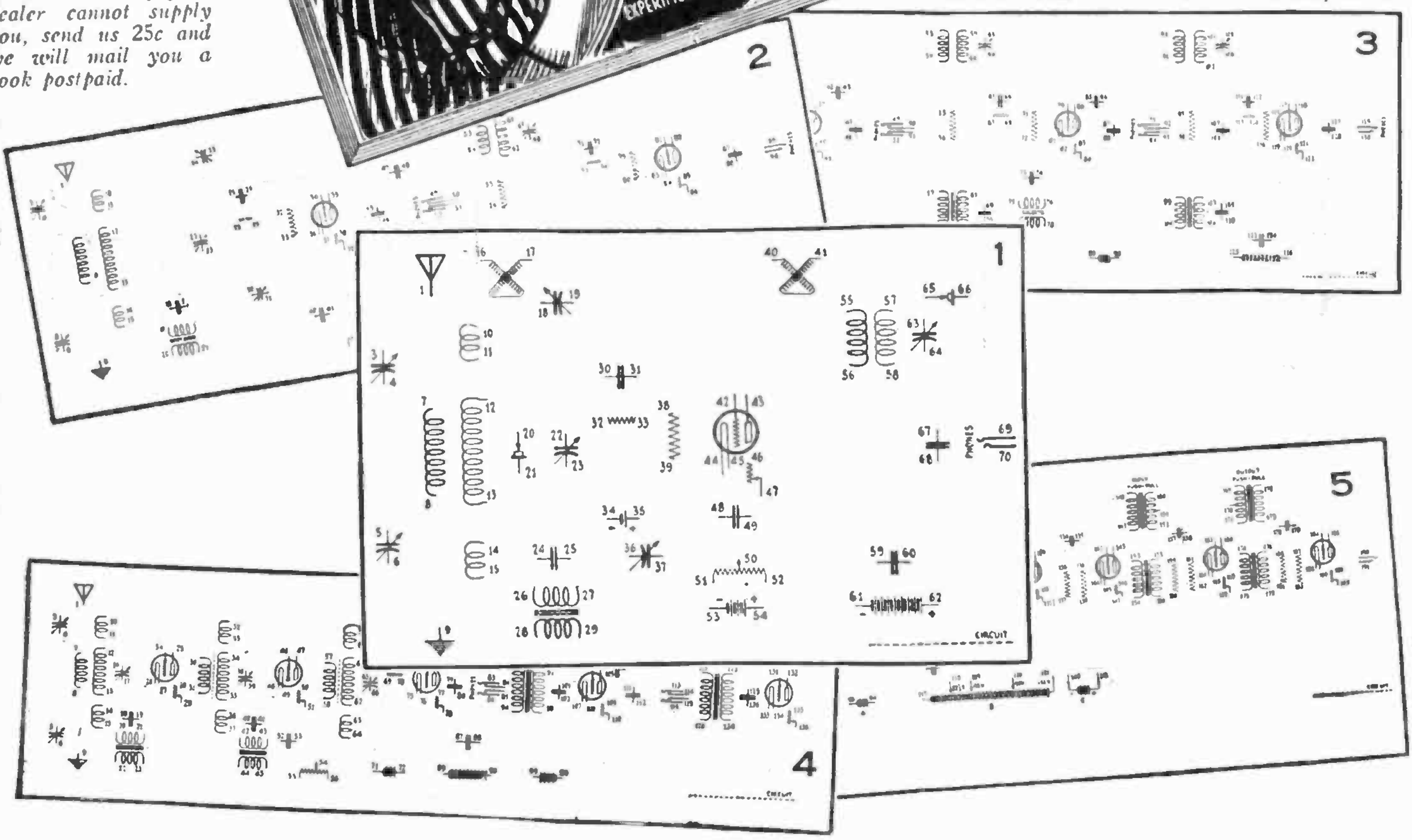

'Im an' me'll sit fer hours lookin' at each other—thinkin', d'ye see?—an' I've seen Nosey that pensive as'd make you say 'e 'ad brains in 'is beak! 'E'll sit there, thinkin' an' thinkin' till ye begin ter wonder wot tremenjous idea 'e's got. You can see it swellin' up in 'is 'ead, then, sudden-like, 'e'll give 'isself a dust under ther wing. An' anybody can see 'e's got *that* point settled all right. Ah, Nosey's got me beat for thinkin', any day o' ther week!"

"I'd say a monkey'd be more company," Higgins asserted.

"Ah, Tom, ah!—fer *you!* Birds of a feather make good company," Smithers said pointedly. "A monkey's got no brains an' 'u'd suit you splendid. Nosey's my mark. 'E's got plenty."

"Oh, all right, Sam," said the abashed Higgins. "If you fancy old Solomon Levi as much as that, good an' well. But a bird like that'd give me the creeps."

"Possibly, Tom, possibly," Smithers said with solemn pride. "A bird like Nosey wants some livin' up to."

"I'd stay for a day or two," Grumstock announced, "if only for something to laugh at."

"That's right, Jack," Smithers said placidly. "Stay an' advertise your vacant mind as much as ye like!"

His withers quite unwrung by this peculiar extension of hospitality, Grumstock elected to remain, and he and the stolid Sam saw us drop down the river one morning early. The last glimpse we had of the pair showed Sleepy Sam sitting like a graven image on the steps of the wharf, hands on knees, gazing fixedly downstream after us, while Grumstock, beside him, was regarding his old shipmate perplexedly and was scratching his head in a state bordering on despair.

To New Orleans by the Steamer "Gluthn" and Return

We reached New Orleans in good shape, and found Travers Lippencott with a cargo ready for us. This included our refining plant for the oil, piping, tanks for the pure spirit, and in fine the last of the material apart from the airship itself. There was also a large amount of food, tinned and otherwise, cement, grain—and, when we were ready to return, coops of chickens and ducks.

I handed him the airship drawings, and fixed a date for our return to pick up the parts. We arranged between us that the parts and the materials should be invoiced to a so-called North African Aerial Transport Company, and that the manifests and bills of lading should be made out for some of the North African ports. We built up a ramified and intricate deceit, not because it would have been difficult to get clearance for our cargo, which was innocent enough, but to hide our traces beyond recovery when the hue and cry would be raised against us perhaps years hence. At the time when the parts of the ship were ordered, there was a great boom in the building of dirigibles in America and Europe, and we anticipated no trouble in having the orders filled. But to make assurance sure, and to see that every single part was submitted to accurate testing, I asked Brooks to stay in America until everything was collected at New Orleans.

Brooks was a little chagrined at the prospect of banishment from the plateau, but I pointed out to him that there was nothing left in the cave but rough work, or jobs that he could not tackle, until we could have the parts of the airship brought there, and he consented. He was a good man, Brooks, who was not likely to get drunk or talk, and he was thoroughly capable of the business of seeing our orders properly carried out. He was to draw upon Lippencott for money—we treated him generously—and in the end I imagine the prospect of traveling importantly about the United States rather took hold of him, for he set about the business with apparent pleasure. He was primed with a clear-cut and circumstantial story to trot out to inquirers, and we even went to the length of printing prospectuses of the company for him. This point was a trifle overdone, for though the scheme outlined was of the maddest, I believe he had difficulty later in keeping people from trying to invest in it.

The two New Orleans young men, Lippencott and Curtis, made the most of their leave from the Amazonas Exploration Company, and trotted their fellow explorers, Fitzalan and Greyson, about the city in great style, to the evident edification of the latter. They roped in two other men for the company, one of them a young oil engineer from Texas.

At last, however, the cargo was stowed, and we set off on our return voyage. Less than a fortnight brought us off Manaos, and there we had a slight scare.

Off the city we were boarded by a Brazilian official who insisted on inspecting our cargo. But our papers were in order and, in the end, though I fancy he thought us a trifle mad, he thanked us warmly for helping to develop the resources of his fatherland. We sacrificed on him and his fellows a bottle or two of very sweet champagne, stored aboard for just such an emergency, and when we dropped them over the side into their own boat, I do not think they were in a condition to remember whether we were going upstream or down. We were shouting fond

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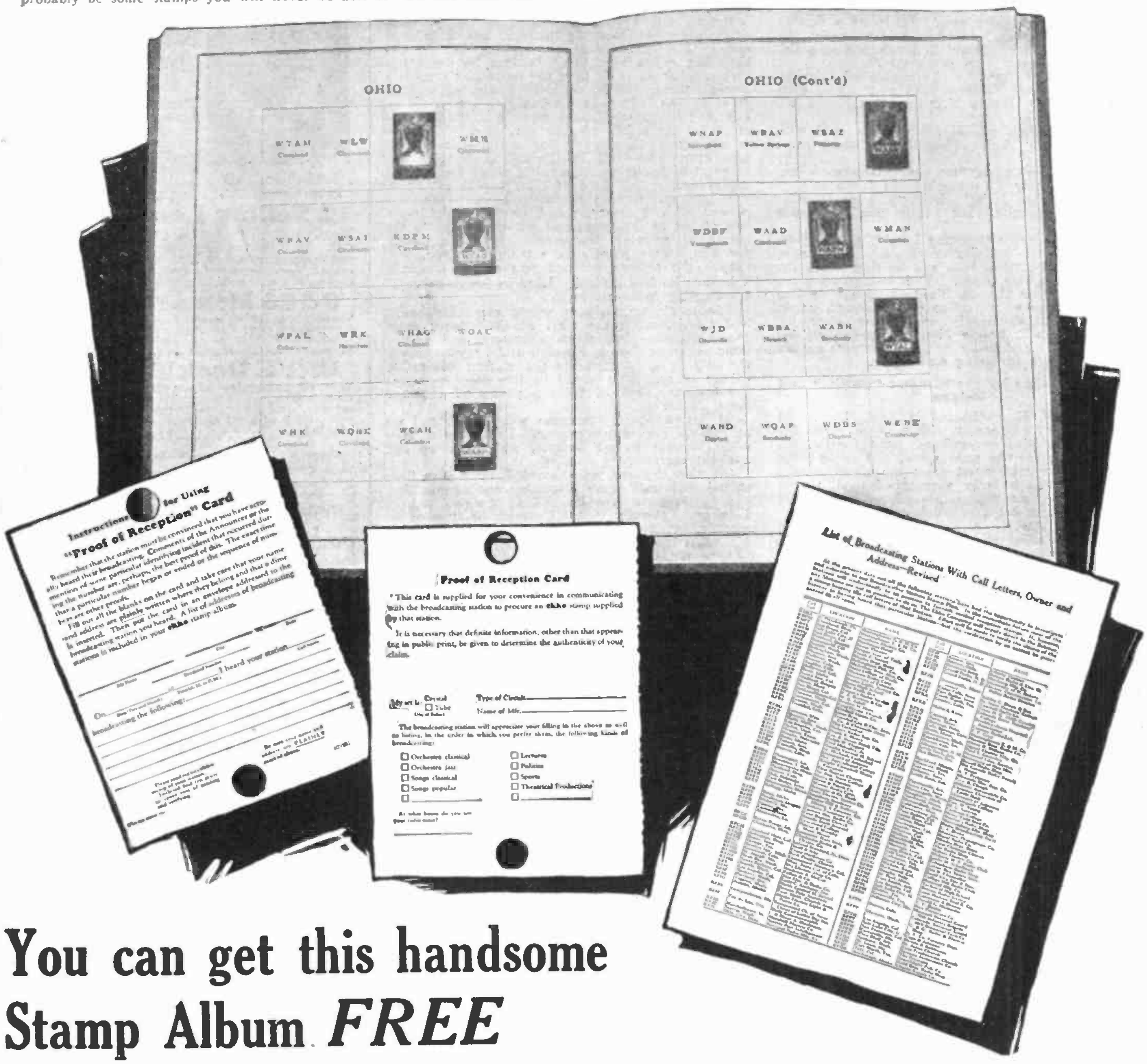

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farewells to them, and they protestations of undying amity to us, even as our engines began to turn for the run up the river. Some weeks later the Chief was welcoming us and our new comrades to the Plateau of the Red Scar.

IV

An Uncanny Discovery in the Cave

The young Texas engineer, Lin Greensleeve by name, fell in with the idea of the League right away, and the other new comrade, Matthew K. Whittaker (he insisted on the K.), was little behind for enthusiasm. Both men had fought for America in France, and our tally of wounded men was unbroken by their adherence. Greensleeve pronounced our drilling and capping of the well to be quite professional, and waxed eloquent on the quality of our oil. He set about the erection of the fractional distilling plant, and ruled out as unnecessary our idea of forming a reservoir. He superintended the piping of the oil direct to the stills, laid down the tanks for the gasoline (as he called it), and when that was done, took over the piping of the aithon to the hangar caves and to the site of our pressure and freezing tanks.

Meantime, Matthew K., who understood what might be called raw lumber, had organized a party for tree-felling. Tall trees were felled and dressed down the river, and were towed by launch into the cave to make the stocks for erecting our airships. The putting up of the stocks when sufficient timber was collected fell to myself and the seamen of the company. I was inclined to drag that master shipwright, Smithers, from his splendid isolation so that we might have the benefit of his professional experience, but I forebore, and disturbed him and Nosey only once, when I sailed down to thrash out a knotty problem with him. We managed, however, without his personal supervision to put up quite a shapely scaffolding in readiness for the arrival of the airship parts.

In the midst of these preoccupations, Lin Greensleeve made a discovery which was the beginning of a series of thrills for us.

In the east walls of the main cavern, whence came our water-power and our aithon gas, running up close to the edge of the red-topped pipe a series of varying tunnels wandered, seemingly the dried-up courses of ancient hot springs. These bored up to the surface in several places, to end sometimes in high sinter cones on the top of the plateau. The sweet air of the cavern's was due in measure to the ventilation that these passages brought about, for in many of them one could feel the rush of air.

It occurred to the versatile mind of Lin Greensleeve that if he could search out a separate passage and connect it up to the furnaces of his refining plant, he would be in possession of a natural flue and save himself a lot of trouble. To this end, he dragged me off on a tour of investigation among those upper passages.

For hours we scrambled and crawled with pocket compass and torches through tortuous ways, checking directions and measuring distances. Among other things we discovered a good passage up to the top of the plateau, but that fact was temporarily lost sight of in the amazing find that followed.

Lin discovered his flue—to a certain extent. The only thing that prevented it from being an excellent flue was the fact that it came to an abrupt end underground. Lin, however, had his measurements—which were all out, owing to an unseen influence on his compass, as will transpire—and he was ready to wager that by hewing through for a certain distance he would connect up with another of the dried spring courses, and so have a good draught to the outer air by one of the sinter cones.

Since the idea was merely a fancy of his, and since the other members of the company had their own particular tasks to perform that day, he determined to carry out the operation by himself; but since Lin was one of the most cheerfully determined devils it has ever been my fortune to meet, and the most engaging companion withal, I volunteered to help him. I knew nothing of mining, but I thought it was not too late to learn a little.

Lin decided that it was useless to attack the barrier with the pick, for the rock was a particularly hard limestone, and, as he put it, the only method was by "a shot or two." We descended, therefore, to the store-cave for a stick of explosive, "or two," detonators and a coil, a drill and a forehammer, and other weapons necessary for the attack.

I now received my first lesson in mining. The little chamber was stifling hot, for some reason, but we commenced operations undeterred. My instructions were to hold the drill while Lin smote it, and to turn it slightly after each stroke. How the man could deliver such blows in such a cramped position I am unable to say definitely, but I take it that for the hundredth time I was in the position of the neophyte admiring that precision which belongs only to the master of any craft. We—or rather Lin—soon had a goodly hole sunk, and into this he inserted the explosive with its detonator all prepared. He put in some sort of tamping, and we retired round a corner or two to where the coil stood ready in connection.

"Hug the wall, Seton," Lin ordered. "Now!"

He dropped his weight on the plunger.

From the cavern round the corners there came a dull roar, and a gush of hot air came rushing down the passage. I was hugging the wall according to instructions, but was almost dragged away from it. We were among particularly pungent fumes.

"Foof! Foof!" Lin spluttered. "This will soon pass away when the little draught gets down to it. You won't be poisoned, Seton—but it's derned unpleasant."

We waited some considerable time, but the little draught did not "get down to it."

"Funny!" said Lin. "I could have betted we'd be through. Wait a bit, then let's go and see."

We retired to the end of the passage above his refinery, and while we waited we smoked and yarned. When Greensleeve thought it would be safe we returned to the *cul-de-sac*. The place was blocked by a heap of rubble, which Lin and I started to clear away. When we had made a way to the shattered wall, Lin fell to flashing the light of his torch on it.

"My, my!" he exclaimed. "We're through to a dyke rock. Gentlemen, don't snigger! I didn't expect that. Well, here goes!"

He picked up the drill and he rapped the end of it against the blackish rock. It sounded hollow, and he turned a grin on me.

"I'm not sold," he smiled. "It's boss, as the Cornish say. Another little shot will do the business."

Again we fell to drilling. We set the stick of explosive and the tamping, then went back to the coil. Once more that hollow roar, the rush of hot air, the pungent smell. But even now the expected draught was absent. Lin Greensleeve was puzzled, and his face as we made our way back to the entrance to await the dispersing of the fumes was a comic study in chastened expression.

"I can't be far out, Commander," he said ruefully when he caught me smiling. "We've driven deep—and it was hollow, too. Gentlemen, don't snigger! Maybe debris has fallen from the roof and blocked the passage. We'll soon have it out, if it has."

We returned to the scene of the explosion after another smoke. As we turned the last angle of the passage, Lin suddenly gripped my arm.

"Now, what's your verdict on that?" he demanded, and pointed ahead.

From the further wall there rose a strange greeny lambency, silhouetting the heap of rock that was piled on the cave floor. Something uncanny it was which made the hair prickle on the scalp. A strange sense of some appalling power behind the rocks gripped me hard, and I was fain to turn on my heel and run. That, indeed, was what Lin Greensleeve bade me do.

"Get back, Seton," he whispered. "Get round the angle of rock. I dare not think what it is—but I'm going to see."

"Stop, Lin, stop!" I exclaimed. "There may be fumes from it!"

"We'd get them now if there were," he replied, sniffing, "though there's an unaccountable whiff of bromide or chlorine," he added with a puzzled air. "Get behind the rock angle, Seton. I am going to see."

All in ignorance as I was, I could neither stop him nor permit him to go forward. I could not tell if it would be wise to follow him, but the Scot in me dictated the waiting attitude, to be ready to pull him out if he were in danger. Lin crept forward on his hands and toes, and came back in a rush with a lump of rock.

"If it's what I think it is," he panted, "I'm either mad or drunk—I don't know what I'm saying, Seton. I'm rattled. Let's get out of this. I have something that may provide a clue. The Chief is the man for us."

We hurried for the entrance of the passage and climbed down to the main cavern floor. We ran across the bridge that now spanned the lake, and rushed up to the Chief's laboratory. We were bidden to enter.

Lin poured out his story in a rush, while the Chief listened with his usual mild expression—unastonished, unmoved.

"A lambent, greenish glow," he murmured. "Let me see the rock."

Lin took it out of the coat in which he had hurriedly wrapped it. It was a blackish rock, with a reddish side to it, and to this reddish side there was a pinkish crystalline deposit, very thin.

"Pitchblende, I think, with a filling of rhodolite," said the Chief, when he had placed it on a bench to examine it. "An extraordinary combination! Look, my good Greensleeve—Seton, look!"

He charged an electroscope until the two leaves were held out at right angles to the stem. He put the piece of rock over the cap of the instrument, and the leaves fell at once!

"That tells its own story," the Chief said. "Your specimen, Greensleeve, is highly radioactive—and the pinkish salt that clings to the rhodolite side of it is one of the radio compounds—I should say bromide, with a slight barium impurity."

He looked at us mildly quizzical.

"I have ceased to disbelieve in miracles, Seton, since we found the aithon reservoir. Though the glow you describe may easily be only the fluorescence caused by a minute quantity of radium acting on some substance readily so affected—radium, pure radium does not glow, to the eye, at least—the thin deposit of radium bromide clinging to the rock specimen makes me really believe you have come upon a natural pocket of the metal itself!"

(*To be continued*)

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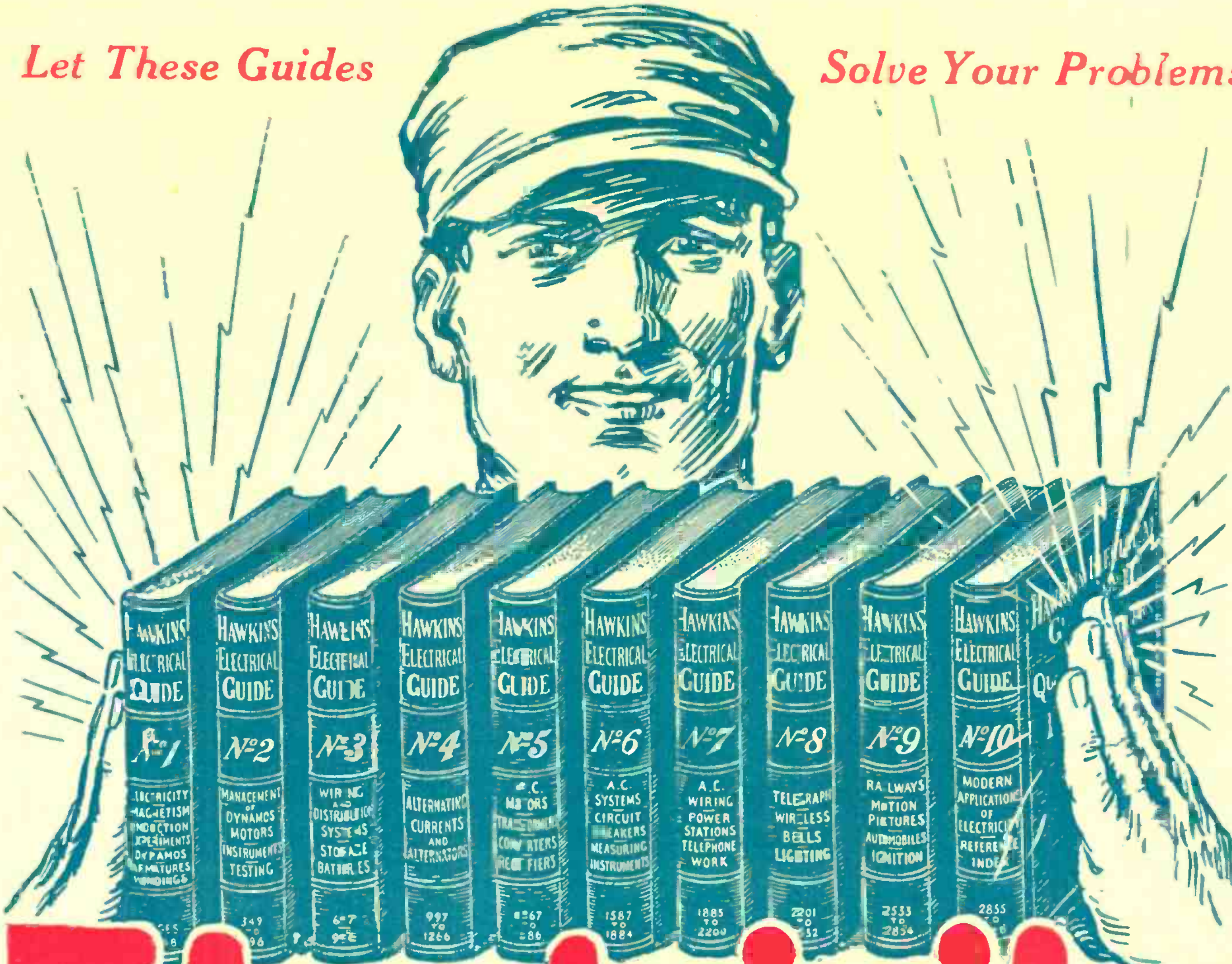

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