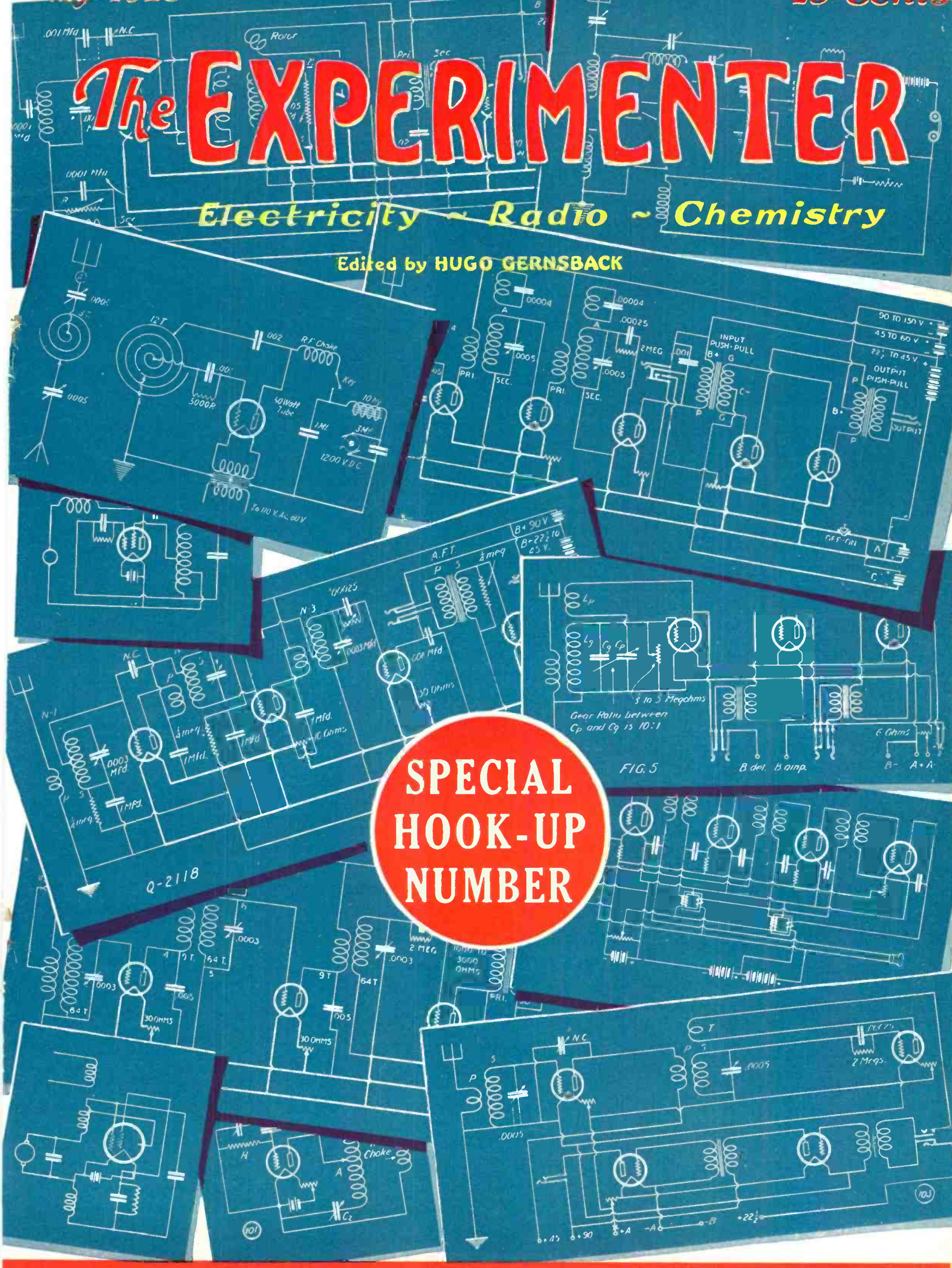
July 1925 — 25 Cents

The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK



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To Practical Men and Electrical Students:

Yorke Burgess, founder and head of the famous electrical school bearing his name, has prepared a pocket-size note book especially for the practical man and those who are taking up the study of electricity. It contains drawings and diagrams of electrical machinery and connections, over two hundred formulas for calculations, and problems worked out showing how the formulas are used. This data is taken from his personal note book, which was made while on different kinds of work, and it will be found of value to anyone engaged in the electrical business.

The drawings of connections for electrical apparatus include Motor Starters and Starting Boxes, Overload and Underload Release Boxes, Reversible Types, Elevator Controllers, Tank Controllers, Starters for Printing Press Motors, Automatic Controllers, Variable Field Type, Controllers for Mine Locomotives, Street Car Controllers, Connections for reversing Switches, Motor and Dynamo Rules and Rules for Speed Regulation. Also, Connections for Induction Motors and Starters, Delta and Star Connections and Connections for Auto Transformers, and Transformers for Lighting and Power Purposes. The drawings also show all kinds of lighting circuits, including special controls where Three and Four Way Switches are used.

The work on Calculations consists of Simple Electrical Mathematics, Electrical Units, Electrical Connections, Calculating Unknown Resistances, Calculation of Current in Branches of Parallel Circuits, How to Figure Weight of Wire, Wire Gauge Rules, Ohm's Law, Watt's Law, Information regarding Wire used for Electrical Purposes, Wire Calculations, Wiring Calculations, Illumination Calculations, Shunt Instruments and How to Calculate Resistance of Shunts, Power Calculations, Efficiency Calculations, Measuring Unknown Resistances, Dynamo and Dynamo Troubles, Motors and Motor Troubles, and Calculating Size of Pulleys.

Also Alternating Current Calculations in finding Impedance, Reactance, Inductance, Frequency, Alternations, Speed of Alternators and Motors, Number of Poles in Alternators or Motors, Conductance, Susceptance, Admittance, Angle of Lag and Power Factor, and formulas for use with Line Transformers.

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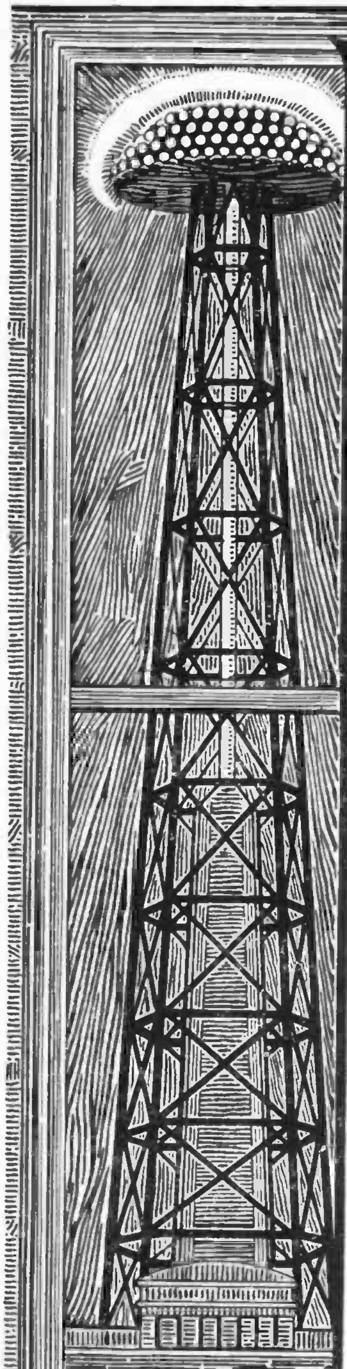
The EXPERIMENTER

Vol. 4 **Contents** No. 9



FOR JULY

IMPORTANT ARTICLES IN AUGUST ISSUE

THE TUNGSTEN ARC LAMP. Descriptive of the latest of the tungsten arc lamps, contained in a bulb like that of an incandescent lamp; an impending development in arc lighting.

REPAIRING ELECTRIC FANS. Continuation of Mr. Secor's practical article, of interest to all who have to do with the omni-present electric fan.

AN IDEAL "A" AND "B" BATTERY CHARGING PANEL. A very excellent addition to the experimenter's laboratory, this charger is a very practical unit which is ever handy in charging "A" and "B" batteries and keeping them in the best condition.

INTENSE MAGNETIC FIELDS. Remarkable article by Dr. T. F. Wall in which he describes interesting and striking results and in whose development he hopes to disintegrate the atom.

THE MUTOCHROME—NEW COLOR MACHINE. The electric light projects colors on portions of a design so as to enable color effects on textile fabrics, wall paper and the like to be studied out and reproduced when desired.

HOW TO MAKE THE RADIOTONOSCOPE. Suggestions for making the Radiotonoscope, which gives a visual representation of radio in color patterns.

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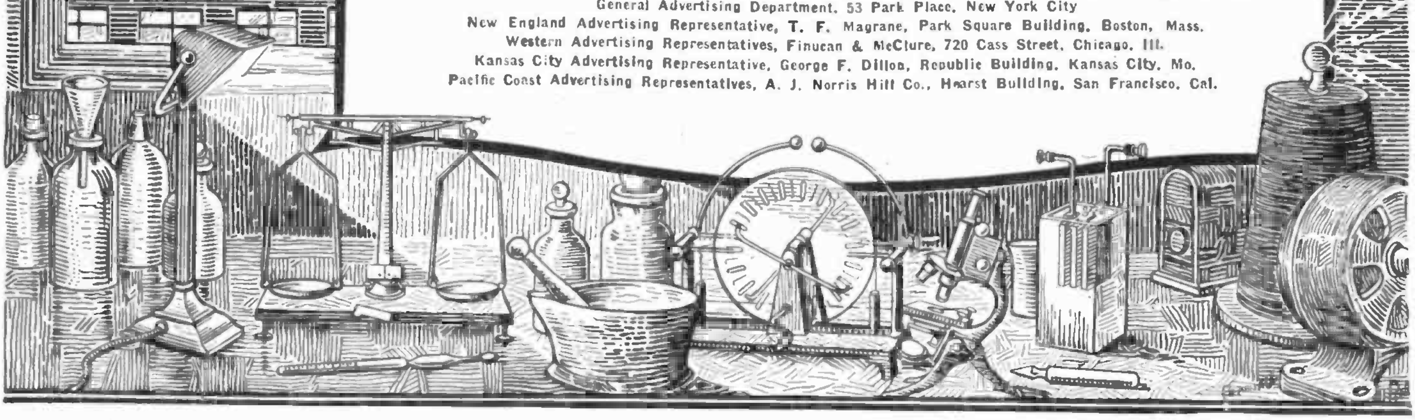

THE EXPERIMENTER is published monthly on the 20th of each month, by THE EXPERIMENTER PUBLISHING CO., INC. (THE GERMOTT PUBLISHING COMPANY, INC.), owner, at 53 Park Place, New York City. THE EXPERIMENTER is entered as second-class matter, October 11, 1921, under act of March 3, 1879.

All communications and contributions to this magazine should be addressed to: Editor, THE EXPERIMENTER, 53 Park Place, New York City. Unaccepted contributions cannot be returned unless full postage has been included. All accepted contributions are paid for on publication. A special rate is paid for novel experiments; good photographs accompanying them are highly desirable.

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7-25

How to Build The Ultradyne (Model L-2)

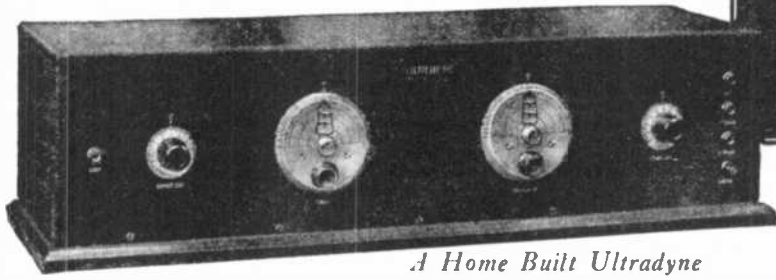
by R. E. Lacault, E.E., A.M.I.R.E.

formerly Associate Editor, Radio News

How You Can Build This Remarkable Super-Heterodyne In Your Own Home

R. E. LACAULT

Designer of the Ultradyne Receivers and formerly Associate Editor of Radio News, is now Chief Engineer of the Phenix Radio Corporation.



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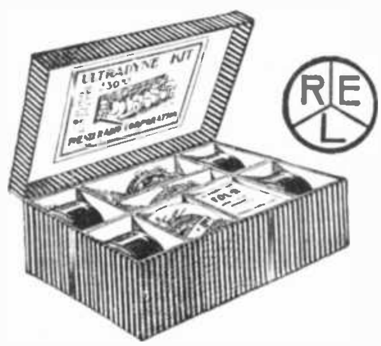

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Exp., July '25.

Volume 4 No. 9

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

July 1925

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

"Book" Experimenting

By Hugo Gernsback

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

THERE are two classes of experimenters, those who really experiment, actually performing experiments in their laboratories or workshops, and those who are, in the writer's terminology, "book experimenters."

The difference is vast and complete. He who actually conducts physical experiments gets all the benefits, all the surprises, all the excitement inherent in experimenting, which can never be appreciated by one who has not been engrossed in such work. The other class read up experiments assiduously in books, magazines, pamphlets, and derive their knowledge therefrom. This class of experimenters is very much to be pitied. They obtain no more joy or pleasure from such mental experimenting than does the hungry urchin standing in front of a plate glass window from the choice foods of all kinds displayed within.

To be sure, we all must be book experimenters to a certain degree. It is not possible to perform every experiment that we see described or illustrated in literature. We must accept some facts as stated. For instance, nearly everyone knows the experiment of Galvani, how he made the frog's legs jerk by touching them with two pieces of metal. The experimenters who have actually performed this experiment may be designated as few and far between. Then there are a number of other classic experiments which are either so complicated or so difficult to perform, that the investigator takes them for granted, knowing, perhaps, full well, that there is not much more to be gained by actually performing the experiments than by reading about them.

Then, of course, the time element also enters into consideration. If we attempted to duplicate every experiment that we are interested in, we should never accomplish any work ourselves. On the other hand, many experimenters go too far. They read up everything within sight and gain their entire knowledge by reading. As mentioned above, studying and reading descriptions of experiments is a very good thing by which to gain knowledge, but you can never get the benefit of practical experience from book experiments. You will always miss something.

It is impossible to foretell what a certain experiment, if actually performed, will do to different mentalities. The writer mentioned in one of his editorials a few months ago that Elihu Thompson, when experimenting with a spark coil, noticed that two wires of the coil welded together. This gave him his idea for commercial welding. Possibly 100,000 people performed such experiments before Elihu Thompson, but the great idea never occurred to them. It did to Thompson. Hence the world has commercial welding, whereas perhaps it would not otherwise have had it; had Elihu Thompson been a book experimenter and merely read all about spark coils, he would never even have seen the effect, which told him the story of electric welding.

The writer wants to be very emphatic in this regard—it is not always the experiment that counts half as much as the by-product of the experiment, which may have nothing at all to do with the original work. It is the unexpected and the unforeseen that often become valuable, and lead to new developments while the investigator is doing the experimental work. The main thing is to train oneself to keep the senses alert and to be ready to draw conclusions from even the most insignificant occurrences.

Only after having actually experimented for many years does it become possible to devote more attention to book experimenting, because the experience gained in doing a quantity of actual work renders it possible for one to discern and understand many things in reading about certain experiments, things which would remain hidden altogether had we not had our actual schooling in the laboratory.

After a while it is possible to gain sufficient experience to know whether a thing will work or not simply by looking at a rough sketch, but even here caution is necessary. The writer, for instance, due to many years of diligent laboratory work, finds it possible to visualize and complete, down to the last detail, a new piece of apparatus is his mind's eye, so that when he finally brings it down to paper the device usually works right from the start and little experimentation is necessary.

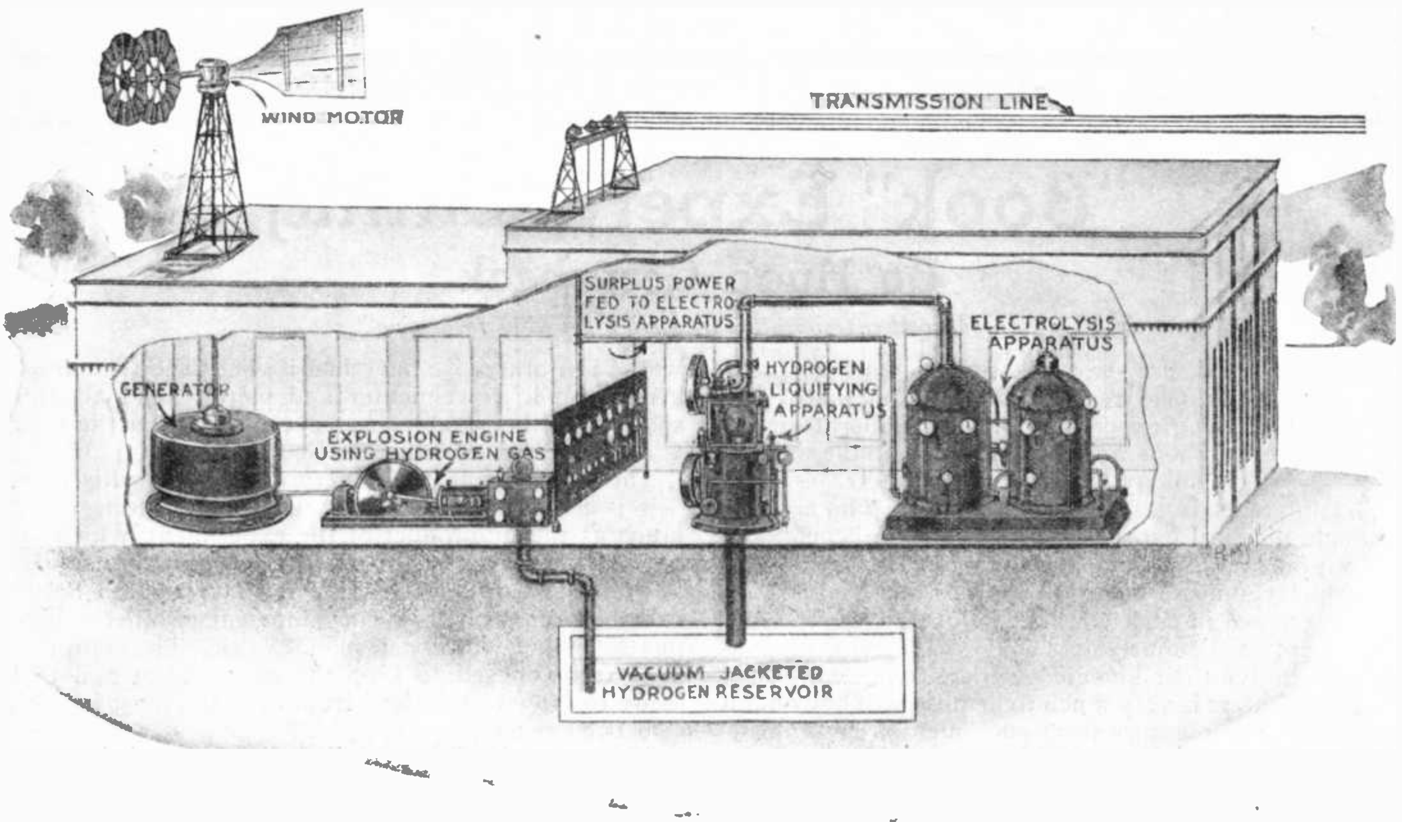
Such a state, however, cannot be reached unless there has been actual training.

The important part is to learn how to handle materials; whether they are metals, wood, glass, or what not, the experimenter must have the knowledge to actually handle and shape these materials to his will. A thorough knowledge of materials will go far and will prove an education of itself, and while one may read about these things in books, it is impossible to gain full understanding until one actually has done real practical work in the domain of experimentation.

The title of this magazine is the best comment on what is said above, for the reader will find book experimenting galore in our columns. The effort of the Editor has been to bring experimenting to the front. He is so thorough a believer therein that for years under one title or another he has published a series of magazines, of which this one is the culmination, which have always had for their feature the one thing, experimenting, originally in electricity and now in chemistry and radio as well. You can do little in any of these branches of natural science without experimenting.

Power Generation In the Future

By William Grünstein, E. E.



J. B. S. Haldane, Reader in Cambridge University, Eng., visualizes the future power station. Surplus electrical energy supplied by generators using wind motors as prime movers is used to decompose water into hydrogen and oxygen. The gases are liquefied and stored in large vacuum jacketed reservoirs from which in times of calm, the two are supplied to an explosion engine which drives the generator.

WE are living in an age of machinery. Mechanism, the machine, has achieved such an important position in our civilization that it is now a vital part of our social organization. To the inhabitants of the great metropolises, society seems a vast entanglement of machinery and human beings. Man has been building machines so rapidly that they have become Frankenstein monsters and one might almost question whether man or machine is the master.

But to the large mass of men these questions never occur and our mechanical world continues to grow and develop. Power is consumed on a greater and greater scale, until to the man who makes a comprehensive survey of our various sources of power supply the danger of the latter's exhaustion looms very large. Much has been said of the rapid rate of consumption of our coal supply which today plays so large a part in the generation of electrical energy. Sources of hydraulic power are scant and, in the event of the exhaustion of oil and coal supply would hardly satisfy the demand for power. Some scientists foresee these impending difficulties and have advanced methods of meeting them, more or less practicable. We might add, indeed, that some of these plans which to us seem hardly applicable are yet full of possibilities.

The most extensive methods of generating power depend on the relative motion of two generating elements as the rotor and stator of alternators, driven by a prime mover, which usually is a form of heat engine. In these machines the heat employed is liberated by the chemical reaction of burning coal or oil. Such reactions are called by the chemists exothermic because they give up heat, this heat being produced by the combining elements and generated only during the reaction. So in this type of power generation we depend on the satisfaction of chemical affinity liberating energy.

In some forms of power generating plants, heat is received directly from some source continuously generating it. Such is the case in the so-called sun plants in which the heat rays from the sun are concentrated on boilers developing steam which is then fed to turbines or engines driving electrical generators. To these forms belong the plants which tap the internal heat of the earth, where steam boilers are sunk to great depths in volcanic regions. This method has been successfully applied in Italy.

In another general type of power generating systems, energy for driving alternators is derived directly from some moving medium such as waterfalls, rivers, tides and air currents. In these systems the energy of motion of water or air is directly communicated to turbines or windmills, which in turn communicate the energy to electrical generators.

We mention these two large divisions of generating systems because the work of two prominent English scientists has brought to public notice possibilities of generating electrical energies by either one of these two methods. In our next issue we shall refer in detail to the work of Dr. T. F. Wall, who by the aid of intense magnetic fields seems to have disrupted the atomic structure of conducting mediums with the consequent release of twice the electrical energy he put into the system. This is not as might seem at first glance a form of perpetual motion machine or a machine with more than 100 per cent. efficiency, but depends for its operation on very sound principles. Its method is, in fact, similar to the generation of power by the use of exothermic reaction, in so far as in both cases energy in the system is developed; in this specific case it may be termed latent energy. In the burning of coal this energy is heat, while in the case of Dr. Wall's method this latent energy is the energy of the electron in the atom.

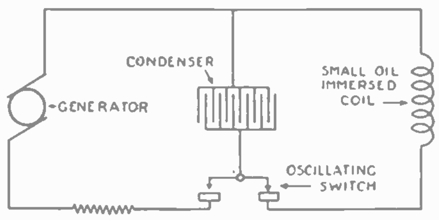
The diagram in Fig. 1 illustrates the operation of Dr. Wall's method of disintegrating the atom. A small generator supplies energy to a condenser which is connected to the generator by means of an oscillating switch which makes alternate contact (a) between condenser and generator and (b) between condenser and a small coil of wire. The condenser being charged, it will discharge through this low resistance coil, sending a current of 40,000 amperes through the coil, which in consequence sets up enormous magnetic fields of about 1,000,000 lines of force per square centimeter. Before performing the experiment, Dr. Wall computed the value of the current in the circuit, but found to his surprise that the current actually obtained was twice the computed value. Where did this additional current come from? Is it not possible that these tremendous magnetic fields liberated the electrons in the wire, thus giving rise to a new source of current? In the illustrations accompanying Dr. Wall's article, the theory of this process of atomic disintegration is explained. If so, may not the subsequent development of this method yield new and inconceivably large sources of electrical power?

Another and more immediately applicable method of generating electrical energy is suggested by Professor J. B. S. Haldane, who relies upon winds as prime source of power. The chief objection to windmill power plants in the past has been the irregularity and unreliability of wind as a source of power. Haldane, however, in his system suggests means for storing energy during windy periods and the subsequent consumption of this energy at times when the air currents are insufficient to drive the windmill.

A simplified form of Haldane's power

plant is shown in the illustration. The windmill drives a generator which feeds electricity to the bus bars. It directly supplies power through the transmission lines, and surplus power, that is, power not in demand by the consumer, but capable of being supplied by the generator is fed to a large electrolysis apparatus, where water is decomposed into hydrogen and oxygen. The oxygen and the hydrogen are delivered to a liquefying apparatus where they are reduced to a liquid state and delivered to large vacuum jacketed reservoirs sunk in the ground. It is claimed by Haldane that the loss due to evaporation of hydrogen so stored will be very little. In times when the windmill is inoperative, the gases are utilized in an explosion engine in which the energy given up during its recombination with the oxygen is employed to drive the alternator. It will be noted that the product of the recombination in this explosion engine is ordinary steam and that no smoke whatever will be produced by the operation of the plant.

Once this system is developed to an efficient stage, its advantages will become manifest. For here we depend upon air currents to supply energy to the system, and we are reasonably sure that air currents, that is, the wind, will be in existence so long as the sun continues to shine. None of the dangers of exhausted raw material sources with which to feed the prime mover are to be dreaded here, and so long as water and wind are available we need fear no lack of electrical energy.



Dr. Wall, an English scientist, makes use of this circuit in generating very intense magnetic fields by which he is experimenting on the atom.

Power generation of the future will depend on the tapping of sources in which either mechanical energy or heat energy are directly available, in the development of natural powers, either water power, the wind, or volcanic or solar sources. In closing we should mention the possibilities of this latter. The sun delivers enough energy to give one horsepower in a "solar engine" using a reflector surface of 10 feet square. What is needed here is an efficient means for the absorption and conversion of this energy, and the modern inventive experimenter will do well to give time, thought and trouble to the exploitation of this power.

Ants in a Telephone

THE base and cover of a microphone telephone transmitter such as are in use on everybody's desk are shown here.

A multitude of ants which crawled into a telephone receiver and died there. They could not go through the diaphragm and they were supposed to have been electrocuted.

The case is sealed tight except for a hole through which the transmitter cord passes. A legion of red ants found this little hole and for some reason crept in until they packed it so full that they died there.

It is said that the telephone continued to work until it was removed from the subscriber's desk, there being no suspicion that it was inhabited. This happened in New Orleans, where red ants are exceedingly numerous and where remarkable stories are told of their wearing a pathway up a tree or across a varnished floor in an unoccupied house. Whether these ants were electrocuted or died a natural death is not perfectly clear.

We are indebted to Edward R. Austin, Esq., of the Southern Bell Telephone & Telegraph Company for this interesting photograph.

The back case of the telephone making the chamber into which the ants crept in such large numbers.

Gas Filament Lamp

MACFARLAN MOORE, the inventor of the Moore light, has recently constructed a lamp in which a "gas filament" gives light in place of the metallic or carbon filament of the ordinary incandescent burner.

Our illustration shows the new gas filament lamp. Inside of a glass bulb, not shown in the picture, there is a capillary tube (*a*) in which the gas filament is brought to incandescence. The gas is neon, under 20 millimeters' pressure. At its ends the capillary tube widens out and in the same ends there are two iron electrodes which are to be connected to the lighting circuit of 110 or 220 volts.

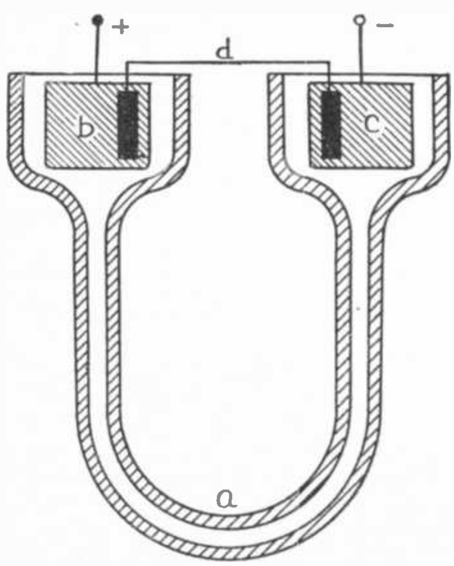


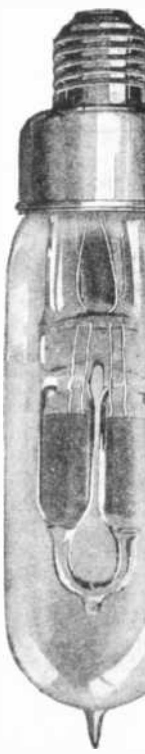
Diagram of a new lamp with incandescent gas filament on which the great exponent of gas lamps is now working, and which he hopes soon to perfect. Very interesting results have already been obtained with this lamp and it may yet play an important part in illumination.

The feature of the last invention of MacFarlan Moore is that the gas at ordinary potential of a lighting circuit becomes incandescent. This low potential lighting is made possible by the two auxiliary electrodes, *b* and *c*, which are connected by the wire, *d*, with each other. These are about one-third millimeter (1/64 inch) distant from the iron electrodes and a condenser charge is produced across the little distance intervening, which makes the gas conductive so that it becomes incandescent.

At present the incandescent gas filament lamp has several infantile troubles: A short life, disintegration of the electrode, disagreeable color of the light, etc. We hope that they will be removed and that the lamp will help the luminescent light on a victorious course.

Translated from Technik Für Alle.

We take pleasure in publishing what may be termed a German appreciation of the last ingenious invention of MacFarland Moore, who has been so long identified with vacuum tube illumination. Here the vacuum tube represents the filament of an ordinary incandescent lamp, and while the invention is not yet practically developed, it is in the line of getting rid of the tungsten filament and really simplifying greatly the construction of the lamp. Our readers will be kept informed of any interesting developments brought about by the distinguished inventor.



Reproduction of the MacFarlan Moore gas filament lamp. The light is given by the gas in the U-shaped tube projecting downward.

The Pianor, an Electric Piano

FOR a long time numerous inventors have tried to remedy the imperfection of the piano. Some, availing themselves of a cylindrical spring moved by a pedal, transform the piano into a pseudo-violin. Others have invented the combination termed the piano-organ, which amounts to the coupling together of a string and a wind instrument. Finally, we have had presented to us the piano-harmonium, whose music is quite different from that of the piano.

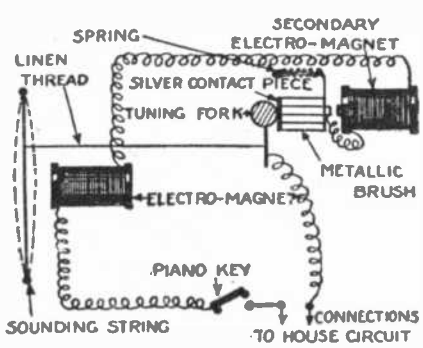
Recently a degree of progress of considerable interest has been effected. In pianos made up to the present period the pedal acts upon the whole range of the keyboard. The performer is forced to prolong the notes of the accompaniment, when it is the notes of the harmony alone which should be prolonged, or it may be that the reverse is the case.

At the Exposition of Physics in Paris last year a piano was shown whose pedal would affect only one portion of the range of the instrument at the will of the performer.

However this may be, the electric solution seemed the only one possible, and was the more seductive because, theoretically speaking, it is very simple.

Let us imagine a piano string made of steel, as are all the strings of the instrument with the exception of those for the extreme base, which are made of a copper core around which a wire is wound. Now place in front of this string, of course, a steel one at a distance of the order of a millimeter (1/25-inch) an electromagnet. When we pass an electric current through the coils of the magnet it attracts the string which, being fastened at its two extremities, curves toward the magnet pole.

The instant we interrupt the current the cord flies back to its original position and vibrates like a harp string plucked by the finger. A single closing and opening of the circuit are all that are required to make the string vibrate as when it receives the hammer blow in the regular piano movement.

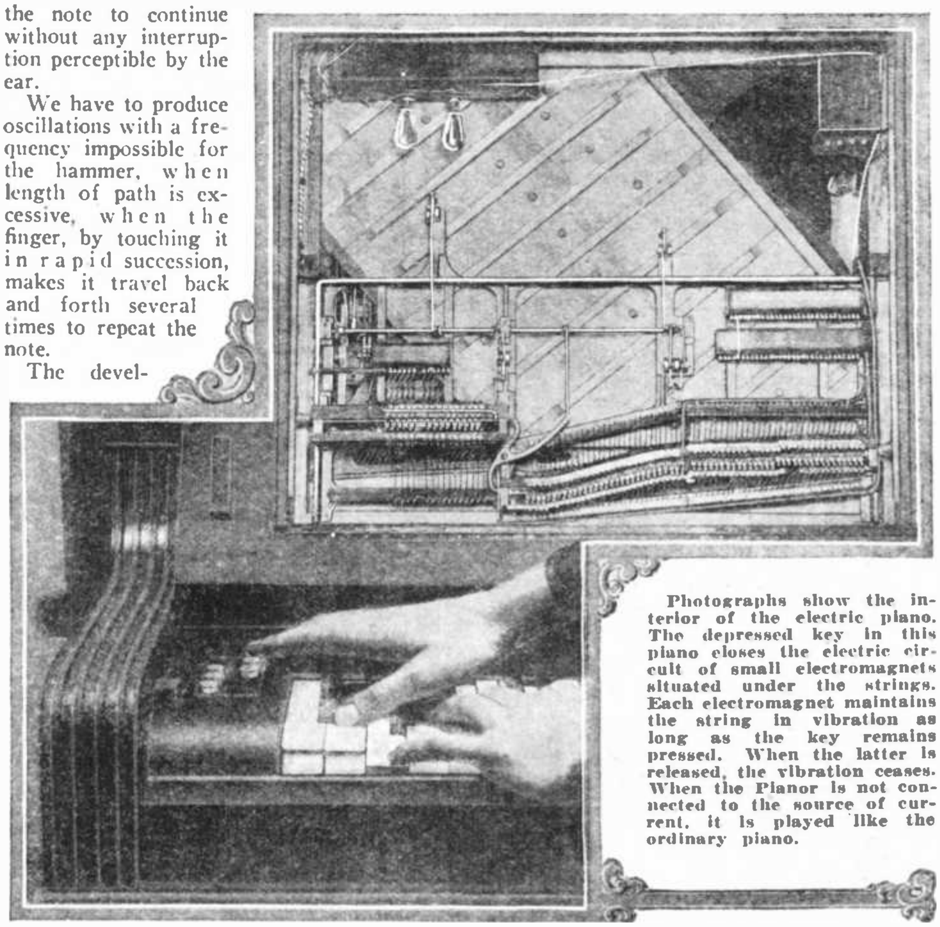


Connections of the new electric piano; the piano string is kept in vibration by a magnet, whose connection is perpetually broken and renewed by the vibrating action of the string itself affecting a tuning fork.

The vibration thus obtained gives a purer sound, because while this sound includes the fundamental vibrations of the cord and of its harmonics, there is an absence of any discordant vibration resulting from friction or percussion.

Having obtained this vibration, by means to be described presently, by one opening and one closing of the circuit, which makes the cord oscillate, we can understand that if we cause these openings and closings of the circuit to succeed each other at extremely short intervals, our cord will receive a series of oscillations, coming and going, colloquially speaking, near enough to each other for the note to continue without any interruption perceptible by the ear.

We have to produce oscillations with a frequency impossible for the hammer, when length of path is excessive, when the finger, by touching it in rapid succession, makes it travel back and forth several times to repeat the note.



Photographs show the interior of the electric piano. The depressed key in this piano closes the electric circuit of small electromagnets situated under the strings. Each electromagnet maintains the string in vibration as long as the key remains pressed. When the latter is released, the vibration ceases. When the Pianor is not connected to the source of current, it is played like the ordinary piano.

The development of an adequate arrangement has presented considerable difficulties which brought many inventors to a stop. After ten years of study two inventors of Rouen, MM Martin and Maitre, have found an ingenious solution, whose simplicity and effectiveness are altogether French.

Very high frequencies such as *si* 6 for example, give 4,170 vibrations per second, requiring 2,085 closings and the same number of openings of the circuit. The mechanism for this is shown in the diagram from which are purposely omitted the motor accessories, of which only two will be mentioned.

On the one hand a special spring maintains automatically the distance between the tuning fork and the metallic brush on the other hand, variable resistance enable the amplitude of the vibrations to be changed so as to give different sets of expression. It is understood, of course, that the circuit is arranged so as to avoid sparking at the make-and-break.

Externally the new instrument, which the inventors have named "Pianor," cannot be distinguished from an ordinary piano. The body may be a little larger in proportion, but the keyboard is the same as all others.

In the interior the strings are arranged as in an ordinary piano, above the row of hammers and dampers. At the back is installed the set of electromagnets, one for each note, each the size of a small spool of sewing silk, and their accessories. For each note there is an individual connection, as is shown in our diagram, and whose two extremities are brought together by the touch of the keys. The whole is connected in parallel like a lamp circuit in connection with the street service.

Here is what takes place when the pianor is played upon. However, the performer attacks it, when the instrument receives the current it is the touch of the performer's finger which closes the circuit and the note is produced electrically, giving a continuous sound, which persists up to the moment he

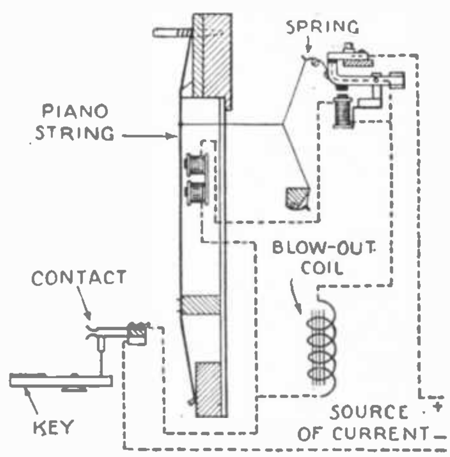


Diagram of the electrical circuit of the Pianor The vibrations of the string control an interrupting relay which makes and breaks the circuit of the vibrator electromagnets.

lifts a finger. Under a strong touch or vigorous attack, as it may be called, the hammer strikes the strings and the vibration by mechanical shock merges into the electromagnetic vibration. On the other hand, the latter vibration is produced alone if the touch is so gentle that although the hammer is displaced it does not touch the string.

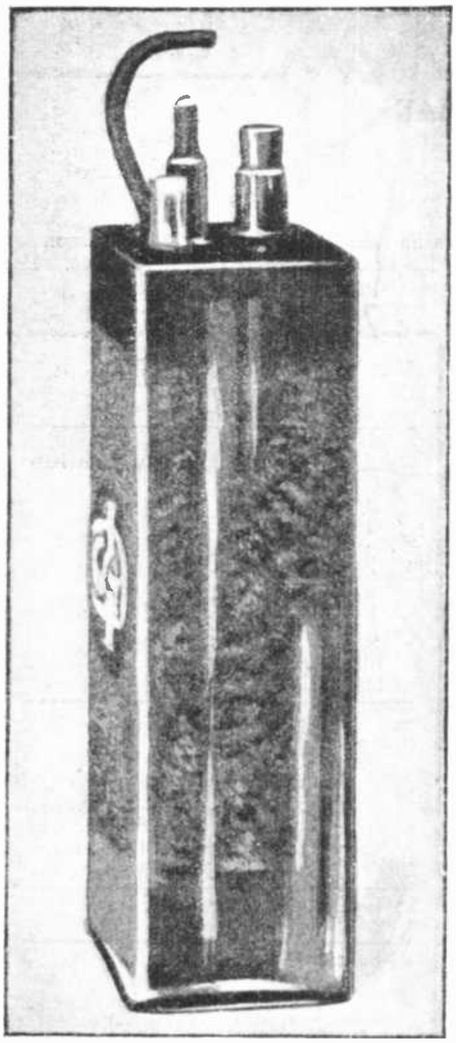
With the Pianor the following executions can be carried out:

1. The regular piano can be played, all that is necessary being to keep the circuit open.

(*Continued on page* 645)

The Fery Storage Battery

By Jacques Boyer



The Fery storage battery, showing one of the forms put upon the market in France. The height of the cell is noticeable, bringing about the desired relation of parts from the point of view of their level and of the action of the oxygen of the air.

WHEN a quantity of electrical energy not to be immediately employed is to be taken care of, it can be stored in a battery of accumulators, a storage battery, which gives it back when required with of course a considerable loss, at the end of several hours, of several days or even after several weeks.

Now, when we study the phenomena of which the electric storage battery is the sea, we find that the marvelous apparatus invented by G. Planté does not operate in the manner of a simple reservoir. During the period of discharge it acts like a primary battery and supplies current produced by chemical reactions between its constituent parts.

In particular, the lead accumulator, the one now used to the greatest extent, contains an electrolyte, dilute sulphuric acid, an electrode of spongy lead and another consisting of a plate of lead covered with lead binoxide, the latter acting as depolarizer.

Hitherto electricians have believed that the heat disengaged in the chemical transformations is converted into electric energy in the external circuit of the system to which the accumulator is connected. In the charge the corresponding phenomena were supposed to be reproduced in the inverse sense. In reality, as the recent work of Mr. Charles Fery proves, the things are not by any means so simple. The theory of double sulphation now generally accepted has to be completely changed.

This skillful physicist, basing his conclusions on absolute experimental results and laying aside all hypotheses, has demonstrated that the reversible action of the lead storage battery is expressed by the following equations:

$$Pb_2 + H_2SO_4 + Pb_2O_3 = Pb_2SO_4 + 2PbO_2 + H_2O$$

It appears then that lead sulphate, $PbSO_4$, is not formed upon the two electrodes, and that this salt in reality is never formed during a normal discharge. This white salt, almost insoluble and an insulator, is produced in an accidental way. If this occurs, it gives rise to sulphation, a great fault of ordinary lead plate storage batteries and the reason for their rapid wearing out.

In brief, the Planté apparatus acts like all batteries of the primary kind; a salt of the metal, which metal is attacked, is formed at the negative pole and the depolarizing power of the positive electrode is thereby gradually reduced. The spontaneous discharge of an accumulator comes from the combined action of the electrolyte and of the oxygen on the negative plate according to the reaction

$$Pb_2 + H_2SO_4 + O = Pb_2SO_4 + H_2O.$$

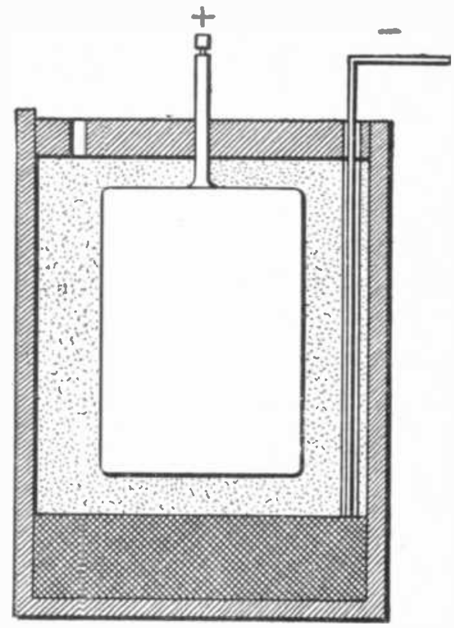
But when a battery which has not been discharged is out of use and idle, the action becomes more extensive and lead sulphate appears according to this formula:

$$Pb_2SO_4 + H_2SO_4 + O = 2\ PbSO_4 + H_2O$$

It appears, therefore, that all that is required to get rid of sulphation is to remove the negative electrode from the action of the oxygen of the air, and also from the active lead oxide, endothermic and very unstable, which coats the positive plate.

Guided by the preceding considerations, M. Fery has invented an accumulator which is really unsulphatable. Utilizing the general dispositions of his ammonium chloride air-depolarized battery, it will be remembered that in this last apparatus the zinc is placed at the bottom of the cell so as to protect it from the oxidizing action of the air, which was the determining cause of the local action.

Referring to the illustration, the upper part of the cell is filled with porous material; near the bottom there is a layer of basic lead sulphate, Pb_2SO_4, and below that lies the reduced lead, the negative electrode, resting on the bottom of the jar. Near the top of the cell is the positive electrode and



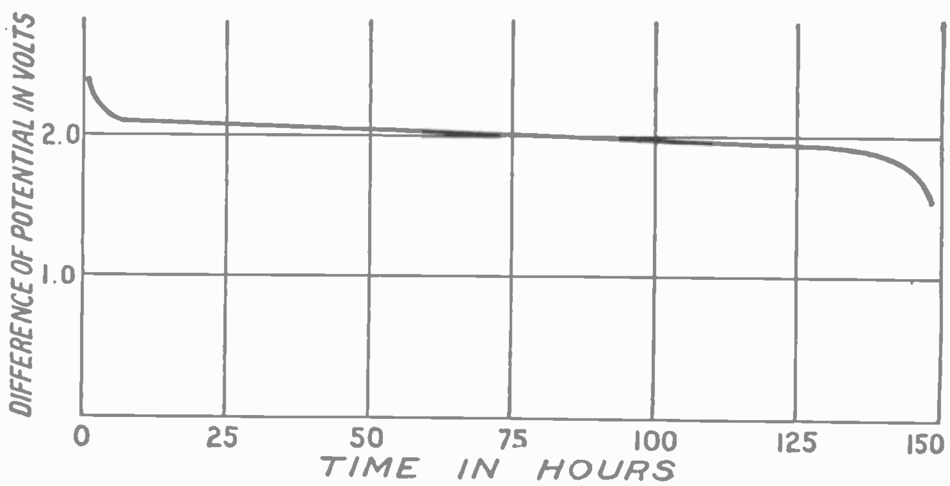
Explanatory section of the Fery battery. The spongy lead constituting the negative element, so called, in the storage battery, is at the bottom of the cell and protected from the oxygen of the air by its location and by being covered with porous material.

the battery is charged with dilute sulphuric acid. The lead wire or rod connecting to the lower electrode is insulated for its entire length.

After lying idle for 26 months, this battery still retained one-third of its original charge, where an ordinary storage battery is supposed to discharge itself in about four months. Its interior resistance is slightly greater than that of the ordinary storage battery, but on examining the diagram it will be seen that the graph of discharge holds a nearly horizontal direction. It is claimed that it is more portable than the ordinary battery, because of the porous material which keeps the electrolyte from splashing about.

The inventor of this battery has attained rather remarkable results with primary batteries, as he has taken cognizance of the action of the oxygen of the air thereon. In this battery his endeavor is to exclude the air from any action, and the chemical equations show his idea and theory.

(*Translated from La Nature*)



The graph of discharge of the Fery battery showing what a remarkably even voltage persists during its range of action; and the rather sudden fall in voltage at the end acts to give a very definitely timed warning.

EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

Circuit Analysis

THERE are so many circuits—good, extra good and nefarious ones—that a beginner is most apt to become bewildered and throw up his hands and exclaim, "I give up." Whether that startled you at the time you entered the radio game—a most entrancing hobby, to be sure—does not mean that you are to be classed with the well-known "dumbells" that infest the radio art and go about acclaiming their superior intellect—and, inferiority complex! Rather, you are to be pitied. For, since the beginning, there has been no fully compiled or completely classified list of all these circuits which are continually the bane of one's existence.

Perhaps there is a very good reason why such a list has not been compiled. Perhaps, it is the very fact that the progress of radio has been so rapid in the past few years, that it would have been an endless and unceasing task to consolidate all of them into a handy classification. However, the information which appears for the first time, in this article, will be found to be of real value to the experimenter and radio man. It will serve as an unerring guide and be instrumental in showing what has been done in the way of improving radio reception and will probably open many new channels which have remained dormant because these channels have been obscured by lack of sufficient realization of existing conditions. Therein lies the real value of this work.

There are but five avenues in which to classify all the existing receiving circuits. Circuits can be, fundamentally, of the non-regenerative, regenerative, radio frequency, super-regenerative or super-heterodyne types. To date, there are no other classes in which circuits may be placed, but undoubtedly, although many leading engineers believe the contrary, it is probable that new classifications will be evolved. The following list should be copied and filed away, so as to be at hand whenever necessary. It is advisable to memorize it, since the information is well worth knowing and having at instant command.

With two fundamental circuits to start with, in the non-regenerative classification and the choice of eleven different types of detectors; five fundamentals and two detectors in the regenerative classification; seven fundamentals with seven separate modifications of but one of them in use with three types of detectors in the radio frequency classification; three fundamentals in use with three types of detectors in the super-regenerative classification and four fundamentals with the use of four different types of detectors in the super-heterodyne classification, it is indeed not surprising that many are at a loss which of so many to choose. Again, one should not lose sight of the fact that audio frequency amplification can be of the transformer, resistance and choke coil coupling types. Also, push-pull transformer coupling, push-pull resistance coupling and power amplification can be used. All this complicates matters more, but by careful analysis it is not only possible to designate the proper classification of the circuit, but with a little practice one can readily resolve it into its simplest fundamental form.

On these pages we will find a fundamental circuit and one of its best practical forms and the experimenter need but follow the given specifications, so that he can build up the receiver.

It is taken for granted that the reader has sufficient knowledge of circuits to know the fundamental principles underlying their operation. If he has not, recourse should be had to some of the excellent books now on the market and obtainable at nominal cost.

With but a slight stretch of the imagination, one can readily perceive the almost infinite number of circuits possible to make; and although the three element tube is by far the most popular form of detector and amplifier, with the crystal detector as a far distant second, still the numerous circuit combinations that are possible could not be consummated and built up by the average experimenter in years.

Reflex circuits alone—there are hundreds of them—find great favor in the eyes of the experimenter. Then again the conductively, inductively and capacitatively coupled antenna systems further increase the number of combinations, until dazed by the complexity we find ourselves in, we shout, "Don't give up the ship" and "Do or die." And it is no vain hope either that we will soon say, "Eureka," success is bound to come. Perseverance pays! Experiment!

1. NON-REGENERATIVE.
   - A. Auto-coupled.
   - B. Loosely-coupled.

   ---
   1. Coherer.
   2. Crystal (with and without battery).
   3. Microphonic.
   4. Electrolytic.
   5. Magnetic.
   6. Colloidal.
   7. Tikker.
   8. Heterodyne.
   9. Two element tube.
   10. Three element tube.
   11. Sodion.

2. REGENERATIVE.
   - A. Auto-coupled.
     1. Inductive feed-back.
     2. Capacitative feed-back.
   - B. Loose-coupled.
     1. Inductive feed-back.
     2. Capacitative feed-back.
   - C. Regenerative reflex.

   ---
   1. Three element tube.
   2. Four element tube.

3. RADIO FREQUENCY.
   - A. UNTUNED.
     1. Resistance coupled.
     2. Impedance coupled.
     3. Transformer coupled.
   - B. TUNED.
     1. Impedance coupled.
     2. Transformer coupled.
        - a. *Loosely coupled.* Positive feed-back.
        - b. *Closely coupled.* Negative feed-back. Losser. Absorption circuit.
        - c. *Neutralized.* Hazeltine. Rice. Farrand.
   - C. REFLEX.
     1. Straight.
     2. Inverse.

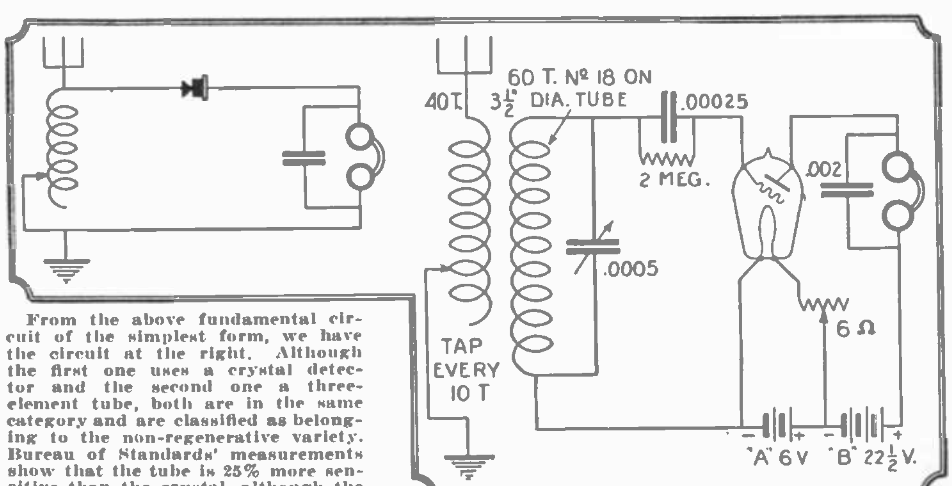
   ---
   1. Two element tube.
   2. Three element tube.
   3. Four element tube.

4. SUPER-REGENERATIVE.
   - A. Straight.
   - B. Flewelling.
   - C. Autoplex.

   ---
   1. Two element tube.
   2. Three element tube.
   3. Four element tube.

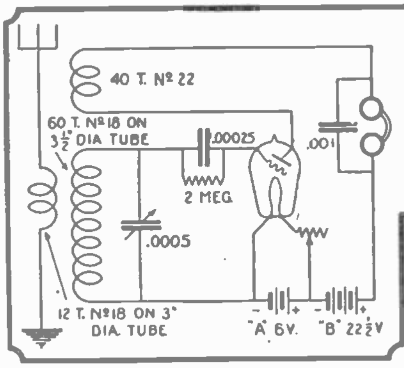
5. SUPER-HETERODYNE.
   - A. Straight.
     1. Tropadyne.
     2. Ultradyne.
   - B. Second Harmonic.

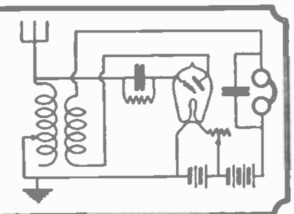
   ---
   1. Electrolytic detector.
   2. Two element tube.
   3. Three element tube.
   4. Four element tube.



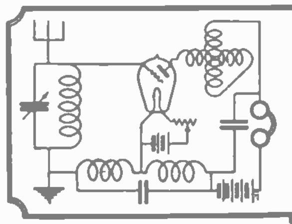
From the above fundamental circuit of the simplest form, we have the circuit at the right. Although the first one uses a crystal detector and the second one a three-element tube, both are in the same category and are classified as belonging to the non-regenerative variety. Bureau of Standards' measurements show that the tube is 25% more sensitive than the crystal, although the latter gives 50% more clarity.

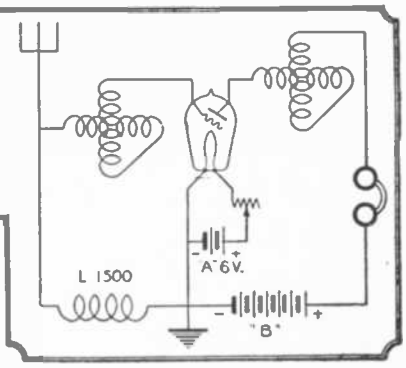
Circuit Analysis



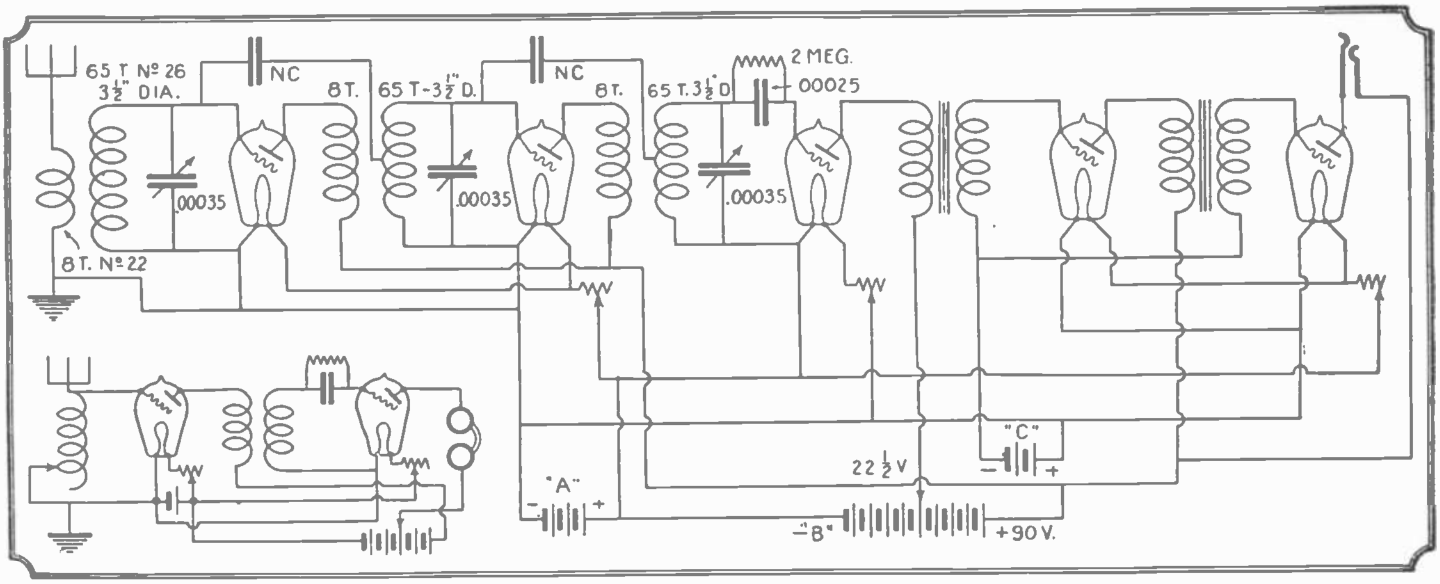


With the discovery of the three-element tube came the regenerative detector. Regeneration increases the volume and sensitivity of a set in a very large degree. There is one drawback, however, that of radiation when the set starts to oscillate due to over-regeneration. The above diagram shows a three-circuit regenerative receiver using tickler feed-back. Regeneration can also be obtained through the use of a tuned plate system, in which case the internal capacity of the tube plays an important rôle and by capacitative feed-back as in the Reinartz circuit. The single circuit regenerative set should be tabooed, as it is a persistent pest on account of its radiating qualities. The diagram gives complete details for the construction of the set which is familiarly known as the old standby three-circuit regenerative.

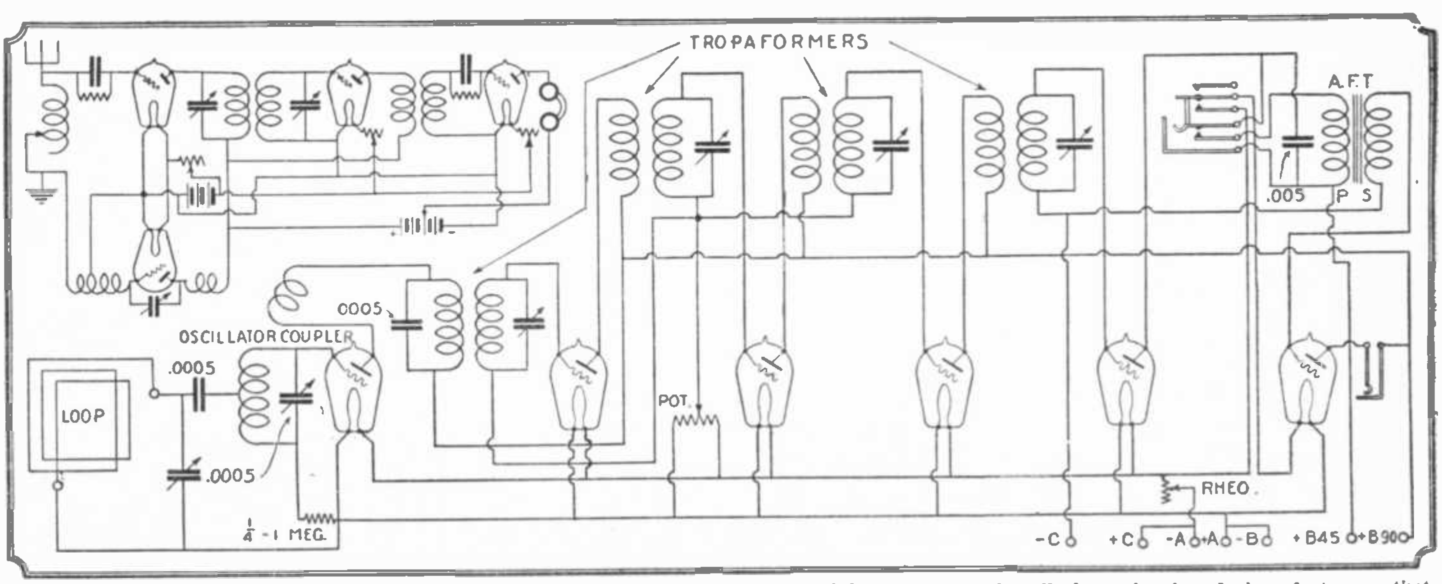




A very interesting development is the super-regenerative receiver. The super-regenerative set works on an entirely different principle from that of its predecessor. The circuit is such as to allow a condition whereby oscillations of both an audio and radio frequency nature are set up. Due to the audio frequency component, the grid assumes a "negative resistance value" and passes an enormous amount of current, thus greatly intensifying an incoming signal. Of course, there is the problem of coping with the audio frequency "squeal," as it is called, but the circuit has been perfected to an extent where it is hardly noticeable. The well-known Autoplex receiver is shown as the adaptation of the fundamental. The circuit, which is simplicity itself, is capable of excellent results. Note absence of capacities.



The field of the radio frequency amplifier circuit is by far the largest and the great number of "dynes," "plexes" and reflexes are the result of various combinations using radio frequency amplification. Note that the fundamental circuit is represented as one stage of tuned R.F., auto-coupled with untuned transformer coupling to a non-regenerative detector. The adaptation can be recognized as the neutrodyne circuit, which has given much satisfaction. In analyzing the neutrodyne, it is at once seen that it belongs to the radio frequency classification and employs tuned transformer coupling, is neutralized by the Hazeltine method and uses, in combination, a non-regenerative detector and two stages of transformer coupled audio frequency amplification.



The super-heterodyne is a circuit which works on an entirely different principle from those described previously. It is safe to say that the super-heterodyne is one of the most selective sets and for this reason is used by many amateurs for short-wave (100 to 200 meters) work. If reference is made to the fundamental circuit, it will be seen that the circuit is comprised of a first detector, a heterodyne oscillator, one stage of intermediate frequency transformation, and a second detector. The success of the super-heterodyne lies in the design of the intermediate transformers which raise the wave-length of the incoming signals and thus allow more accurate tuning. The well-known Tropadyne adaptation is shown here. This circuit does not radiate, and, using a loop, gives very good results.

Progress in Short Wave Receiver Design

By Fred A. Parsons, 2ABM

EVERY day finds new developments in the art of short wave radio reception. New circuits, modifications of old ones, and even older ones in unveiled disguise find a wide field for publication. Many of them are indeed excellent ones, while others are practically worthless for the specific purpose for which they are used. Always eager to try these adulterated circuits, the experimenter often finds that he cannot get them to function properly after having followed with precision the exact details outlined in the article. Generally, the blame is placed on the tube, the batteries, or even the antenna. The circuit alone finds immunity from the free flow of the usual line of profanity accompanying the completion and testing of the "super-super-super . . . !"

This article is intended as a review of the best circuits to use for a given wave-length range. It is also intended to point out what to avoid and the precautions to take.

Modified Reinartz

Circuit 1 will at once be recognized as the familiar Reinartz circuit, slightly modified so that it falls in the same category as does the Hartley oscillator. An untuned or semi-aperiodic antenna system is used. Loose coupling between primary and secondary is also employed and both together afford a very selective arrangement which results in minimum interference.

L_1, the primary, consists of three turns of No. 18 bell wire, wound one inch away from L_2, the secondary which consists of 20 turns of the same size wire. L_3 employs 12 turns wound in the same direction as L_2. Using C_1 and C_2, both of .00025 mfd. capacity, the set responds to a wave-length range of from 70 to 225 meters. The coil L_4 when connected across the inductance L_2 and when having a total of five turns allows the set to be tuned from 30 to 70 meters. With a 10-turn coil, the range is increased from 35 to 110 meters, while with a 15-turn coil, 40 to 150 meters can be reached very nicely. The reason for this is that the combined inductance of two coils in parallal is less than that of the smaller coil alone. Again, it is possible to increase the wave-length range of the set by adding small fixed capacities in parallel with the tuning condenser. Thus, a .00025 mfd. fixed capacity increases the wave-length range of the set so that it covers from 190 to 290 meters when L_4 is used alone. A .0005, .00075 and a .001 allows a wave-length range of from 250 to 380, 370 to 430, and 400 to 600 meters, respectively.

Undoubtedly many may object to the use of coils in parallel and instead of believing that lower direct current resistance results in their use, these people clamor that stray fields, distributed capacity and higher skin resistance would nullify any gain in this respect. However, it need only be stated here that the circuit has more than proved its worth and is being used by many of the leading amateurs in the country.

A word about the operation. Care must be taken so that L_4 is connected with its windings in the same direction as L_2 and that its field be as far away from the latter as possible. The radio frequency choke coil is composed of 250 turns of No. 30 S.C.C. wound on a two-inch diameter mailing tube. It will be found that the circuit is a steady oscillator but in the case that the antenna fundamental approaches the oscillator frequency, it will be necessary to either use the full capacity of C_2 or else loosen the antenna coupling slightly. If this is not done, it will be found that too much absorption takes place and the circuit will not oscillate freely at that frequency. The receiver in reality resolves itself into a purely single control set. The capacity C_2 does not affect the frequency appreciably, if any at all. One stage of audio frequency amplification is sufficient for all practical purposes as the signal strength is very good on the higher frequencies.

Three-Circuit Regenerative

The three-circuit regenerative receiver when properly designed gives wonderful results when used on the short wave-lengths. With the avalanche of data on how to design low loss coils, we should have in mind which type it is best to use. The so-called stagger-wound coil formed on 13 spokes in a radius of 1¾ inches is the heart of this 50 to 250 meter set. The antenna is of the tuned type but very loosely coupled to the secondary. It consists of a single wire, 125 feet long, in series with which is placed a .0005 mfd. variable condenser and the primary winding of 12 turns of No. 18 D.C.C. wire on a 3½-inch diameter tube. See Fig. 2.

The secondary consists of 50 turns of No. 18 D.C.C. tapped at the 20th, 30th and 40th turns. Tuning is accomplished by means of a .000125 mfd. condenser. Instead of switch points, the clip method of tapping is used. and with the clip on the 40th turn tap, a wave-length range of from 120 to 200 meters is obtained. The plate tickler coil is wound on a rotor three inches in diameter and consists of 20 turns of No. 22 D.C.C. wire.

Best results with this circuit can be obtained with the use of UV-199 or C-299 tubes. Hand capacity in this type of receiver will be predominant unless the precaution of using a long extension handle on the tickler coil rotor is taken, and the rotary plates of the condenser connected to the filament side of the circuit.

R.F. and Regeneration

Radio frequency amplification on the short waves has not been found necessary, but its application is interesting. The use of one stage of tuned neutralized radio frequency amplification preceding a regenerative detector and one stage of audio frequency amplification is shown in circuit 3. Neutralization is accomplished, not by direct connection to the grid of the radio frequency amplifier tube, but by means of a small metallic plate in proximity to the secondary coil. The constants for the circuit are as follows: The primary consists of six turns of No. 18 D.C.C. wire, the secondary of 22 turns of the same wire, on 4-inch diameter tube; the plate circuit inductance consists of four turns of No. 22 D.C.C. wire, while the input coil to the grid of the detector tube is composed of 20 turns of No. 18 tapped in the exact center. The tickler coil in the plate circuit of the detector tube has a winding of ten turns of No. 22 D.C.C. wire. Two .00025 mfd. condensers and one three-plate condenser do the tuning. A .00025 mfd. condenser is used across the tickler coil of the detector tube and gives excellent control of regeneration.

Extreme separation of the coils is necessary to prevent inductive feed-back. The tubes will operate best in the circuit when the bases are removed so that they can be suspended vertically. The wave-length range of this receiver is from 70 to 190 meters and one should find it to be unexcelled for selectivity. The proper care in the disposal and layout of the parts together with correct neutralization are absolutely necessary for the highest efficiency to be obtained.

Improved Reinartz

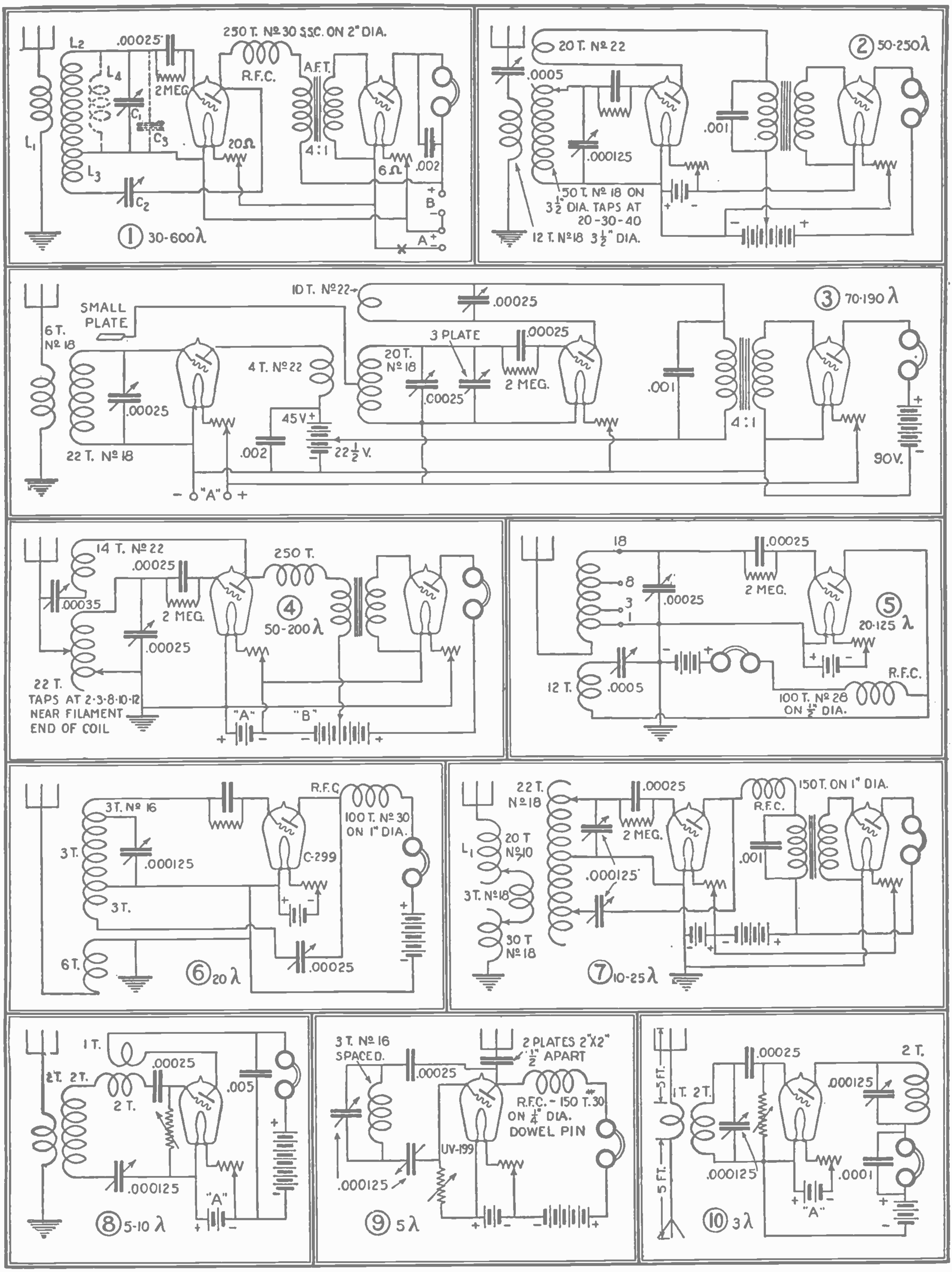
In circuit 4 we have an exceptionally fine receiver covering from 50 to 200 meters. It is of the improved Reinartz or modified Weagent type, and it is particularly adapted for short wave work because of its exceptional qualities as a steady oscillator. The secondary inductance to which the antenna is directly connected by means of clips is a four-inch diameter basket-wound coil containing 22 turns of No. 14 D.C.C. tapped at the second, third, eighth, tenth and twelfth turn. A .00025 mfd. tuning condenser and a .00035 mfd. feed-back condenser are used. The plate coil which is a winding containing 14 turns of No. 22 D.C.C., is variable in coupling to the secondary. One stage of audio frequency amplification completes the receiver. The R.F. choke is one containing 250 turns of No. 28 wire, of practically any insulation except enamel, wound on a one-inch diameter tube.

In the operation of the set which employs clips for varying the inductance of the secondary circuit, it will be found that but two turns in the antenna circuit will give sufficient signal strength and also prevent too much interference or QRM. In tuning, as is common with tickler coil type of regenerative receivers, it will be found that a variation in coupling produces a more or less marked change in wave-length. Hence, this receiver, unless in the hands of an experienced operator, will be difficult to handle. However, the results that may be had with this type of set covering as it does a range of from 1,500 K.C. to 6,000 K.C. will more than repay the builder.

Reinartz Again

The Reinartz circuit is again shown in Fig. 5. The receiver depicted there has a range of from 20 to 125 meters, surely an exceptional one because of its flexibility in this respect. The main inductance which is tuned by a .00025 mfd. condenser is an 18-turn coil of No. 16 D.C.C. also wound in basket-weave fashion and tapped at the first, third, eighth and eighteenth turns. The plate coil is a 12-turn tickler 2¼ inches in diameter and rather loosely coupled to the input circuit. A .0005 mfd. condenser is used in series with it. Again, the base of the tube is removed, and the tube is suspended from its connecting wires and thus results in a non-microphonic detector. The R.F. choke,

(Continued on next page)



All the circuits shown on this page are excellent ones. They represent the types of receivers generally used by the amateurs in their short wave communication work. As each is designed for a particular wave-length band, it is not possible to specify which is best. However, an excellent receiver of the type shown in Fig. 6 is fully described elsewhere in this issue, and covering, as it does, a range of from 20 to 200 meters, the set is bound to find favor with all who construct it. Especially interesting are the circuits of Figs. 3, 8, 9 and 10. Due to the very high frequency which these receivers are able to generate, and due to the difficulties in making them function properly, they can be classed only as experimental circuits. In the course of time, there will be but one real short-wave low-loss receiver, for a given wave-length range.

Progress in Short Wave Receiver Design

(Continued from preceding page)

as is usual with this type of circuit, is not very critical and can be consummated by winding 150 turns of No. 30 D.C.C. on a ½-inch diameter dowel pin.

Reinartz's Own

Many readers of this article will be intensely interested in circuit 6. It is the one used by Reinartz at his station 1XAM. It suffices to say that this type of set, being used by the foremost pioneer in short wave development, is undoubtedly a very excellent one, if not the best to use. The constants for the circuit are given herewith. The primary winding consists of five turns of No. 16 D.C.C. wire in a three-inch diameter and is of the basket-weave type. The secondary is similar in respect to the primary except that it, contains nine turns and is tapped at the third and sixth turns. A .000125 mfd. tuning condenser and a .00025 mfd. feed-back condenser are the two controls, the coupling between secondary and primary remaining fixed. The R.F. choke contains 100 turns of No. 30 D.C.C. wound on a one-inch diameter tube. If desired, although not necessary, the base of the tube can be removed; the UV-199 type will work slightly better than the UV-201A type. This 20-meter receiver has logged many foreign stations and works excellently during the day time. At night, however, 20-meter reception is practically nil and just why this is so has not yet been satisfactorily explained. A short antenna from 30 to 40 feet is all that is necessary for the reception of signals of this high frequency. Even smaller ones will work admirably well.

Hartley-Reinartz

The Hartley type of receiver depicted in Fig. 7 is one covering a wave-length range from 10 to 25 meters. Somewhat different from other types of sets, the antenna system is made up of a single wire 125 feet long, a loading coil of 20 turns of No. 10, a primary coil of three turns of No. 18 and a second loading coil of 30 turns of No. 18. Thus the antenna system is not only tuned but allows the elimination of so-called "dead spots." The loading coils are tapped at every second turn. The grid or secondary coil consists of 22 turns of No. 18 D.C.C. wound on a four-inch diameter form in the so-called pickle-bottle manner. Here again clips are used to change the wave-length range and the tuning condenser is of .00025 mfd. capacity, as is the feed-back condenser. The circuit is a powerful oscillator and with its one stage of audio frequency amplification brings in 20-meter signals very loudly at noon.

Series Tuned Regenerative

In Fig. 8 we have a five- to ten-meter set which has given some splendid results, and its outstanding feature is the single control operating the .000125 mfd. tuning condenser. A variable grid leak and a UV-199 or C-299 with its base removed are requisite in order to get down. Two turns in the primary, two in the secondary, two in the grid pick-up and one turn in the plate coil are the necessary inductances required. It is necessary also to provide a means of coupling the plate coil to the grid coil. Of course, tuning is extremely sharp at this high frequency, but with proper precautions taken it becomes possible to successfully operate the set without much trouble. It may be found necessary by the builder to add one or two turns to the coil specifications given here in order to get the set to oscillate. Especially will it be found true in the case of the tickler coil where from one to three turns are necessary and where a difference of only one-half a turn intervenes between steady and unstable operation.

Ultra Audion and Tuned Plate

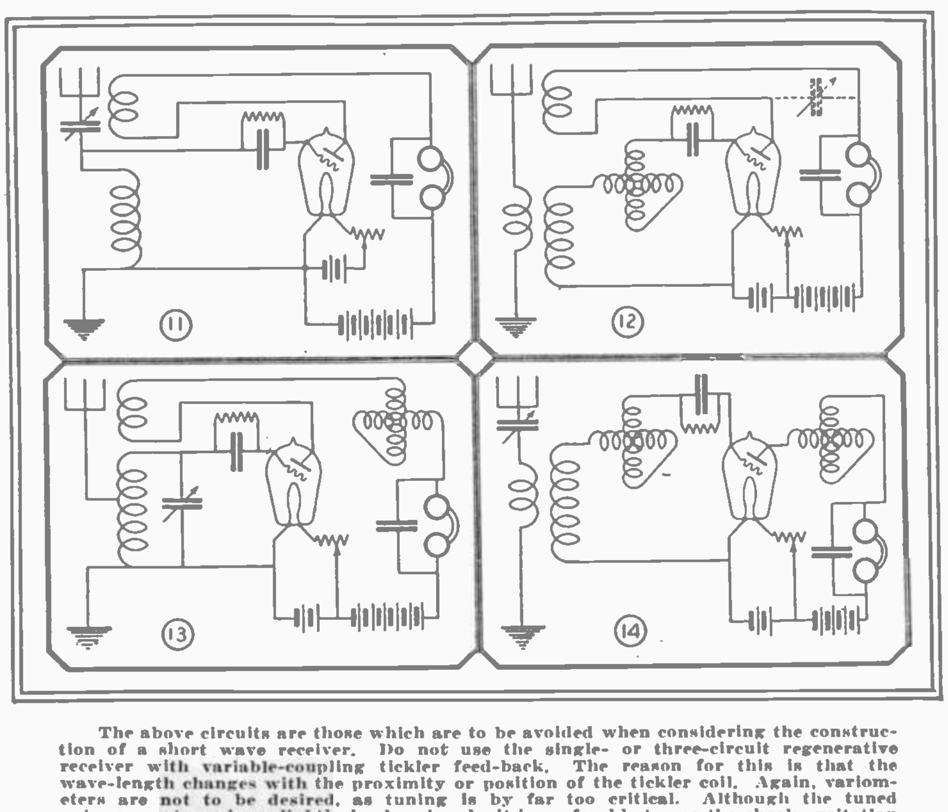
Going still lower in wave-length, we come to the five-meter set of Fig. 9 and the three-meter set of Fig. 10. Fig. 9 is practically a modified ultra-audion circuit and has an antenna 10 feet long coupled capacitatively to the receiver by means of a condenser consisting of two metallic plates about one-half inch apart and two inches square. Although this receiver has three controls, it is an exceptionally good one to experiment with. The radio frequency choke is 150 turns of No. 36 S.C.C. on a quarter-inch dowel pin, while the main inductance is a three-turn self-supporting coil of three-inch diameter. A UV-199 type tube gives best results.

Getting down to three meters is indeed a difficult task and undoubtedly many of those who have attempted it have been discouraged. The circuit shown is of the familiar tuned plate regenerative type and employs an antenna and a counterpoise, each five feet long, connected together by means of the primary winding of one turn. Here again, the smaller type tube finds itself at an advantage over the "A" type tube. With two turns in the grid input and two turns in the plate circuit and a .000125 mfd. condenser to tune both of these circuits, a frequency of 100,000 K.C. can readily be obtained.

What to Avoid

So far, we have considered only those circuits which find favor generally because of their flexibility, ease of operation, and because of the excellent results obtainable with them. It would be well to keep in mind what to avoid in the construction of low loss short wave sets. If reference is had to circuits 11, 12, 13 and 14, one can see those which are not to be recommended. Circuit 11 shows the single circuit regenerative set, which besides being a bad radiator is also a poor set for selectivity. In Fig. 12 we find a receiver which is not only hard to tune, but which has a limited wave-length range, besides having too many controls. Fig. 13 has a conductively coupled antenna system with a tuned plate and tickler feed-back arrangement which, from obvious reasoning, is not desirable at all. In Fig. 14 we have the familiar variometer—regenerative set with tuned inductively coupled antenna system, which circuit does not work well at all below 100 meters. Of course, all the above circuits will work to some extent, but it is not worth while for the experimenter to try to improve them or waste time in trying to get his present set, if it happens to be of a similar type, down to lower wave-lengths by removing turns on the inductances or removing plates from the capacities.

By adhering to the above suggestion, one will not waste time, money and energy in an attempt to construct a real worth-while receiver. All the receivers described have been actually built and thoroughly tested by amateurs throughout the entire country, and this statement alone should be reason enough to those not acquainted with the problems to be met in short wave receiver design to follow the suggestions carefully and incorporate them to better advantage.



The above circuits are those which are to be avoided when considering the construction of a short wave receiver. Do not use the single- or three-circuit regenerative receiver with variable-coupling tickler feed-back. The reason for this is that the wave-length changes with the proximity or position of the tickler coil. Again, variometers are not to be desired, as tuning is by far too critical. Although the tuned antenna system gives slightly louder signals, it is preferable to use the shock excitation type.

Radio WRNY

Preparing for the opening night. Here is the office personnel of Station WRNY—at the left Mr. David Reed, director of programs, is rushing along his work of lining up artists for the opening night. Mr. Gilson Willets, chief engineer and manager, is busy attending to the thousand and one details which come to the attention of the manager of a large broadcast station. Miss Comoro, the station secretary, who is a talented entertainer as well as an efficient stenographer, will be heard by the WRNY radio fans. In order to facilitate ease and dispatch in operation, the station is equipped in an interesting and novel manner with special monitors and signal circuits throughout. An inter-communication buzzer system connects all departments and every member of the staff is familiar with the code.

(*Continued on page* 600)

Installing WRNY's speech input system. Here you see the towering instrument rack on which is mounted half of the complicated speech input system. Mr. E. W. Novy, former operator and announcer at station WSUI, the State University of Iowa, Iowa City, is shown adjusting some of the delicate mechanism. When completed, this system will be one of the best in the country and the most novel in its operation of any station we have today.

Right: The Hotel Roosevelt, 45th Street and Madison Avenue, New York City, and the tall masts supporting WRNY's antenna system. Below: Side view of the main transmitter. Note the big 250-watt tubes directly beneath which may be seen part of the modulating system and tuning units. The highly perfected filter system, which clarifies the high voltage before it reaches the plates of the transmitting tubes, can be seen on the bottom tier.

Front view of the main transmitter panel and to the right the power control panel. One of the engineers is observing the meter readings after the power had been thrown on for the first time.

Working on the speech input equipment. The finishing touches are being put on, the engineers testing out the cables which form a network throughout the entire hotel. Note the heavy sound-proof door which separates the control room from the main studio.

"Circuitgrams" Now Broadcast By WRNY

By Hugo Gernsback

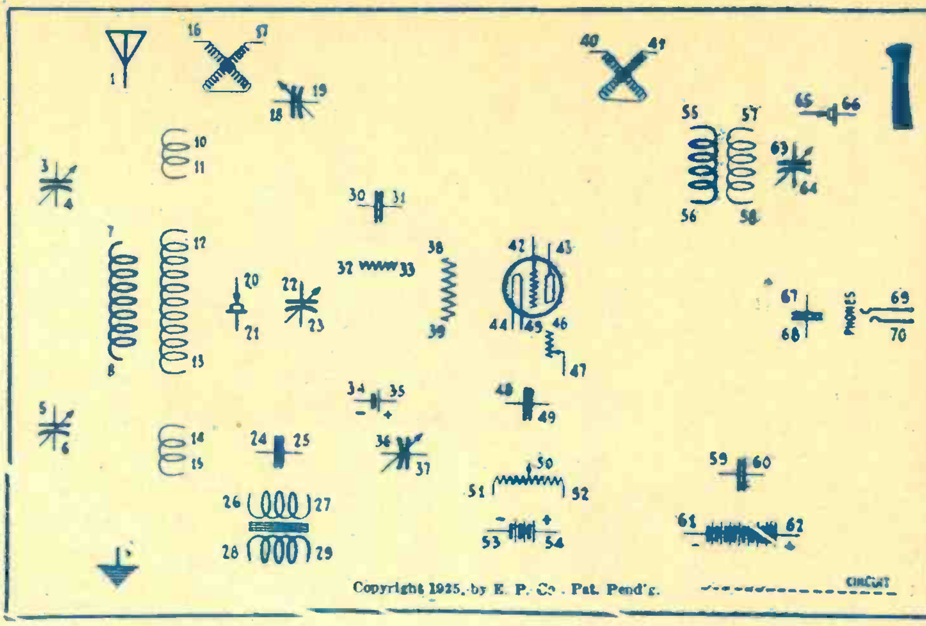
For the first time in radio history complete radio circuits are now actually broadcast by means of a new system outlined here.

THE writer presents herewith somewhat of a novelty, in connection with the broadcast station operated by the owners of this magazine. The new station WRNY, located at the Roosevelt Hotel, New York, and operating on a wavelength of 258.5 meters, will broadcast the new radio circuitgrams once a week, on Mondays at 9 P. M., commencing June 22. This will be a regular weekly feature, which should soon become popular in the radio fraternity.

The writer, who has originated the circuitgram, on which patents are pending, has kept in mind the fact that the radio fans are always on the look-out for the latest radio hook-up. New hook-ups are originated almost every week, and it is the purpose of WRNY to broadcast these the moment they make their appearance.

The method of broadcasting any and all circuitgram hook-ups is extremely simple. The WRNY announcer will first state what sort of hook-up it is, whether it is a regenerative, a reflex, a super-heterodyne circuit, or what not. He will then advise that you use circuitgram blank 1, 2, 3, 4 or 5—whichever is best suited for the occasion.

Suppose the hook-up of a single-tube, tuned radio frequency reflex circuit is to be broadcast. The announcer will then speak as follows:

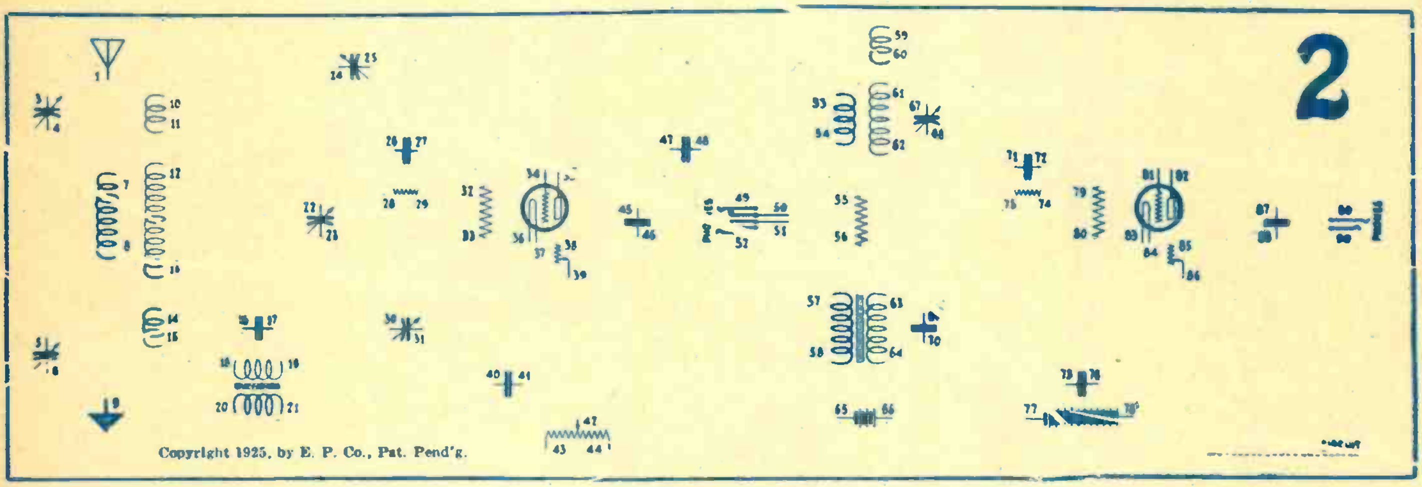


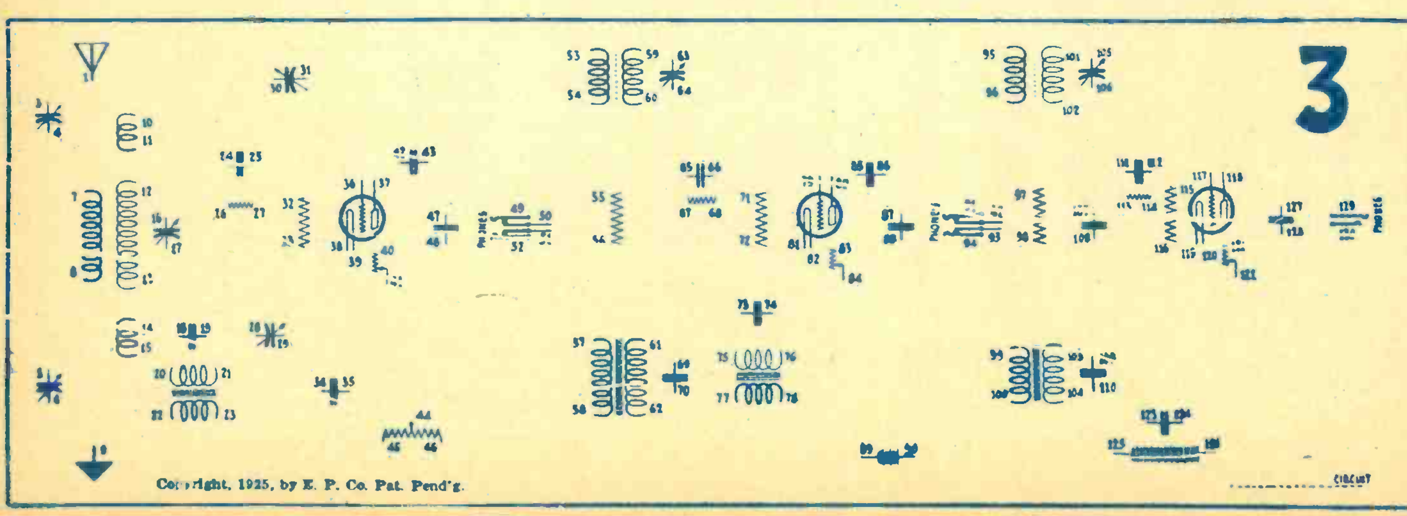
"We shall now broadcast a tuned radio frequency reflex hook-up. Please refer to circuitgram No. 1, single tube."

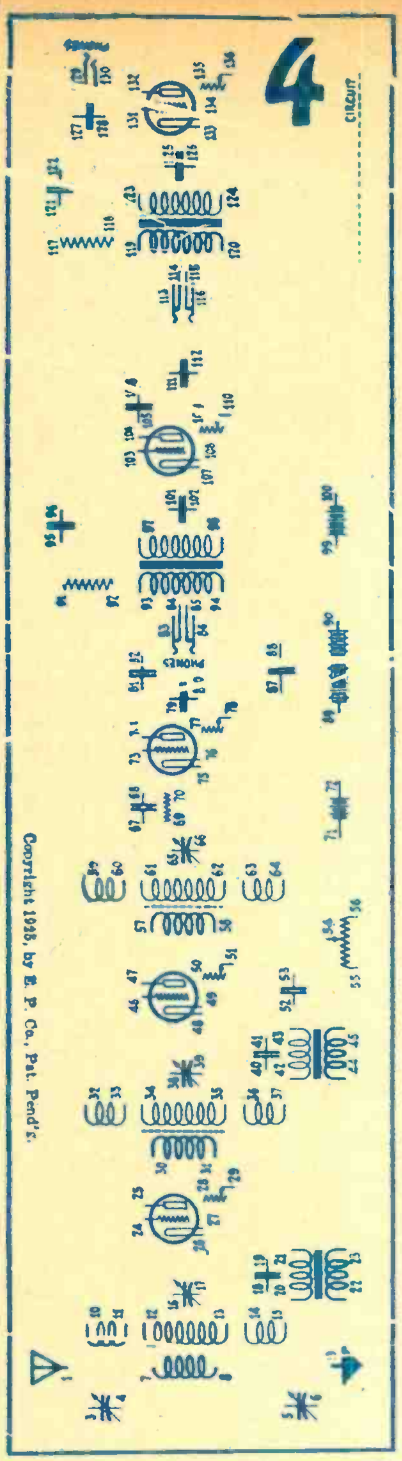
The announcer will then read off the connection numbers as follows: "Connect 1-7, 8-9, 12-42, 13-23, 22-12, 13-28, 9-29, 8-47, 44-54, 45-46, 47-52, 26-64, 27-66, 43-55, 56-69, 57-63, 63-65, 58-64, 70-52, 61-54."

As he slowly reads these numbers, all you have to do is take them down. After reading off all numbers, the announcer will repeat them, so you can go over your record and make sure that you have copied all numbers correctly.

If any special information is needed, as, for instance, in the completed hook-up shown in Fig. 6, the announcer will give such information immediately after the numbers have been read. Thus, for instance, he will give the number of turns and size of wire







of coils 7-8 and 12-13; the ratio of transformer 26-27, 28-29; what crystal to use in 65-66; and all other necessary information.

And that is all there is to it. After the announcer has finished, all you have to do is take your record with the key numbers and fill in the lines on the circuitgram. You will then have a complete hook-up, as shown in Fig. 6. This is simplicity itself, and provides not only a lot of entertainment, but useful instruction as well.

It will be noted that the blank circuitgrams shown on these pages have been laid out in such a manner that it is possible to broadcast any modern hook-up, no matter what circuit is used.

Thus, for instance, it will be seen that the one-tube hook-up circuitgram provides for any possible circuit that could be used, such as detector, regeneration, reflex, radio frequency or for any combination of these employing a single tube.

As will be noted from illustration No. 6 the instruments that are not used in any particular hook-up are simply left unconnected. For this reason, even though the reader does not listen in to WRNY in order to take advantage of new hook-ups that are being broadcast, he can now draw his own hook-ups on the circuitgrams, without the necessity of first drawing the usual radio symbols.

It is interesting to note that it takes only two minutes to broadcast a hook-up of the type shown in Fig. 6.

The publishers of this magazine have prepared a tablet with blank circuitgram forms similar to those illustrated here, containing a goodly quantity of blanks. They will be furnished at 25c per tablet, sent postpaid.

The author would very much like to hear from our readers as to how they like this new feature, and any suggestions and improvements will be very gratefully received.

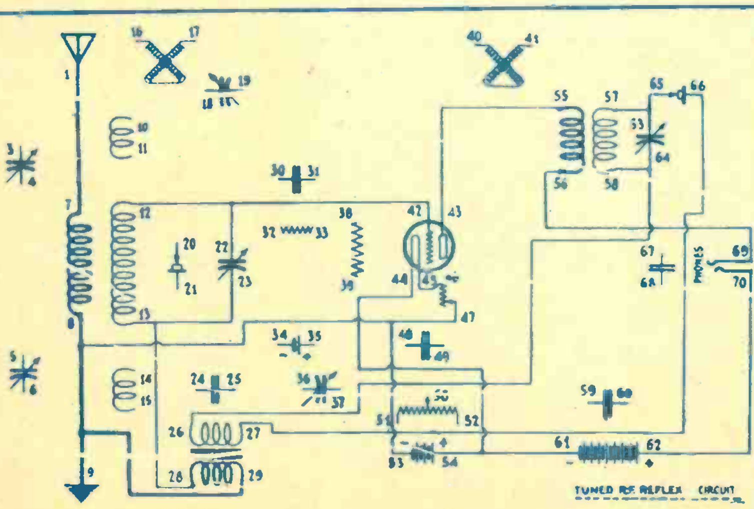
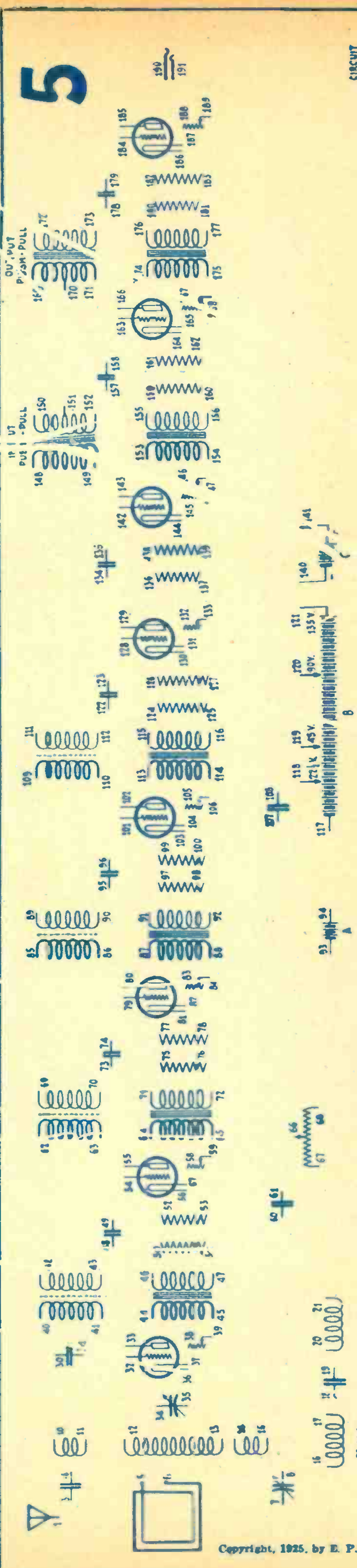


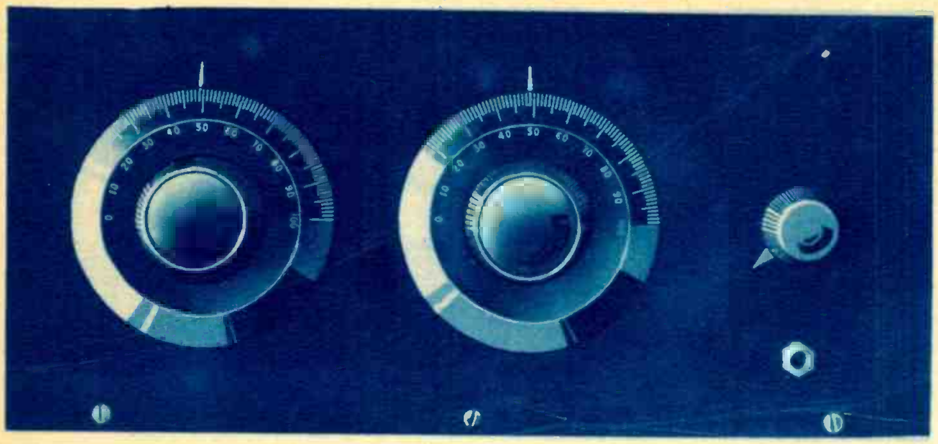
Figure 6. This illustration is a repetition of Illustration 1, except that the wire connections have been drawn on the Circuitgram. When the announcer says, "Connect 22 to 12," it is understood that it is not necessary to run the wire over where the figure 12 is, but simply making connection on the 12 wire is sufficient. The same is the case with 13-28, and other similar ones.



Here is the most complicated of all—the super-heterodyne Circuitgram. Provision is made for 9 tubes, but of course any number of tubes as mentioned by the announcer at WRNY can be used. It will be seen that the intermediate transformers have dotted lines in them. The reason is that sometimes, as for instance in the Tropadyne circuit, iron core transformers are used, whereas in the Ultradyne circuit air core coils would be used. The announcer, when giving the details of the set, will give the information indicating whether the intermediate coils are iron core or air core. It will be noted that both aerial and loop are used, and provision has also been made for push-pull transformers if such should be used in a special circuit. In case it should be necessary to advise the use of resistance-coupled amplification, it will be seen that the new Circuitgram provides for this as well. It is of interest to note that a complicated diagram, as for instance, a 7-tube super-heterodyne can be completely broadcast within ten minutes, giving all the details of the circuit, repeating numbers, etc.

A Remarkable Short Wave Receiver

By Alfred R. Marcy, 2DK



Showing the front panel of the receiver. The dial at the left is the regeneration control, while the one next to it is the tuning dial.

HAVING blazed the way in our search of the possibilities of the shorter wave-lengths for amateur communication, the Reinartz receiver stands today as the very best to be used for the purpose. What with the numerous peculiarities of the short waves, including maximum signal intensity at high noon, when the sun is shining brightly, the fact that it is only long distances which can be reliably bridged (1,000 miles and further) on wave-lengths of 20 meters and lower, and the exceptionally clear and loud signals accompanied by periodic fading—all go to make the subject very entrancing and are sure to inspire every experimenter.

The set to be described is one that has been in use for more than half a year, and has logged numerous stations in every part of the globe. When it is stated that west coast stations are heard regularly, that English, French, Dutch, Italian, South American and even Russian and African short wave stations are heard with relative ease on this receiver, incredulity is excited in many people, but nevertheless such statement is true. Almost every evening reports from WJS, the Rice expedition in the jungles of the Orinoco, could be copied; 6's and 7's, almost never heard in the East on 200 meters, come "pounding in" like locals on 20, 40 and 80 meters!

Employing two tubes, a detector and audio frequency amplifier, the set is readily adaptable for change in wave-length ranges from 20 to 200 meters. Arrangement is made such that it is possible to plug in four different coils for use in receiving. Thus, there is a 20-meter coil, one for 40, another for 80 and the last for 200 meters. In this way, an adequate frequency range is obtained and practical efficiency is kept at its highest.

The set employs a single tuning condenser that has been modified so as to give very fine tuning. Both the stator and the rotor plates have been cut, so that the minimum capacity of the condenser is very low. The feed-back condenser has very little effect on the tuning, and it will need adjustment only when changing from one coil to another, and then a slight change will suffice.

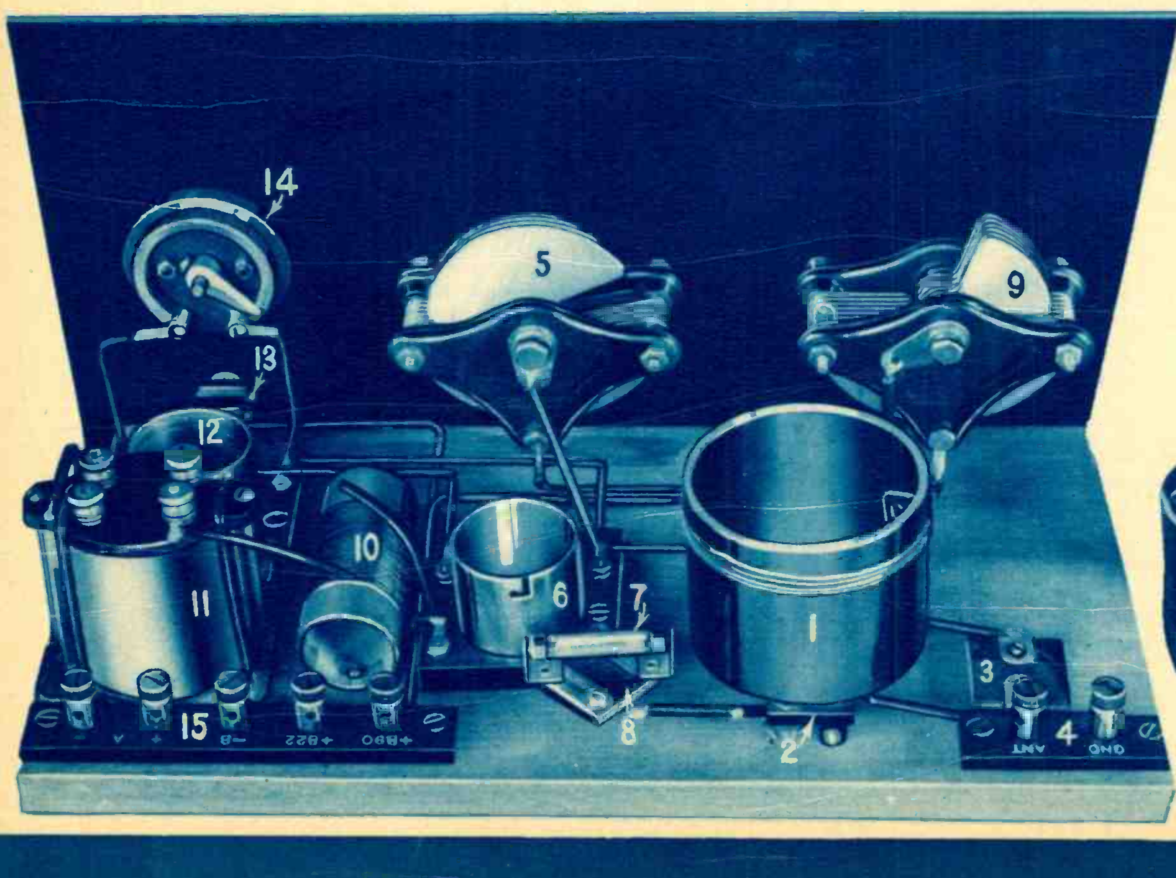
The radio frequency choke is composed of 125 turns of No. 28 D.S.C. wire wound on a cardboard tube one inch in diameter. It is essential that the wiring be as short as is consistent with a neat layout of the parts. A 7" x 14" panel accommodates all the parts very nicely.

As will be seen in the wiring diagram, there is interposed a .00005 mfd. series fixed condenser in the antenna circuit. This is necessary in order to bring down the fundamental of the antenna for short wave reception. For the best all around results, a single wire—No. 14 enamel—about 60 feet long, including lead-in, will do.

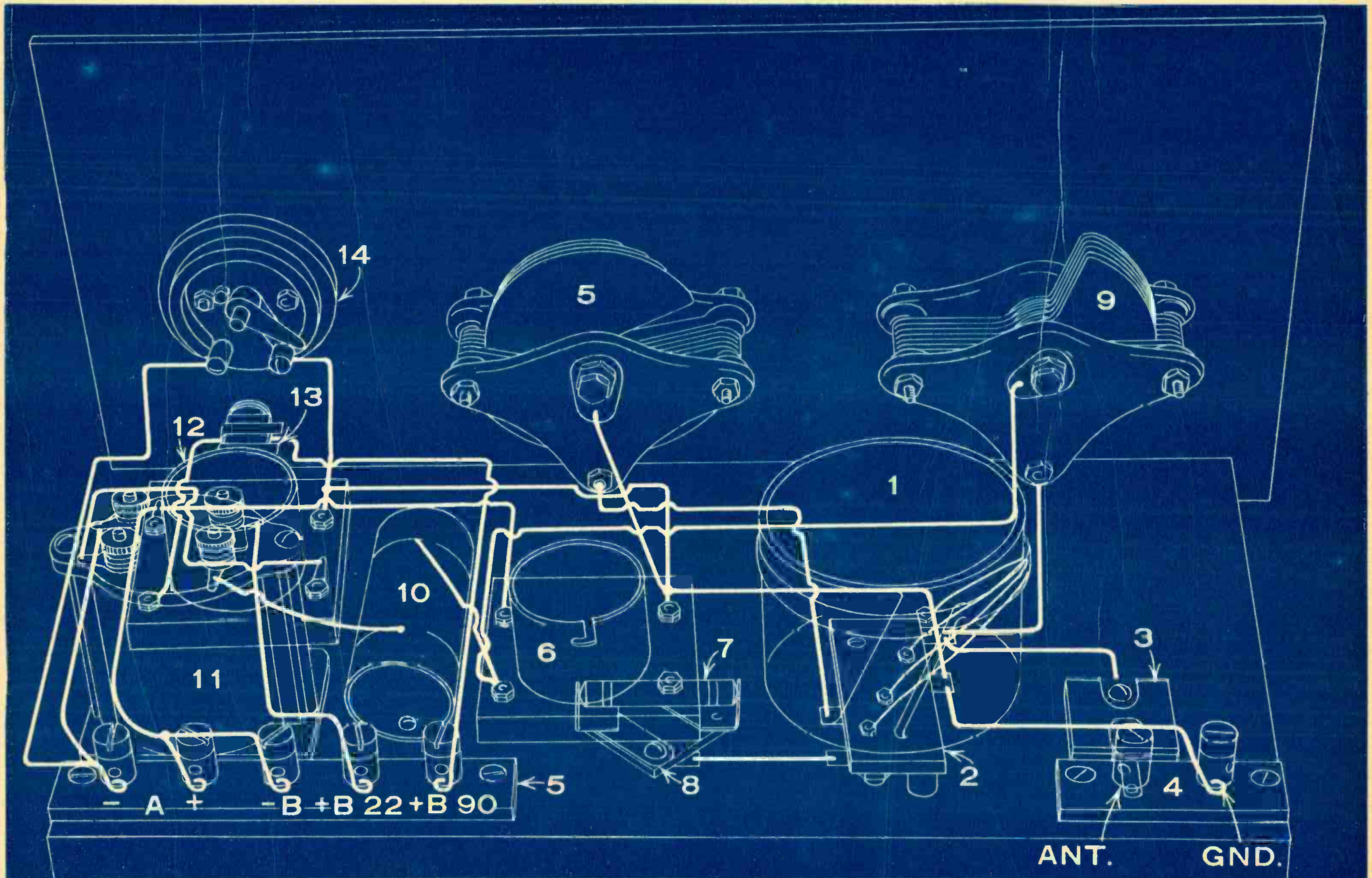
It has been established as a positive fact that the "A" type tubes are just as good as the dry cell type, in this particular kind of circuit. At least, one will not experience any difficulty in getting down to wave-lengths of 20 meters or a little lower. It is not necessary to remove the bases of the tubes, nor is it advisable to dispense with sockets. These latter precautions are requisite only when such high frequencies as 30,000 K.C. and higher are to be generated.

As regards the construction of the various coils used, it will be necessary to procure four forms. Bakelite is good for such forms, as it is non-hygroscopic, is strong and suitable in every way. If at all possible, space-wound coils can be used, but it is worth while to bend one's efforts to procuring the material as outlined in this article. For the 20-meter coil, wind five turns of No. 16

(*Continued on page* 606)



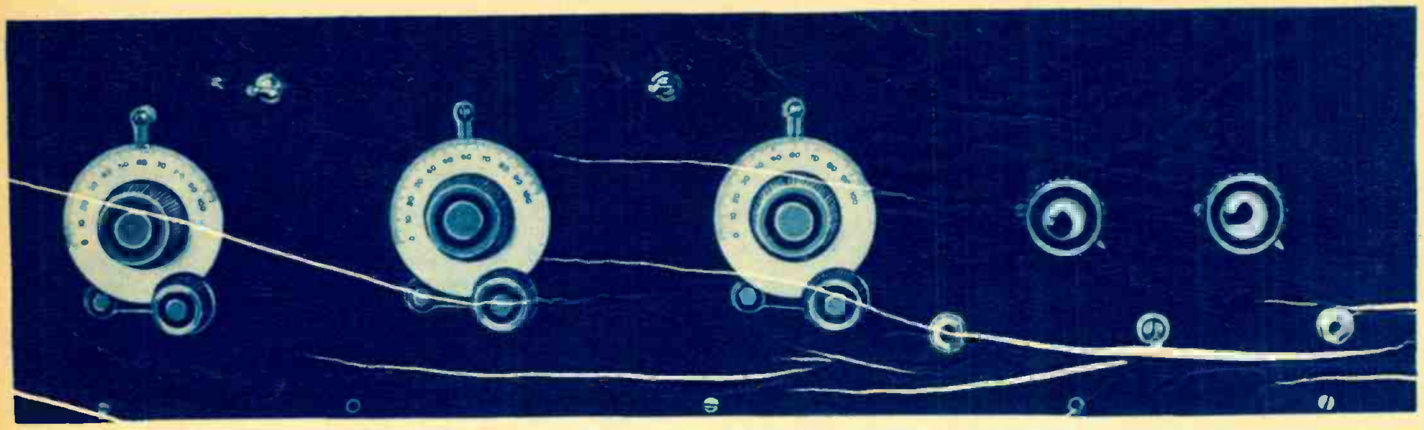
The arrangement of the apparatus is clearly defined by the above photo. 1 is the coil; 2, coil mount; 3, antenna condenser; 4, terminal strip; 5, tuning condenser; 6, detector tube socket; 7, grid leak; 8, grid condenser; 9, feedback condenser; 10, radio frequency choke; 11, audio frequency transformer; 12, amplifier socket; 13, fone jack; 14, filament rheostat. Note extra coil alongside for different wave-length range.



Showing a clearly defined view of all the parts and apparatus used in the short wave receiver. The numbers correspond with those on the photograph and one should find no trouble in wiring the set correctly. Note how the plates of the tuning condenser are cut successively. This method allows extremely fine variations in frequency change, most necessary for proper operation in order to receive the high frequencies.

An Exceptional Broadcast Set

By Joseph H. Kraus



Panel view of the ideal broadcast receiver. Note vernier control dials.

"WHAT type of receiver do you own Bill, and you, Jack?" Indeed, quite an ordinary question, which one hears occasionally. And when the answer from Bill shows that he owns a five-tube tuned radio frequency receiver, while Jack owns a three-tube three-circuit regenerative set, we may be inclined to believe that the five-tube set gives its owner much superior results. Evidently, to some, it will appear that due to the fact that Bill's set has five tubes, it is undoubtedly better than Jack's. Yet, Jack claims all and even more for his set than does Bill!

Thus is the man who is about to construct his first successful set rather at sea, and the contradictory advices that he receives from his friends only add to his perplexity.

The really excellent set pictured on these pages is one that will, undoubtedly, "bring home the bacon." Combining radio frequency amplification and regeneration, the receiver also has one step of transformer coupled audio and one stage of push-pull. Distance, clarity and volume are its outstanding points of excellence. What more could one desire?

A feature of this set is that it has a small wave-length change switch allowing a range of from 180 meters to 400 and from 350 to 600 meters. The set is thus made very selective and little, if any, interference is experienced.

The data for the construction of the various parts are as follows: The primary winding of the radio frequency transformer consists of six turns of No. 14 bare copper wire which is supported by means of thin bakelite strips. The secondary is wound

The following is an exact list of the parts used in the construction of the set:

- 2 Bruno .0005 variable condensers.
- 1 Genwin RFT.
- 1 Genwin coupler.
- 2 Caldwell sockets.
- 3 Federal sockets.
- 1 Federal transformer.
- 2 Como push-pull transformers.
- 3 Cutler-Hammer toggle switches.
- 1 Federal 30-ohm rheostat.
- 1 Federal 20-ohm rheostat.
- 1 Bradleyleak.
- 2 Dubilier .001 fixed condensers.
- 1 Dubilier .00025 fixed condenser.
- 2 Rasco jacks (one 2-circuit and one filament control).
- 7 Rasco binding posts.
- 1 Rasco binding post strip
- 3 General Radio 3" vernier dials.

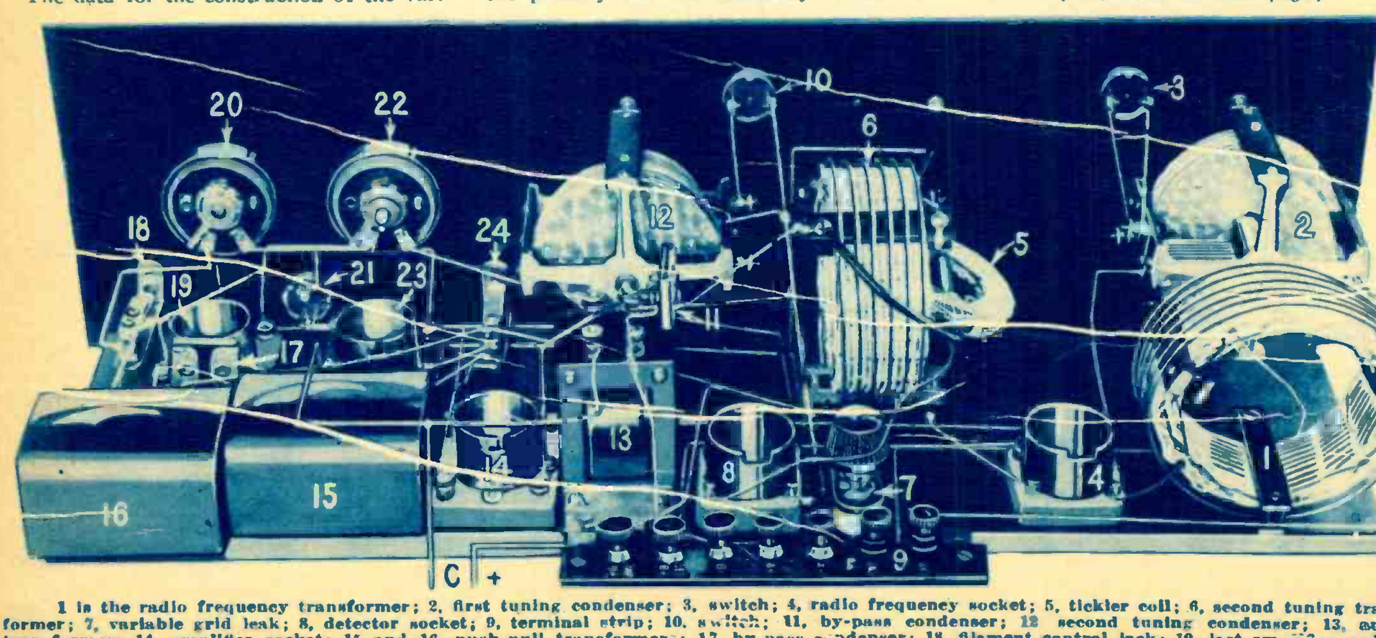
in stagger fashion and contains 45 turns of No. 16 D.C.C. in a 3½-inch diameter circle. A double section .0005 mfd. condenser is used for tuning. The next coils, the primary and the secondary of the detector input circuit are of the same dimensions as those of the first transformer. The tickler coil contains 50 turns of No. 24 D.C.C.

The panel is 7" x 24" and is fastened to a baseboard upon which all the apparatus not on the panel proper is mounted. Note carefully the disposition of the various parts. It is essential that the same relative layout be used, otherwise trouble may be had on account of inductive or capacitative feed-back which cause squealing.

Vernier dials are used, there being three of them, two for tuning and a third for regeneration control. Other refinements include the variable grid leak for the detector tube, and the fact that either the type 201A or 216A tubes can be employed for the push-pull amplifier. The 216A tubes are to be used wherever possible. The amplification constant of these tubes is so much greater than that of the others that it becomes an easy task to bring in distant stations with the volume of locals.

Again, because broadcast stations are reducing their wave-length, this receiver will find many adherents. A double circuit jack is provided after the one stage of audio and sufficient volume with which to receive the local stations can be had. All connections are brought out to binding posts arranged on a rack. Although the amplifier uses a "C" battery, it is not shown in the photo and blueprint diagram because it would com-

(Continued on next page)



1 is the radio frequency transformer; 2, first tuning condenser; 3, switch; 4, radio frequency socket; 5, tickler coil; 6, second tuning transformer; 7, variable grid leak; 8, detector socket; 9, terminal strip; 10, switch; 11, by-pass condenser; 12 second tuning condenser; 13, audio transformer; 14, amplifier socket; 15 and 16, push-pull transformers; 17, by-pass condenser; 18, filament control jack; 19, last amplifier socket; 20, amplifier tube rheostat; 21, filament switch; 22, detector tube rheostat; 23, input socket of push-pull amplifier, and 24, double circuit jack.

An Exceptional Broadcast Set

(Continued)

plicate matters by concealing some of the connections. The "C" battery is placed on top of the output push-pull transformer.

In wiring the set it is best to wire the filament circuit first. Note that the last jack is of the filament control type. This is so because it would be needless waste of battery current, if one wanted to listen-in on the one-step of amplification alone to keep the push-pull amplifier tubes burning. Only two rheostats are necessary, one for controlling the amplifier tubes, both audio and radio, and the other for controlling the detector tube.

A few words about the operation and the results obtained with this receiver will stimulate more interest in those who are undecided concerning the type of receiver they should like to build. At 7 or 8 o'clock in the evening, when as many as ten powerful local stations, broadcasting on wavelengths from the lowest to the highest assigned, the set has proved its superior qualities by bringing in stations over 2,000 miles away with loud speaker volume. Then as evening draws on Cuba, the West Coast and Canadian stations come rolling in with remarkable ease and steadiness. And the quality of the music is such that one does not turn away in disgust. Pure tonal reproduction is at once apparent and this point is stressed because quality should come first when considering the building or purchasing of a radio receiver.

Again, with the general tendency of the broadcast stations to begin the use of the lower wave-lengths in transmission—the only feasible outlet for them—the simple switching arrangement which allows the receiver to go down to as low as 180 meters—will find many advocates to the idea and enhance their appreciation of the set. If for instance, a station is transmitting on 375 meters and trouble is experienced from interference when using one setting of the wave-length change switch, the simple expedient of changing the position of the switch and re-tuning to 375 meters will in most cases clear up the trouble. In other words, we have a super-selective receiver which is entirely different from the usual set. With other types of receivers, trouble is generally experienced when approaching wave-lengths of 300 meters and lower. This greatly handicaps the set and in many cases eliminates the possibility of receiving stations within this band. And again, the crowding of the stations that occurs at the lower end of the dial spoils the chances for reception of many of them. With the use of the features incorporated for wave length change, we completely overcome this difficulty.

From the above, therefore, it can be seen that the set is ideal from every standpoint.

An antenna about 100 feet long of a single copper wire, clear of all surroundings, will do very nicely. The coupling of the antenna primary coil is fixed and is of the semi-tight variety, which allows a good degree of freedom from interference.

For selectivity and for volume and quality the set ranks among the very best. Enough can be inferred from the statement made concerning the use of the push-pull amplifier. As a conclusion, it is well to bear in mind that the idea of using a double section condenser to allow both high and low wave reception is without doubt a real step forward towards the time when many of the broadcast stations will be down on the shorter waves.

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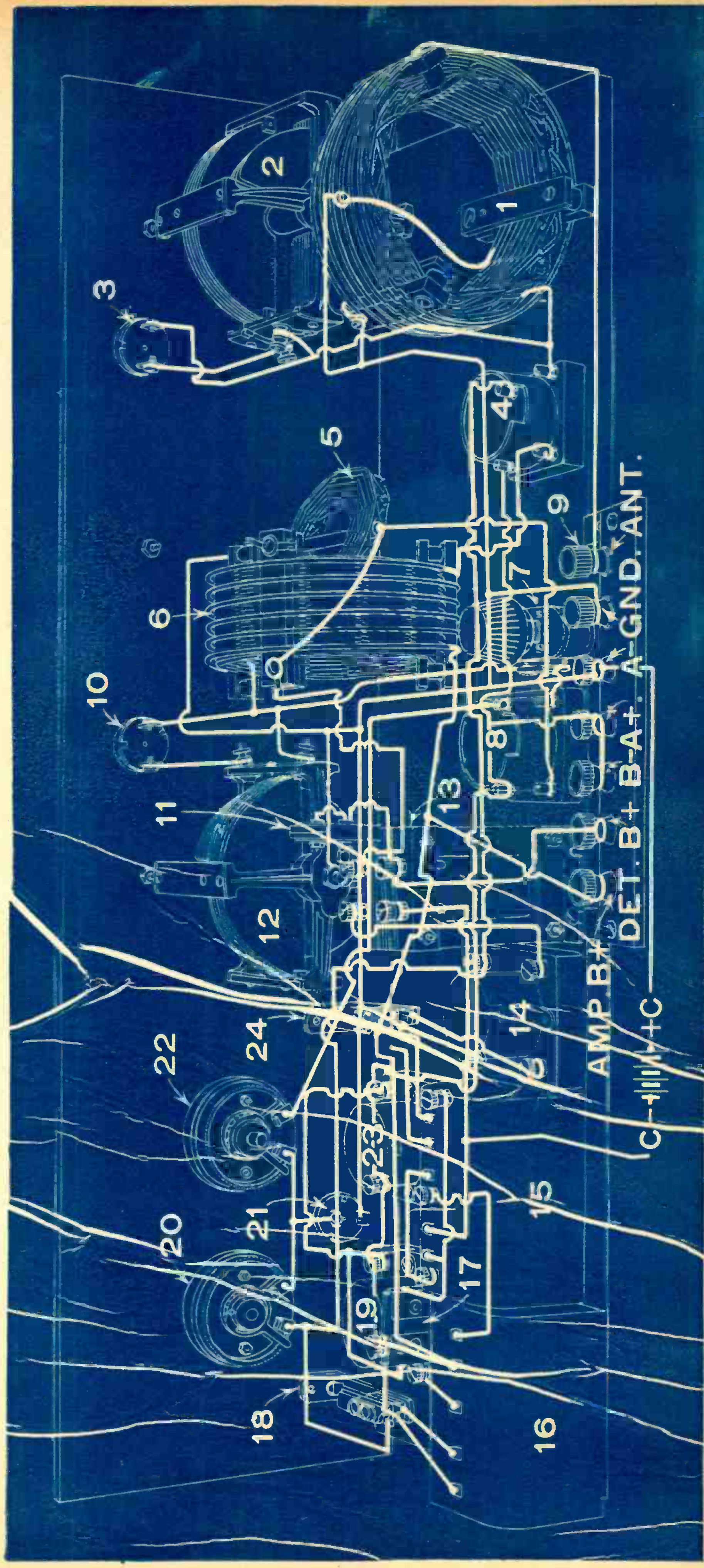
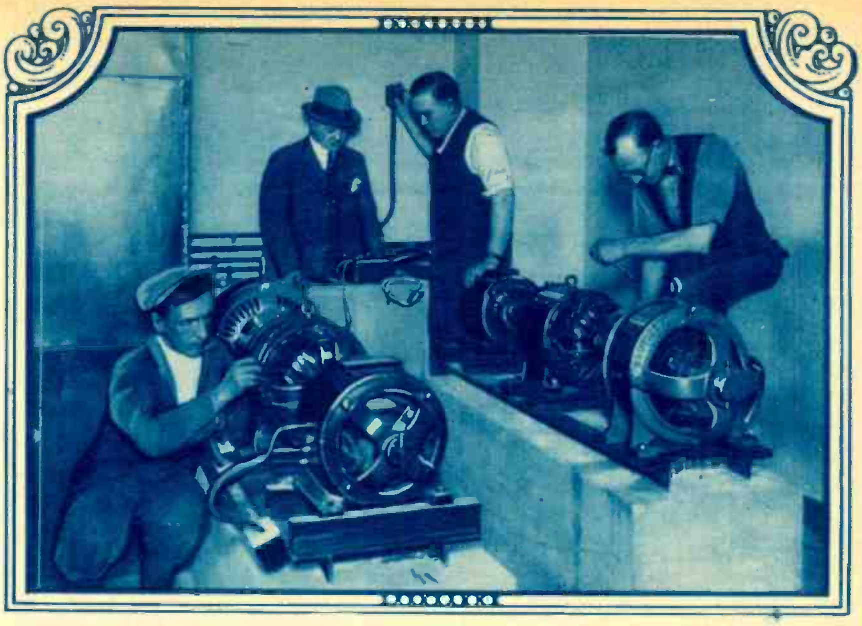


Radio WRNY

(*Continued from page* 593)

The power plant in duplicate. Mounted on solid concrete foundations, these powerful machines are placed in a special fireproof room and are remotely controlled from the operating room. Chief operator Novy is about to throw on the current which will supply 1800 volts for the plate circuit and 15 volts for the filament circuit, actuating the main transmitter two floors below.



Front view of the speech input panel. Note the multiplicity of meters, tubes, coils, pilot light, switches, jacks, plugs and relays. Surely a complicated system, but it is only one part in the endless detail of an efficient up-to-date broadcast station.

Chief engineer Willets is trying to calculate how long it will be before he will be able to discard the huge 250-watt transmitting tube and use in its stead the tiny five-watt tube shown alongside.

WRNY Radio News New York

THE Experimenter Publishing Company is erecting what is to be the last word in radio novelty. Radiophone WRNY, under construction in the Hotel Roosevelt, 45th street and Madison avenue, will embody many novel features, which will not be made public until the occasion of the formal opening of the station some time in June.

Mr. Hugo Gernsback, Editor of THE EXPERIMENTER, has devised a method for broadcasting radio hook-ups which is so simple that the multitudes of radio listeners will be supplied with the very latest ideas in radio construction within a short time after their conception. In the broadcasting of Station WRNY, many special devices are utilized which will enable listeners to hear a continuous program from the instant the station goes on the air until the actual moment of signing off. This means that there will be no delays of any kind whatever, that there will constantly be something broadcast at every moment, of a character sufficient to hold the listeners' interest, even though the announcer and the artist may not be before the microphone.

The station is equipped throughout, with the exception of the main transmitter board, with duplicate apparatus and every possible device to insure the continuity of mechanical and electrical operation.

In the program department, the same thought is brought into play and by means of several unique devices, the station will always be giving the public something new and interesting.

WRNY will be distinctly a superb station, using Western Electric equipment throughout, but installed by the *Experimenter Publishing Company's* own engineers in a manner which will enable them to bring features into their broadcasting which under ordinary conditions in the average installation could not be accomplished without considerable loss of efficiency.

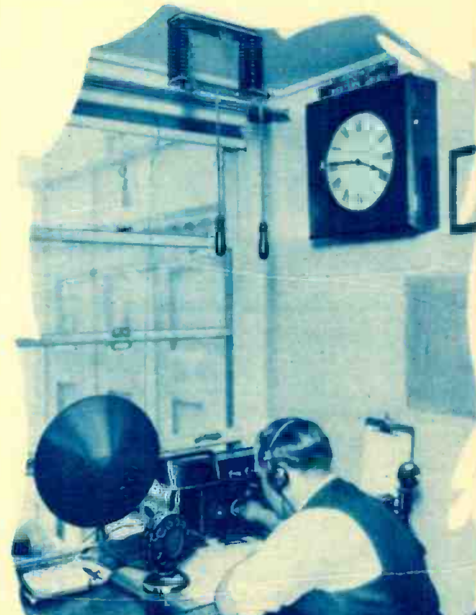
In addition to the main equipment of Station WRNY is connected to the public address system of the Hotel Roosevelt, and from that source will be able to broadcast at any time concerts, recitals, banquets, and all other entertainments at public or private gatherings, which take place within the hotel.

A unique feature of the station is the monitoring system which enables every department of the station and many points scattered throughout the hotel to hear the programs being broadcast direct from the point of transmission. Each monitor is equipped with a volume control, although as a unit they work from a common amplifier. The advantage is obvious.

The powerful generators which supply the filament and space current for the large transmitting tubes are each located in a special power room and are remotely controlled from the main operating room. This complete power plant is installed in duplicate, and with a single throw of a huge 12-pole double-throw switch, the control man can throw his set to receive power from either plant.

The station is equipped with special automatic relays, which terminate in a signal system and a cleverly devised switching connection which is carried about concealed in the hands of the announcer. He can, in the middle of an announcement, cut himself off the air to clear his throat or to interrogate an artist without the listening public being aware of the fact that this is taking place.

Special filtering systems will insure clear and perfect transmission, and the installation of the latest type of Western Electric harmonic suppressor will eliminate the annoyance of tuning WRNY on other waves than its normal wave.

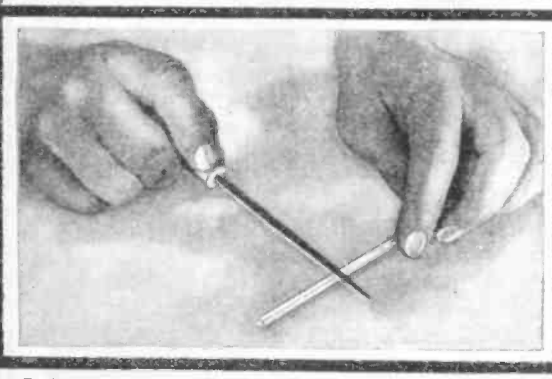


The operator on watch is continually alert for distress calls. Here is shown the commercial "op" and above him the handles of the huge lightning switch, which effectively shuts off the station.

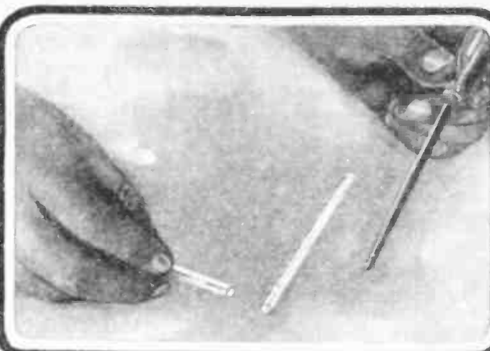
Autobiography of a Home-Made Grid Leak

By HERBERT ERWIN

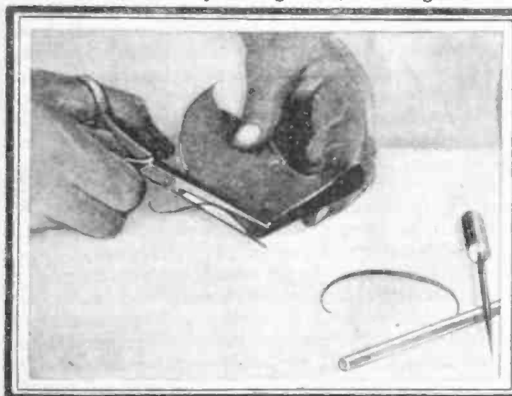
The grid leak plays an important part in the functioning of the radio receiver. It can be readily constructed at home, and the experience is well worth while the time.



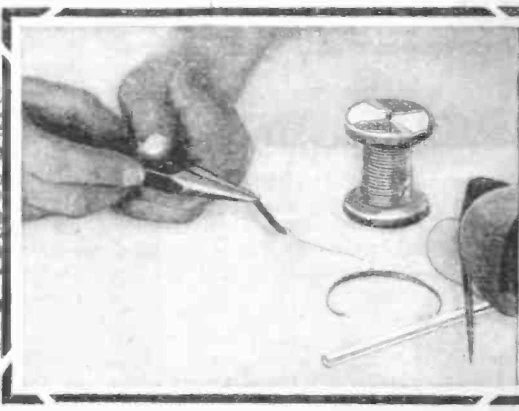
I, known as a short length of glass tubing, will play an important part in the life of the grid leak. My purpose is to give protection, rigidity and strength to its vital organ. I am a good insulator. I do not absorb moisture, am transparent, and without boasting about it will serve to better advantage in my position than any other material possibly can. You can get me by calling for 3/16-inch glass tubing.



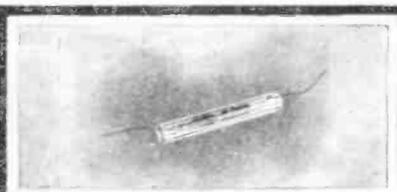
A sharp triangular file is really the best agent which can cut me up into desired lengths. All one must do is to file a small incision, grasp me firmly in both hands, and apply a slight pressure by means of both thumbs, directly opposite the file cut. Round ends in Bunsen burner flame.



My name is ordinary carbon paper. I proudly boast that I am to play the most important part in the operation of the grid leak. See how easy it is to cut me into long, thin strips.



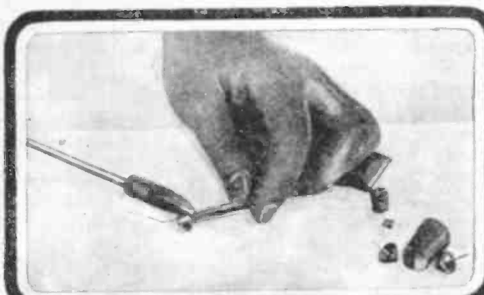
Two short lengths of clean copper wire aid me in establishing positive connections. One must take care not to injure me when winding the wire tightly about my ends. A pair of long-nosed pliers are very handy in accomplishing the desired result. No. 28 bare copper wire is best to use.



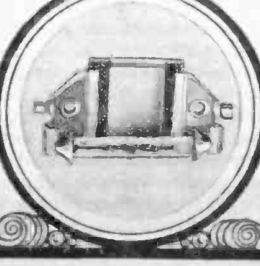
Notice how nicely I am protected from the elements and from prying fingers by the glass tubing. You must allow the wire to stick out of the ends of the tubing. This will allow for the connections to be made. Rather inconspicuous now, but watch me grow!

How delighted I am to be able to serve in the construction of the grid leak. I am but an humble piece of cork. My lot is to keep the carbon paper from sliding through the ends of the glass tubing and also to permit fastening the conical-shaped brass tacks which act as the contact members.

I lay claim to being the best looking part of the grid leak. I am known as a conical head brass thumb tack. Almost any hardware store keeps me in stock. Just ask for two bright, shiny articles like myself. Push me solidly into the cork.



I get hot under the collar when the soldering iron comes so close, but I guess it is for the best, since a soldered connection cannot be beaten. Be careful not to apply the iron directly to the glass tubing otherwise it will crack. Use a small amount of soldering flux.



Here I am all completed. See how nicely I am installed in my home. My position is indeed an elevated one, and I perform my duties without any attention whatsoever. When the grid condenser becomes charged to a maximum value and then discharges, I can feel the surge of current, but remain unaffected until the grid current must of necessity discharge through me back to the filament battery. I am proudly known as a two-megohm leak.

Two-Tube Radio Frequency Circuits

By Frank Frimerman, 2FZ

DIAGRAM I shows a two-tube circuit utilizing one stage of tuned radio frequency amplification, impedance coupling to the detector tube and regeneration in the latter. This circuit gives excellent results when properly made and adjusted. The primary of the input radio frequency transformer can be wound with No. 18 D.C.C. and consists of 10 turns on a 3½-inch diameter tube. The secondary winding should preferably be of No. 26 D.C.C. and contains 60 turns of wire. The coupling transformer consists of a primary winding containing 50 turns of No. 28 D.C.C. on a 3½-inch diameter tube, while the tickler coil is one containing 40 turns of the same size wire on a 3-inch diameter rotor.

The variable condensers are both of .00035 mfd. capacity. A .00025 mfd. grid condenser and a two-megohm leak are requisite for the proper functioning of the detector tube. A six-ohm rheostat readily controls the filament current for both tubes.

The tuning of this receiver is slightly difficult in that three controls are necessary. The first step after turning on the filaments of the tubes is to tune the first variable condenser to resonance with the desired frequency. The plate tuning condenser is then adjusted in order to obtain maximum signal strength. It will be found necessary to adjust the coupling between the feed-back coil of the detector tube and the tuned impedance transformer in the plate circuit of the first tube. The circuit may cause squealing to some extent, but radiation is effectively blocked by the first radio frequency tube. Audio frequency amplification can readily be added.

Circuit 2 is a modification of circuit 1. It is of the non-regenerative variety and consists of one stage of tuned radio frequency amplification and tuned transformer coupled detector. Ordinary neutroformers find ready application for use in this circuit.

The average neutroformer, which term by the way applies only to a tuned radio frequency transformer of special design, has a primary winding consisting of six turns of No. 26 D.C.C. and a secondary winding of 65 turns of the same size wire. The primary is wound on a tube 3⅛ inches in diameter while the secondary is wound on a tube of 3¼ inches diameter. The relation between primary and secondary windings is such that the primary winding is at one end of the secondary coil, the low potential side or that side which connects to the filament circuit.

If the attempt is made to use more than six turns in the primary of the coupling transformer, the set will generally become regenerative and may burst into oscillations quite freely. The neutroformer angle, 54.7 degrees, is not necessary when building this circuit but possible trouble can be avoided if the coils are mounted in this manner.

The variometer has long been known as an exceptionally fine tuning device. Its qualities are such that it surpasses the condenser for efficiency. Circuit 3 shows the use of two variometers in a circuit comprising one stage of tuned radio frequency amplification and impedance coupled non-regenerative detector. As a foreword, the circuit is very critical of adjustment. The input transformer to the first radio frequency tube has a 40-turn secondary instead of the usual one of 60 turns. The circuit does not give as much volume as circuit 1, but it reproduces very clearly, providing the condition for self-oscillation is avoided. It may be necessary to alter the plate voltage to 45 volts or lower, but generally 90 volts on the plate of the radio frequency amplifier tube is approximately the correct value.

Circuit 4 shows an experimental circuit which is extremely difficult to handle and which has many difficulties in getting it to work properly. As will be noted there are three controls. Analyzing the circuit we see that it is of the conductively coupled type, the antenna being directly connected to the grid inductance; that tuned transformer coupling is employed and that regeneration from the detector tube is introduced to the grid of the first tube by means of a feed-back arrangement. This latter consists of an ordinary variocoupler having a 40-turn secondary and 35-turn tickler coil. The coupling transformer can be made by mounting a 12-turn coil in close relation to the stator of the variocoupler. This circuit will be found difficult to handle unless loose coupling is employed at the beginning and only an experienced operator will find joy in working it.

In Fig. 5 we see an arrangement whereby a unit known as one stage of radio frequency amplification can be added to a receiving set comprising a detector and one or more stages of audio frequency amplification. The owner of the well-known three-circuit regenerative set will welcome the use of this device because it will materially increase his range of reception and act as a blocking tube to prevent annoying radiation. The materials necessary are an ordinary neutroformer, a standard socket, one 6-ohm rheostat, 8 binding posts, a small panel and cabinet. Fig. 5 shows that the grid circuit of the detector tube is untuned. It should be shunted with a .00035 or .0005 mfd. condenser. Care should be taken so that the fields of the coupling coils do not interact and do not cause excessive feed-back. Both the antenna and ground connections to the primary coil of the detector input circuit should be disconnected, and if the primary and secondary happen to be connected so that the filament is at ground potential, this connecting wire should be taken out. The above precaution is necessary so that the "B" battery current, which will flow through the primary winding, will not burn out the filaments of the tubes through short circuiting.

In Fig. 6 we find perhaps the best possible arrangement for using one stage of tuned radio frequency amplification and regenerative detector coupled by means of a tuned transformer. Here again neutroformers will find a special use to good advantage. A plate variometer in the detector circuit is commendable from the standpoint of ease in control of regeneration. A neutroformer angle of 54.7 degrees should be used for best results. This circuit is bound to give extremely good reception, and has proved its merits time and again. If so desired, although not necessary, a small neutralizing condenser can be employed. This can be connected from the grid of the first tube to a tap placed 15 turns from the filament side connection on the secondary of the coupling transformer.

In summarizing, tuned radio frequency amplification, even if applied through the use of but one tube, will greatly enhance the distance receptive qualities of any non-radio frequency amplifying set. This, of course, brings to the fore the old three-circuit regenerative receiver of which we have previously spoken.

It is obvious from the above that the addition of more stages of radio frequency amplification leads to a condition where excessive feed-back is bound to take place. When this occurs, violent oscillations ensue which are hard to control. It is thus necessary to disregard what is known as low loss parts and discriminately employ the necessary high resistance wire, small diameter coils, widely separated coupling transformers, long leads and other absorption circuits. And all this for the reason that the radio frequency transformer has not been developed to a stage where maximum efficiency can be obtained. There is much more to be done in the development of the radio art and the experimenter is urged to bend his efforts to help solve the many problems before us.

Radio frequency amplification can be of several different types. There is the straight radio frequency amplifier using as the input circuit a conductively or inductively coupled antenna system. The input unit can be of the tuned or untuned variety. To this arrangement can be coupled additional stages of either resistance, impedance or transformer coupling. The latter two types may be of the untuned or preferably of the tuned variety.

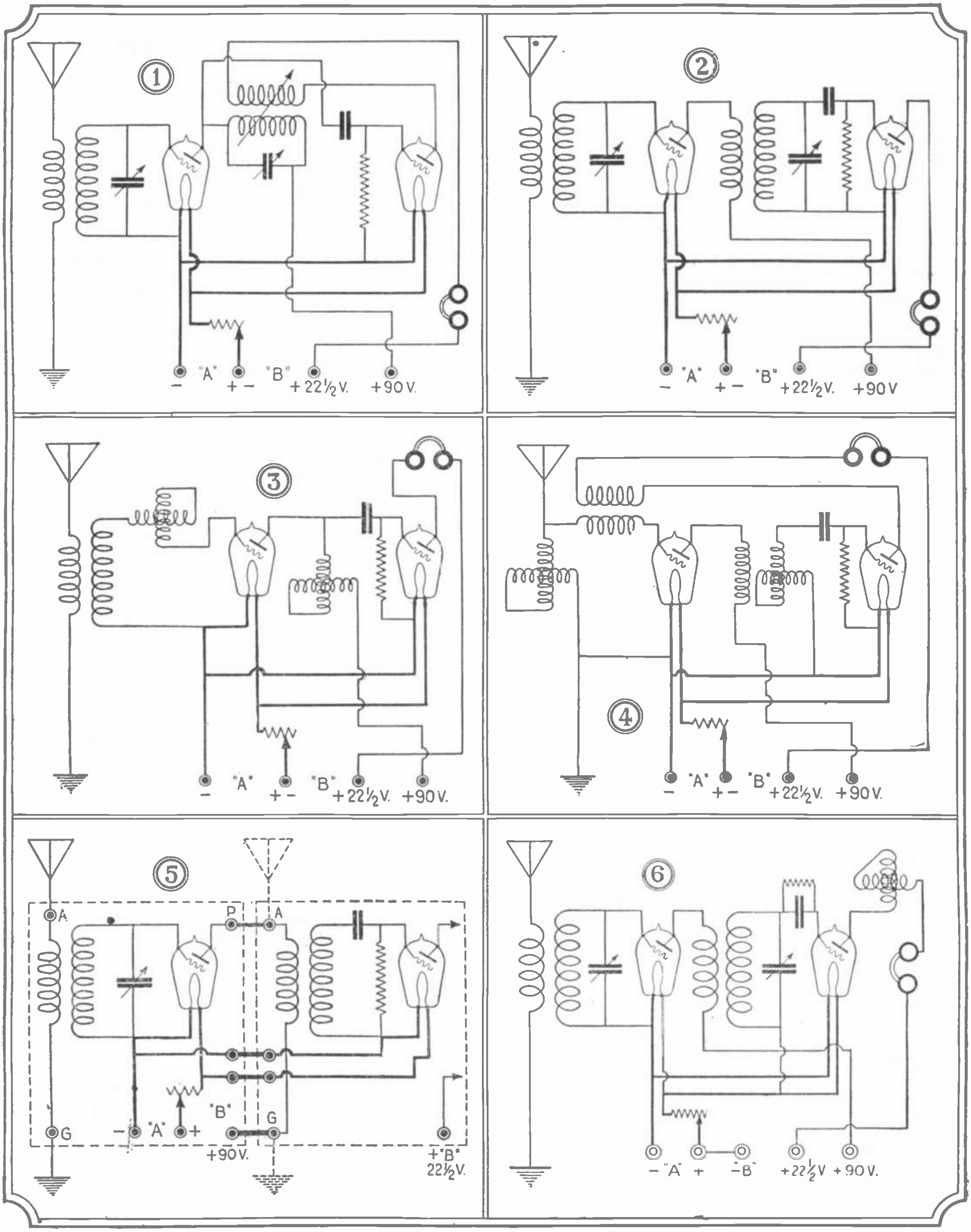
More than three stages of R.F. amplification has been found to result in unwanted and undesirable complications. Excessive feed-back due to interstage coupling, both of the inductive and capacitative types causes too much squealing. Self-oscillation is difficult to control and reception of signals becomes a tiresome task that involves expert manipulation, so that the oscillation can be avoided. Two stages, therefore, are all that have been incorporated into the majority of present-day receivers. Especially is this the case with the neutralized receivers. There are several types of these latter. Among them are the monophase, neutrodyne, neutralized receiver of Rice, that of Farrand, the superdyne, the tertiary bucking coil, the potentiometer or losser and other adaptations.

Regeneration, either that due to inherent feed-back within the receiver or else that which is applied by the use of a tuned plate in the detector circuit, a tickler feed-back coil or other means, is without doubt the most important factor to consider when summarizing the causes which contribute towards the successful operation of any radio frequency amplifying receiver. Not due to the amplification constant of the tubes, nor due to the ratio of voltage step-up in transformation from successive stages of amplification, the volume possible to obtain from this type of set lies, mainly—and in a very large measure—in the amount of regeneration present. Bearing this in mind, the author has spent some time bending his efforts in a direction whereby the use of a two-tube receiver would bring as much in results as a four- or five-tube set could do.

The problem resolved itself into the perfecting of a circuit which would use one stage of radio frequency amplification in conjunction with a regenerative detector. (See Circuit 6.) Knowing full well the amount of trouble to expect when trying to consummate such a condition, the radio frequency amplifier tube was first used with a non-regenerative detector. The results were poor in comparison to those when regeneration was applied. Not only were signals very much weaker, but the range of the set was far below that possible with the use of regeneration.

Thus is strongly brought out the fact that the very first principle which was uncovered after the invention of the three element tube still finds and plays the most important function in our receivers. The only decisive attempt to improve regenerative tendencies in a set was the introduction of the super-regenerative circuit. But this being an entirely different principle, leaves the field wide open for more experimental work to be done along this line.

Two Tube Radio Frequency Circuits



In circuit I is given a diagram which can be classified as being of the loosely coupled variety, having a tuned radio frequency amplifier, tuned impedance coupling and tickler feed-back. The circuit of Fig. 2 shows tuned transformer coupling and non-regenerative detector. In Fig. 3 we see a different form of tuning arrangement, a variometer impedance coupling and non-regenerative detector. Fig. 4 shows a modification of circuit 3. Here, tuned transformer coupling and regeneration is successfully employed. Fig. 5 is a diagram of one stage of radio frequency amplification to be added to a detector tube. The circuit of Fig. 6 employs tuned transformer coupling and a regenerative detector.

Getting On the Air

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

The Fifth of a Series of Articles Outlining the Design and Construction of the Power Supply Apparatus for an Amateur Transmitting Station.

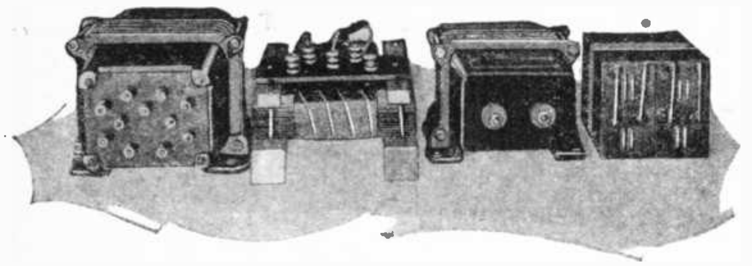


Fig. 4. The layout of the power apparatus with the exception of the rectifier.

DURING the last few months while you have been listening in on amateur traffic, you have noticed that there are hundreds of different types of notes audible. Some of them are on the order of high-pitched whistles which easily pierce through interference and static and are usually plainly audible. Others are rough, coarse notes which oftentimes blend with a crash of static to such an extent that one or more characters are lost to the receiving operator. It is the high-pitched note or whistle that is to be most desired in a transmitter and is the one which should be worked for. If a good power supply is used and is carefully filtered, no trouble at all should be experienced in obtaining such results. A power supply such as used by the writer is described below and in using it other operators have often inquired as to whether or not pure D.C. was being used. Pure D.C. gives that much-to-be-desired high-pitched whistle and can usually only be obtained from a motor-generator. If, however, a rectifier is carefully constructed and used in connection with a good filter, the results will be all that can be desired.

In this article we will assume that the reader has A.C. at his command, which is usually the case, and furthermore that he cannot invest the necessary large amount for the purchase of a motor generator. Therefore, stepped-up and stepped-down A.C. must be used for the plate and filament voltages respectively. The plate voltage must be passed through a rectifier and the least expensive of all forms is that known as the electrolytic type. This humble device has been so mistreated by various amateur operators that it has lost caste and is often spoken of in a slighting tone. If, however, the directions are carefully followed, a rectifier will result which will give months of steady service without the least bit of trouble.

The jars or containers used by the writer are ordinary jelly glasses, 24 being required for rectifying the output of a 1100-volt transformer with a center tap. The next requisite is a quantity of pure aluminum and lead plate. Sufficient material should be obtained to make 24 strips 1 inch wide by 3 inches long of each metal, one lead and one aluminum strip for each jar. Too much stress cannot be laid upon the fact that pure aluminum must be used. If foreign matter or impurities are present, the rectifying action will not be correct and poor results will be obtained.

After the metal has been cut to size and a hole drilled in the end of each, the next step in the construction is the cleaning of these electrodes. Here again the average constructor falls down. The actual cleaning work will take several hours and therefore it is often slighted. However, this time will be well spent, for when the rectifier has once been put together, it will need no further or only slight attention. After bending the strips to the required shape, polish both surfaces of each one of the 48 strips vigorously with fine sandpaper. Then prepare a hot solution of strong lye and water in an earthenware crock, and then you must dip the electrodes in it one at a time, allowing them to remain for about five seconds. For this step, hang the elements on a wire hook. Remove and without touching with the fingers, wash the metals thoroughly in running warm water. Be careful during the entire process that you do not get any of the lye solution on the hands as it will inflict a painful burn. Now taking care not to touch the three-inch faces of the metals with the fingers, bolt the 24 couples together, one lead and one aluminum strip comprising each couple. Use brass machine screws and nuts, and after assembly dip the joints in hot paraffin, so that corrosion will be avoided. Put one couple in each jar, arranging the jars in a suitable framework such as illustrated in Fig. 1.

The solution for a high voltage rectifier may be any one of the many recommended, but the one usually found most satisfactory is a saturated solution of borax in water. Heat sufficient water to fill all of the jars and add borax, stirring thoroughly until no more can be dissolved. Allow this solution to stand for 24 hours, whereupon the clear portion is poured off and used for filling the rectifier jars. Fill to within ⅜ of an inch of the top and then on the surface of the solution place a ⅛-inch layer of clear mineral oil or paraffin oil. This effectually prevents evaporation and eliminates the necessity of periodically placing more water in the rectifier jars.

Much has been said about the forming of the plates of an electrolytic rectifier. All that you have to do is to construct the rectifier as above, place it in the circuit as shown and press the key. The formation of the plates will take care of itself.

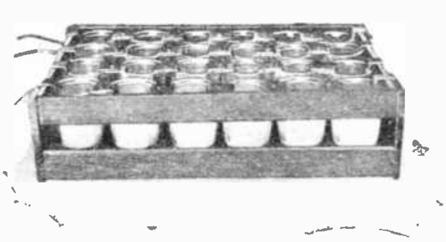


Fig. 1. The completed rectifier assembled in its rack ready to use.

The next important point is the construction of the transformer. Various types can be purchased ready made and unless you are willing to spend many hours in the construction of these instruments, such should be purchased. However, for the benefit of those who delight in making their own, the necessary details for the windings are given below. We will consider two different types of transformers, the circuits for which are given in Figs. 5 and 6. In the first instance, a transformer with two secondaries is utilized. One secondary supplies 1,100 volts across the outside terminals and is equipped with a center tap so that 550 volts is supplied to each half of the rectifier, leaving approximately 450 volts applied to the plate of the power tube through the rectifier and filter. The second secondary section supplies the heating current for the filament. In the circuit in Fig. 6 two separate transformers are shown. This system is to be desired, although it is somewhat more expensive in construction. The advantages are that when the key is closed, the voltage drop across the filament is not so great as when a single transformer is used, and consequently the transmitted note is steadier. Also, primary keying, described below, may be used with two transformers.

In Fig. 2 is shown the method of building up cores for transformers. Silicon steel strips, .014 inches thick and two inches wide, are used. Enough are cut to build up a core 2 inches thick and the following windings are used for a transformer to supply both plate and filament voltages. The primary consists of 250 turns of No. 14 D.C.C. wire, wound 26 turns per layer and fully insulated from the core. This is wound on the 6½-inch leg. The plate voltage secondary is wound on the opposite leg and consists of 2,500 turns of No. 28 D.C.C. wire, wound 90 turns per layer and with a tap brought out at the 1250th turn. This is also well insulated from the core and from the filament winding which is wound directly over it and which consists of 22 turns of No. 10 D.C.C. wire, tapped at the 11th turn.

If separate transformers are used, the same size core as described above and illustrated in Fig. 2 should be used for the plate transformer. The same number of turns should be used on the primary and secondary, but No. 16 or even No. 18 D.C.C. wire may be used on the primary.

For the filament transformer, the same dimensions may also be used, but the 7-inch legs can be reduced in length to 5½ inches. The same number of turns, 250, are used on the primary, No. 20 D.C.C. wire being employed. The secondary for this transformer is the same as the filament secondary described in the combination transformer. Let the writer reiterate here that two separate transformers are far more desirable than a single combination type. The filaments will not dim, nor will the plate current drop. Make use of two if at all possible.

The next item to consider is the filter system, consisting of one large choke coil, having an inductance of about 30 henrys and two or more large size condensers which may be of the paraffined paper and tinfoil type. The more condensers used, the better the note. Divide them so that the same number are on each side of the choke as shown. The writer uses four of these condensers, each having a capacity of 1 mfd. and a breakdown voltage of 1500. Even though the voltage normally applied to these condensers is nowhere near that figure, still it is wise to leave a margin of safety so as to take care of any surges which may occur in the circuit. The choke coil and condensers are wired as shown in Figs. 5 and 6.

The construction of the choke coil is rather difficult; one type made by an amateur is illustrated in Fig. 3 of honeycomb coils. Fifteen hundred turn each were used, four being placed on a silicon steel core and connected in series, end connections being brought out to suitable terminals. The coils as shown were thoroughly taped and shellacked, whereupon the core was built up inside the coils. This type of construction is far simpler than the winding of many thousands of turns of fine wire, and if a choke coil is not to be purchased, this form of construction is to be recommended. The layout of the power supply, less the rectifier, is shown in Fig. 4.

The question of keying a transmitting circuit, even of low power, is a serious one, particularly if it is to be operated in districts congested with broadcast listeners. Even though C.W. transmitters emit an extremely sharp wave and do not interfere in that respect, still what is known as key clicks interfere with nearby receivers. These clicks distribute themselves over a large band of wave-lengths and can be heard on even the highest broadcast waves. Therefore, the beginner must do all in his power to reduce to a minimum or abolish these clicks so as to avoid friction with his neighbors and keep within the law. If a single combination transformer is used, key clicks will be reduced by keying in series with the choke coil as shown in Fig. 5. Even this form of keying will occasionally give trouble, the writer found, but upon the installation of a separate filament transformer, the key being placed as shown in Fig. 6, clicks were entirely abolished, except in the case of one or two nearby broadcast listeners who insisted upon using single circuit tuners. With this type of neighbors, the only thing to do is to convince them that they must change to a coupled circuit tuner or must endure the clicks. In the case at 3MO, however, the clicks in single circuit tuners nearby were not annoying even though audible. As mentioned, however, keying in the primary of the plate transformer reduced them still further, and when the broadcast listeners installed coupled circuits, they were entirely abolished.

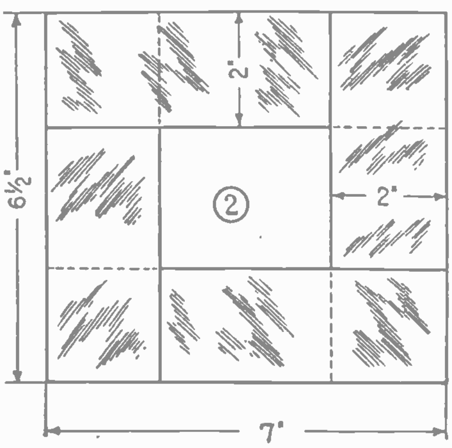


Fig. 2. How silicon steel strips are lapped over each other to form a transformer core.

Let us sound another warning here. Keying in series with the filament return or grid is often advocated, but such a procedure is to be deprecated. It will lead to serious key clicks and consequent trouble. Follow the system described herewith and you cannot go wrong.

Now that you have all of the apparatus constructed for your transmitter, the next thing to do is to tune the set.

The old method of tuning a transmitter was to adjust it till its antenna ammeter read highest. However, it has been proved so many times that antenna current means very little in the way of actual radiation, that the modern amateur no longer uses this method. Now, in these days of inductive coupling, a plate milliammeter is our best help in tuning. To go about tuning an inductively coupled transmitter, one should first disconnect the antenna and the counterpoise from their binding posts. The oscillator should then be adjusted so as to draw the least amount of plate current for the desired wave-length. The circuit oscillates most strongly at this point. Check the set for oscillation by listening in on the double wave on the receiving set. Then the antenna and counterpoise should again be connected and the antenna or counterpoise condenser slowly turned till the antenna ammeter registers highest. It does not matter just how much antenna current is shown, as long as it is the maximum attainable by turning the condenser. In this case the meter is used only as an indicator of resonance. A small lamp (Christmas tree light) may be used in the absence of an ammeter, the only difference being that the ammeter may be left in the circuit while the lamp should be shorted out after tuning the set.

Now, perhaps, when adjusting the oscillator it will be found that there are several points at which the plate current drawn is small and at no one point less than the others. If this is the case, one should choose the point nearest the wave on which he wishes to work, or better yet make tests with some other station to determine at which wave his antenna is efficient. Sometimes it will be found that when the antenna circuit is brought into exact resonance with the oscillator, the set refuses to operate. This usually happens when the antenna is worked near its fundamental wave-length and is caused by the antenna absorbing energy from the oscillator in such a large amount as to cause it to stop working. This is remedied by bringing the wave-length of the antenna circuit just below the resonance point. This is not advisable because of losses and the best way to get rid of the trouble is to loosen the coupling of the antenna coil.

An excellent way to check up on the wave

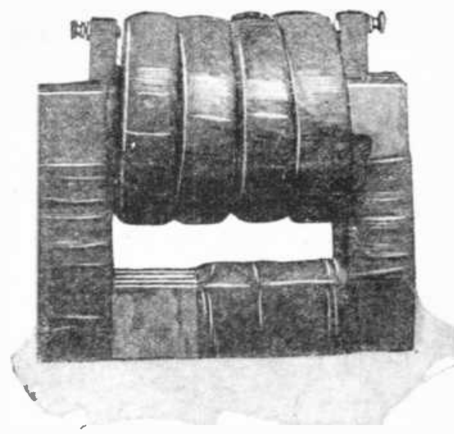


Fig. 3. An excellent type of home-made filter choke coil consisting of four large honeycomb coils and a silicon steel core.

and note of one's transmitter is to listen in on the receiving set to the double harmonic which is, of course, at double the wave-length of the transmitter. Thus, if you are sending on a wave-length of approximately 80 meters, your double harmonic will be about 160 meters. Of course, in this case the transmitter, working on 80 meters, does not emit an 160-meter note, but the receiver receives on what is known as the second harmonic. This can readily be understood when looked at in this way: the set, receiver, is oscillating at 160 meters and also produces faint 80-meter oscillations. It is these latter which beat with the incoming 80-meter wave from the transmitter, which causes the reproduction of the note in the fones. Having used your receiver for some time, you are undoubtedly familiar with it to an extent where you can set it to any desired wave-length.

After you have checked the wave-length by listening in on the double harmonic, note the tone of the wave particularly. If the tone is rather rough, you may need more capacity in your filter or a slight adjustment of the plate condenser may clear up the note. Continue your adjustments until the tone is a pure whistle. Another reason why a rough note is sometimes obtained is because the rectifier is not working correctly. Inspect the aluminum plates and if they are not a clear gray color, clean them thoroughly and then try again.

Let me hear from my readers by radio, or at least by mail. We will be glad to communicate with any amateurs, particularly if they have built their stations in accordance with the writer's articles. CUL es 73.

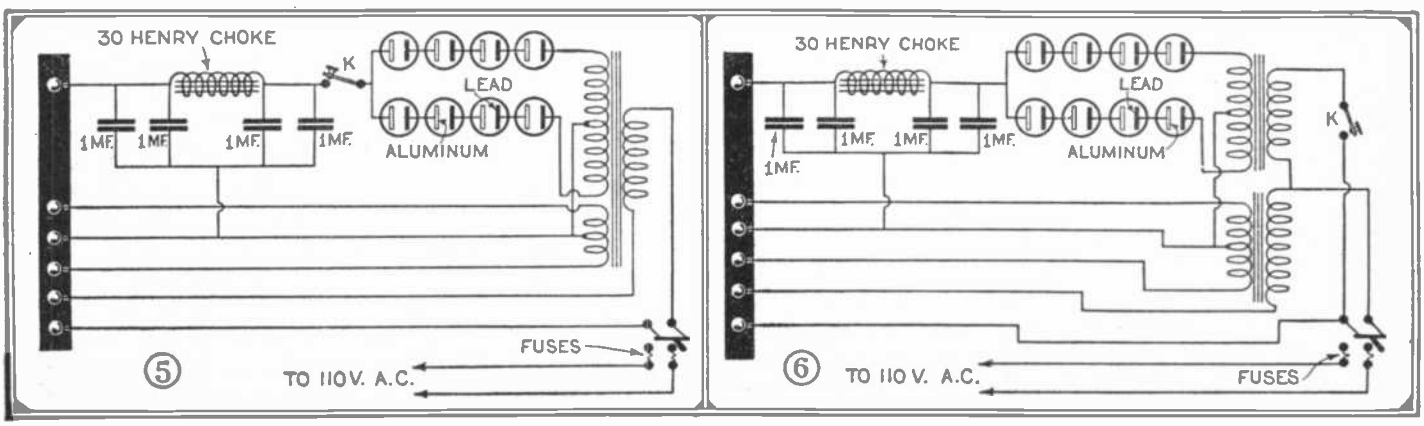


Fig. 5. A circuit of a transmitter power supply using one transformer. Fig. 6. The same rectifier and filter, but with two separate transformers.

A Remarkable Short-Wave Receiver

(Continued from page 596)

D.S.C. and take a tap off at the first and third turns. A total of nine turns of wire will be required for the 40-meter inductance. This coil must be tapped at the third and sixth turns. For the 80-meter coil, eighteen turns tapped at the sixth and twelfth will be necessary. Finally, for the 200-meter coil, thirty-five turns tapped at the twentieth turn, thus giving twenty turns for the grid coil and fifteen turns for the plate inductance are needed. The coil form is 2¾ inches in diameter.

The tuning operation of the receiver is not unlike that of most sets, but it must be kept in mind that the dial must be turned very carefully and slowly in order to pick up the short waves. It is very easy to pass over a dozen stations close together on the dial if care is not exercised. But having once tuned in a station, it is a simple matter to bring it in with exceptional volume. Patience is required and a steady hand.

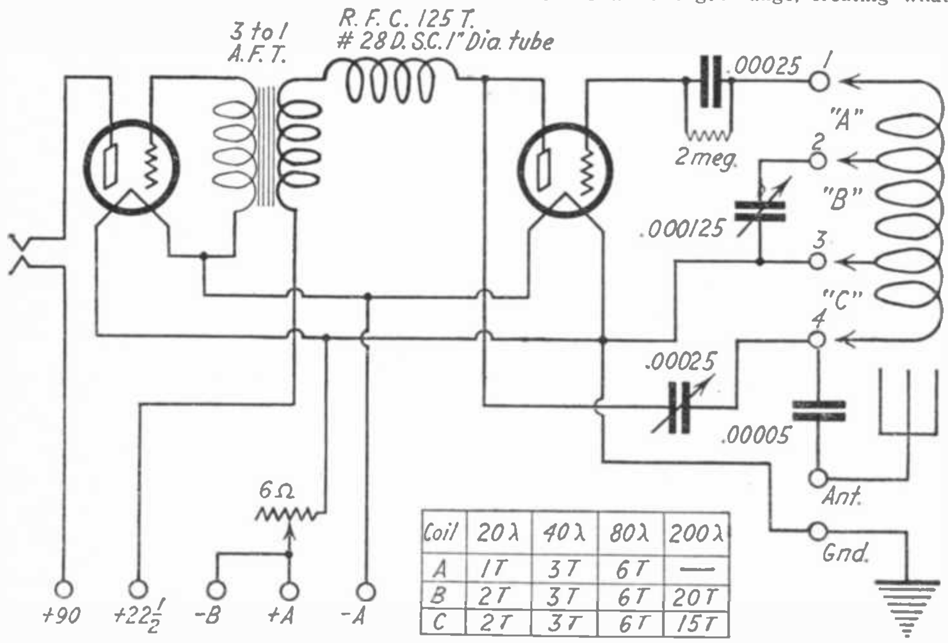
If the antenna system absorbs too much energy, shorten it or else increase the amount of capacity in the feed-back condenser. When excessive absorption occurs, the set usually fails to oscillate properly over the entire wave-length range, creating what is known as "dead-spots." And, failing to oscillate means that the chances for reception of signals become nil.

It is well to repeat here that the condensers should be wired so that the rotors are at "ground" or low potential. In the case of the feed-back condenser, the rotor should be connected to the antenna.

There are a great many stations now operating on 80 meters. In fact, conditions are as bad on this wave-length as they used to be on 200 meters.

Much better results can be had on 40 meters and still better on 20 meters, than on 80. It is obvious, therefore, that the near future will witness a general migration to the short wave-length bands. For daylight communication, 20 meters have been found an excellent medium, messages being steadily sent and received across thousands of miles of space when the sun is shining high over head. What a different condition than when operating on 200 meters! Heretofore daylight communication was not to be attempted, as it was wholly unreliable, but now with the use of 40 meters for night transmission and 20 for daylight, twenty-four hours of uninterrupted and ideal service can be obtained.

Most of the operators on the air who are using 20 and 40 meters employ pure D.C. current supply. Not only can they cover greater distances, but the note is usually of a particularly high-pitched character and is easily read through static. Fading is very marked on short wave-lengths, and it has often been noticed by the writer that whenever the sun was obscured by a cloud, a 20-meter signal would be considerably weakened. Forty meters at night offers a splendid medium for long distance communication, and one should not be surprised to learn that within approximately a 500-mile radius you will not be able to work anyone nor perhaps hear any signals. Beyond this distance, signals come in like the proverbial "ton of brick."



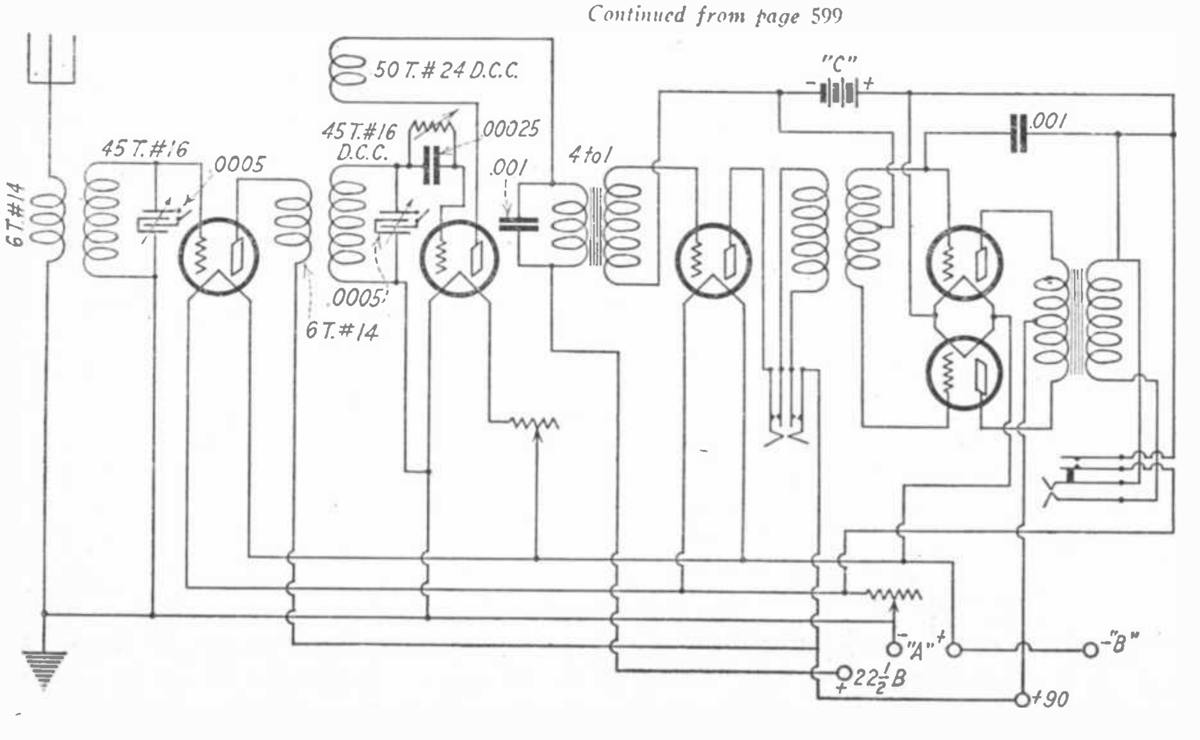
Coil	20λ	40λ	80λ	200λ
A	1T	3T	6T	—
B	2T	3T	6T	20T
C	2T	3T	6T	15T

Schematic wiring diagram of the short-wave receiver which has given such excellent results.

LIST OF PARTS
1 .000125 mfd. variable condenser.
1 .00025 mfd. variable condenser.
2 Sockets.
1 Audio transformer.
1 6-Ohm rheostat.
1 Jack.
4 General radio coil forms.
1 General radio coil mount.
2 Binding posts strips.
7 Binding posts.
1 .00005 mfd. condenser.
1 .00025 mfd. grid condenser.
1 2-Megohm grid leak.

An Exceptional Broadcast Set

Continued from page 599



For those who prefer wiring their receiver from a schematic diagram, the accompanying circuit will serve the purpose. Particular care should be taken in placing the various instruments at proper distances from one another so that magnetic coupling does not cause distortion. Note the variable grid leak and the small single-pole wave-length change toggle switches, features which augment the flexibility of the receiver. All connections, as can be seen, with the exception of the "C" battery, are brought to a small binding post rack which facilitates quick terminal connections.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

DETERMINING THE VALUES IN RADIO TUNING CIRCUITS

RADIO data sheets 1-30 and 1-31 explain the use of the oscillation constant in designing tuning circuits. The simple method explained of making use of the table of oscillation constants in connection with tuned circuits may be applied to any circuit in which inductances and capacities are in series.

For instance, in the secondary circuit of a two- or three-circuit receiver, the inductance L is the inductance of the secondary of the variocoupler. The coupling between the secondary and the primary and the secondary and tickler is supposed to be very loose. In this case the determination of the constants of the circuit will be sufficiently accurate for ordinary purposes. The capacity in the circuit is that in the tuning condenser connected across the ends of the secondary. As explained in data sheet 10-7, the secondary circuit is really a series circuit.

In the case of the antenna circuit comprising only the antenna and the primary coil of the variocoupler, C is the capacity of the antenna and L is the inductance of the primary coil. For approximate purposes, the inductance of the antenna may be neglected, as it is small compared with the inductance of the coil. For exact calculations, if the antenna inductance is known, it is to be added to the inductance of the primary, and the sum is divided by three. The resulting value is then to be used in the calculations with the oscillation constant. This idea of dividing by 3 is not generally known and the student should be careful to remember it. It results from the fact that the current in the antenna circuit is not uniformly distributed throughout the whole antenna circuit.

In the case of tuned radio frequency coupling transformers, the inductance is that of the coil and the capacity is that of the condenser used in shunt with the coil. The case is the same as that of the secondary circuit. The same principles apply to wave traps or filters. (See 10-6 and 10-7.)

For practical purposes when precision is not required, a rough estimation of the required inductance and capacity necessary to approximate a given wave-length range can be relied upon. Thus for 80 meters, a 15-turn inductance and a .000125 mfd. capacity will be found adaptable for the purpose. Again, for a 200-meter range, a 40-turn coil shunted by a .00025 mfd. capacity will be suitable.

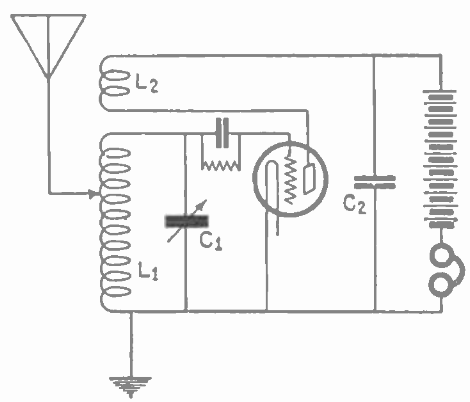
The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

FUNDAMENTAL TUBE CIRCUITS

FOLLOWING through data sheets 10-2 to 10-5 we have gradually evolved a complete radio receiving set employing one electron tube. We have said that there are many things that can be done with the output current from the tube, and in this sheet we will discuss how a tube circuit may be made more sensitive and selective by means of regeneration.

Suppose we have a circuit such as shown in the diagram. The signals coming in from the antenna are received into the circuit L_1C_1, which is tuned by the condenser C_1. These signals are of radio-frequency and are amplified as they pass through the tube into the plate circuit of the tube. These high frequency oscillations do not affect the phones, as their frequency is far above audibility. They will pass readily through the condenser C_2, however, which is called a by-pass condenser.



It will be noted that the plate circuit is broken and connected to a coil which is coupled to the input of the tube. This is L_2. Some of the energy has been taken from the output of the tube, and sent back through it again for further amplification. This circulation of energy increases until a condition of equilibrium is reached, and the rectified current, which is audible in the phones, is considerably greater than it would be if there were no regeneration.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

DESIGN OF INDUCTANCE COILS

COILS are pieces of electrical apparatus designed so that they have a great amount of inductance and little of anything else. Inductance and capacity and resistance are scattered around the electrical circuit, and since it would obviously be difficult to control any of these, being so scattered, electrical design attempts to concentrate these things into separate parts of the circuit, as in coils, condensers, rheostats, etc.

A coil, to be an efficient one, should have the amount of inductance required in the circuit and should have as little capacity and resistance as possible. Resistance in the circuit causes losses of energy (see 1-3.41, 1-3.4), while capacity in a coil makes the coil act as if its resistance were higher than it really is, if only the resistance of the wire in the coil is considered.

More than this, capacity in a coil causes the inductance of the coil, or rather the apparent inductance to change with the frequency of the current flowing through it. In other words, the inductance of the coil would change as the wave-length of the received signals changed. It is evident that this is not desirable, as it renders the design and operation of radio sets more complex and unreliable.

The resistance of a coil depends upon the following:

Direct current resistance of the wire.

Skin-effect in the wire due to the frequency of the current.

Coil capacity (or distributed capacity, as it is generally termed.)

Dielectric losses.

The skin-effect will be treated in another section of the data sheets. The dielectric losses in the coil are those which are due to the leakage of current between the turns of the coil through the insulation on the wire or through the material supporting the coil. It is also due in part to absorption effects in the insulating materials. This is treated more in detail in connection with condensers.

There are a great number of different types of coils. There is the stagger wound, pickle-bottle coil, basket-wound, self-supporting pancake, Lorenz type, straight solenoid type, star type, honeycomb, duo-lateral, hexagonal and other miscellaneous types, such as the helical and toroid coils. Each have their respective advantages and disadvantages. The most efficient is perhaps the stagger wound, self-supporting coil having cotton insulation.

CUT ALONG PERFORATED LINES

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

A SIMPLER WAY OF DETERMINING WHAT INDUCTANCE AND CAPACITY TO USE IN A CIRCUIT

IN data sheets 1-30 and 1-31 we have shown how the inductance and capacity required in a tuning circuit can be arrived at by means of the well-known formulas given there, and also how to simplify their use by means of the oscillation constant.

In the chart shown below, we have a very much simpler way in which to do this. The writer has computed the various combinations of inductance and capacity that will tune to the various wave-lengths, and has plotted them in the chart shown below.

The method is extremely simple. Merely follow the broken lines. Thus, suppose we have a .0005 microfarad condenser and wish to build a coil to go with it, that will tune between 200 and 600 meters. Starting at a point A on the diagram, which represents the capacity .0005, go horizontally until the 600-meter line is reached. On looking downward from this point, we see the point which immediately gives the inductance required, *viz.*, 200 microhenries. We can also find what minimum capacity our condenser must have, for this is shown by going horizontally from

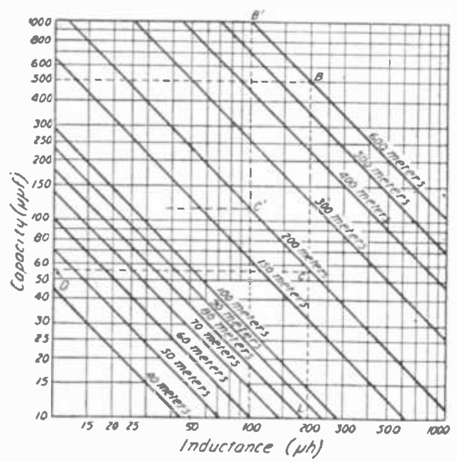


FIG 1

the point where the vertical line crosses the 200-meter line.

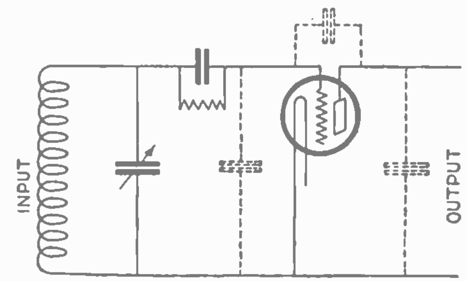
The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

FUNDAMENTAL TUBE CIRCUITS

IN radio data sheets 14-6 the method of obtaining regeneration by feeding back to the input of the tube some of the output energy through a tickler coil was described. This is not the only way in which regeneration can be obtained.

The other method is much more difficult to explain. The action depends upon what is called the "inter-electrode capacity" of the tube. It can be readily understood that



the grid and plate of an electron tube, being two conductors of electricity, separated by a space, constitute an electrical condenser, and since they act as a condenser, they must of necessity have a certain amount of capacity.

High frequency currents such as we deal with in radio circuits pass rather easily through condensers, and even where the capacity of these is as small, as that between the grid and plate of the tube, some energy can leak through. The idea is illustrated somewhat, in the figure below. There are virtually three small condensers within the tube, *viz.*, one between the grid and plate, one between the filament and plate and one between the filament and grid. Each one of these has an effect upon the other, so that the total capacity within the tube may be many times the actual capacity we should obtain by individual measurement.

As a consequence, some of the energy in the output circuit passes back through the tube into the input, reinforcing the oscillations in that circuit, having the effect of making the received signals stronger than they originally were. This is the reason why regenerative circuits are more sensitive than the non-regenerative ones.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

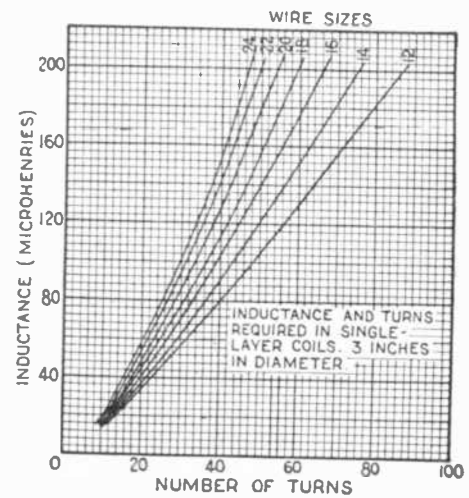
DESIGN OF INDUCTANCE COILS [Continued]

THE table below shows the number of turns of wire of various sizes required on a coil 3 inches in diameter.

As an example of the use of this chart, suppose that, by using the method outlined in data sheets 1-50 and 1-51, we have found that we require an inductance of 100 microhenries in our coil. Following the broken lines in the diagram below we find the following combinations:

Wire-Size	Number of Turns
12	49
14	43
16	39
18	36
20	34
22	33

Thus, the number of turns found by this method will not be far from the actual number required. The exact number required will depend on several things. The chart applies strictly to coils isolated in space, that is, to coils which have no other coils or circuits coupled to them.

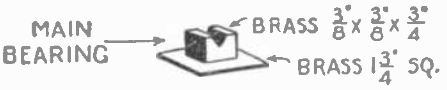


CUT ALONG PERFORATED LINES

Making a Sensitive Balance

By Edward Grindle

THE amateur experimenter in chemistry often wishes to make experiments calling for exact weights, but cannot perform them because of the high price of



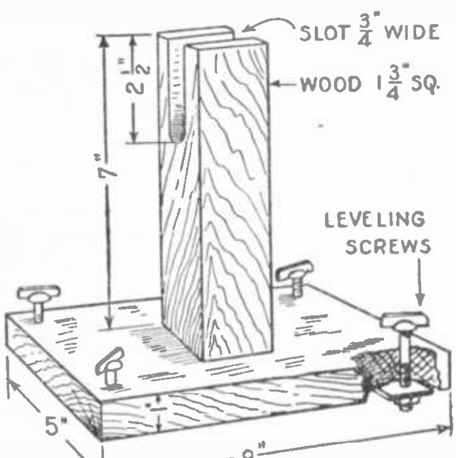


FIG. 1

Standard and platform of a chemist's balance. This balance is quite adequate for the simpler range of work and is an excellent introduction to the use of the more elaborate and expensive bought balance. Observe the four leveling screws.

good balances. The following article tells how an ingenious man can make an accurate balance at practically no cost, and if it is carefully made, it will weigh down to one centigram.

First select a piece of board one inch thick, five inches wide and seven or eight inches long (these figures need not be followed exactly), and secure to it an upright standard seven inches high and one and three-quarter inches square. This upright has a slot cut in its upper end, three-fourths of an inch wide and two and a half inches

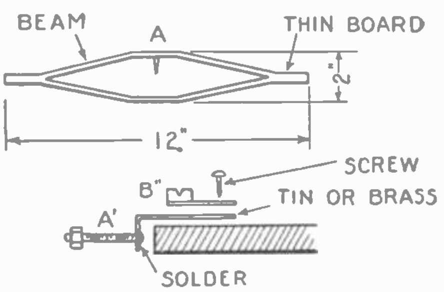


FIG. 2

The balance beam made of thin wood and its bearing. The central bearing must be on a line with the end bearings.

deep (see Fig. 1). This slot is cut lengthwise of the base.

Next, the leveling screws may be made. They are made from four two-inch round-headed stove bolts. A hole is drilled in a small square of sheet metal and the nut is soldered to it. This is secured to the under side of the base, one on each corner. A hole is then bored through the base to accommodate the bolts. To make the bolts easier to turn by hand, file four bits of brass to shape and drive them into the slots on top of the bolts as shown in Fig. 1 and solder them securely.

Next comes the most important part, the main bearing. It is made as follows: Take a plate of brass the same size as the top of the upright, and solder to it a piece also of brass about 3/8 x 3/8 x 3/4 inch. In the upper side of this last piece the groove is cut for the beam to turn on. This must be cut carefully, for the better it is made, the better the balance will work.

Now, the beam must be made. This is cut from a single piece of thin board to the shape and size shown in Fig. 2. On the upper side of each end is fastened a brass bearing and a balancing screw. These parts must be of the same weight so that the beam will balance. The bearing (A) is made of a section of safety razor blades soldered to a thin strip of metal and screwed to the under side of the center of the beam, as shown. Fig. 5 shows how the beam sits on the bearing, the under side passing through the slot in the upright. Do not screw the main bearing to the upright until the last thing, as the beam cannot be removed once it is in place (see Fig. 5).

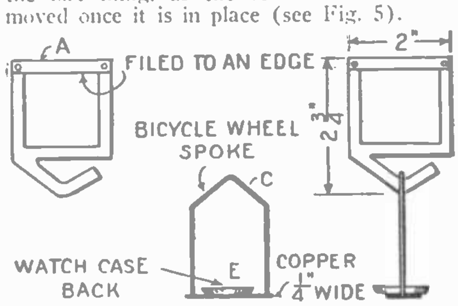


FIG. 3 FIG. 4

Stirrups for holding the pans, one for each end of the balance. These must be very carefully made and the edge must be very true.

Next the hangers and pans are made. These must be of the same weight so as to balance. The hangers are cut from copper with the exception of part (A), which should be steel with the under side filed or ground to an edge. The hangers measure 2 x 2¾ inches, Fig. 3. The pans are made as follows: The piece (C) is bent from a bicycle wheel spoke. (D) is a strip of copper about ¼ inch wide, D is a watch case back. All parts are soldered together. Fig. 4 shows how they are assembled.

A pointer is fastened to the top of the beam and passes before a scale near the bottom of the post. This is shown by (G) Fig. 6.

The last thing to make is the plumb bob. Cut a diamond-shaped piece of brass and solder a long slender bolt to the back. Bore a hole through the upright post from front to rear, and then pass the bolt through and screw the plate to the post so that the end of the bolt extends through the back. At (B), Fig. 6, bore a hole near each end of a strip of brass and bend it to a right angle. Fasten this to bolt (B) by a nut before and behind it (see Fig. 6). On top of this solder a nut and pass bolt (D) through it. Solder a tiny hook to the end of it, as shown. Whittle a small lead plummet, E (—) and split the top. Put a silk thread in the split and squeeze together. Tie end of thread to hook on bolt *D*, (—). Solder a tack to a strip of brass and screw it to the post, so it extends out under the lead plumb bob, Fig. 6.

Now to assemble the balance. Place the

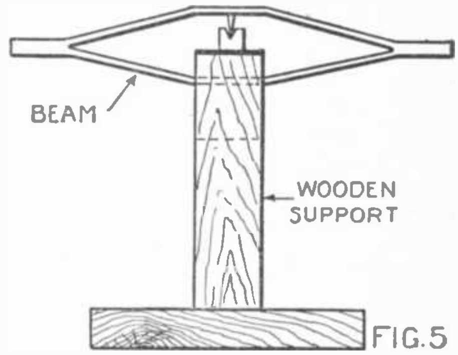


FIG. 5

The beam upon its support; the slot in the upright admits the lower member of the beam. It must touch nothing but its bearing.

beam on the main bearing and screw it down to the top of the post. Then hang the pans in place. Next the balance should be leveled. Take the beam off the main bearing and with a spirit level adjust the leveling screws until the main bearing is perfectly level. Then adjust the plumb bob until it hangs exactly over (F) and almost touches it. Then whenever the balance is moved it can be leveled with the bob.

Next the beam must be adjusted. Make a temporary scale to place behind the pointer.

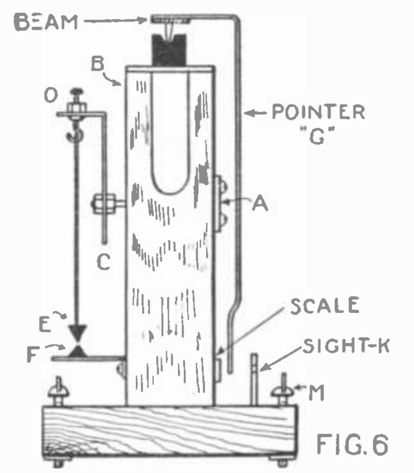


FIG. 6

A side view of the balance, showing the plumb bob for leveling it up, the beam bearing, the beam pointer, the position of the scale and sighting hole, and other details.

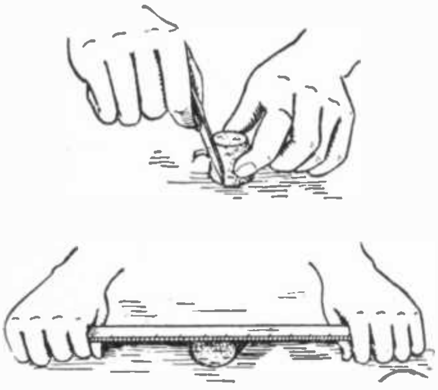
Make a mark on it exactly behind the pointer when it comes to rest. Now place a light object in one pan and mark the scale the distance the pointer moves. Now place the same object in the opposite pan. If the needle is deflected the same distance, the balance is all right. If the pointer does not

(*Continued on page* 634)

Chemical Manipulation

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

MANY years ago a chemical student who had matriculated in a French scientific school presented himself in a laboratory. He was asked if he could speak French and replied he could speak a little. The next



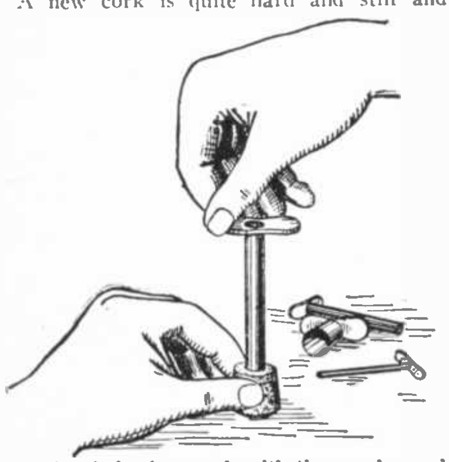
The upper illustration shows how to cut a cork with a pen knife, but the knife must be very sharp and the soft cork has a mysterious way of dulling tools used upon it. The lower figure shows how to soften a cork by rolling it back and forth under a stick of wood, such as a ruler.

question asked was: "Do you know how to file a cork?" He had probably never heard of doing such a thing, so giving him the cork and file his first lesson in chemistry was how to fit a cork and how to perforate it. It was a good example of the thoroughness of the French, starting at the very bottom of things, and giving proper prominence to manipulation in the chemical laboratory.

The tendency at the present day is to use India rubber corks or stoppers. In most cases these are perfectly adapted to the work, but a full set of all sizes is rather expensive and there is something very attractive in seeing good work done with the bark cork.

To reduce the cork in size it may be filed, great care being taken to file it evenly on all sides and to keep the file bearing over the full length of the cork, so as to preserve the proper taper. Sandpaper may be used successfully for the same purpose.

A new cork is quite hard and stiff and



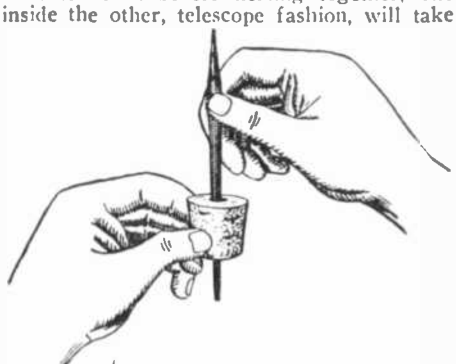
Boring holes in a cork with the regular cork borer. A set of these sold in stores includes half a dozen or more sizes.

we have all seen cork squeezers in the drug store, but these are not usually to be found in the laboratory. To soften a cork, a very excellent plan is to lay it on its side on a table, roll it thereon, pressing it with a ruler or strip of wood as it rolls to and fro. Some mistaken enthusiasts soften a cork by biting with their teeth, or place it on the floor and roll it under the foot. These two practices are deserving of reprehension.

The cork may be cut down by a very sharp knife, which leaves it of course polygonal, and then it has to be sandpapered or filed to the proper circular contour.

Boiling a cork in water makes it very soft, so that it can be forced into quite a small clasp or bottle neck. This way of softening a cork was spoken of in a previous paper, where the securing of corks around the neck of a wash bottle was described. The cork must be impaled on the end of a file, or some other means must be adopted to keep it under water in which it is being boiled. It is quite wonderful to see what can be done with a cork which has been thus treated.

We now come to perforating corks. Cork borers are sold in sets for this purpose. They are brass tubes, one end chamfered down to an edge and the other end fitted with a transverse handle soldered or brazed on. With one of these a hole may be quickly bored in a cork. The cork is placed on its larger end on a table, so that it cannot rock, and the cork borer is forced through it with a twisting motion, cutting out a core of its own internal diameter. Half a dozen of these cork borers nesting together, one inside the other, telescope fashion, will take

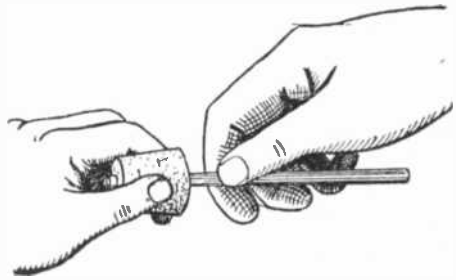


Making a hole in a cork, using a round file, commonly called a rat-tail file. This operation has to be done very nicely in order to get a perfectly cylindrical aperture.

good care of the ordinary requirements of the chemist.

Very nice work can be done with a round or rat-tail file. The tang or handle end of the file should be sharpened to a point. To use the file on a cork the tang is thrust first into the exact center of one or the other of its ends, perhaps half way through each time, and then it is worked through from end to end so that the apertures meet. They can be enlarged in a rough way by turning the file around so as to ream them out. The next thing to do is to get the other end of the file through. This is pushed in as far as it will go without straining and pulled out again, and this is repeated at both ends several times, and the filing action in each case increasing the diameter of the hole until at last the file gets all the way through. The cork is then held between the fingers and thumb of one hand, the file thrust through the hole and kept in a strictly vertical position; the hole is then gradually filed out, little by little, until it has attained the proper size. Sometimes when the file works freely, the cork is laid on the table and rolled back and forth as it is being filed, but the other method is far the better. The essence of doing a good piece of work is to take time and let the file gradually bring it to a true contour. If the work is hurried the hole may come out irregular in shape or even grooved by the filing stroke.

It may seem a simple enough thing to insert a glass tube through the hole in a cork, but like much else in the laboratory, there is a right and a wrong way of doing this. The end to be forced through the cork must be rounded in the flame of a Bunsen burner or otherwise. If it is a straight tube it is to be held a short distance back from the cork, perhaps an inch, while it is being forced through, being turned around constantly. If the tube is thin, there is always danger of its breaking. If it is pushed by the end the danger is accentuated, and not only that, but if it does break, it may penetrate the hand and give a very bad wound. Some serious accidents have



Thrusting a glass tube into a cork; the tube is not allowed to point against the hand, because if it breaks it might make a very serious wound.

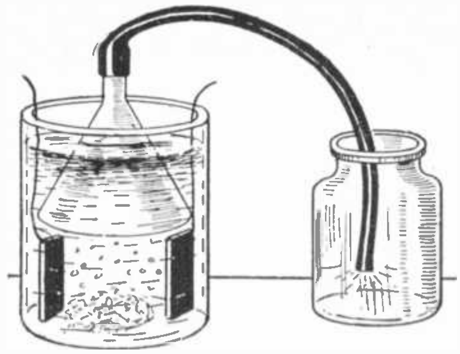
occurred in this way. The hand may be protected if it seems to be a case where there is some risk, by using a towel to hold the tube. It is not likely that the broken tube would go through a towel and then into the hand but no chemist ever pushes on the end of a tube.

If a bent tube is to be thrust through a cork, it should be held close to the cork as just described, on the straight part, and turned about with pressure until it goes through. The bent portion may be used as a sort of handle to turn it with, but on no account should any pressure be applied to it, as it will probably break at the bend if this is done.

Moistening a tube will sometimes help it to go through and soap or sodium or potassium hydroxide solution may be used, especially for rubber stoppers. This process is objectionable to the extent that it introduces a chemical where presumably none is desired.

Inserting a bent tube in a cork; the same care is taken as in the preceding case, so that if the tube breaks it will not mutilate the hand. It is an excellent plan to wrap a towel around the tube while inserting it.

The above may seem very simple, but it is by the way in which he sets up his apparatus that a chemist is to be judged; nothing is more disagreeable than poor work with corks. In many cases India rubber corks are not desirable and there was much good sense in the French test spoken of in the article, the trying out a student by his filing a cork.



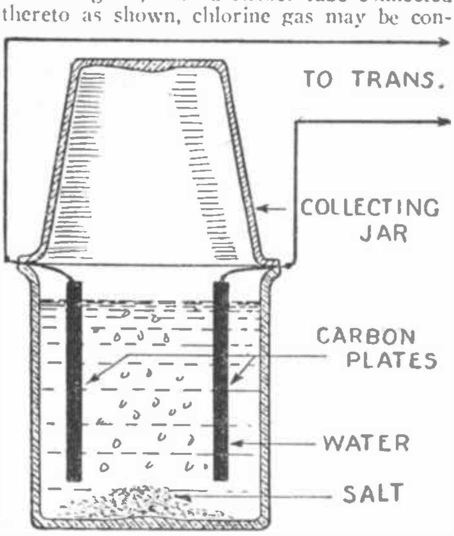
Production of chlorine gas by electrolysis and collection by downward displacement possible on account of the high specific gravity of the gas.

Electric Production of Chlorine Gas

IN an ordinary glass jar a solution of ordinary table salt is placed. Two metal plates, preferably of copper, are immersed therein, and if connected to a battery or other source of direct current at 12 volts potential difference or more, chlorine gas will be evolved.

It will rise through the solution from one of the plates in bubbles and its very disagreeable odor will make it only too easily recognized. Before turning on the current, a glass is filled with water, a piece of paper held over its mouth, and it is inverted in the lower glass as shown. It thus collects chlorine.

The water dissolves a good deal of the gas, but the experiment is an interesting one, and by using a funnel in place of the inverted glass, with a rubber tube connected thereto as shown, chlorine gas may be connected by displacement. This arrangement is also shown in the illustration.



Another version of chlorine gas by electrolysis; this time it is collected in the inverted jar from which it will at once escape when the jar is removed.

Contributed by CARL W. ANDERSON.

Experimental Production of Chemically Pure Sodium Chloride

By BOLIVAR BYERS

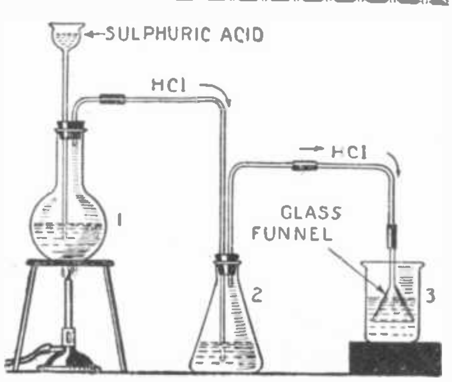
CHEMICALLY pure sodium chloride can be prepared from rock salt at a small cost and with a very simple apparatus. The quantity of the reagents may be varied as required by the amount of raw material used; the quantities given here will yield approximately twenty grammes of pure sodium chloride.

Dissolve twenty-five grammes of rock salt in seventy-five cubic centimeters of water and add one gramme of sodium carbonate dissolved in a little water. Filter and pour into a beaker marked 3 in diagram. Put 50 grammes dry rock salt into the liter flask marked 1. Pour 250 cubic centimeters concentrated hydrochloric acid (S.G. 1.2) into the Erlenmeyer flask marked 2. Connect up the apparatus with glass tubing as shown. Pour 95 cubic centimeters of concentrated sulphuric acid through the thistle tube into flask marked 1.

Heat is required to carry forward the reaction. This can be obtained from a Bunsen burner, alcohol lamp, Gilmer electric heater or other convenient source. If a flame is used for heat, be sure to place a sand bath or a wire gauze under the flask. Hydrochloric acid gas is evolved and passed into the "scrubber" marked 2 where it is freed from impurities, and thence to the beaker marked 3, which contains a solution of rock salt. Sodium chloride is less soluble in the presence of HCL (due to the increase in concentration of the chlorine ions), hence sodium chloride is precipitated in beautiful white crystals as the hydrochloric acid goes into the solution.

When the action ceases or the desired quantity has been precipitated, the apparatus is disconnected before removing the source of heat. This is done to prevent the contents of 3 from being drawn back into 2 and thereby causing trouble. Separate the sodium chloride in 3 from the mother liquor by a suction filter.

Test filtrate for sulphates by adding a few drops of barium chloride solution. A white precipitate of $BaSO_4$ immediately forms if sulphates are present. Wash the crystals with hydrochloric acid till no test for sulphates is obtained. Remove the crystals from filter and heat gently in a porcelain dish till all decrepitation ceases. This expels the hydrochloric acid. The product is C.P. NaCl.

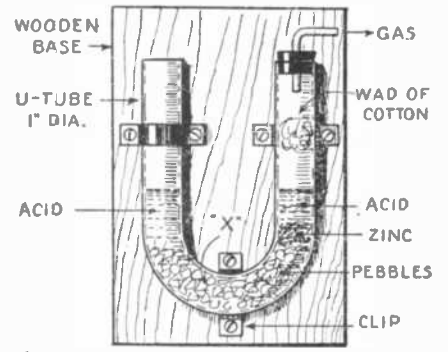


A very interesting experiment in the formation of chemically pure sodium chloride from sodium carbonate and hydrochloric acid added to ordinary rock salt.

U-Tube Gas Generator

By C. A. OLDROYD

FOR laboratory work where only small quantities of gasses for tests, etc., are required, a very simple and efficient gas generator can be made from a glass "U" tube.



A very neat appliance for generating small quantities of gas, the generation ceasing when a pinch-cock is closed, particularly available when many gases are to be made.

The latter should have a diameter of about one inch; such tubes can be obtained very cheaply from dealers in chemical apparatus; on the other hand, they can be bent over a powerful gas burner flame, if one is expert enough to do it.

The bottom of the "U" tube is filled with pebbles as indicated. On the right-hand side, the material from which the gas is to be generated (zinc, for hydrogen) is placed on top of the pebbles. The upper end of the right-hand arm of the tube is fitted with a stopper through which a small bent glass tube passes; the gas is to escape through this tube.

The left arm of the tube is left open. To generate gas, the tube is filled with dilute acid to the level indicated. As long as the acid is in contact with the zinc or other material, gas will be produced.

When the pinchcock over the supply tube is closed down, the gas developed in the tube will force the acid back below the zinc and evolution will gradually come to a stop.

The acid will, therefore, rise in the left arm, but can never be forced out of the tube mouth, for as soon as the fluid has been forced beyond the lowest point of the tube ("X"), the gas will escape backwards in bubbles through the liquid in the bottom and other arm of the tube.

To filter the gas, a wad of cotton wool is placed below the stopper; this should be loose and not too tightly packed. Any acid or other moisture of the gas will be absorbed in great part by the wool, and the gas will be pure enough for ordinary experiments.

The easiest way of mounting such a gas generator is the one shown. The "U" tube is attached to a wooden base by three clips made from thin brass. The baseboard, which may be half an inch thick, is secured to the wall.

A number of these generators, each for a different gas, may be mounted on a common panel and in this way, an immediate supply of several kinds of gases is available for experiments.

Interesting Experiments in Organic Chemistry

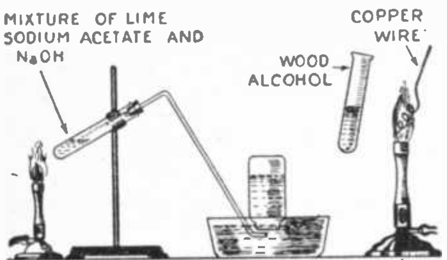
By E. W. Blank

TO the average experimenter organic chemistry seems a remote and difficult subject, encumbered with long names of various substances. However, it is not this, but it is built up upon a series of compounds logically arranged, classified and governed by the same laws that govern other chemical combinations. It is not a science independent of inorganic chemistry, but is linked to it in such a manner that they are indispensable to one another.

Organic chemistry is to a large extent structural chemistry. For example methane, one of the simplest organic substances, consists of one atom of carbon in combination with four of hydrogen; thus it has the formula CH_4. Since this does not show in what respect the hydrogen atoms are related to the carbon atom, the substance is given the structural formula, and by means of it, various reactions are easily explained. One methane molecule will then be represented as:

$$\begin{array}{ccc} & H & \\ & | & \\ H - & C & - H \\ & | & \\ & H & \end{array}$$

Methane is also known as fire damp and marsh gas because it is found rising from pools of stagnant water in marshes and swamps. It is also found in coal mines, mixed with air, and since such a mixture is explosive within limits, serious explosions sometimes occur. The products formed when it burns are carbon dioxide and water. The carbon dioxide is known to the miners as choke



PREPARATION OF METHANE

OXIDATION OF METHYL ALCOHOL TO FORMALDEHYDE

The cut with its descriptive matter tells how methane or marsh gas can be made. If one hydrogen atom of methane is replaced by hydroxide, we have wood alcohol and its vapor is oxidized to an aldehyde by catalytic action of a hot copper wire.

damp, or often damp, since if he is not killed by the explosion he is suffocated by the carbon dioxide.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

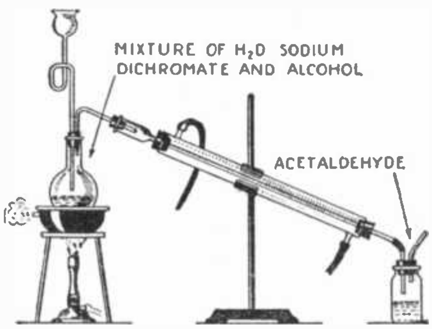
Methane + Oxygen → Carbon-Dioxide and Water

To prepare it, place about 15 grains of a mixture of sodium acetate, sodium hydroxide and lime in a hard glass test tube, provided with a rubber stopper and delivery tube. Gently heat the tube until the substances start to react and then collect the evolved gas over water. As soon as the heating is discontinued, withdraw the delivery from the water to prevent the liquid from rising into the hot tube. Burn a bottle of the gas and then add a little clear lime water and shake. The clear liquid will become cloudy; the calcium hydroxide plus the carbon dioxide gas forms white and insoluble calcium carbonate.

Under certain conditions two molecules of methane will unite to form ethane, a second substance of the same type as methane. This can be represented as follows:

$$\begin{array}{cccccccccc} & H & & & H & & & H & H & \\ & | & & & | & & & | & | & \\ H - & C & - + - & & C & - H & \rightarrow H - & C & - C & - H \\ & | & & & | & & & | & | & \\ & H & & & H & & & H & H & \end{array}$$

CH_3 may be taken as the methane radical, methane one of whose hydrogen atoms is missing, resulting in what is called an unsaturated radical. If to this radical we attach an OH group, we obtain methyl alcohol CH_3OH, the well-known wood alcohol.



PREPARATION OF ACETALDEHYDE

Formaldehyde may be called somewhat inaccurately the aldehyde of formic acid and acetaldehyde may be called in like manner the aldehyde af acetic acid. Here it is made from alcohol and the reader will remember that fermented alcohol will give vinegar, which is acetic acid.

$$\begin{array}{cccc} & H & H & \\ & | & | & \\ H - & C & - C & - OH \\ & | & | & \\ & H & H & \end{array}$$

If the alcohol loses two H atoms, we obtain a compound known as an aldehyde, C_2H_4O.

The aldehydes are named after the acid into which they are converted by adding an atom of O. This aldehyde is thus known as acetic aldehyde, and the aldehyde obtained from methane by the same steps is termed formaldehyde, since it is converted into formic acid by oxidation. As a summary the relations in composition between the hydrocarbons, alcohols, aldehydes and acids are shown by the following formulas:

Hydrocarbons	*Alcohol*
CH_4 methane	CH_3OH methyl
C_2H_6 ethane	C_2H_5OH ethyl

Aldehyde	*Acid*
$HCHO$ formaldehyde	$HCOOH$ formic
CH_3CHO acetaldehyde	CH_3COOH acetic

We have already prepared methane on an experimental scale.

The next subject closely related to it is alcohol. By abstracting 2 atoms of hydrogen from it we obtain formaldehyde.

To make formaldehyde experimentally dissolve about 2 drops of methyl alcohol in 3 cc. of water in a test tube. Prepare a spiral of copper wire by winding some about a lead pencil, leaving one end free to act as a handle. Pass the spiral rapidly through a Bunsen burner flame and plunge the red-hot wire into the solution. Repeat several times when the characteristic odor of formaldehyde will be detected.

From the hydrocarbon ethane we obtain ethyl alcohol, and by the loss of 2 atoms of H we obtain acetaldehyde. To prepare acetaldehyde set up the apparatus as the diagram shows. In the flask place a mixture of 17 cc. of concentrated sulphuric acid and 75 cc. of water. Heat the solution to gentle boiling and slowly add a solution of 35 grams of sodium dichromate in 60 cc. of water and 50 cc. ethyl alcohol. The above must be slowly added during the course of about 30 minutes. The acetaldehyde has a very low boiling point and is caught in a stoppered bottle, which has a safety tube.

Aldehydes are recognized by the characteristic reactions which they give. In making these tests some of the aldehyde just prepared may be used.

Silver Mirror Test

Make an ammonical solution of silver nitrate by adding some silver nitrate solution to ammonium hydroxide until the precipitate first formed redissolves. Add some of the aldehyde and quickly mix. Metallic silver is deposited on the sides of the tube forming a brilliant mirror. To get best results the tube should be perfectly clean.

Reduction of Fehling's Solution

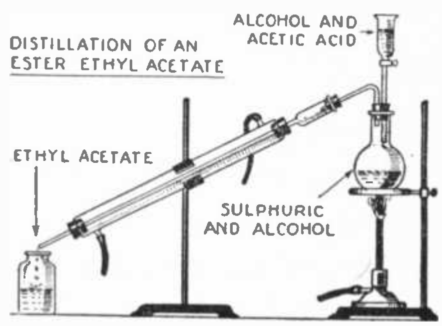
Place a small amount of Fehling's solution in a test tube and heat to boiling. Add a small amount of aldehyde and boil again. A yellow and then a red precipitate of cuprous oxide will be formed.

Resin Formation

Heat a little aldehyde and a small quantity of concentrated solution of sodium hydroxide. A resin will be produced. Bakelite is based on the reaction between formaldehyde and phenol.

If to our ethyl alcohol we add acetic acid we obtain a substance known as ethyl acetate, an ester. Esters correspond to the salts in inorganic chemistry and show the analogous reactions. The majority of them possess pleasant odors and are used in large quantities in the perfumery business.

To prepare ethyl acetate place a mixture of 10 cc. ethyl alcohol and 12 cc. of concentrated sulphuric acid in a flask provided with a dropping funnel and connected with a condenser. Gently heat the flask and then slowly add a mixture of equal quantities of glacial acetic acid and alcohol. As soon as the action proceeds regularly add the mixture at about the same rates at which the products distill. When all has been added place the distillate in a flask and add a concentrated solution of sodium carbonate. The liquid will effervesce and the ethyl acetate



Distilling alcohol with acetic acid produces ethyl acetate. The alcohol must be grain alcohol, which is ethyl hydroxide, so it is very natural to find the hydroxide replaced by the acetic acid group. The salt of an organic base is called an ester.

will separate as the upper layer. When the mixture no longer effervesces carefully decant the ethyl acetate into a bottle. It is a light mobile liquid with a very pleasant odor. Use pure alcohol.

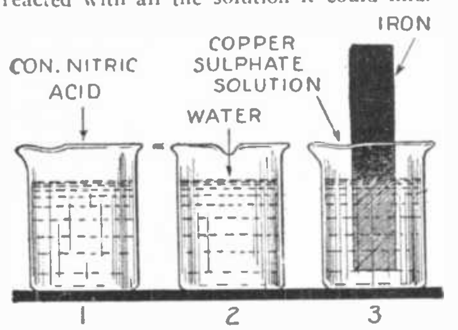
A Most Astonishing Experiment

By Harry R. Lubcke

It is common experience to plate a key or other iron object with copper by placing it in a solution of a copper salt. The plating, which is really electrical in character, takes place because iron is a "baser" metal than copper. It therefore replaces the copper in solution while the copper is reduced to the metallic state.

But to prevent this action, or make it take place at the tap of a stick, is a phenomenon unknown to most people. It will be found that if the iron strip is placed in concentrated nitric acid, removed, rinsed in cold water, and then lowered into the plating solution, not a speck of copper will plate out. If, however, the strip is taken *out* of the solution and given a tap with a stick, a coating of copper will start on immersion, where the iron was struck and spread, almost instantaneously, over the entire surface that was immersed! This is a most peculiar and startling behavior which baffles even those who have a training in elementary chemistry. This action can be repeated over and over and makes a very mystifying trick.

What causes it? If I were to tell you that the iron was "Pacified" you might think I had my ideas concerning chemistry and baby-tending slightly mixed. But this is exactly what has happened. By placing the iron in the concentrated nitric acid it has been rendered inactive, or "passive" and refuses to react with the copper. (Don't try pacifying the baby with concentrated nitric acid!) The iron is therefore made nobler than the copper. When you struck it with the stick you made it wake up and realize that it was only iron after all, so it promptly reacted with all the solution it could find.



A piece of iron brought to the passive state by immersion in concentrated nitric acid will not precipitate copper from any of its solutions. A slight blow restores activity to the iron and it precipitates the copper.

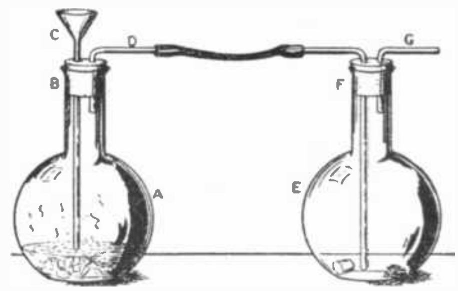
According to theory the iron should have been dissolved speedily by the nitric acid; for, certainly, iron always dissolves in acid and gives off hydrogen. It was because the acid was concentrated and such a strong oxidizing agent that it halted this action. The acid should be the strong, fuming, variety for best results. The rinsing in water simply washed off the excess acid and kept it from contaminating the copper solution. For this solution ordinary copper sulphate ($CuSO_4 5H_2O$), sometimes called "blue vitriol," is satisfactory.

If the experiment is to be performed as a trick the three solutions—acid, water, and plating liquid—should be placed side by side in identical containers as shown in the figure. First the strip, which should be large for demonstration purposes, can be dipped into the water and then into the plating solution where the copper will plate out as usual. If now the iron is placed in the nitric acid, the copper film will be removed and the iron pacified. Then rinse and place it in the plating solution where no action takes place. Then the performer can strike it with his "magic" wand and the copper appears. He can claim that he has control over mother nature, the realm of chemistry, or make any other suitable boast. The action can be repeated in a different order to muddle the audience. Take care to lower the iron carefully into the solution, for if you strike it against the side of the container, the latter will be the magic wand and wake up the iron before you are ready.

This action of iron has considerable applications. Other oxidizing agents such as potassium bichromate ($K_2Cr_2O_7$) or lead oxide (PbO_2) have a similar effect on iron. For this reason "red lead" is used extensively as a paint for iron, since it makes it passive, besides acting as an ordinary paint, and therefore is doubly effective as a protective coating.

Fire in Carbon Dioxide

By Stearns McNeill



Phosphorus "burns" with iodine in an atmosphere of carbon dioxide; the latter does not support combustion in the usual sense.

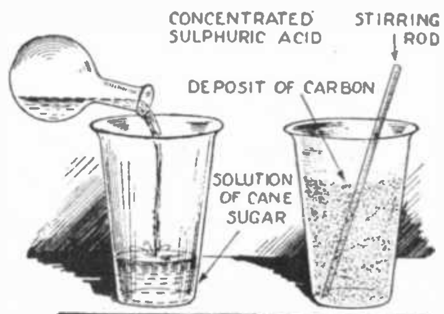
Although the usual examples of combustion result from the uniting of oxygen with some other element, there are a few examples in which this substance takes no part.

One of the most common and one that requires very little apparatus is the combination of phosphorus with iodine.

To prove that there is no free oygen present, we will conduct the experiment in carbon dioxide. The flask (A) is arranged to generate carbon dioxide by the action of hydrochloric acid on marble chips. It is fitted with a two-hole rubber stopper (B) through which are inserted a funnel tube (C) and a delivery tube (D). The flask (E) is fitted with a two-hole rubber stopper through which are inserted the tubes (D) and (G). Now put a few marble chips in flask (A); in flask (E) on one side are dropped a few crystals of iodine and on the other is dropped a small lump of yellow phosphorus about the size of a pea—no more. Now pour some dilute hydrochloric acid into the funnel tube (C). The acid will immediately decompose the marble chips and carbon dioxide will be forced through (D) into flask (E).

After you are sure that all the air has been driven out of the apparatus, tilt the flask (E) just enough so that the lump of phosphorus will roll to the other side of the flask and come in contact with the iodine. In a few seconds the mass will ignite with the formation of phosphorus tri-iodide and clouds of brown vapor will issue from the tube (G).

If properly conducted, the above experiment will prove both interesting and instructive.



Sulphuric acid separates carbon from sugar, an interesting example of carbonization in a solution of a carbohydrate.

Chemical Welding

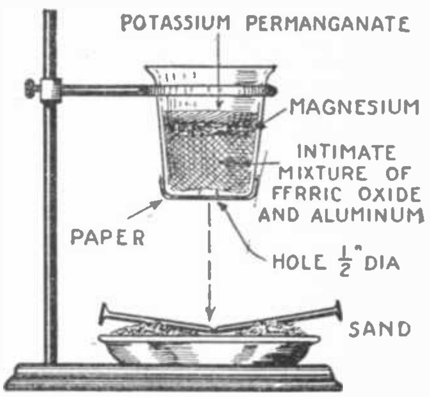
By Jack M. Porter

A very interesting experiment, illustrating the intense heat of chemical action, One Illustration can be performed by anyone with the simplest apparatus and chemicals.

All that is required is an old crucible (or, lacking that a small ten-cent flowerpot serves admirably) with a hole through the bottom. This hole, which the flowerpot always has, is covered by a sheet of paper. Then an intimate mixture of equal parts of ferric oxide and metallic aluminum powder are put in, filling the crucible about half full.

On top of this about 0.5 grams of magnesium is heaped. A few crystals of potassium permanganate are placed in the center of the pile of magnesium and when all is in readiness a few drops of strong sulphuric acid are dropped on the potassium permanganate crystals.

A violent chemical action ensues which starts a second reaction in the iron oxide and aluminum mixture; drops of molten iron run through the bottom hole of the crucible, and if allowed to fall on two iron nails over a tray of sand, the nails will be welded firmly together. Iron pipes can be welded thus so that the joining can hardly be seen.



A simple version of the thermite reaction, where aluminum reacts with ferric oxide, giving intense heat.

Two actions are used in the practical application of this process. Pure melted iron pouring out through the bottom of the crucible may be used to fill holes or open fractures by a sort of autogenous soldering. By using a crucible with no bottom aperture and pouring the melted iron and slag from the top, it becomes only a source of intense heat and will produce welding rather than soldering.

Sulphuric Acid

By Simon Liebowitz

A very interesting experiment to illustrate the remarkable affinity that sulphuric acid has for moisture may be performed with the following materials easily found in the household or laboratory.

Into a long glass beaker is poured about 25 c.c. of a strong solution of cane sugar. (Ordinary sugar dissolved in water.) To this is added a small quantity of concentrated sulphuric acid and both substances are stirred with a long glass rod. Immediately a smoke, or steam vapor, will be observed leaving the mouth of the beaker, while a thick, heavy, jet black deposit of carbon remains at the bottom and up the sides of the beaker.

The beaker may now be inverted without the slightest fear of spilling the remaining liquid, as it has disappeared entirely. Strange? Rather, but here is the explanation: The formula for cane sugar is $C_{12}H_{22}O_{11}$. It will be observed that the ratio of hydrogen to oxygen in this compound is the same as that in water, H_2O, *i. e.*, two parts of hydrogen to one of oxygen. Sulphuric acid combines with the $H_{22}O_{11}$ of the cane sugar and precipitates the carbon C_{12}.

The Ark of the Covenant

By Victor Mac Clure

[What Has Gone Before]

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

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

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

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

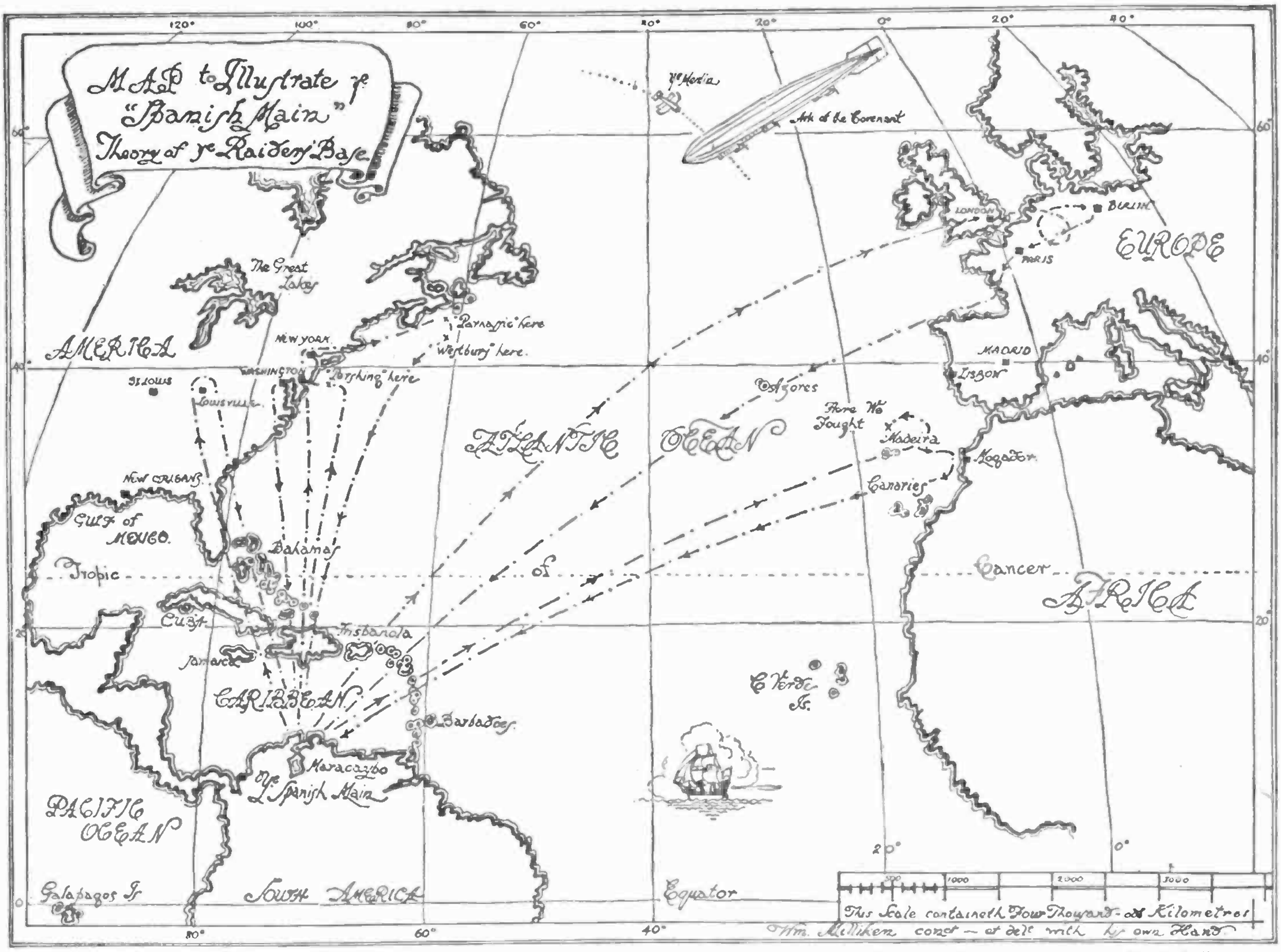
"I was just in time to catch Kirsteen, swaying, as she fell.

A Whiff of the Gas from the Enemy's Airship, the Ark of the Covenant.

Whether it was seeing Dan keel over in that fashion, or that Milliken and I got a whiff of the gas, I can't attempt to gauge, but we both had the symptoms of being pretty sick. I knew that when my mechanic went to fetch a pillow to put under Dan's head, he reeled and went white, while I was as dizzy-headed as could be. Dan was breathing quietly and, despite our anxiety, there seemed no need to inject ether or try artificial respiration as he had showed us.

"Pluck, if you like, sir," Milliken muttered, and very gently he lifted Dan's head and put the pillow under it. That was all we could do, for Dan's shirt collar was open and his clothing loose. We made the little fellow as comfortable as we could.

We were just rising to our feet, Milliken and I, when the cabin shook to a distant thud. A wispy ball of smoke was drifting from one of the barbette guns of the cruiser, and, as we watched, a string of bunting was broken out on her signal halyard.



"Let the reader examine Milliken's map of the North Atlantic at this point, and learn what a curious fellow my mechanic is."

"Look!" said Milliken. "There's a plane up!"

Sure enough, while we had been attending to Dan, the cruiser had catapulted one of her machines into the air, and it already was climbing after the airship.

"Reel out the aerial, Milliken," I said. "We might pick up a message or something."

Radio Messages from all Participants in the Struggle with a Friendly Enemy

I switched into the open receiver as he let the wire down, then we watched the progress of the fight. The aeroplane was climbing steadily and cleverly after the dirigible, which was making no attempt to get away, but as the pink haze still lay about the enemy, I saw that the men in the open machine would be doped before they could attack. I sprang to the radio to warn them if I could—for the aeril was a bit short for sending, since we were afloat—but just then a message came belting across the phone:

"His Britannic Majesty's ship *Brilliant* to the damned pirate: Surrender!" came the voice. "The game's up!"

Immediately came the calm reply.

"Airship *Ark of the Covenant* to H.M.S. *Brilliant:* On the contrary, the game has not yet begun. Don't be absurd, *Brilliant!*"

A second machine flashed off the cruiser's stage, and began to soar after the other. I switched into transmission.

"U. S. seaplane *Merlin* to H.M.S. *Brilliant*," I shouted. "Keep your pilots out of the pink haze round the airship. It is the sleep-producing gas!"

"Thanks, *Merlin*," came an English voice. "That was a jolly good try of yours. Hope you aren't damaged?"

"Don't know yet." I said.

Up above us the first plane opened fire with a machine gun. We could hear the "rat-tat-tat!" of it. But as the sound came, and we heard the warning go out from the cruiser, we saw the plane enter the fringe of the haze. Only for a second after that was it under control. It stalled, then got into a spinning nose-dive, righting just before it crashed flat into the sea. As it crashed, its companion also went out of control on a sudden, though it had not reached the haze. Then it righted, to go gliding down after its fellow.

"That wasn't the gas," said a voice behind us, starting us. "It was some other piece of devilment."

It was Danny, who stood behind us, fully recovered. Milliken and I each grasped a hand of his, silently. Thud-thud! The anti-aircraft guns of the cruiser were speaking. Thud-thud!

"Cease fire, you idiots!" came the voice from the airship. "Stand by to pick up your airmen, unless you want them to drown. We don't want to sink you just yet."

"Sink and be damned to you!" spluttered a British voice.

"Tut-tut!" the calm rejoinder came from the airship. "Don't be so melodramatic. You sound like a penny novelette. Stand by and pick up your men. The first lot are unconscious. Or you, *Merlin*—you do it. Hurry! Your engine is all right and you'll find your area free of the gas."

Certainly the pink haze had gone from our vicinity.

"How about it, Danny?" I asked.

"Take their word for it."

Milliken had the hatch open on the instant, and was down on the floats without harm. The engine picked up as if there had never been anything wrong with it.

As the mechanic climbed in through the hatch and we were taxiing along to the rescue of the downed airmen, we saw the airship assume an angle of forty-five degrees and mount at incredible speed far out of range of the now silent guns of the cruiser.

Presently she was lost in the upper air, apparently heading for the African coast.

CHAPTER XI

The League of the Covenant

I

The Construction, Size and Power of the Great Airship.

We found the pilot and observer in the first machine inert and unconscious, stretched out in their cockpit, which was filling fast. The crash had sprung all their timbers, and we were just in time to drag them out on our floats before the water-logged plane turned nose down, to sink with the weight of its engine. We hoisted both men into the cabin of the *Merlin*, and put their heads against the nozzle of the oxygen cylinder. Then we went on the second machine, a big, amphibious, two-engined de Hamiville fighter.

Here the crew were in better case. They had made a good landing in the sea. They were afloat and cursing their engines, over which they were clambering in an endeavor to locate the trouble that had brought them down. We persuaded them to reconnect their leads and flip over their propellers. To their intense surprise, the engines acted at once.

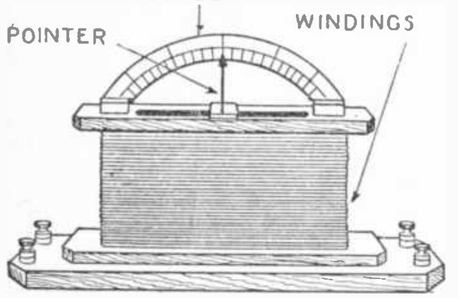
In a little the cruiser came smashing through the seas to us, and a casual hail invited us to breakfast. With the big fighter, the *Merlin* was hoisted up to the landing-platform and snugged down. The air mechanics of the ship took charge of Milliken, and Danny and I were besieged by the commissioned officers. The doped airmen were still unconscious when they were taken from

(*Continued on page* 638)

Sensitive Galvanometer

By Harry L. Elder

THIS instrument presents no great difficulties in construction and will be found to be really very sensitive and of much general utility. It presents several advantages over the simpler types, having a much greater range of sensitivity, not being affected by earth magnetism, and is much more free from the prolonged swinging of the needle. It is, moreover, fairly robust, and, having a double-sided scale, can be seen by several experimenters when working together.



General view of a galvanometer to be made by the experimenter, and which possesses a high degree of sensitiveness.

The illustration gives a clear idea of the woodwork required, and any well-seasoned wood can be used. The pieces separating the top and bottom of the bottom are simply glued into place. Any desired finish can be adopted, a good rubbing with linseed oil serving well and preserving from damp. When the glue is set, cut a strip of thin, strong brown paper 2 inches by 20 inches long. Slightly dampen and then wind it around the two separating pieces and between the flanges of the bobbin, snipping the corners and securing the commencing and finishing ends with a touch of glue. When all is dry, the paper will be stretched tightly and will form a good foundation on which to wind the wire, besides strengthening the woodwork.

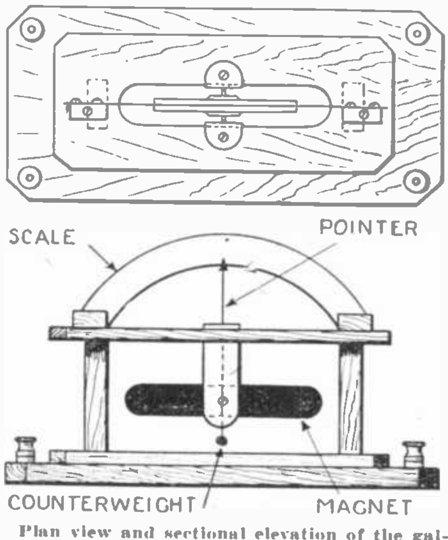
There are two windings of wire. The first is a high resistance winding of two even close layers of No. 36 (or a gauge somewhere near that) D.C.C. The beginning and finishing ends are led through two small holes at one end of the lower flange. This winding is then given a coat of shellac varnish and a strip of paper is laid over it and also shellacked. The outer winding consists of two close layers of No. 20 D.C.C., also varnished, and forms the low resistance. The ends of this layer are led through holes at the other end of the lower flange. A final layer of varnished paper could be put over all if desired.

WOODWORK FOR GALVANOMETER

The wooden frame and base which carries the coil and within which the magnet oscillates.

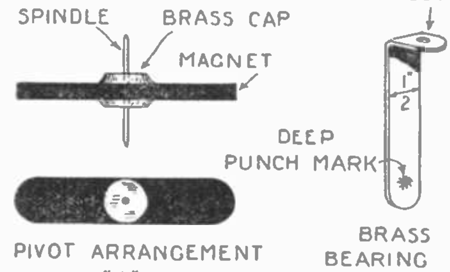
The magnet is made of a strip of steel with parallel sides, as we want the magnet as large as possible, and there will be no need for accurate balancing. Instead of a cap such as is used in ordinary compass needles, a brass boss is formed in the center hole, this being done by cutting off the end of the brass rod quite close to the steel. The spindle is made from a piece of knitting needle which is just slightly too large to pass through the small hole in the brass boss. If the reader finds the steel needle a little too hard to work, he may use as a substitute a small round wire nail, which is quite soft. It will not, of course, be just as good a job, but will answer very well. The ends must be worked up to nice points, which must be quite central and finished very smooth.

Those who are fortunate enough to have a lathe will find no trouble with this, and those without will find a good method is to put the spindle in the chuck of a small hand-drill. This can be held in the vice and turned with the left hand, while a smooth file is rubbed along the rotating end with the right hand. When finished, its over-all length should just exceed half an inch. Now it may be driven into the hole in the brass boss. This may best be accomplished by holding one end of the spindle in the vice and then driving the needle on by using a hollow punch or a little block of metal with a small hole in it. The spindle should project equally on either side of the needle. Magnetizing which ought to be left till this stage, can now be done and the pointer and counterpoise can next be attached. They are made from a bit of the No. 20 wire that was used for the outer winding with the covering removed, of course. They are fastened to the boss with just a trace of solder, a warning being necessary here. Do not make the soldering too long a job or the heat of the iron will injure the magnet. For this reason the magnetization might be left till later, though it is not then so conveniently done.



Plan view and sectional elevation of the galvanometer, showing the counterweight and magnet which give the balance required.

The lower end of the counterpoise is formed of a small loop of the wire filled with a small blob of solder. By holding the ends of the spindle between the finger and thumb, a little manipulation of the counterpoise will cause the needle to come to rest horizontally with the pointer upright. The bearings are very simple (Fig. 16b). Two strips of brass (preferably hard) ½-inch wide, are shaped as shown, and sockets for the ends of the spindle formed by deep dents made with a center punch while the brass is resting on the end grain of a piece of hard wood. The bearings should be screwed into place with ¼-inch No. 2 screws, and the magnet carefully lowered into place so that the ends of the pivot rest in the center-punch marks. Adjust the spring of the bearings so that the magnet can swing freely, but with no chance of slipping.

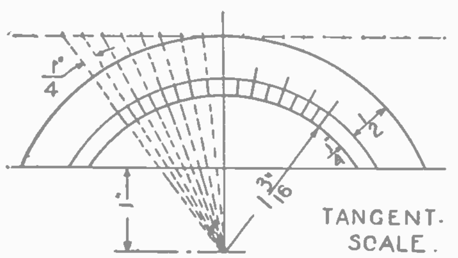


Various details of construction showing smaller parts of the apparatus.

The scale is drawn on a piece of stout white card exactly as shown, taking care that each side coincides with the other. This can be insured by letting the compass point pierce the card and then continuing the center line to the edge. This will give the center line for the reverse side. The measurements along the top line (the tangent) may be anything the maker chooses provided they are all equal. Those in the diagram are ¼-inch. The scale is now cut out. Use a sharp knife, resting the card on a piece of hard wood, and do not try to cut too deep at once. Several light cuts are better than one or two heavy ones. The ends of the scale can be glued to two little blocks of wood which are screwed in place on the top flange.

The whole can now be fitted on the base, after drilling holes in it for the passage of the wires and terminals. Channels should

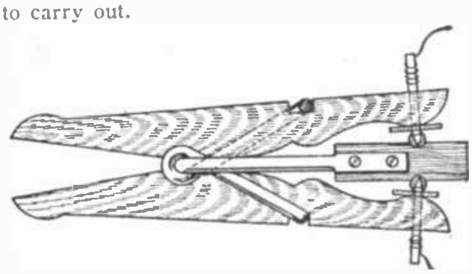
(*Continued on page* 638)

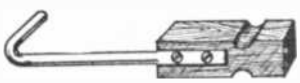


Laying out a tangent scale, so useful in a certain range of experimentation.

Two Wire Clothespin Clamp

SPRING clothespins have many uses and we have already had occasion to describe them to our readers. Here is one which enables instant connection to flexible cords such as used for house connections. The modification of the simple clothespin is easy to carry out.





A spring clothespin is arranged so as to grip a pair of wires and connect them in so doing so as to close the circuit.

Holding it closed, a hole about 1/25th inch in diameter is made through both jaws. The heads are cut off two pins and near the point of each a little brass washer is soldered. The pins are then passed through the holes in the clothespin from within their jaws, and the washers, which have been soldered on the pins, prevent any pressure driving the pins out.

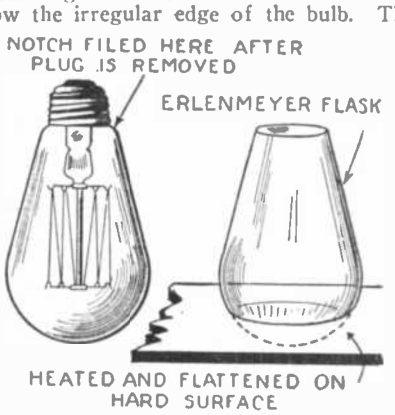
A wire is then soldered to the extremity of each pin. In order to be able to connect the two wires and avoid a short circuit, a little block of wood or ebonite (a b) is prepared, with two transverse grooves and screwed to a bent wire whose bent end goes through the spring of the clothespin, separating the two ends of a double flexible cord. An end is put under each of the pins and the clothespin allowed to close upon them as shown, making an instant connection.

(*Translated from Science et la Vie.*)

Chemical Flasks from "Dead" Bulbs

By Clyde E. Volkers

TO make these flasks is a simple matter. First, tap the brass screw-plug with a hammer. This loosens the cement around the joint between glass and metal. Second, file a neat ring around the bulb a short distance below the irregular edge of the bulb. The

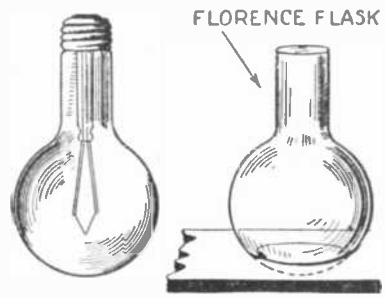


Using burned-out lamp bulbs for the construction of chemical vessels. The larger size will obviously be the most useful.

filing is done in a manner similar to that used in the cutting of glass tubing, except that the notch should be a continuous ring around the top of the bulb. When held in a flame for a few seconds, the glass will break in an even line, following the notch.

The third step consists in heating the opposite end, which will serve as the bottom of the flask in the hot flame of a blast lamp. When the glass has become plastic, press the bulb down on a piece of slate or asbestos board, flattening the rounded portion so that the flask may be stood on end.

The old style bulbs make excellent Erlenmeyer flasks, the pear-shaped bulbs being made into Florence flasks.

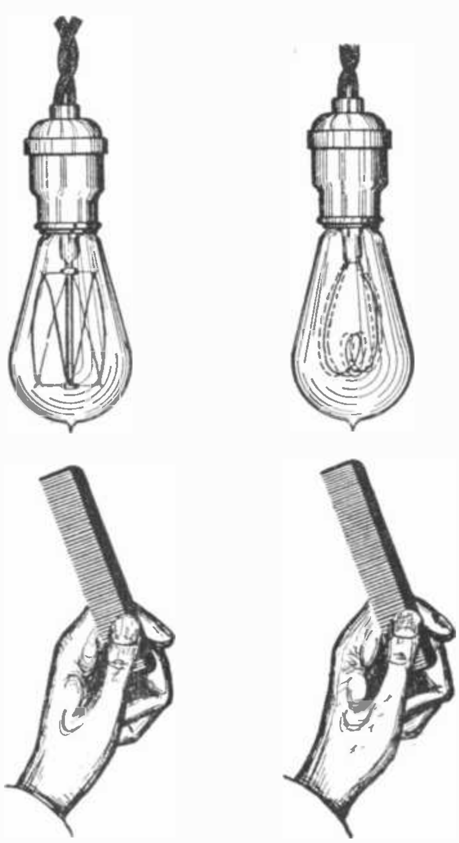


How to make a Florence flask from a large-sized incandescent lamp bulb.

Experiments with a Vulcanite Comb

AFTER drawing a hard rubber comb through the hair several times, hold it close to the chain of someone's eye-glasses. The chain will be uplifted from the person's face and will remain suspended in the air as long as the comb is in close proximity.

Present a similarly charged comb to the bottom of a tungsten filament lamp in its socket. When the comb is within three inches of the base of the bulb, the filament begins to bend outwards in the middle. This curve becomes more accentuated as the comb draws closer until the filament looks dangerously ready to break, especially if it is at



Experiments with an India rubber comb; trying its effect upon a tungsten and on a carbon filament.

all loose. When the comb is presented to the side rather than the bottom of the bulb, the filament nearest the comb is strongly attracted. These effects are no greater but are more easily seen if the light is turned on.

When the charged comb is presented to a *carbon* filament lamp, lighted in its socket, the attraction is very great, even at a considerable distance. As the comb approaches still closer, the filament is seen to vibrate. If the bulb is lying on a table when the

Experiment with the excited comb and carbon filament lamp. The filament is just beginning to show the effects of the excitation.

comb is presented, a loud vibratory sound is distinctly heard. The comb must be kept a considerable distance from the bulb, as the writer broke the filament of one in this manner. This suggests the surprise that would be evinced by a person standing combing his hair under a carbon filament lamp, if the comb came close to the lamp, thus breaking the filament and leaving all in darkness.

Contributed by Arnold Foster.

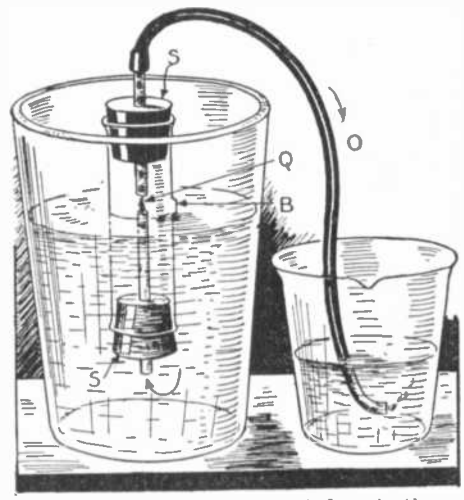
Automatic Syphon

By D. Terriere

PERHAPS the simplest and most curious syphon in existence is shown in the illustration.

The tube (B) is about 1 or 1½ inches in diameter with a small hole at (B) made by blowpipe. Two small glass tubes are fixed in ends of same by perforated stoppers (S). The lower tube does not touch the upper tube at Q, but is separated by about ⅛ inch from it.

When the whole instrument, rubber tubing excepted, is placed in a liquid, and the end (O) is lower than the surface of the liquid the liquid will enter at both I and B.



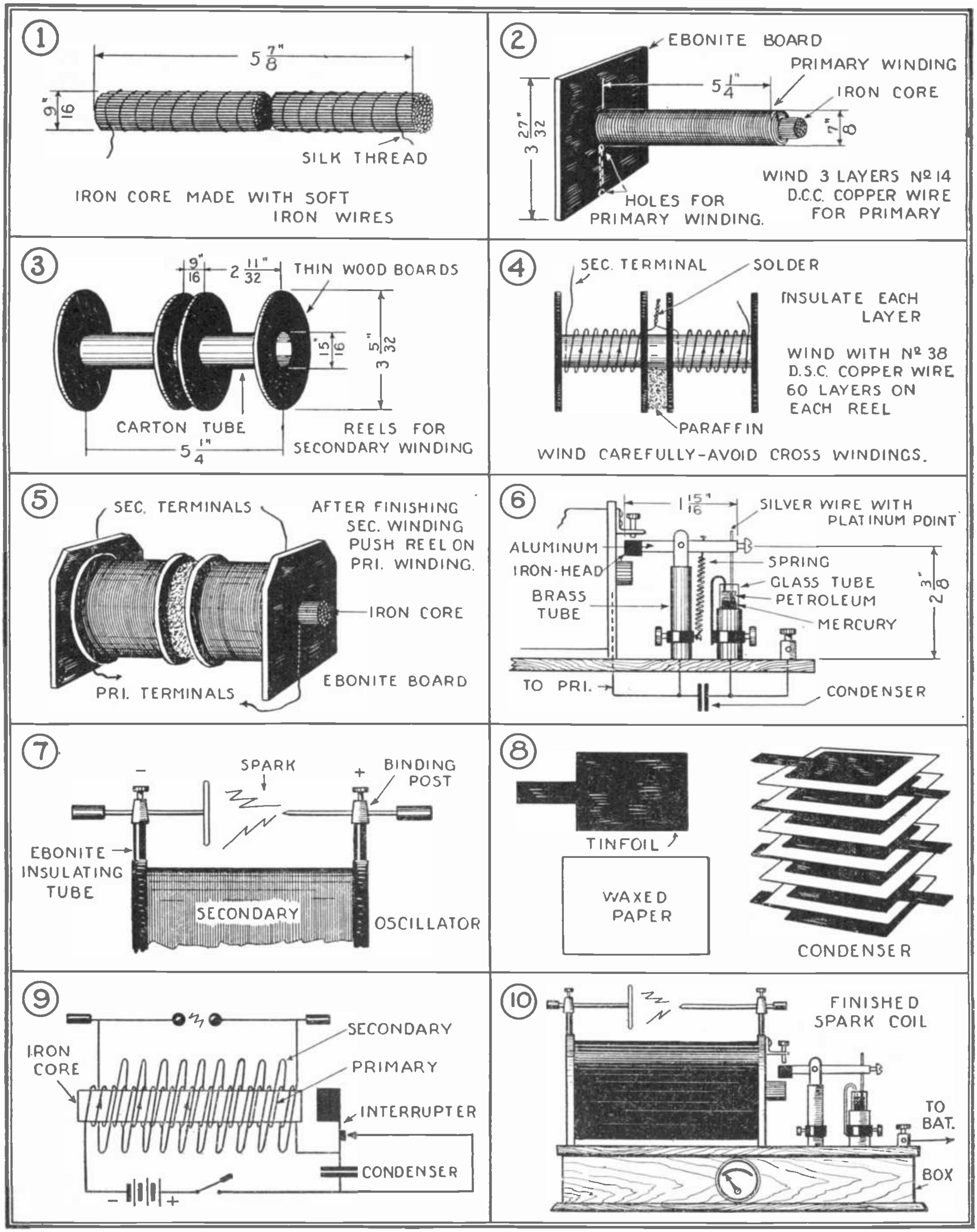
A very curious arrangement for starting a syphon. It will be useful for syphoning battery acids in order to avoid mouth suction.

As it enters B, it compresses the air in the larger tube. This causes the liquid which flows up the longer tube to continue its course upward into the upper tube, and so on out.

It is a very serviceable instrument for the laboratory and functions so perfectly as to appear almost mysterious.

A Four-Inch Spark Coil

By Ricardo Luedeke



1. Laminated iron core made of soft iron wires. 2. Primary winding with terminals passing through end board. 3. Two carton spools used for secondary reels. 4. Showing method of winding the secondary. 5. Space between secondary windings filled with paraffine. 6. An unusual mercury interrupter. 7. Gap adapted for brush discharges. 8. Showing construction of tinfoil and paper condenser. 9. Diagram of connections. 10. An assembled spark coil with condenser mounted in the base.

A Four-Inch Spark Coil

By Ricardo Luedeke

1. *Iron Core:* Soft iron wire 4/100 inch thick is heated over a gas flame until it becomes red hot; then let it cool slowly so that you obtain very soft iron. Insulate each wire by painting with shellac in order to reduce Foucault currents, which heat the core and impair the magnetic action. Bind all the wires together with silk thread.

2. *Primary Winding:* Use No. 14 D.C.C. copper wire and wind three layers on the core. Leave space at both ends of the core, to be occupied by the end boards. Insulate all windings with shellac dissolved in alcohol. The endings of the winding go through holes drilled in the end-boards as shown in Fig. 2.

3. *Secondary Reels:* Make two reels as illustrated. Take a pasteboard tube one inch in diameter and put on wooden end-flanges. Insulate all with shellac.

4. *Secondary Winding:* This is the most difficult part of all the construction. You will need much patience and a little care. Use No. 38 D.S.C. copper wire. Buy three pounds, a little over 20,000 yards of wire. For winding I advise you to use a sewing machine or a film roller such as used in motion picture machines. An emery grinder can be arranged to do it. I wound my coil with a film roller. Wind each reel separately but in the same direction as shown in the illustration in Fig. 4. When both windings are finished, solder the inner terminals. *Take the greatest care in insulating well* every year, by means of waxed paper and shellac. You have to wind about 60 layers, which involves much work, but if well done you will obtain fine results. A four-inch spark is a nice thing!

5. *Secondary Coil Finished:* Once finished, put the secondary coil over the primary coil and put on the end-boards. The space between the two coils must be filled with paraffine poured in while melted to secure better insulation. Cover the outside of the coil with a piece of silk. For better protection make a cover of a thin ebonite piece which has been made flexible by putting it for some minutes in boiling water.

6. *Mercury Interrupter:* From Fig. 6 you will see clearly how to make the interrupter. On the silver wire you must solder a platinum point of one or two mm. 1/12 to 1/25 inch diameter. The screw above the armature is to regulate the length of the path of the interrupter. All metal parts may be nickeled for better appearance. In the glass tube put a little mercury and above it a little petroleum.

7. *Oscillator:* Take two pieces of copper wire 3¼ inches long and about 0.1 inch thick. On one end file a point, on the other solder a circular disc of brass. The binding posts are connected to the terminals of the secondary winding.

8. *Condenser:* This consists of 250 or more sheets of tinfoil, 2½ x 3½ inches, separated by waxed paper 3¼ x 4½ inches; they are put in them alternating, one tag to the left and the next tag to the right. To protect the condenser put it in a box, which may be placed inside the wooden box on the base of the assembled spark coil. To know the exact amount of sheets required, begin with 150 and then measure the length of the spark obtained. Add 20 or 30 more sheets to the condenser and measure again, and so continue until the spark has reached its greatest length.

Take care that the spark produced in the interrupter disappears completely. A well balanced condenser produces the best spark on the oscillator and prevents all sparking of the interrupter. Operate with six to twelve volts.

9. *Connections:* Fig. 9 shows how to make the connections of the different parts.

10. *Assembled Apparatus:* A voltmeter and an amperemeter may be put on the apparatus.

A rheostat may also be connected in the primary circuit, for better regulating the length of spark.

If the spark coil is properly constructed, following exactly all data given here, you will obtain a nice, strong spark. With my coil I obtain a four-inch spark with 10 volts in primary circuit.

Bank with Electro-Magnetic Lock

By Maxim Pick, E. E.

THE action of this bank is based on an electro-magnet through which a lever is moved in order to open the lock. A combination contact arrangement is used so that only those who are familiar with it can open the bank.

Fig. 1 shows the arrangement and wiring of the combination lock. It is reproduced in natural size so that no measurements need be given. (AAAA) is the inner side of one wall of the bank to be made of any wood selected. (D) is a sectional cut of the lid. The various parts are mounted on the board as shown. (M) is the electro-magnet. (H) and (H_1) are lever hooks, the construction of which is plainly shown in Fig. 2. They are screwed to the wood so that they can turn upon the screw. The spiral spring (S) holds them in position so that they lock into the staples (R) and (R_1) fastened to the lid and thus keep the bank locked. If a current goes through the magnet, the broad flaps at the lower end of (H) and (H_1) are pulled against the ends of the magnet—thus opening the lock. (I) and (I_1) are placed about one-eighth of an inch from the ends of the magnet to prevent the spring (S) from pulling the hooks too close together.

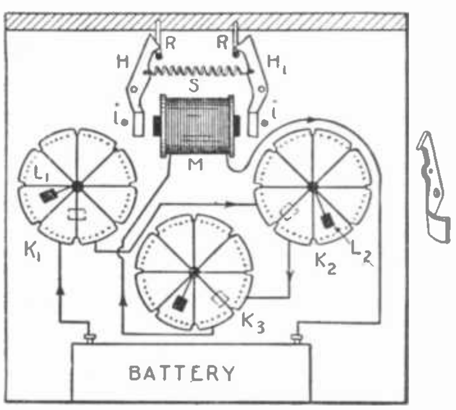


FIG. I

Interior view of the combination electro-magnetic lock. When the three dials are properly placed, the circuit is closed and the magnet M attracts the levers H which release the pins R.

As core of the magnet, a piece of 6-millimeter wire on which the thin wooden spool is slipped is suggested. The spool is wound with copper wire in five layers of forty to fifty turns each, with a layer of paper between each layer of wire.

The combination contact comprises three star contacts (K), (K_1) and (K_2). They consist of three round pieces of wood about two and a quarter inches in diameter, on which three somewhat larger zinc plates are cemented. These zinc plates should be cut down to the wood in eight sectors with a fine saw, so that the sectors are insulated from each other. A hole (I) is made in the outer part of each sector. Strip contacts which can be moved from outside the box by turning a knob make it possible to connect any neighboring pair of sectors desired in the circuit.

The diagram shows the current broken. The full squares (Q), (Q_1) and (Q_2) are the rotary contacts at rest. If these are moved over to the dotted squares, the current is closed and the bank can be opened. Secret marks must be made on the outside of the knob or a regular combination dial can be fitted to them so that the correct position is recognizable for the closing of the contact. The small dry cells obtainable in any ten-cent store are sufficient for the current.

The bank itself is made of wood as a square box with hinged lid. Fig. 2 shows a proposed arrangement that at least is novel and striking. The lock arrangement having been mounted on the inner side of the front wall, the knobs on the outside can be given the form of the two eyes and nose of a grotesque face, as shown in the illustration, which first of all is unusual; and second, affords a means of recognizing the proper contact points.

Fig. 3 is the sectional view of one of these arrangements. (W) is the front of the box. (A) a round piece of wood, about an inch and three-quarters (eye or nose); (Z) a wooden pivot is let into (A) passing through (W) and fitted with a spring at its end

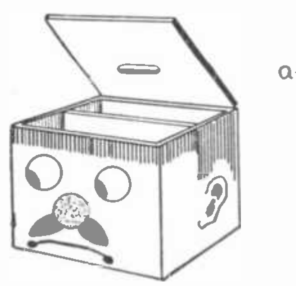


FIG. 2

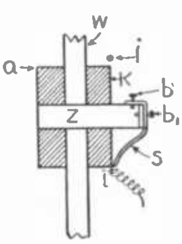


FIG 3

Fig. 2. An exterior view of the bank. The two eyes and the nose form the combination dials. Fig. 3 shows the method of mounting the dials and contactors.

whereby the button is held in place. This spring (S) is also the revolving contact for the star contact plate (K). The spring is fastened to the pivot by two screws (E) and (E_1). The circuit wire is passed through the holes (I) in the protruding part of the metal sectors. This simple way of connecting allows the "combination" to be changed whenever desired. The locking mechanism should be closed off from the "moneyed" part of the bank by a partition (S). The lid is hinged and must, of course, have a coin-slot. In case the battery in the bank becomes too weak to open the magnetic lock, two extra wires leading from the battery poles through the bottom of the bank and ending in two small insulated nail-heads, can be connected to an exterior battery, which will open the mechanism from the outside. Colors can be arranged to suit.

Home-Made Oscillating Rectifier

By Siegfried Langsdorff

THE special dry cell tubes are receiving more and more attention in wireless. With them it is possible in one and two tube apparatus to use simple dry batteries for heating the filament, but these batteries are not adapted for long periods of use, when a very constant potential (as for example in receiving a distant station with newly installed back coupling) is essential.

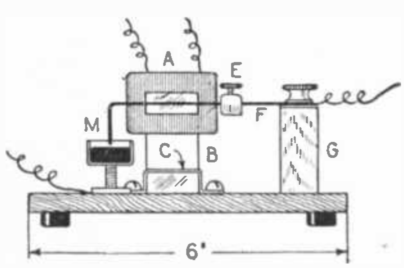
The potential of the dry batteries gradually goes down during the discharge; in contrast to this the action of the storage battery right up to its point of complete exhaustion still shows two volts potential. In all cases where a longer period of use is required, according to my belief, the future will give us tubes which will require less current than those now in use, which exact the use of an accumulator for heating the filament.

If storage batteries are used, the question of charging comes into the foreground. If you have direct current available, the storage question is a simple one. It is only necessary to use sufficient resistance (easily calculated by ohm's law) based on the maximum charging currents of the accumulator in use), which resistance must bring the current down to the proper value.

In introducing in the circuit a resistance coil, the charging becomes exceedingly uneconomical, if the circuit is one of high potential. In this resistance, the greater part of the energy taken out of the lighting circuit, which we are assumed to be using, will be wasted, and only a small percentage will be used for charging the battery.

In using a direct current for charging, the great point will be to have the potential of the battery to be charged as large a per cent as possible of the potential of the circuit. This makes it clear why the installer who can charge a large number of battery cells at one operation, can do it much cheaper, than when only a single cell has to be charged.

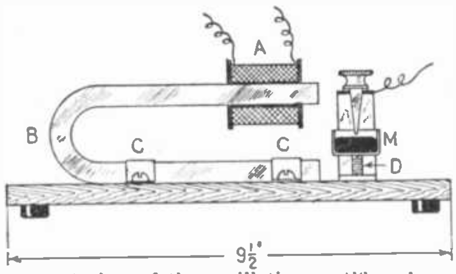
In the case of alternating current, the potential relations are much more favorable, because by a transformer it is easier to get a proper potential for charging any given battery without any considerable loss. If a rectifier is used, it will only permit the current to go through it in one direction. This can be attained in various ways. In what is to follow an oscillating rectifier will be described in detail which is sure to give satisfactory results and may be termed a simple home-made apparatus.



An oscillating spring tuned by a sliding weight makes and breaks the circuit in a mercury contact cup.

The principle of the oscillating rectifier consists in the contact of a vibrating arm that oscillates in synchronism with the changes in the alterating current, which only lets the current go through when it comes in a given direction, so that when it is in the opposite direction the current is completely cut off. We give sectional, both side and end views, of the apparatus. The intermittent contact is here brought about by a vibrating steel spring (F), which when in operation makes a contact with its point (S) in a cup of quicksilver. As may be seen in the illustration the spring is close to a pole (P) of a permanent magnet (M).

The steel spring (F) follows the changes in the flux of lines of force. A perfectly



Front view of the oscillating rectifier shows the shape of the magnet core and the contactor at the end of the vibrating reed. For best operation the normal position of the reed should be slightly above the center of the core.

synchronous operation of the make and break will only be attained when the spring is in mechanical synchronism with the frequency of the alternating current. In practice this is easily brought about mechanically by giving the oscillations of the spring a higher frequency than the normal frequency of the alternating current, and the final exact adjustment is given by a little weight (G) clamped to the spring, which is eventually permanently fastened at a given distance from the post (U).

The magnet coil (Sp) is placed upon one limb of the horseshoe magnet (M); the winding of this coil corresponds to the polarity of the particular limb on which it is placed. For 8-volt potential some 25 yards of a very fine insulated copper wire are wound.

It is not greatly to be recommended to make the transformer yourself, as they can be bought of the right type in the stores. It is well to select one with several taps for different potentials. The secondary winding of this transformer must stand a current running up to 2 amperes for a prolonged period. The secondary winding will represent 8, 12 and 20 volts. It is obvious that the transformer must be adapted for the circuit used, which will usually be one of 110-volt potential.

The hook-up of the rectifier is also shown. In parallel with the spring contact, there is a condenser of 0.5 to 2.0 microfarads capacity for getting rid of the sparking. One can replace the permanent magnet by an electromagnet which will be excited by the accumulator to be charged. In this last arrangement there is also the advantage that after the hook-up is properly arranged, it is immaterial which pole of the storage battery will be connected to the terminal binding post of the rectifier, as it is only after the closing of the accumulator circuit that the electromagnet is excited. An accidental wrong connection of the accumulator is impossible, as the polarity of the electro magnet is then automatically changed and the proper polarity is again obtained.

In case of different numbers of cells to be charged, it is advisable to permanently install a tap-switch for the different taps of the transformer. For controlling the rectifier, it is advisable to connect into the charging circuit an ampere meter, which will pass a current of about 3 amperes. A variable resistance from 1 to 10 ohms should be installed in the same circuit, which instrument must stand a continuous current of 2 amperes. It is for regulating the charging current. The mercury contact cup must be so placed that the spring when at rest will not dip into the liquid, so that the circuit will be open.

The adjustment of the spring is so disposed that the operating magnet will be very close to the spring, and then the distance of the adjusting weight of the spring from the supporting post will be changed about so as to give the greatest amplitude of motion to the spring. The tuning is made very sharp, and it is only by perfect tuning that the satisfactory operation of the rectifier will be brought about.

The amplitude of the oscillations of the spring can be changed over a certain range by varying the distance from the permanent magnet, which normally is from 2/10 to 4/10 of an inch. This amplitude is independent of the strength of the magnetic field, due to the magnetizing coil. It should not be too great, as this will throw the quicksilver out of its vessel. The spring is best made of sheet steel about 1/50th of an inch thick, and it may be from ⅛ to ¼-inch wide. The complete length of the spring is about 3½ inches. About 6/10ths of an inch of the length is used in attaching it to the post (U). The corresponding portion at the other end of the spring, which is to dip into the quicksilver at (M), is about the same length as can be seen in the diagram, Fig. 1 and 2, and is bent down and sharpened to a point.

In operation the height of the meniscus of the quicksilver must be such that the spring closes the circuit at the instant when the current is changing in direction. At this instant there is no potential so that the rectifier operates without any spark whatever. The perfect installation of the rectifier is best accomplished by using a slight secondary circuit with resistance in circuit.

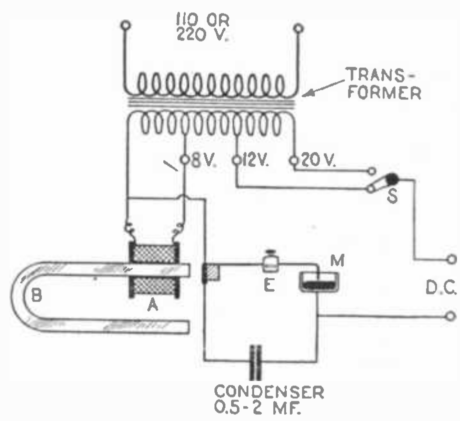


Diagram of connections of the oscillating rectifier. A half mfd. condenser is used across the interrupter to suppress sparking.

It is only after the exact regulation of the weight (G) of the spring upon the synchronizing apparatus and by the adjustment of the height of the quicksilver by the adjusting screw (Sch), that the successful operation of the rectifier is obtained.

The rectifier just described, properly adjusted and installed, will take care of charging currents up to 2 amperes at 4 to 6 volts potential. It is obvious that the dimensions here given need not be followed to the ultimate detail; the critical thing is that the principle of operation be understood and all changes and improvements will be easily applied by the amateur.

Iron-Clad Lifting Magnet

By William J. Edmonds

THE small iron-clad lifting magnet described in the article can be made to serve many useful purposes. In the construction of the device there is nothing very difficult, as a glance at the diagrams will reveal.

The first thing in the construction of the magnet will be the iron coil, which is 1⅞ inches in diameter by 2½ inches long. The method of producing this field piece involves the procuring of a piece of 1½-inch pipe, 2½ inches long. A 1½-inch pipe will be found to have an internal diameter very near 1⅝ inches, so the dimensions are all based on this size. The ends of this pipe are turned or ground off exactly square with its axis and the inner top edge is slightly beveled.

An iron disc is next made, having an outside diameter equal to the inside diameter of the pipe. This disc also has a ¾-inch hole drilled in its center. This disc is now soldered or, better, brazed into the end of the pipe as shown. The center core is a piece of round iron ⅞ inch in diameter by 2¼ inches long, with a shoulder turned on one end ¾ inch in diameter by ¼ inch long. This is now riveted into the circular disc before it is brazed into the pipe.

In the center of the upper end of the disc and core a hole is drilled and tapped for a ¼-inch eye-bolt which is made of ¼-inch diameter stock, as this magnet, as small as it is, is capable of holding a very good weight. The field may now be smoothed up on the exterior, which will improve its appearance considerably.

The winding is next made and it will be necessary to make a special winding bobbin as shown in Fig. 2. This winding bobbin can be turned to shape from soft wood. To make this it will be necessary first to turn a cylindrical mandrel having a diameter of ⅞ inch. A block of wood 3 inches in length, having a ⅞-inch diameter hole bored through its center, is next inserted on the mandrel and turned to form the bobbin or form. No. 18 single covered magnet wire is used on the coil and the form is filled to the level of the end flanges. The form can be driven on the mandrel held between centers of the lathe while the winding is done. After the winding, the mandrel is withdrawn and the coil is thrust over the central core of the magnet body.

The terminals are left sufficiently long so that connections can be made with old battery binding screws on the outside of the iron shell. The two wire ends are inclosed in small fibre or rubber tubes (spaghetti) and holes are drilled in the tops of the magnet shell large enough to permit these tubes to pass through. The ends of these wires are then soldered to battery binding screws as shown. This finishes the magnet, with the exception of the armature, which may or may not be constructed, although this armature will be found very useful in connection with the magnet.

The armature is constructed from a piece of flatiron or cold rolled steel of a diameter of 1⅞ inches and a thickness of ¼ inch. This disc has a ¼-inch diameter hole drilled centrally through it, in which an eye-bolt made of ¼-inch diameter round iron is passed through, riveted over and brazed in place.

The magnet can be made to work satisfactorily on different voltages and current values by using the proper size and amount of wire in the coil.

This magnet is capable of lifting a considerable weight when the coil is excited, and it may be found quite useful in the study of various magnetic fields as well as in many laboratory experiments.

There are many varieties of this type of magnet. Sometimes a solid block of iron will have a channel annular in contour turned out of the solid, and in this the actuating coil will be embedded. Magnets of this type have very high power of traction, however, with one feature that as a rule their tractive force is very limited in its range of action: while such magnets will hold an armature with great power, practically they will attract only from a very small distance.

Two of these magnets laid face to face will exercise great force even with little supply of current, comparatively speaking. A moderate current will hold them so that two men can hardly pull them apart, and the term "Electric Magdeburgh Hemispheres" has sometimes been applied to them, although we doubt if the Otto Von Guercke test of great teams of horses have ever been applied to try their force of adhering to one another.

The magnetic circuit produced by this type of magnet is quite characteristic. One effect of the jacketting or enclosing the coil in a mass of iron is that the outer stray field is almost nonexistent and the whole force of the magnet is concentrated.

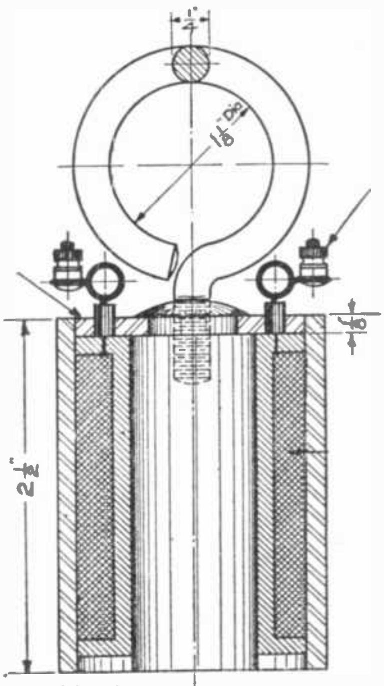


FIG. 1.

A small sized but powerful lifting magnet can be constructed with very little difficulty by any amateur experimenter. Its essential features as shown above are a solid iron core about which the exciting coil is wound and a soft-iron cylindrical case slipped over the coil and constituting part of the magnetic circuit. By the use of this iron case the strength of the magnet is considerably increased.

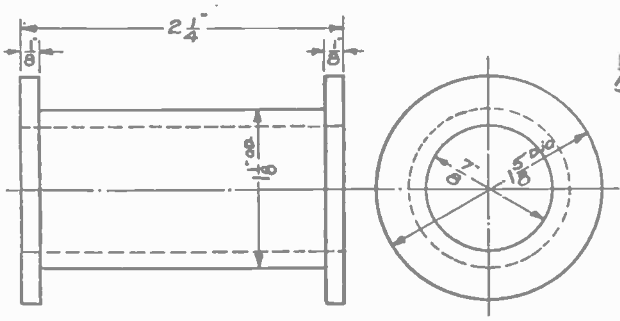


FIG 2

A detail drawing of the insulating hollow core which serves as a frame for the exciting coil.

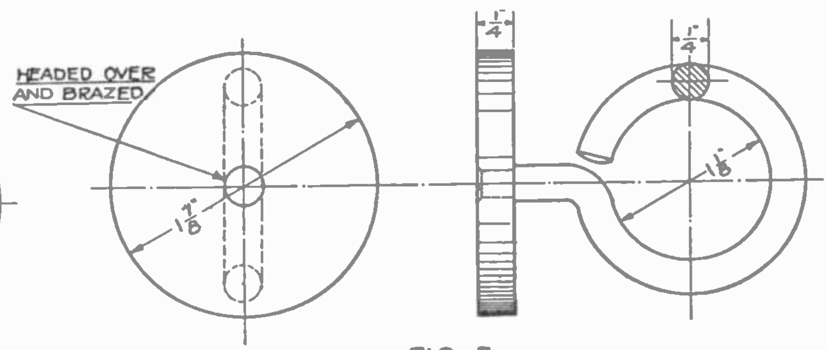
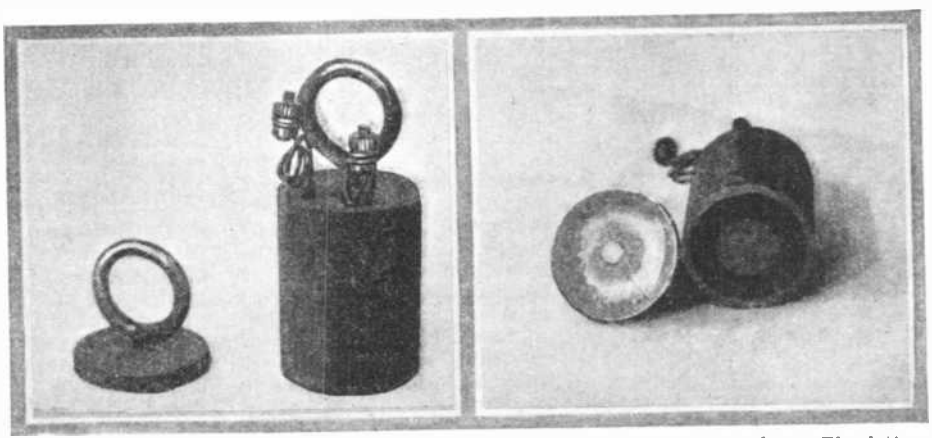


FIG 3

The iron armature plate of the lifting magnet to which a strong hook is attached.



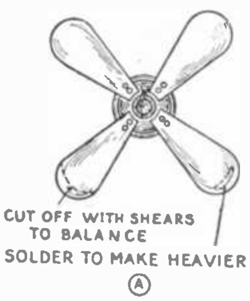
The photograph shows the completed lifting magnet and its armature plate. The latter closes the magnetic circuit beween the central core and the surrounding iron sheet. Note the terminals at the top of the coil.

Repairing Electric Fans

By H. Winfield Secor, Associate Member, A.I.E.E.

ELECTRIC fans, although quite perfect when they leave the manufacturers' hands, are subject to several ailments after a year or two, and some practical hints of interest to the amateur fan repairman are given here:

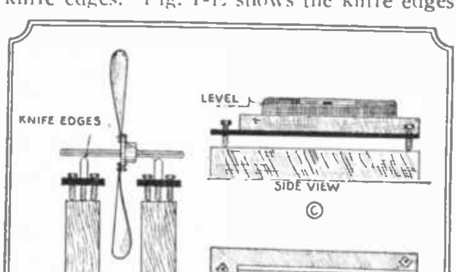
A trouble not easily located with electric fans is vibration, sometimes manifested by considerable noise. This rumbling, readily distinguished by an expert, is frequently due to the fact that the fan blades as well as the rotating armature are not correctly balanced. To check up on the balance of the blades, as well as the armature, we resort to a pair of knife edges constructed as shown in Fig. 1. These so-called knife edges are generally made from two pieces of T-iron, provided with three pointed bolts



Electric fans frequently become noisy due to the fan blades being out of balance mechanically. In the present article details are given for balancing fan blades, as well as armatures, and the picture at the left shows how to lighten a blade by cutting off a circular strip on the outer edge; or to increase the weight of the blade with solder.

threaded through the ends in the manner shown. By means of a spirit level the two straight edges, which have their upper edges filed to V-shape and perfectly straight, are leveled both lengthwise and across the two upper edges, so that the plane of balance is level in all directions. A fan blade may then be mounted on a dummy shaft or else on the shaft with the armature, as shown at Fig. 1-F, and the balancing then proceeded with.

To balance the fan blade or fan blade and armature, there are several tricks. The blade or blade and armature are properly balanced when they can be turned to any one of several positions on the balancing knives and remain there without turning. If any of the blades are too heavy to make perfect balance, this is evidenced by the heavier blade swinging to the bottom, and this blade may then be trimmed around the outer edge with a pair of tinner's snips. Another method is to place solder, by means of a soldering iron and flux on the outer edge of a light blade or a thin piece of brass or a washer may be riveted on the outer edge of the same blade. The quantity of solder or other weight added or subtracted in any case has to be changed until the fan blade will remain stationary in any position on the knife edges. Fig. 1-E shows the knife edges

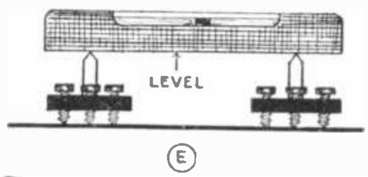


Above we see how the two knife edges are leveled for balancing a fan blade. The blade is fitted on a shaft of the proper size. When properly balanced, it should remain in any position without turning.

being cross-leveled, while Fig. 1-F shows a fan blade with the armature being balanced simultaneously. Where this is done, the rotating element is balanced by inserting a length of flattened solder in one or more of the armature slots, as shown in Fig. 1-G, and in some cases holes are drilled in the armature laminations, as shown at H, but this is not desirable. The flattened strips of solder are forced into the slots on the upper or lighter side of the armature, and this method of cut and try is followed until the rotating element of fan blade and armature will remain stationary in any position on the knife edges.

Commutators and Brushes

The commutator and brushes need a little attention now and then, in addition to the essential filling of the fan grease cups with vaseline every season. It is well to examine the brushes, removing them from the brush holders, as in some cases they may be used up and need replacing. In some cases it will be found that the brushes have become stuck in the holders and merely rest up against the commutator, which is a very bad condition, causing burning of the commutator surface and sparking. When replacing carbon brushes, care should be taken to properly face them in contact with the commu-



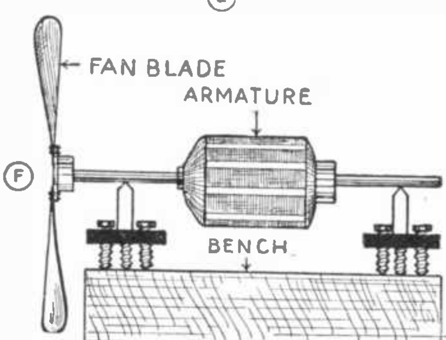
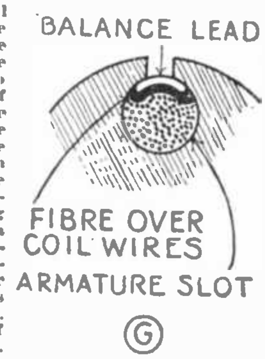


Fig. E shows level across the blades, and Fig. F shows preferred method of balancing fan blade and armature together. Mark fan hub and shaft, so that fan will be placed in the same position after assembling in motor.

tator, as shown in Fig. 2-A and B. This is done with a strip of sand-cloth or sandpaper (never use emery cloth) held by the fingers and pulled back and forth, pulling the cloth toward the commutator, so that the curvature of the brush face will conform perfectly to that of the commutator. Otherwise sparking will occur and also undue heating due to the small area of contact between brush and commutator.

Another method of using the sand-cloth or sandpaper is to place a strip around the commutator, as shown at B, holding the two ends together with the fingers of one hand, and then while squeezing tightly on the ends of the sandpaper, rotate the armature back and forth through one-fourth of a revolution when the brushes will be ground to shape nicely. Blow out all carbon dust after properly facing the brushes. Occasionally small motors such as used on fans are fitted with woven wire brushes, and these can be faced almost to the correct curvature of the commutator by means of a half round or rat-tail file, and then finished with a piece of sandpaper or cloth in the manner just described for carbon brushes.

Alternating current fan motors frequently have an automatic centrifugal switch mounted on the rotor, which comprises two semi-circular brass segments normally held against two stationary contacts by means of two spiral springs. Occasionally alternating current motors overheat and the cause is



There are several ways in which the armature can be balanced. One of the best methods is to flatten a piece of wire solder and drive it into a slot on the "light side" of the armature, as shown in Fig. G at the right. This is usually possible, taking care to see that a piece of fibre is placed over the coil before the solder or strip of brass is driven in the slot. Various lengths of metal may be tried.

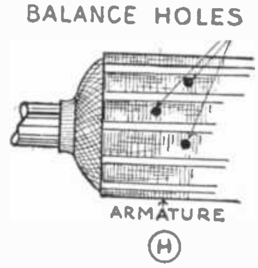
often found to be due to the fact that these contacts have become gummed by oil or grease, or perhaps a spring has broken and they do not work properly. They should open the circuit of the starting winder by flying outwards as the rotor reaches normal speed. Such automatic switching devices should be thoroughly cleaned with gasoline or other liquid, and then lubricated with a little light oil on the sliding parts.

Removing and Replacing Commutators

In making repairs to armatures and commutators, it is frequently necessary to remove the commutator from the shaft for replacement by a new commutator, or for the purpose of rewinding the armature. The simple jig shown at (C), (D), (E) and (F) at Fig. 2 serves to remove the commutator easily. This is made from a few pieces of wrought iron bar, using 1/4 x 1 1/2 inch stock for the pressure bar (a) and 1/8 x 1 inch stock for the two bottom members (b). These lower members (b) are linked together, as shown at Fig. 2-E, one of the links having a slot, as shown, so that when pulled outward, the two members can be pulled apart, and placed behind the commutator and over the shaft, as shown at (C). After all of the armature coil leads have been unsoldered from the commutator and bent out of the way, the split member (b) is placed behind the commutator, and the top member (a) in position at the end of the shaft.

Next the two bolts are put in place, and by applying pressure with a wrench on the

In some cases where balancing weights cannot be driven into the coil slots as shown in Fig. G above, holes may be drilled in the "heavy side" of the armature, these holes being bored into the iron core teeth. This method is not recommended except in an emergency, where other methods cannot be applied.



nuts, the commutator is gradually pulled off the shaft. In some stubborn cases, heat may have to be applied to the commutator to expand it, and where it is badly worn and has to be replaced, it has occurred that the segments must be removed and the commutator shell turned off the shaft in the lathe, or else cut with a hack-saw, so that it can be ripped off. This latter case was one where the commutator shell had rusted fast to the shaft. A trick to remember here is that by applying heat to the commutator shell or similar member on any machinery and applying ice or ice water to the shaft or inner member, the expansion of the heated part working conjointly with the contraction of the inner cooled part will give sufficient clearance so that the two can often be separated, when they will not yield to unaided mechanical pressure.

To replace a commutator after repairing or in the case of a new one, it can be driven into place on the shaft as shown at Fig. 2-G, placing the end of the shaft on a piece of fibre, lead or end wood, so as not to damage the shaft when driving the commutator down on the shaft by means of a piece of pipe. Care should be taken in doing this work that the segments be aligned in exactly the same position, as were those of the old commutator before removal. This is checked by means of a file mark corresponding to one of the mica divisions, placed on the armature core. In resoldering the leads the same care is necessary, *i. e.*, to see that the leads are brought down from each coil in exactly the same position or angle as they were before disturbing them. This is important in fan motors because the brushes cannot be moved or swung around on the commutator to find the neutral commutating plane. In soldering leads on commutators or on any other joints around motors and dynamos, a non-corrosive soldering flux should be used, the proper flux being available at any electrical supply store.

One of the most ticklish jobs that the fan repairman meets is that of machining the commutator after it is in place and the leads have all been soldered into the slots of the new segments. It should have been mentioned that commutators without slots can easily be provided with them by means of a hacksaw before placing in position on the shaft. Old slots are cleaned of solder in the same way or else by means of a hot soldering iron and a piece of fibre or cardboard drawn through the slots while the segments are hot. At Fig. 2-H is shown the use of a finishing tool for machining the commutator face. The principal point to learn in *turning down* commutators, as it is called in the shop, is never to take a heavy cut, and also to be thoroughly sure by pulling on the belt and spinning the armature around between lathe centers, that on the first cut across with the tool, it will not meet any high spots and cut in too deeply so as to rip the commutator to pieces. The first cut across may only remove metal from a few high spots, but this is the safest plan, gradually working the tool in on each cut. Or such small commutators as those of fan motors, it will be best to traverse the tool back and forth by hand and not try to use the gear feed of the lathe, as this has frequently spelled disaster, for the reason that the tool carriage clutch could not be released quickly enough with the result that commutator segments were thrown all over the shop, not to mention the broken leads on coils which necessitated rewinding the whole armature and a brand new commutator.

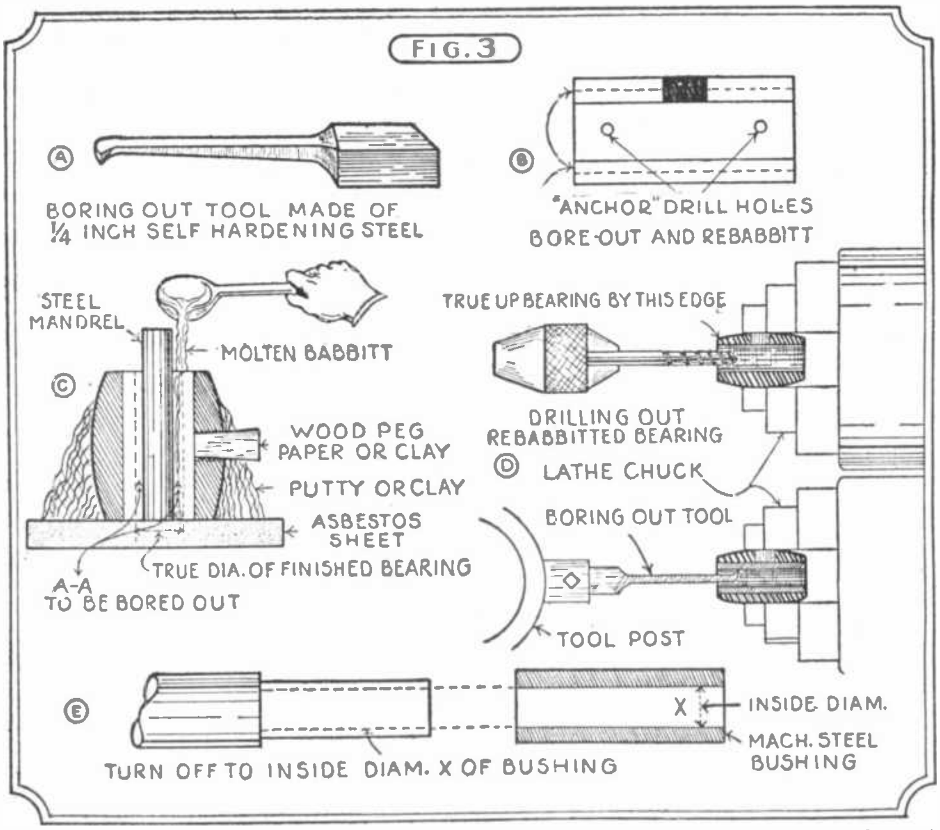


Fig. 3 above illustrates a number of interesting details in the repair of small motors including those used for electric fans. The cheapest method today is doubtless to replace worn bearings with new ones. These cannot always be obtained, however, when desired, and therefore, details are given in the text for boring out worn bearings and renewing them by lining with Babbitt metal. The steel mandrel shown at "C" should be greased or graphited to prevent the Babbitt metal sticking to it, but if it has a smooth surface, it can be driven out with a few sharp blows of the hammer.

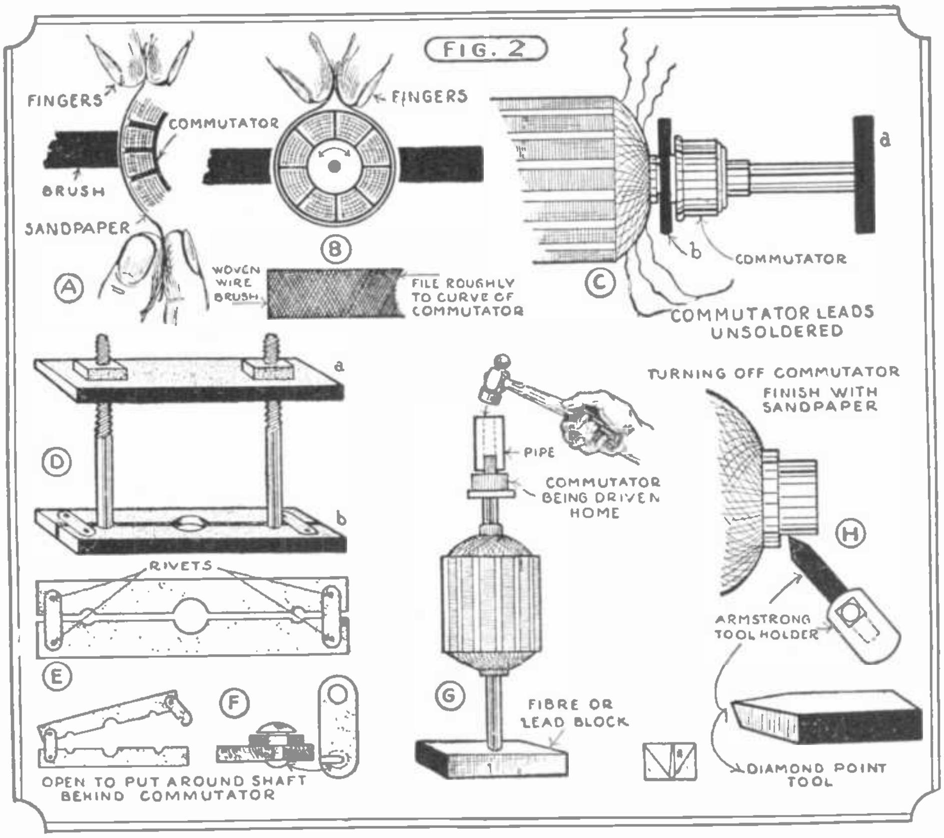


Fig. 2 at left shows several practical hints in grinding and adjusting brushes on fan and other small electric motors, as well as a few ideas for removing and replacing commutators and machining them in the lathe. All soldering of connections should be done on the commutator before it is machined. The diamond point tool shown is easily ground from a piece of self-hardening steel, and is held in an Armstrong tool holder. After machining, the commutator is finished with fine sandpaper

The writer usually preferred a tool of the type shown at Fig. 2-H, comprising a piece of self-hardening steel ground in the manner shown, and held in an Armstrong tool holder. Care is necessary in setting the tool so that its edge does not strike the lugs on the commutator segments when making the finish of a cut. After using the tool to machine the commutator down to the point where the tool is cutting the copper evenly all around, this operation may be stopped and the commutator may be smoothed up with a fine file and then finished with fine sandpaper. The mica between the copper segments is sometimes undercut below the level of the copper by means of a broken hacksaw blade.

Repairing Bearings

Badly worn bearings should be replaced with new ones obtained from the manufacturer. If these cannot be obtained from the local electrical shop, the data on the name plate should be included in a letter written to the manufacturers for new bearings. This is the simplest and best way of meeting this problem. Where this cannot be done, then the bearings may be bored out with a small boring tool, as shown at Fig. 3-A. The worn bearing is held in the jaws of the lathe

(Continued on page 634)

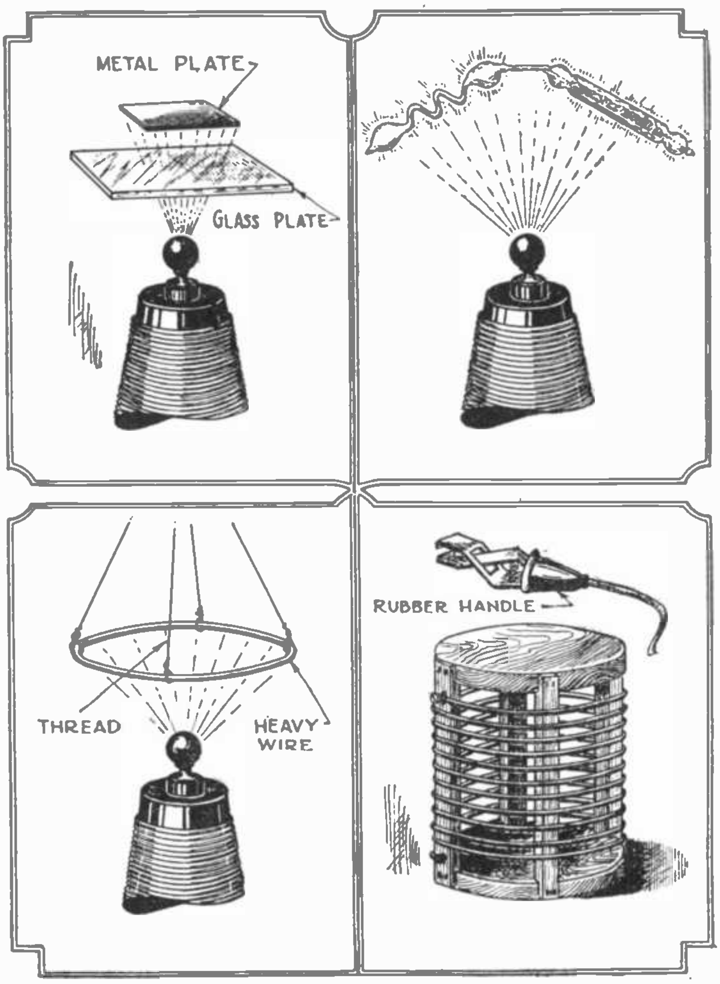
Experiments with Tesla Resonator

By Kenneth M. Swezey

YOUNG experimenters usually possess an insatiable love for the spectacular, and, goaded on by this desire, they often plunge into the construction of a piece apparatus, the uses of which they know less than nothing about. Practically everybody has a sufficient understanding of Tesla coils to realize that, when properly excited, they have a tendency to shoot off flaming sparks and violet streamers. Few—a very few—know that these coils are not mere scientific toys to be played with, but are practical, everyday instruments of industry.

Tesla resonators were once used for wireless transmission, and the circuits which the noted inventor used in his original experiments —in the early 1890's—were never surpassed, or even approached, until about 1914. Today they are used in electro-therapeutics, in the treating of illness, of induction, by direct application, or by application through vacuum tubes, and in supplying energy for X-ray tubes; in high frequency electricity plant culture; in the testing of high tension insulators; and in the high frequency electric furnace. Scientific laboratories find other uses, numerous and varied. Tomorrow a modification of the resonator will again be used to transmit radio telegraphic and telephonic communications around the world—and will also be used as the oscillating piston of a Brobdingnagian system of world power transmission.

For those who have a Tesla resonator, and for those in particular who built the one according to the directions in the November issue of THE EXPERIMENTER, I will dwell for a moment upon the auxiliary apparatus that is essential for the proper working of the coil; for this shares equal importance with the resonator itself.



Contrary to what appears to be the law of electrical currents, high frequency, high potential currents from a Tesla coil will pass readily through thick panes of glass to a metal plate held above it.

The familiar Geissler tube is here made to glow with its usual fascinating display of brilliant colors, without any metallic connection to a source of current.

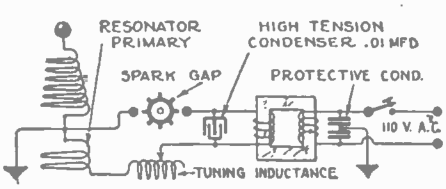
A beautiful brush discharge can be drawn from the terminals of a Tesla coil by suspending a few inches above it a large ring of copper.

The illustration at the right shows the tuning inductance to be used in series with the primary of the Tesla coil. Connection to it is made by clips such as that shown above.

The transformer has been mentioned, and the condenser has been described in a separate article. A fused switch should connect the transformer with the A.C. power line, and care should be taken to see that the fuses used are of sufficient size to carry the current necessary to operate the transformer under full load, yet small enough to amply protect the meter and the house wiring. It is a wise policy to provide a pair of protective condensers, or protective resisters, connected across the transformer primary, and grounded in the center, to safely carry off any possible high tension kick-back surges. The condensers should have a capacity of two microfarads each, and should be connected in series, the joining connection being led to the nearest good ground.

If you only want to use the coil for a series of short intervals, it may be more convenient to connect a radio transmitting key in series with the transformer than to close and open a knife switch.

An important item that must not be neglected is the spark gap, for the voltage and rate of flow of the current in the secondary of the resonator depends largely upon this. Any arc that forms is simply a short circuit and an extravagant waster of energy. A quenched or a rotary gap is preferable to the ordinary open gap, but even this latter may be made fairly efficient, by providing the electrodes with large copper flanges and having a fan blow on it. However, the other types will increase the spark length at least a few inches over the best obtainable with the open gap.



Above is a diagrammatic view of the electrical circuit used in connection with the Tesla resonator.

The author suggests an arrangement of tinfoil strips as shown above to form a sparkling electrical advertising display.

No resonator will perform properly unless the primary and secondary circuits are tuned carefully to resonance. In fact, almost every experiment requires a change in tuning to be most effective. This is accounted for by the variation in the capacity of the secondary high-potential terminal, due to the different pieces of apparatus used.

The physical limitations of a high tension condenser prevent its being made variable, except in comparatively large steps, and therefore the alternative, the variable inductor, will have to be used. One of these may be constructed easily and cheaply by winding about 30 turns of No. 6 or 8 bare copper wire around a skeleton form, made of well seasoned wood, eight inches in diameter. Space the turns at least a half inch apart. A clip may be made as shown, out of a springy piece of brass or phosphor bronze, provided with an insulating handle.

By adjusting the amount of inductance in the primary circuit, the top of the resonator can be made to throw off anything from a delicate purple haze to a crashing spark. This article might have been illustrated with some more photographs of different effects, which, with the aid of a tuning device, the coil is capable of producing, but the violet tinged phenomena has thus far proved too elusive for the camera, and the prints invariably lacked the detail and beauty of the original.

High potential electricity at high frequencies seems to disobey all the laws of common currents, and offers to the lay mind just one continuous string of paradoxes.

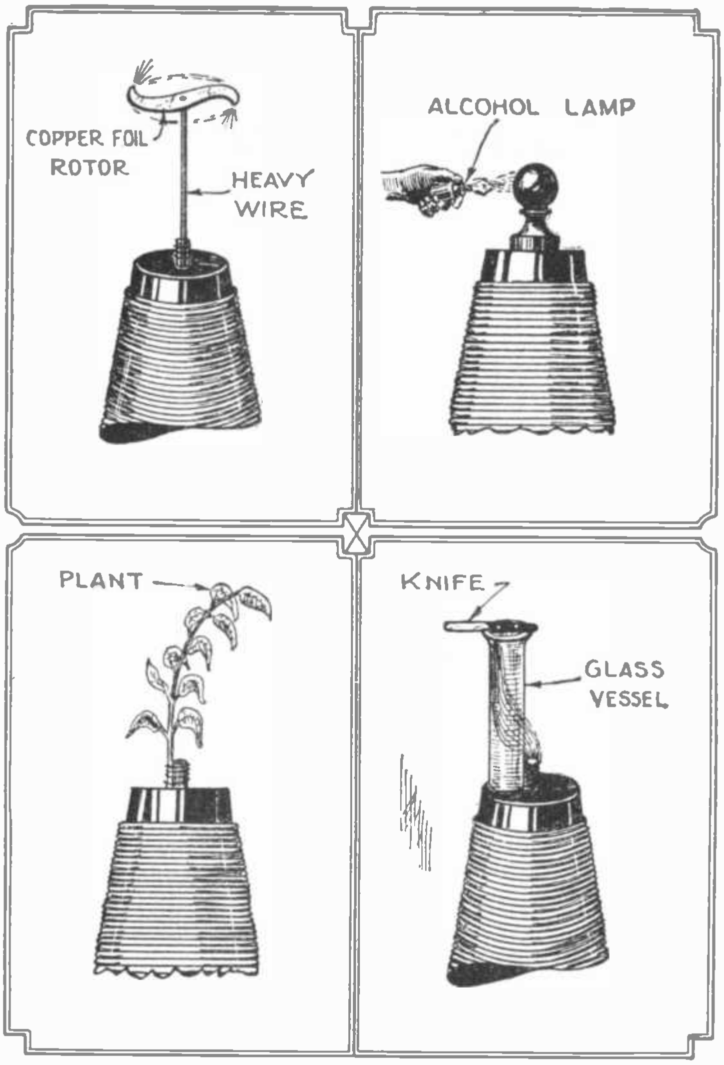
A most impressive experiment is to show the long sparks jumping right through a thick plate of glass, to a metal object suspended above it, and then show the same sparks jumping to a piece of metal held in the bare hand. The sparks will pass readily through the glass at first, seemingly making no hole, but finally the glass will puncture. Sparks will jump through the glass of old electric lamp bulbs held in the hand. The sparks destroy first the filament, then the vacuum by perforating the glass with tiny holes. Eventually a piece will break out.

The higher the frequency of the current, the nearer to the surface of a body it will travel, just as the material in a centrifuge clings more and more closely to the walls as the speed is increased. It is for this reason that high frequency currents are practically harmless to life, and hardly any sensation is felt up to a million or two volts.

There is absolutely no danger with the resonator described last month, if care is taken to keep away from the circuit in which the secondary of the power transformer is included. It makes little difference whether the connecting wires are insulated or not—unless you use cable with special high tension insulation—for if you touch them you are liable to get a nasty shock. Ten to twenty thousand volts, at a low frequency, and with a power of almost a kilowatt, can, under favorable conditions, do considerable damage. With a condenser shunted across the secondary, the ends of two iron wires used as a spark gap melt like sealing wax, and the molten material first gathers in globules and then drips down. A sixty cycle, high voltage, shock is positively the most sickening thing one can imagine.

Geissler tubes may be brilliantly lighted by holding them several feet from the resonator. If they are connected in series with a large loop of a few turns of heavy wire, and the loop is tuned to resonance with the high frequency coil by means of a variable condenser, they can be lit at distances much further away—demonstrating in a limited manner one system of radio power transmission. With good tuning, and a correct apportionment of power, ordinary electric light bulbs may be substituted for the Geissler tubes—the induced current lighting the filament to its usual brightness.

A metal alcohol lamp, held in the hand, can be lit by sparks from the ball without any difficulty. The only precaution necessary when approaching the ball is always to have some metal object closer than your hand. The more surface the metal has, and the tighter you grasp it, the less you will feel the current. Sparks that jump directly to the skin sting a little, and if prolonged cause burns. However, burns derived in such a way are just the same as ordinary burns, and do not possess the deadly characteristics of X-ray burns.



A small copper-foil rotor mounted on the terminal of a Tesla coil will rotate, impelled by the slight force due to the reaction to the electrical brush discharges emitted by its pointed tips.

An alcohol lamp brought near the terminal of an excited Tesla coil can be lit by the sparks drawn from the coil. This is only possible because alcohol has an extremely low ignition point, for the Tesla discharge has as a rule a low temperature.

The high frequency current of a Tesla coil will cause plants connected to the coil to wither. A peculiar characteristic of high frequency discharges is their tendency to adhere to insulating surfaces, as illustrated at the right.

A person can directly grasp the ball without experiencing any sensation whatever. And another person can draw sparks from any part of the first person's body. The alcohol lamp can be lit from his finger, his nose, or his tongue. With the great capacity of the body, considerably more inductance will have to be added to the primary circuit to compensate for it, and the experimenter can be given a higher charge if he stands on a chair. Occasionally stings are felt in the feet; these are due to sparks jumping to the nails in the shoes, and can be done away with by removing the shoes.

An experiment can easily be performed that beautifully illustrates the fact that the sparks are thrown off into the air with considerable force, and that they have a tendency to push against the air. Remove the ball—if it is removable—and fasten a heavy upright wire to the axis of the coil. The top of this wire should be sharply pointed, or else a needle should be bound to the end of it. Then cut a piece of copper foil, about three or four inches long, in the shape shown in the illustration. Balance it perfectly on the pin by cutting little bits off the heavy side. When the resonator is excited, a beautiful corona will branch out at different points of the upright wire, and heavy sparks will shoot out from the pointed tips of the foil rotor. Slowly at first, but rapidly gaining speed, the rotor will revolve, being pushed around by the flying sparks. If this experiment teaches nothing more, it drives home the fact that where high tension currents are to be conserved, points should be avoided. Electricity that would ordinarily break through insulation a foot thick can be kept in its place without the slightest loss, by providing a terminal of sufficient size for the requirements at hand without any points or angles.

Although the high frequency currents do not penetrate very deeply, they in some way increase the circulation and warm up the blood. Much experimenting with a large coil will prove this. Dr. Tesla told the writer that in his younger years he used to stand on the high potential terminal of one of his huge oscillators, and allow his assistants to raise the voltage up to three million. At that pressure he was covered with sparks, and his legs felt almost as though they were burning up. A live plant fastened to your small resonator will heat up greatly shortly after the application of the current.

High frequency currents like to follow insulating surfaces, and the spark length can be increased considerably by including an insulator in the path. It is for just that reason that high voltage insulators are usually corrugated—giving them greater surface for actual physical length. Stand a tall glass jar alongside of the terminal of your coil, and place some metallic object on its upper end. The sparks will seem to enjoy following the surface of the glass.

Spark letters are quite easily made and give an exceedingly pretty effect in the dark. They are made by pasting a strip of tinfoil on a glass plate, and then cutting the foil in the form of letters or designs, leaving little gaps so that the sparks will have a jump across to reach their destination. These gaps require much thought in their arrangement, and each gap must be made a b s o l u t e l y uniform throughout its length. There are various ways that are permissible, but the gaps must be so arranged that sparks must jump across each one, there being no other way around. It is certainly a test of ingenuity.

By making a ring of copper wire, and centering it exactly, a few inches above the ball, a lovely cone of sparks can be formed, or a closely interwoven brush discharge—depending upon how it is tuned. The sparks will liberate much pungent ozone into the air.

These experiments are but a few, and are not exhaustive by any means. Others may easily be devised by the thoughtful and alert experimenter. He should remember that the vast field of high frequency law and phenomena has as yet been comparatively little investigated. Furthermore, it is the most promising field that is offered this and the coming few generations to explore.

Electrical Notes

Eight hundred and thirty-nine nails, one hundred and sixty-three wood screws, and forty pounds of metal help to give a telephone booth a total weight of two hundred and seventy-five pounds.

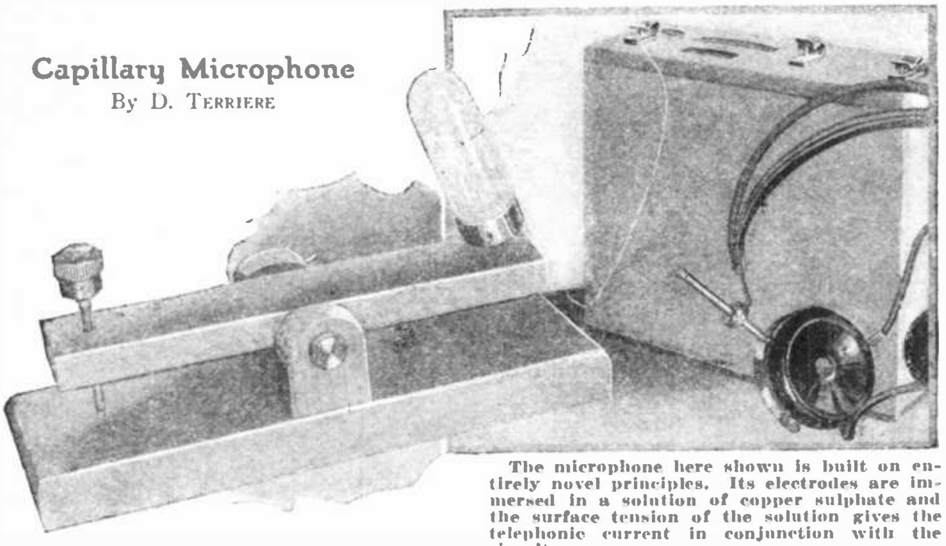
More than a ton of ink is used to print the year book of the Western Electric Company. As many as 248 manufacturers are represented by approximately 65,000 different items in this catalog.

The world's telephone workshop—which is the Chicago works of the Western Electric Company—has forty thousand employees who produce and assemble 110,000 dissimilar parts. This compares with a prominent automobile plant which employs 60,000 persons to produce and assemble 3,000 dissimilar parts.

And now in New York a telephone building is fast approaching completion which will be the largest one in the world. It will be 480 feet in height, comprising 29 stories, and looking out over the Hudson River and the New Jersey shore and hills. Its basement goes down for five stories. Eight central offices are to be housed therein, and these will serve an average of 15,000 telephones each. It covers a complete block, so that each story, counting for nearly an acre, it figures out as having 25 acres of floor space and it will accommodate 6,000 workers.

Capillary Microphone

By D. Terriere



The microphone here shown is built on entirely novel principles. Its electrodes are immersed in a solution of copper sulphate and the surface tension of the solution gives the telephonic current in conjunction with the circuit.

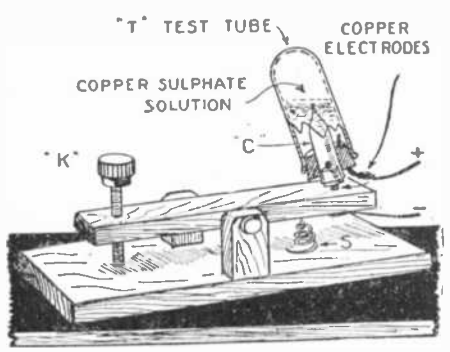
A NEW microphone operating upon the capillary action of an electrolyte is illustrated. The cost is practically nil, as all the parts are quite certain to be found in the experimenter's junk box.

A short length of glass tubing (C) is drawn out into a capillary point as shown. The orifice should be approximately 0.2 to 0.3 millimeters (1/50 to 1/75 inch) diameter. A short length of test tube T is inverted over the capillary tube and is filled with a solution of copper sulphate. The rubber stoppers securing the tube are shown in dark tint in the diagram.

Copper electrodes should be used as they remain neutral to the copper sulphate solution, whereas iron would be dissolved.

The microphone is mounted on a fulcrum on a base, balance-beam fashion, and is held in position by means of the screw (K) at one end and the spring (S) at the other, as shown in the illustrations. In operation, the screw is adjusted so that the sub-base, or the rocking-base, permits the meniscus of the copper sulphate electrolyte in the large test tube to just graze the capillary end of the tube (C).

The proper operation of the device is as follows: If a watch is placed on the base, the tilting arm will rock slightly and lessen the tension between the capillary opening and the meniscus, resulting in a variation of resistance. This microphone works best connected in the ordinary way, using about 15 volts, and a low resistance 5-ohm receiver.



Vibrations communicated to the capillary microphone cause a change of resistance between the two electrodes by changing the position of the meniscus.

Rectified H. T. Circuit

By Belgrave F. Gostin

THE following experiments were carried out at the suggestion of *Practical Electrics*, and have given satisfactory results.

In Fig. 1, the transformer T. was an Acme .2 k.w., 8000 v., sec. It is necessary

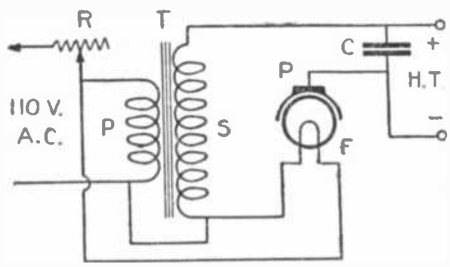


FIG. 1

An effective single-tube two-electrode rectifier using a step-up transformer and supplying high potential D.C.

to insert a power rheostat in the primary of the transformer to cut down the power to about 100 watts.

The rectifier tube B. is a 50 w. globe. "CAUTION: Use only a nitrogen globe, a tungsten was first used and the filament was shattered as soon as the current was turned on." The "PLATE" of the rectifier is a tinfoil coating glued on the globe, covering about ¾ of the surface. The connection to the plate must be made by a strip of tinfoil wrapped around the plate; if copper wire is used the current will be concentrated at the end of the wire and the globe will be punctured. These two cautions cost me several globes before I learned better.

The condenser may be a glass plate type of 11 plates or more.

Be sure all connections are well separated and insulated, and above all, handle the experiment with care.

In Fig. 2 the same transformer was used with the addition of two condensers and another globe.

The condensers in this circuit should be at least 25 plates (5x7) each. The center tap is negative and the filament positive. Two tubes may be used in parallel on each side if desired, but I have drawn as much as 40 Mil. Amp. from a single tube in No. 1 hook-up and a pair in No. 2 hook-up. No. 2 is the best circuit in that it gives a full wave rectified current.

This method has successfully been used at H.T. on a C.W. transmitter of 50 watts.

Many other uses will suggest themselves to the experimenter.

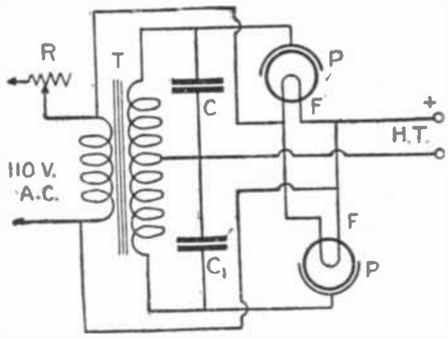
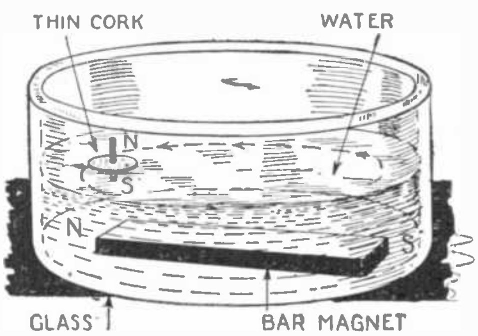


FIG. 2

A two-tube rectifier supplying high tension D.C. In this circuit both halves of the wave are utilized.

Paths of Magnetic Curves



A very simple experiment with a bar magnet and a polarized needle, illustrating electro-magnetic curves by the motion of the needle floating in water sustained by a cork.

A SIMPLE yet effective way of showing the laws of magnetism (like poles repel, unlike poles attract) is shown in the accompanying diagram.

A steel needle is magnetized by rubbing one end on a north pole and the other end on a south pole of a permanent magnet. The needle is then forced through thin cork, the two ends, N_1 and S_1, projecting one above and one below. A bar magnet is laid at the bottom of a vessel of glass, porcelain or aluminum, not of sheet tin or galvanized iron, which is partly filled with water allowing one end of the needle to project towards but not touch a pole of the magnet.

If the cork does not move, it is because the adjacent poles, needles and bar are unlike. If, however, the cork moves away, describing a curve, and settles at the other end, it is because like poles were in juxtaposition.

The cork should then be inverted placing N_1, where S_1 was or vice versa. The cork will again describe a curve. The shape of the latter will depend entirely upon the position of the needle relative to the magnet pole, being different when placed over the bar, than when placed next to it. This illustrates magnetic principles very clearly.

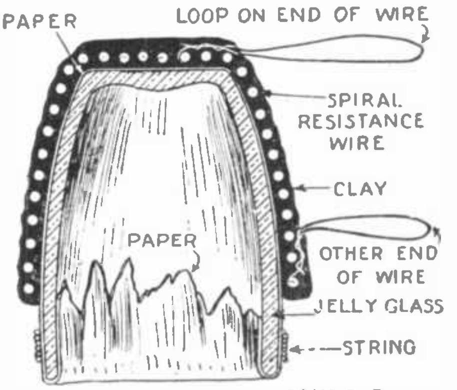
—*Contributed by Raymond A. Lepesqueur.*

Notes on the Electric Crucible

(*See* The Experimenter *for May*, 1925, *page* 480)

Since I described my electric crucible, I have made another and in so doing have developed a few improvements.

Instead of using a piece of copper wire for the terminals or ends of the resistance wire, make a 3- or 4-inch loop at the end of the wire and have about 2 inches of it extend out of the clay.



CROSS SECTION SHOWING CRUCIBLE BEFORE GLASS AND PAPER ARE SLIPPED OUT

In this electric crucible a heating coil of resistance wire is imbedded in the clay of which the crucible is made and a jelly glass gives the shape.

Instead of coating the spiral wire with clay, work the clay into the spiral so that there is a solid core of clay and wire, then when coiling into a crucible place between the coils rolls of clay about the diameter of a lead pencil both to separate them and bind them together.

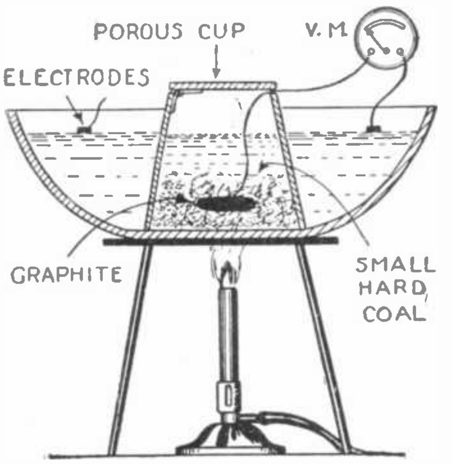
To get a good shape, fold a piece of thin waxed paper over the bottom end of a jelly glass. Fold the ends of the paper into the glass, then wrap string around the paper at the top of the glass to hold it on tight and smooth. Turn the glass bottom up and begin coiling the wire and clay rolls at the center of the glass and squeeze them together smoothly.

When through coiling, coat inside and out with clay ⅛-inch thick.

Contributed by Ray Duncan.

Carbon Consuming Battery

By D. Terriere



An interesting experimental heat-cell in which carbon is consumed during the generation of current. The carbon electrode is located in a porous cup.

WE have with us wet, dry, heat, actinic and gas batteries. Chemical action abounds in all of them, at the expense of some element or electrode of each.

In the sal-ammoniac and in the dry battery, there is the seemingly imperishable carbon element, which comes through the ordeal of "collecting" and passing on the current without a mishap. The carbon element can be used over and over again, year in and year out. The other electrode alone is attacked and used up.

A carbon-consuming battery is depicted here. It consists of a dish, such as an evaporating dish, containing a porous cup with a loosely fitting cover. The dish contains a mixture of 80 per cent. powdered and fused borax (borax glass) with 20 per cent. manganese dioxide.

The two, well mixed, are placed in the dish and an electrode E is connected with it, such electrode being in the form of a ring. A piece of graphite or a bunch of pencil leads are the other electrodes and pulverized hard coal is packed around. The whole is heated to a high temperature with a Bunsen or other burner.

With 8 square inches of coal surface, the voltage produced was 0.9 volt and the amperage 0.184. The internal resistance of the cell in action is therefore 5 ohms.

One theory of the carbon-consuming cell is that the manganese dioxide (used also in dry cells) is reduced by the hot carbon (coal) and its density (weight) changes (due to loss of oxygen) and it rises to the top, where it is oxidized by the air from the loosely fitting cover; and the process is again repeated. The voltage drops off as the carbon (coal) is used up.

Experimenters should try out one of these cells. The manganese dioxide can be taken from old dry cells by boiling the contents with water, filtering and using the black powder on the filter paper after drying it. It is impure but will serve the purpose.

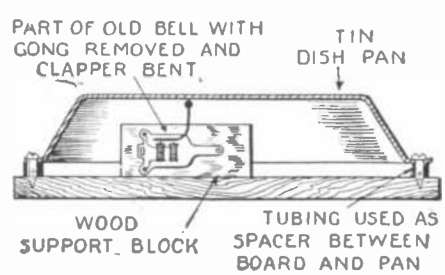
Bell with Dishpan Gong

IT is sometimes desired to have a loud-ringing gong attached to the door bell or signal bell, especially when one is working outside, but the expense attached to the purchase of a large brass gong is out of proportion to the benefit derived therefrom.

An old electric bell, with the small gong removed and the clapper-rod bent, makes an excellent substitute, when used with a metal dish pan. The magnet-box assembly of the bell is mounted on a small wooden block, and the block in turn is fastened, with brackets, angle-irons, or small wooden strips, to the supporting board. This mounting allows the clapper of the bell to vibrate at right angles with the wall or other support. Over this arrangement fasten the pan, allowing the bottom to be close enough to the clapper to be struck, but not so near as to prevent vibration.

The pan should be fastened to the wall with sheet-iron supports or wooden blocks and screws, allowing about an inch between the rim of the pan and the wall, so the sound will not be muffled. The result is not exactly musical, but is certainly effective, and can be used where the quality of the sound is not objected to.

—Contributed by Richard C. Tarr.

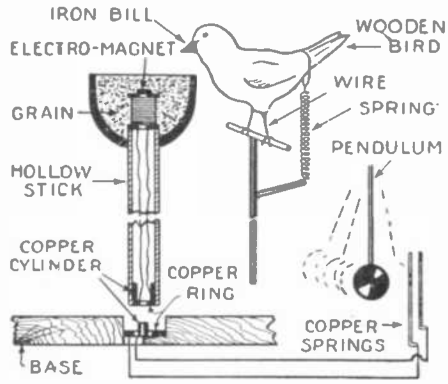


Experimenters who do not find the usual bell sufficiently annoying may construct a more noisy gong out of a dishpan mounted as shown.

Automatic Bird

THIS bird will peck steadily at a bowl of corn; but as soon as one pulls out the stick supporting the bowl to show there are no wires, it will stop and wait patiently until the corn is put back again.

The bird is carved from soft wood. Anyone with a sharp knife and several bright paints can make one that is presentable. It is mounted on a cross piece with a light spring fastened to its tail. An electromagnet made of a bolt about 1½ x ½-inch wound with No. 22 S.C.C. wire is placed in the bowl and covered with some grain. A hole is drilled in the bottom into which a hollow stick for the wires is pushed.



This novel electromagnetic bird will continue pecking at the grain in the small tray so long as the pendulum at the right continues swinging and closing the copper spring contacts. If the tray with its supporting rod is removed, the bird stops pecking.

The other end of the stick has a copper circle on the bottom and a cylinder inside. The wires are soldered to these. The hole in the base in which the stick fits has a cylinder to fit inside the first and a circular piece to make connections with the other. These connections go to dry cells and a mechanism to control the regularity of the bird's nods, as the magnet pulls down the iron bill painted like the real one.

One method is with the pendulum of a clock. It strikes two copper springs which are long enough not to affect its swing, thus making a connection periodically.

—Contributed by Arthur Flinner.

Body Capacity

By J. Bront

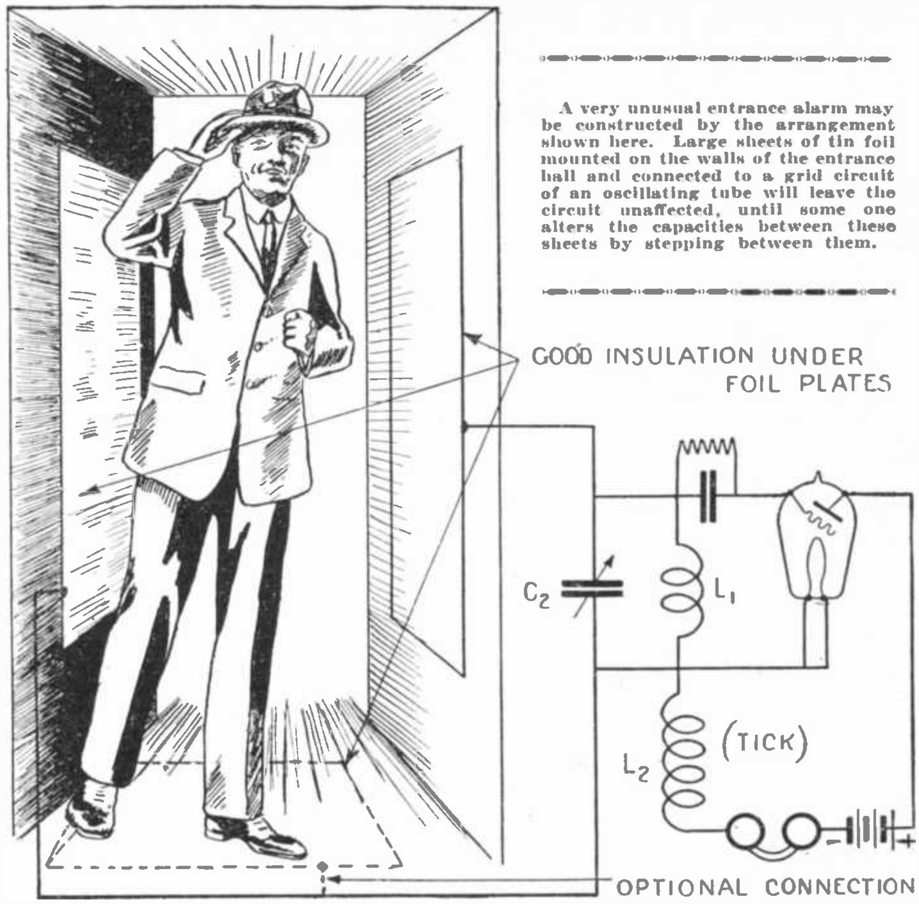
BODY effects may be noticed if large size capacity plates are placed in a narrow door or passage way and connected to a receiver balanced on "dead beat." One of the plates may be placed on the side and one on the flooring, or else both may be affixed to the wall.

The plates may be of foil and must be well-insulated from possible conducting paths, which might cause leakage or grounding. Leads from the plates are run to the grid circuit of the regenerative receiver.

For good results, the grid circuit should incorporate as small an inductance as possible and still allow oscillations with tightest coupling with the tickler coil. The shunt condenser tuning the grid circuit should be as large as available.

The receiver is balanced on "dead beat." Care and patience may be necessary in doing this, but it can be effected after some little maneuvering and will stay on that point for a considerable time if undisturbed.

An assistant should then walk through the narrow passage or doorway. The slight detouring of the circuit caused by the body capacity effect in relation to the foil condenser plates will unbalance the "dead beat" adjustment and the receiver will howl, notifying the listener of the passage of the assistant near the foil plates. Adjustment of grid leak and "B" battery may be necessary to aid in satisfactory results.



A very unusual entrance alarm may be constructed by the arrangement shown here. Large sheets of tin foil mounted on the walls of the entrance hall and connected to a grid circuit of an oscillating tube will leave the circuit unaffected, until some one alters the capacities between these sheets by stepping between them.

Self-Feeding Arc Lamp

By George Vatchen

DESIRING to construct an arc lamp for photograph and experimental purposes, which would operate satisfactorily on a six-volt storage battery for an appreciable length of time without need of adjustment, the author designed one similar to that described below.

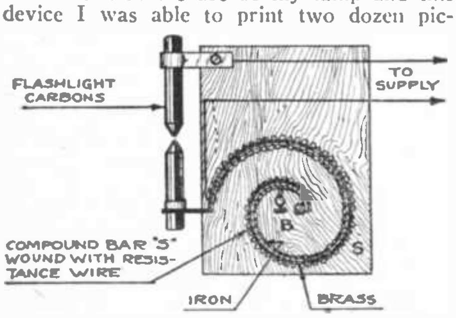
In the diagram the spiral, S, consists of a strip of brass about ten inches long and three-sixteenths of an inch wide, and a similar strip of iron, which are riveted together in at least three places after being bent into shape. This spiral is covered with a thin layer of some insulating material, such as fibre, over which is wound two feet of bare No. 18 copper wire, connected as shown.

B is a small screw with which to adjust the spiral, and thus vary the initial distance between the carbons, C and C'.

In operation the screw, B, is adjusted so that the carbons, C and C', just touch. This causes current to flow through the coil wound around the spiral, slightly heating it, and since the brass strip expands more than the iron, it bends inward, thus "striking" the arc. The light will then operate automatically for a considerable length of time.

This method of automatic feeding may also be used with heavier currents by having larger wire on the spiral.

To further convey to you the fine qualities of this type of feeding, I might mention that with the use of my lamp and this device I was able to print two dozen pictures, exposing them at a distance of about two feet, without further adjustment of the light. I have also been able to make good "portraits" with it by employing suitable screen reflectors.



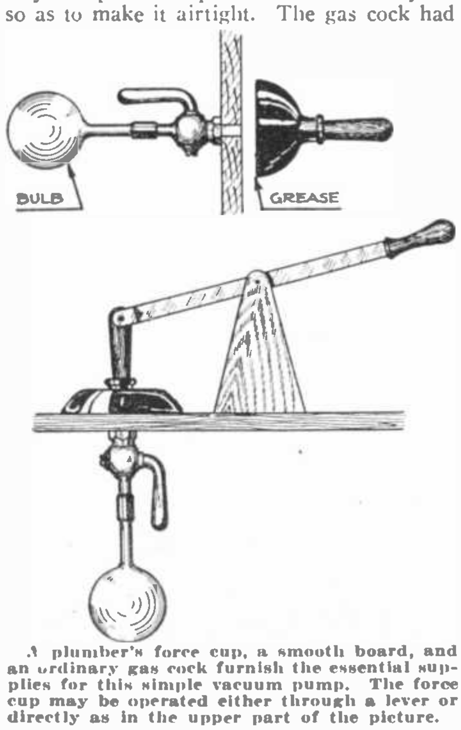
Due to the unequal expansions of brass and iron strips, the spiral compound bar is caused to bend inward with the carbons in contact when a current passes, thus separating them and striking the arc.

Easily Constructed Vacuum Pump

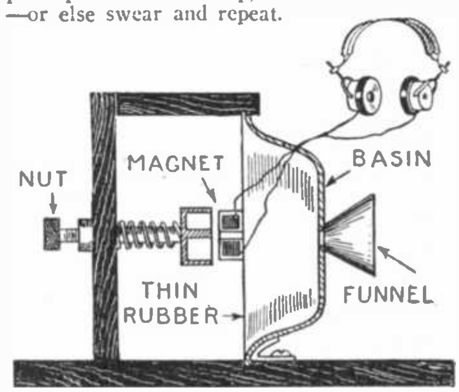
THERE are three main parts to this vacuum pump; namely, a plumber's force cup, a smooth surfaced board slightly larger than the cup, and an ordinary gas cock.

A hole is bored through the center of the board and the stem of the valve or cock inserted therein. Hot sealing wax or battery compound is poured around this joint so as to make it airtight. The gas cock had best be taken apart first to be cleaned thoroughly and before putting it together the insides should be coated with vaseline. The edge of the cup should also be greased well.

To operate, the bulb or tube to be exhausted is connected to the gas cock; force the cup all the way down, open the cock, pull up hard on the cup, then close the cock—or else swear and repeat.



A plumber's force cup, a smooth board, and an ordinary gas cock furnish the essential supplies for this simple vacuum pump. The force cup may be operated either through a lever or directly as in the upper part of the picture.



A somewhat domesticated but effective microphone may be constructed out of a basin, an india rubber membrane and an old-type telephone receiver.

Magnetic Induction Phone

BY means of the simple arrangement here described, I was enabled to generate a telephonic current by the power of the voice, an excellent microphone for experimental work also being developed.

No local current is required; it is a reproduction essentially of the electro-magnetic Bell telephone of his first patent.

The parts were taken from an ear phone, the kind having one pole encircled by the other. The soft iron pole piece can be turned out on a lathe.

The diaphragm is made of balloon rubber drawn tightly over the rim of a tin basin like a drum head. The basin is fitted with a mouthpiece made from a funnel and a hole is cut for the sound of the voice to pass through.

Contributed by Alvin Nunes.

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

First Prize, $25.00	Second Prize, $15.00	Third Prize, $10.00
Roscoe Betts, Box 4, Arcadia, Nebr.	Casimir S. Pawlowski, 120 Oakland Ave., New Castle, Pa.	Author Unknown

First Prize
Microphone

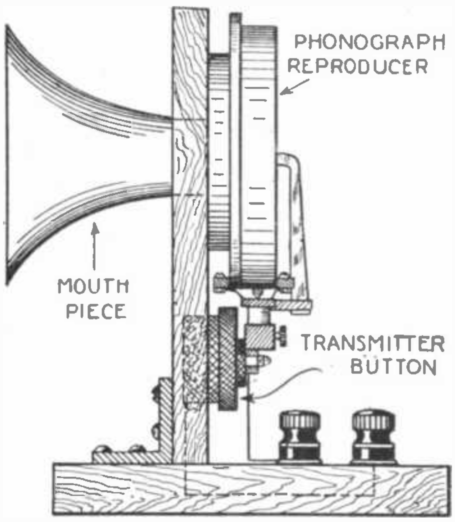
By Roscoe Betts

THE microphone illustrated can easily be made if an old phonograph reproducer and a transmitter button are at hand.

The reproducer is mounted on a suitable piece of board together with the transmitter button.

The transmitter button fits into a small cup or hole which has been bored in the upright board and is held securely there by sealing wax. The button is placed in such a position that the diaphragm electrode fits snugly against the needle socket of the reproducer.

The baseboard holds two binding posts which are connected to the electrodes of the transmitter button and also a brass angle strip, which construction makes the upright piece very rigid. A mouthpiece completes the instrument.



The diaphragm of a phonograph is made to actuate the regular Skinderviken or other transmitter button.

The vibrations of the reproducer diaphragm are transferred to the transmitter button.

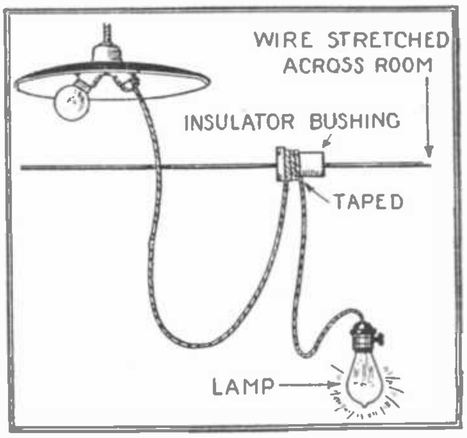
Second Prize
Movable Electric Lamp for Shop Use

By Casimir S. Pawlowski

THE arrangement illustrated is for the purpose of taking care of a lamp which is connected to a flexible cord so as to hang over the work.

In order to make it serve for the full sized work bench, a strong wire is stretched well above the bench and parallel with its length, so as to be within reach of the hand. The wire passes through the hole in a porcelain insulator and the flexible cord carrying the lamp is permanently wired to it.

Enough slack must be allowed to the flexible cord for the lamp to be free to be moved a sufficient distance to cover the bench. This can easily be done, because the upper loop never need come where it would be in the way.



A simple arrangement for shifting a lamp from end to end of the working bench.

$50 IN PRIZES

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

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

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

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

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

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

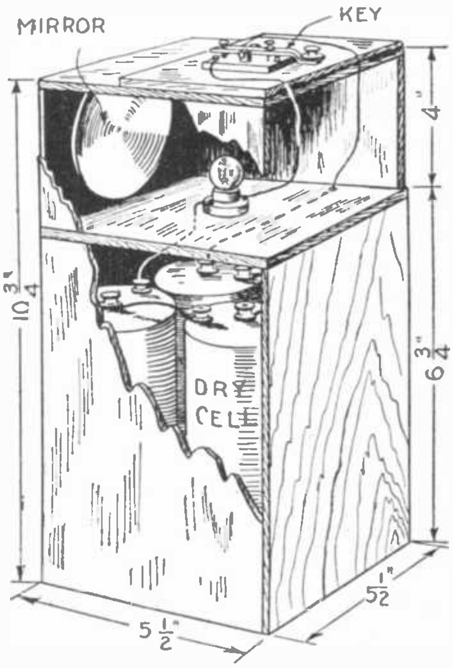
Third Prize
Boy's Electric Lamp Distance Signal Projector

ARMY communication is one of the most important functions of that branch of our army known as the "Signal Corps."

The projector employs a spotlight reflector or concave mirror, four inches in diameter, and an automobile headlight Mazda lamp. The following are the essential parts:

Four standard No. 6 dry batteries, as ordinarily used for ringing door bells, a telegraph key, a Mazda automobile headlight lamp (1½ amperes 6-volt, G[12] bulb), a socket for the lamp and a little flexible cord, which can be obtained at almost any electrical store.

The function of the mirror is to project a narrow beam, all the light originating at its focal point; that is, a point opposite the center of the mirror and in the four-inch size about two inches in front of its central surface. This point may easily be determined by moving the lighted lamp about until the mirror projects a parallel beam producing a four-inch spot of light on a wall a few feet away. When the narrow shaft of light, thus emitted is trained directly at an observer many miles away, the brilliant mirror becomes clearly visible, though no measurable amount of light illuminates the observer. Then by causing the lamp to light for long or short periods by the use of the telegraph key, signals may be sent in the regular Morse or Continental code.



Electric light signalling apparatus of simple construction for young experimenters to practice with.

The equipment may be conveniently mounted in a simple wooden box, as shown in Fig. 1. The wood necessary to construct this box consists of the following, preferably of oak: Two pieces, 5½ x 5½ x ¼-inch; one piece, 5½ x 4¼ x ¼-inch; one piece, 5½ x 6½ x ¼-inch; one piece, 5½ x 10¾ x ¼-inch; one piece, 5 x 5 x ¼-inch; one piece, 5 x 4 x ¼-inch; one piece, 5 x 6¾ x ¼-inch; one piece, 5 x 10¾ x ¼-inch.

Four small hinges are required, though pieces of leather or canvas may be used for the purpose. A pair of hooks and screw eyes are handy to keep the doors closed. The mirror is held in place by four small strips of brass, bent in the form of clips and screwed to the back of the box.

To allow for focussing put the socket on a ⅜-inch threaded pipe through which the wires run down to the telegraph key and batteries. This pipe is held in the insert piece by means of two 1½-inch washers and a couple of lock nuts. The pipe passes through a ⅞-inch hole in the board, thus allowing ¼-inch adjustment each way. The batteries are all connected in series through the telegraph key to the lamp.

What Our Readers Think

Fishing With Electric Light

Editor, THE EXPERIMENTER:

Please allow me to call your attention to the fact that your article headed "Fish Attractor" on page 443 of the May issue of ELECTRICAL EXPERIMENTER may get some of your readers into trouble.

Such methods of attracting fish are in violation of the State Game and Fish Laws of practically every state in the Union.

A person caught fishing with any such device whatever is severely dealt with, as it is one of the most destructive methods of securing fish known to fishermen.

Your readers should be apprised of the above facts.

Yours very truly,
M. T. MCKINLEY.

Freeport, Ill.

(We give statements from the game and fish conservation bodies of four states. These were in answer to requests of ours for information on the legality of the practise spoken of in your letter.—EDITOR.)

STATE BOARD OF FISHERIES AND GAME, STATE OF CONNECTICUT
Hartford, May 7, 1925.

Gentlemen:

In reply to your letter of May 5th, there is no law prohibiting the use of an electric lamp suspended at the end of a line near the fish hook for the purpose of attracting fish to the bait.

We have never encountered this new device for luring fish. I am unable to say what future legislation might follow the general use of such a device. It would depend on how destructive it appears to be. With the intensive fishing which we have in this state, we do not like to encourage anything which will reduce the chances of a portion of the stock in our waters to survive.

Yours very truly,
JOHN W. TITCOMB,
Superintendent.

STATE OF NEW YORK CONSERVATION COMMISSION
Albany, May 2, 1925.

Gentlemen:

The Commission acknowledges receipt of your letter of April 29, and in reply we beg to advise you that the Commission does not construe that it would be a violation of the Conservation Laws of this State for a person to use an electric lamp suspended at the end of a line while angling for fish in any of the waters under the jurisdiction of the State of New York.

We are sorry, however, that we cannot advise you as to whether or not this would be a violation of any of the laws of other States in the Union.

Very truly yours,
ALEXANDER MACDONALD, *Commissioner,*
By John T. McCormick, *Deputy Chief.*

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF CONSERVATION
Division of Fisheries and Game
State House, Boston, May 11, 1925.

Dear Sirs:

Replying again to your letter of May 5th relative to the use of an electric light at the end of a fishing line, I would say that we have no law in this state which will prohibit it.

Our laws forbid night fishing for trout, however.

Very truly yours,
O. E. BOURNE,
Chief Warden.

STATE OF NEW JERSEY
BOARD OF FISH AND GAME COMMISSIONERS
Trenton, May 15, 1925.

Editor, EXPERIMENTER:

Referring to your inquiry as to the use of an electric lamp suspended at the end of a line near the fish hook for the purpose of attracting fish to bait, I call your attention to section 30 of our general act which follows:

"30. It shall be unlawful in any manner to take any trout, bass, pike-perch, pike or pickerel between nine o'clock in the evening and daylight of the morning following, under a penalty of twenty dollars for each fish so taken."

This would preclude the possibility of using a light in any of our waters.

Very truly yours,
U. H. FELL,
Secretary.

(This seems not to preclude using an electric light as described during day-time hours.—ED.)

The Flewelling Circuit

March 2, 1925.

Mr. Herbert M. Daenzer,
St. Louis, Mo.

Dear Sir:

We are obliged to you for the description of your experiences with the experimental Flewelling circuit from the January THE EXPERIMENTER.

If you wish to communicate your results to the author, you can write to R. T. Turner, 427 Franklin St., Washington, D. C.

Very truly yours,
THE EXPERIMENTER.

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

A WORD FROM ESTEN MOEN

Editor, THE EXPERIMENTER:

What is value?

There are all sorts of values. For instance, Editor Gernsback seems to find value in the paper I send him. On the other hand, I certainly find value in the paper (check) he pays me in return.

Now science is valuable because it is fascinating. Why, the artist S. F. B. Morse conceived the telegraph while looking at an electromagnet. There, I said it—artist Morse—artist!

You bet there is art in electricity, but it all depends on what you see in it.

I remember a fine cartoon by Briggs, I think it was. Four rascal boys were looking at their camp-fire. One saw his "ma" with the "spanker"; a second thought of his forgotten school lessons a third dreamed of his girl, and a fourth—saw only plain fire.

S'pose you was looking at Mayer's beautiful experiments with needles stuffed in corks floating in water with a magnet held over them—who can tell what inspiration you might get; and that's value.

So, fellows, take more pride in studying electricity. Look at our magazine, THE EXPERIMENTER; does anyone suggest an inspirational cover? No. Of course I can't suggest any, but I thought one of you fellows might if you had an inspiration.

ESTEN MOEN.

Fosston, Minn.

Ether Drift

Editor, THE EXPERIMENTER:

I am pleased to note that at least part of the theory which I have held is being affirmed in the May issue of THE EXPERIMENTER.

For a long time it has been my opinion that the earth's rotation was the cause of terrestrial magnetism. However, this is as far as I agree with "Philomath." My opinion is that all the ether surrounding the earth, or rather the ether that is in space, is static electricity. The earth rotating in it must of course have some effect upon the ether exactly as a ball would create a wave in air. Thus the earth moving in ether causes a wave in ether. Now we know that a wave in ether is magnetic. This explanation at once clears the whole mystery, whereas in THE EXPERIMENTER it speaks of the earth's electric and magnetic field as an unsolved problem. Another thing that has struck my mind is a passage in the same article where it states that electric charges are continually leaving the earth, but it is being replenished all the time. It states that there is a flow of charge. Now I have always learned that the earth is negatively charged. I would like to know how it could be possible for a negative charge to cause a flow away from it.

HENRY VAN ELBURG.

Hoboken, N. J.

(It is by no means a settled matter that the earth's rotation has the same effect upon ether as a ball rotating has on air. In fact, the famous experiments of Michelson and Morley, two American physicists, were made to determine this particular point. According to their conclusions "there is no ether wind. The velocity of light is independent of the motion of the source of the light through the ether." If the ether moved with respect to the earth, the velocity of light would change depending on the motion of the source with respect to the direction of motion of the earth.

With reference to atmospheric currents, we note that you are quite right in that the earth is negatively charged with respect to the atmosphere. However, a current of negative electricity is quite conceivable. Indeed, strictly speaking, we might term any electric current in one direction a current of negative electricity in the other. If you prefer you might substitute for Philomath's way of putting it, that atmospheric current represents a transfer of positive electricity downward instead of a flow of negative electricity upwards.—EDITOR.)

Sulphur Panels

Editor, THE EXPERIMENTER:

May I offer a suggestion? About two years ago Editor Gernsback gave an editorial in RADIO NEWS on Sulphur Panels, but he made no mention of the fact that the fumes of sulphur are deadly. Perhaps it would be best to let the "Experimenter Fans" know this and give them some precautions.

JAMES WILCOX.

Webster, South Dakota.

(Do you not think that the reason that Mr. Gernsback made no statement of the fact that "fumes of sulphur are deadly" was that sulphur gives off no fumes except at a temperature approaching red heat? A panel of sulphur gives off no fumes and is perfectly innocuous in every way. The idea that a sulphur panel could be of any injury to anybody is quite absurd.—EDITOR.

An Experimenters' League

Editor, THE EXPERIMENTER:

Can you help me get in touch with fellow-experimenters who are doing work with high frequency coils, radio control, or photo-electric cells?

R. V. AMBROSE.

c/o Redpath Bureau,
Columbus, Ohio.

(Few things are so conducive to the extensive development of amateur experimenting as the free exchange of ideas among experimenters located in different parts of the country and working under various conditions. Such free inter-communication among amateurs would be best achieved through the medium of some loosely organized society as an "Experimenters' League." We would certainly encourage the organization of such a society if some one of our readers will undertake to act as an organizing secretary.

The purpose of the society should be the creation of closer relation between individual experimenters over the entire English-speaking world. By establishing such a "clearing house" of experimental methods, the organization would not merely encourage experimentation, but would help considerably the individual experimenter, who usually works very much alone.—EDITOR.)

Home-Made Photo-electric Cell

Editor, THE EXPERIMENTER:

Your reader "Kid Ken" in the April issue of the EXPERIMENTER (page 412) asks for data on "a cheap way of making a photo-electric cell."

It might be said, before the describing of the "cheap photo-electric cell," that it is not the most sensitive of its kind, but is sufficiently so to be used by your readers for their experiments.

Take a piece of zinc foil, and with a fine file or emery cloth, the surface (one side) is rubbed so as to give it a fresh appearance. This is now mounted in a glass bulb; in front of the zinc plate is placed an ordinary grid (collector). The bulb is then sealed off, and the cell is ready for use.

It is obvious of course that the glass bulb should be made of a fine grade of lime glass, as lead glass will absorb the higher radiations, and the cell at its best will not function properly. The introduction of inert gases, such as Neon, Argon, or Helium will help considerably the photoelectric effect.

In any event, the foregoing description gives the facts on the construction of "a cheap photoelectric cell," which was wanted.

Unless one has the proper conveniences at hand, and the knack of handling glass and the inert gases, then the production of a so-called "cheap photo-electric cell" should not be attempted. It will cost as much to have one constructed by a glass blower as it will to purchase one from a reliable manufacturer.

Yours very truly,
SAMUEL WEIN.

Celluloid Case for Lead Electrode In March EXPERIMENTER

Editor, THE EXPERIMENTER:

In No. 5 of THE EXPERIMENTER for March, on page 359 an electro-plating anode is described.

Could you explain to me exactly how, when using celluloid which is an insulator, it would be possible to establish an electric current. What role does the celluloid play? I understand that it is filled with lumps of lead, but if the celluloid itself is an insulator, current could not pass.

I would appreciate your telling me. With thanks and anticipation,

Yours cordially,
ELIE DELAFOND.

Mexico.

(The celluloid is only a container for the pellets of lead; it is perforated with a number of holes and the terminal is connected with the lead by a metal wire running down in among the pellets. This takes care of the current, because the liquid fills up the spaces between the bits of lead.—EDITOR).

Appreciation

Editor, THE EXPERIMENTER:

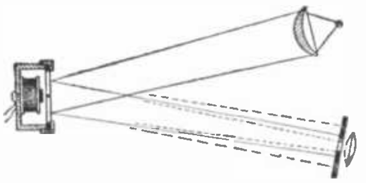
In my home town we formed a club of about ten ardent experimenters and we use THE EXPERIMENTER as a sort of official organ of the club. We carry on very interesting discussions on articles in THE EXPERIMENTER and our own successes in executing experiments described therein. For a long time, it has been a recurring subject of conversation, whether or no our editor himself was an experimenter and whether he spent his leisure time as we do in a laboratory (but no doubt in a more elaborate one than ours). And so it was with a great deal of pleasure that we noted his own comment on page 326 of the March 1925 issue on the subject of The Circulation Power Battery. We were very pleased to find a fellow-experimenter in our editor.

Birmingham, Ala. DANIEL FORDSON.

(We have hardly any comment to make on your letter except, perhaps, to emphasize our own interest in experimental science. We have expressed most of our opinions in our various editorials. It is certainly very gratifying to find so much sympathetic understanding in our readers.—EDITOR.)

Latest Electrical Patents

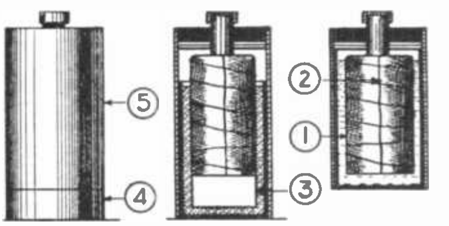
Flexing Mirror



In front of an electromagnet a flexible mirror is mounted whose convexity or concavity changes with the current. A beam of light is cast upon it obliquely and as reflected varies in cross-sectional area according to the curvature of the mirror, so that being received at a distant point through a hole in a diaphragm its intensity varies constantly according to the fluctuations of the current so as to give signals.

Patent No. 1,525,550 issued to Charles Francis Jenkins, Washington, D. C.

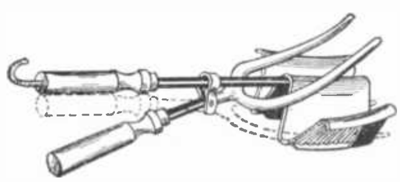
Dry Battery



This battery was designed with a special view to eliminating deterioration before the battery is put to work. When in use the carbon element surrounded by a depolarizing mixture (2) is immersed in the denser exciting fluid (1) formed by the addition of some water to the gelatinized paste (3) with which the interior of the zinc cylinder is coated. Before being started into operation a removable portion (4) of the insulating external cylinder maintains the element (2) in a position only partly enclosed in the lower cylinder.

Patent No. 1,524,561 issued to H. M. Koretzky, New York, N. Y.

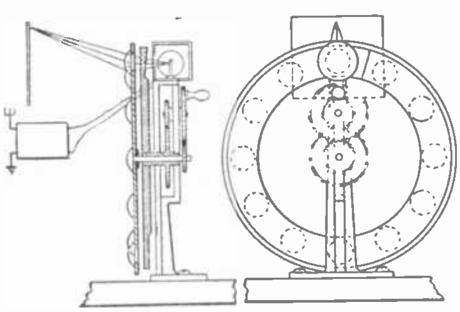
Electric Hair Waver



A corrugated plate of "W" section has embedded in it an electric heating wire and the hair to be waved is pressed into its folds by tongs as shown; to get the "French effect" an arrangement is supplied for moving the hair back and forth longitudinally to the corrugations.

Patent No. 1,488,621 issued to Robert P. Simmons, Cleveland, Ohio.

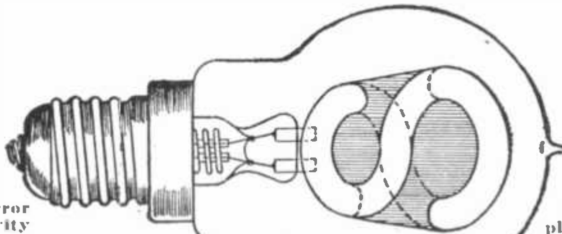
Television



A beam of light is projected through a series of lenses carried on a rotating disc. Another disc rotating on the same shaft is cut to a prismatic contour. The light as refracted, lens by lens, in each case is carried as a straight line across the screen, each line at a different level. Thus when the light is caused to vary by changing the current, a picture will be produced upon the screen. The apparatus is a reproducer for pictures.

Patent No. 1,530,463 issued to Chas. F. Jenkins, Washington, D. C.

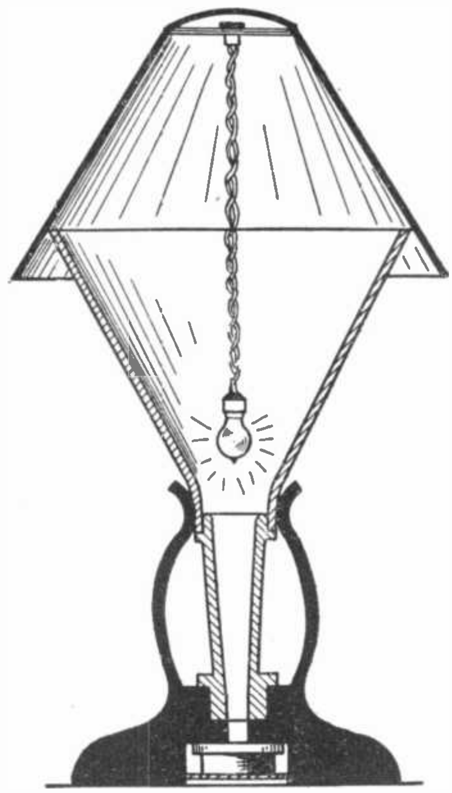
Glow Lamp



This is a neon glow lamp; it carries two plates for electrodes of any desired shape separated by an insulating plate which is opaque; thus two different letters can be produced without interfering with each other.

Patent No. 1,531,036 issued to Franz Skaupy, Berlin, Germany.

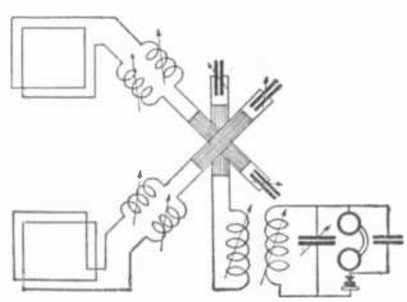
Loud Speaker



A loud speaker is mounted with its axis vertical and large end uppermost. It is surmounted by an ordinary shade and from the center of the shade an electric lamp hangs so as to give a luminous effect.

Patent No. 1,524,673 issued to Joseph A. Rayder, Philadelphia, Pa.

Radio Signaling



By properly spacing and otherwise adjusting and controlling two antennae situated within 25 feet of each other, interference between static waves is produced, so as to obliterate the sound. The same antennae are found to receive signals perfectly.

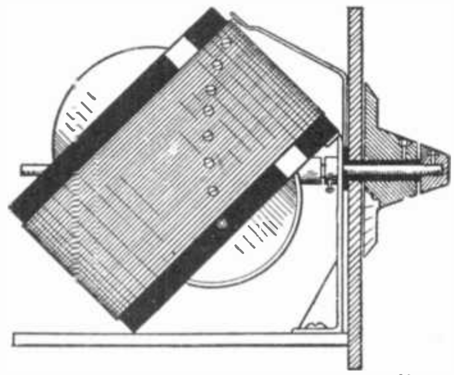
Patent No. 1,532,357 issued to Roy A. Weagant, Douglas Manor, N. Y.

Silent Telephone

This is a head-set with very flexible diaphragms. Projections on the diaphragms press lightly against the temples. When a message comes over the telephone the pressure is varied, so that by the variations in pressure and by the duration of the periods of pressure, code can be received.

Patent No. 1,531,543 issued to James J. Cooper, Atlanta, Ga.

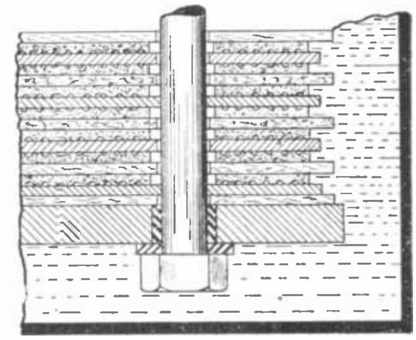
Variocoupler



A contact arm is carried by the ordinary regulating disc of a receiving set and is moved around the periphery of an inductance coil so as to cut in or out varying numbers of its turns and thus to change its effect.

Patent No. 1,524,976 issued to Charles W. Kautz, Jr., Lancaster, Pa.

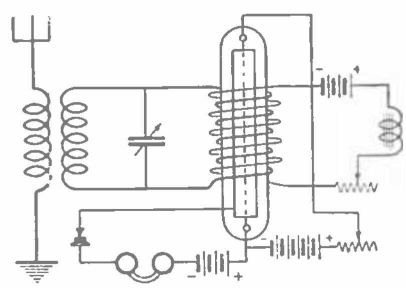
New Edison Battery



In this battery Edison uses a pile consisting of thin sheets of conductive material, such as nickel, separated by asbestos paper, with thin, flat layers of finely divided active material of two specific kinds, disposed between the surfaces of each nickel plate and the adjacent asbestos sheets. Oxide of iron for one side of each plate and nickel hydroxide for the other is suggested.

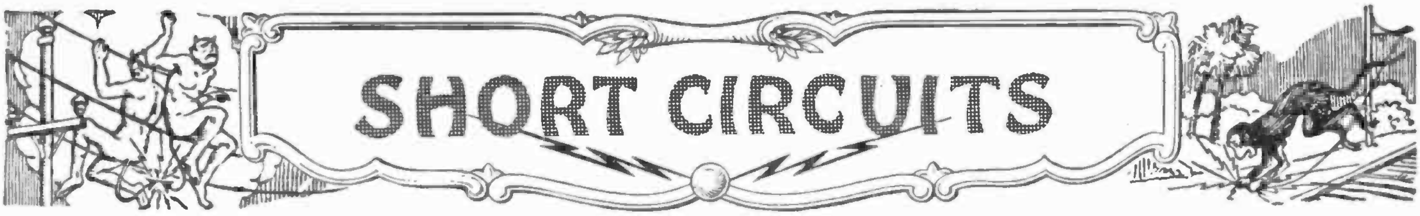
Patent No. 1,526,326 issued to T. A. Edison, West Orange, N. J.

Sine-Wave Oscillator



Mr. Vreeland who is famed for his Vreeland-oscillator has designed this oscillator which makes use of a high vacuum mercury vapor tube which can carry large currents at low voltages.

Patent No. 1,529,455 issued to F. K. Vreeland, Montclair, N. J.



SHORT CIRCUITS

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

This is the grave of
Lineman James Fall,
Who braced himself against
A damp brick wall.
—*P. S. Young.*

Lies sleeping here
Poor Mary Crocket,
Who hung a coat-hanger
On an empty socket.
—*Griffith Woodrow.*

Rests peacefully here
One Larry McLane,
Who climbed a pole
To watch a baseball game.
—*Albert J. Sopata.*

This monument's for
Dear old Alexander McLark;
The tube was wet when
He started a mercury arc.
—*Stanley O. Schlaf.*

Victim of Electric Shock

STEEP FALLS, Me, May 28—Harry I. Chick was killed today when he threw a pail of water on a fire burning about electric wires in his barn. Death was almost instantaneous. He was 31 and served overseas with the 303d Artillery.

Murray Stowe, a brother-in-law, touched Chick's body, and is in bed in a helpless condition. A three-year-old daughter of the dead man, who was nearby at the time, was hurled to the floor.

Mrs Chick Burned

In the home of Joseph Chick, the victim's brother, 200 yards away, transformer trouble developed and Mrs Chick was tossed half way across the cellar, and one of her hands was severely burned when she attempted to throw the switch. Her husband donned rubber boots and gloves and finally succeeded in turning off the current.

The dead man's body was so heavily charged with electricity that the family cat received a severe shock upon approaching the body. The electrical trouble caused a fire in each of the Chick homes, which the village department extinguished.

Here lies Rady O'Ham
We are sorry to mention;
His antenna came "slam"
On a line at high tension.
George Stiles.

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.

Pyroelectricity and Piezoelectricity

(521) David Ravendal, Quebec, Canada, writes:

Q. 1. Will you kindly tell me what pyroelectricity is, and when it was discovered? Is it the same thing as piezoelectricity?

A. 1. Certain crystals, initially showing no electrification develop, if heated uniformly, opposite electrifications on opposite surfaces. If they are cooled from a neutral condition, the polarity is reversed. This phenomenon is known as pyroelectricity, and it was first discovered in the eighteenth century. If these crystals, without being heated, are subjected to pressure along the axis of electrification, it is observed that opposite electrifications develop at the ends of the axis. This phenomenon is termed piezoelectricity, and was discovered by J. and P. Feury in 1880. Pyroelectricity and piezoelectricity are two separate and distinct types and must not be confused with each other

Pyroelectricity was discovered about 1700 when it was found that a tourmaline crystal placed in hot ashes attracted the ashes. In 1756 Aepinus showed that the effect was electrical when the charges were opposite at each end of the crystal. Soon after Canton further proved that the charges were equal as well as opposite. He connected an insulated tin cup filled with boiling water to a pith-ball electroscope. A tourmaline crystal was dropped into the water and the pith-ball showed no trace of electrification, then or during the subsequent cooling of the water. In a further experiment Canton broke a tourmaline prism into three pieces and found that each piece exhibited the same kind of action along the same axis as the whole crystal. He further found that Brazilian topaz acted like tourmaline.

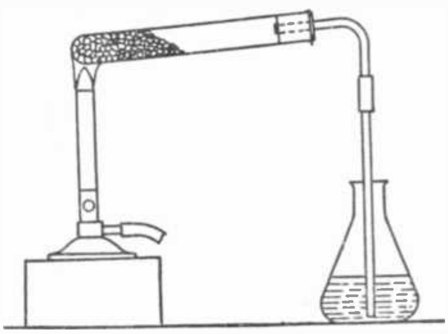
Making Sulphuretted Hydrogen without Acid

(522) Albert Hemingway, Newport, R. I., writes:

Q. I have heard that there is some way of making or generating sulphuretted hydrogen gas without the use of acid or iron sulphide. It was done by heating sulphur with some other substance in an evolution flask or evolution tube.

A. You undoubtedly allude to an old method of evolving the gas for use in laboratories, which is done by heating paraffin wax and sulphur mixed to a temperature such as would be produced by a Bunsen burner flame at one-half or less of its full height.

This method is quite practical; it avoids the use of sulphuric acid and a test tube six inches long with a single aperture cork and delivery tube form the complete evolution apparatus. A rather interesting paper on the subject has been published recently in the Journal of the Franklin Institute. It was found that ten c.c. of the charge gave about 2,000 c.c. of sulphuretted hydrogen gas. An interesting feature is that the evolutions of gas cease within one minute after the removal of the flame. We all know that it takes much longer than this for an ordinary sulphuretted hydrogen apparatus to cease evolving gas. It is also clear that the gas must be of the highest degree of purity, as there is no solution of iron sulphate to be carried over in spray and no need of washing the gas, except where very special precaution is called for.



Apparatus for making sulphuretted hydrogen from paraffin and sulphur.

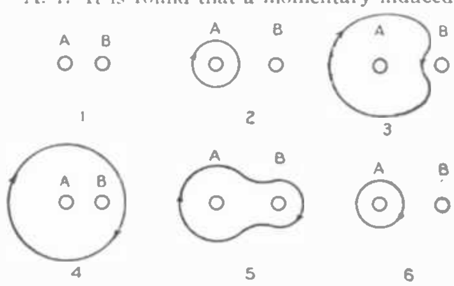
We reproduce from the Franklin Institute Journal the rough diagram of the apparatus. It will be understood that the authors have omitted the ring stand which presumably will be required to hold the test tube in position, but the diagram tells the story. As the evolution proceeds, the flame which is originally applied at the very base of the tube is moved nearer and nearer to the open end. A charge of about five c.c. in volume will precipitate three grams of copper.

Lenz's Law

(523) George Sumhat, Calcutta, India, writes:

Q. 1. Will you please explain Lenz's law?

A. 1. It is found that a momentary induced



Diagrams to explain Lenz's law.

current will be caused in any wire if it is brought near to a wire in which a current is already flowing. Or, if two wires are close together and a current is set up in one, a momentary induced current will be set up in the other. When a current is set up in a wire, the magnetic field comes into existence, and we may suppose that as it spreads out from the first wire, (A) Fig. 2, it bends around the second wire, (B) Fig. 3. Notice that as the field spreads out, the flux curves around (B) in the opposite direction (3) from its path around (A) so that the induced current in (B) is towards the observer and opposite that of the current in (A). Now as the current in (A) stops, Fig. 5, another induced current is set up in (B) when the flux around (A) collapses and is again bent by (B). In this case, however, the current induced in (B) is in the same direction as that in (A). The statement of the relation between the directional flow of the current between the two wires is known as Lenz's law: the induced current always produces a field which opposes the field of the inducing current.

The Vernier in Radio

(524) Lansing Grenthal, Bar Harbor, Me., asks about the vernier as used in radio sets, which he finds does not at all correspond with the description of the vernier given in books treating of mathematical instruments. He writes: "As I understand it, the vernier operates something in the manner of a slide rule, on a very limited scope."

A. The term vernier as applied to the reducing gear used on radio panels is an absolute misnomer, and unfortunately is not the only piece of nomenclature in radio literature to which we may object. But like the others, we suppose it has come to stay. So you will do well to learn for your own satisfaction exactly what a real vernier is.

Usually, the so-called vernier on radio sets is a frictional reducing gear. The day may come when excessively fine adjustments of capacity and inductance will be required, and when the setting of a disc to a given point will unfailingly bring in a desired station. Under such circumstances, the real vernier may be introduced into radio adjustments, but at present the real vernier is not there. In the July issue of RADIO NEWS you will find an excellent article on the vernier by Mr. Sylvan Harris, to which we refer you, knowing that it will cover all the ground included in your query.

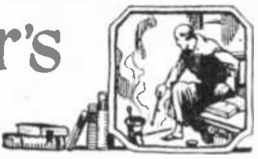
Oscillation of a Vacuum Tube

(525) Austin Ray, Chestnut Hill, Mass., inquires:

Q 1. Why is it that oscillation is necessary for a tube to function properly, yet the rheostat, potentiometer or tickler coil must be adjusted to prevent these oscillations?

A. 1. The tube must be controlled so that oscillation will be kept within requisite bounds and not become riotous. There are points in some receiving sets that require, in greater or lesser degree, more oscillations than at other points. For instance, the oscillator of the super-heterodyne must oscillate freely over the whole designated wavelength band. On the other hand, if the R.F. stages of the neytrodyne receiver oscillate, it is no longer a neutrodyne and the control becomes difficult. The tickler coil or potentiometer, as the case may be, is used to control the oscillation of the tube. The set is operating at the highest point of efficiency when the tube is operating at the "peak," when the tube is about to start oscillating.

The Experimenter's Bookshelf



A Writer's Bible

THE AUTHORS' BOOK. xv. 73 pages. The MacMillan Company, New York, 1925.

This book is stated to be a series of notes for the guidance of authors in dealing with publishers, and is devoted to the preparation of manuscripts and the reading of proofs.

It has fallen to the lot of the writer of this short review to deal with a multitude of authors' manuscripts and to have been troubled greatly by their poor preparations by their being written in pencil or if typewritten they may be executed with an exhausted ribbon, perhaps with no margins to the pages and with the lines so close together that the necessary editorial corrections were inserted only with difficulty. We say nothing of the occasional writing on both sides of the page.

The present book it is fair to suppose is designed to save the feelings of the editors of the publishing firm and in the care with which it is made and the excellent selection of material cannot be too highly commended. The introduction and the first 24 pages of the text are devoted to the MacMillan Company and their new building; then comes what will interest authors, the description of how to prepare a manuscript. This portion is quite exact. If the directions given are followed, manuscript could go directly to the printer, and we cannot but wish that our writers would carefully peruse these few pages.

Practical notes on the legal aspect of copyright and on the promotion of the book on binding and design for the loose cover follow. A glossary of terms adapted from the *Publishers' Weekly* of this city gives a quantity of useful information about printers' terms, paper, bookbinding and the like. A wonderfully good section is devoted to style, which in the printers' vocabulary means everything, or nearly everything. A short section is devoted to proofreading and the usual example of an uncorrected and corrected piece of printing is given. We certainly recommend the book to prospective and to many present authors.

A Compendium of Radio

RADIO-TECHNISCHES LEXIKON (RADIO-TECHNOLOGICAL DICTIONARY), by Hanns Günther and A. Meyer. 187 pages. Franckh'sche Verlagshandlung, Stuttgart, Germany, 1925.

The best qualities of a long tradition of German lexicography are here brought together in a concise dictionary of radio terms. But the book is more than a dictionary. Its authors were not content with mere definitions, but have given accurate yet very simple explanation of the various items. Very little, if anything, has been overlooked in compiling this radio glossary, and besides terms strictly connected with wireless telegraphy, a large number which bear indirectly on the subject have been added. Brief paragraphs, for instance, are dedicated to the explanation of graphical representation (Graphische Darstellung), Kirschhoff's law (Kirschoffsche Sätze), the corkscrew rule for determining the direction of magnetic field around the wire carrying current (Korkzieherregel).

The authors have brought the volume up-to-date with the latest theories in electromagnetic propagation and have incorporated in the dictionary such terms as explain the curvature of radio waves around the earth (Erdkrümmung). The book seems to meet the demands of every radio experimenter. Its one drawback is the absence of illustrations. These together with an appendix of useful tables and formulæ would have raised the volume above criticism.

The State of Science in 1924

HANDBOOK TO THE EXHIBITION OF PURE SCIENCE. Arranged by the Royal Society, 228 pages. Macmillan Company.

Originally written as a guide to the Exhibition of Pure Science at the British Empire Exhibition, this volume contains many of the most important results obtained in every branch of physical science. The list of contributors, aside from the content, is itself imposing. Such men as J. J. Thomson, William Bragg, Ernest Rutherford, F. W. Aston, J. A. Fleming, and numerous others no less important but less widely known, have each presented an abstract of researches in their special departments. It is a compact reference book of modern physics—a book to browse over. But it is by reading through the book that one gets that broad, comprehensive view of the panorama of modern science. If the reader is not too soon discouraged by these numerous ramifications of modern physics, he will be rewarded for his efforts with that co-ordinated view of science which presents every branch in relation to the others. He will then see physics not as a collection of independent departments of information, but as a larger movement ever advancing the boundaries of human knowledge.

The book is written for the educated layman, but unlike some works of similar nature it does not sacrifice accuracy for an easily achieved simplicity. It is a final tribute to the genius of the contributors that they could present in very simple language the niceties of their science. One is here in touch with the sources of important scientific movements, and interesting little-known points are brought out such as the relation of Faraday's electro-chemical equivalent to the measurement of the charge on the electron. In another chapter Bragg develops the new theories of crystal structure. His investigations show that in each of the 32 different classes of crystals there are 230 different arrangements of atoms which present the same outward appearance. Sir Ernest Rutherford develops the relation between electricity and matter and the method of disintegration of the elements developed by himself. He points out the curious anomaly—developed in greater detail in the January, 1925, number of THE EXPERIMENTER—of a loss of matter when four hydrogen atoms combine to form one helium atom (a purely theoretical process). Dr. Aston, the first to discover the existence of elements chemically identical but of different atomic weights and occupying the same position in the periodic table, isotopes, that is, having the same number of planetary electrons, develops his theory in a chapter of some 10 pages. Space does not allow us to enumerate other interesting developments treated in this small volume, but no matter what his special department of interest may be, the reader will be likely to find treatments of it by well-known authorities in this book. Besides the presentation of the three an elaborate descriptive catalogue of the exhibits is contained in the volume. Various electrical apparatus used in the demonstration are described in detail. We not only recommend this book, but say without undue emphasis that no experimenter's library is complete without this volume.

The Magnetic Polarity of Sunspots

AT a recent meeting of the Royal Astronomical Society, a letter was read from Professor Ellerman, who stated that it now seemed certain that the magnetic polarity of sunspots was reversed at each successive cycle. During the spot cycle that ended in 1913 is was invariably the case, in the northern hemisphere, that the eastern end of a spot group was negative and the western end positive: in the southern hemisphere it was the opposite. During the cycle 1913-1923 this state of things was reversed in both hemispheres; but now in this last year, with the beginning of the new cycle, the polarity had returned to what it was before 1913. Professor Newall said that this discovery would require a complete revolution in sunspot theory.—*London, Eng., Morning Post.*

Invisible Ink

By CLYDE E. VOLKERS

AN interesting application of the iodine test for starch lies in the use of a mixture of water and starch for ink.

The mixture consists of common flour or starch which has been reduced to a thin paste with water. This is used with a clean pen for writing. Applied thinly, the writing is invisible.

After drying and at a later time, a weak solution of iodine in alcohol is painted over the writing. The starch immediately turns blue when it touches the iodine solution, rendering the writing visible. This is in reality an old-time test for starch.

This is also available for a code printing telegraph receiver. If a paper tape has its whole surface thus treated, a current of electricity will produce marks upon it and if sent by key can give the code.

Repairing Electric Fans

(*Continued from page* 623)

chuck and the metal bored out for about $\frac{1}{16}$- to $\frac{3}{32}$-inch, depending upon the thickness of the bearing. Fig. 3-C shows how a bored brass or bronze bearing is placed on end on a piece of asbestos and then packed all around with putty or clay before pouring in the molten babbit metal. After boring out the bearing, a drill is used to place a few cross-wise holes in the shell, which will serve to anchor the babbit in place; see Fig. 3-B. These holes do not have to pass all the way through the metal.

Referring to Fig. 3-C the threaded hole into which the oil cup has to be secured is plugged up with a piece of wood or clay. In some cases a steel or other mandrel is placed upright in the center of the bearing before pouring, this mandrel being considerably smaller than the true size of bearing. When the metal has cooled, the bearing is placed in the lathe chuck and trued up by the outer edge of the original bearing, and the boring-out tool is then traversed in and out of the cast hole, the babbit metal being bored out to the true diameter to accommodate the shaft. This is carefully checked with calipers. Where the bearing has been poured full of molten babbit metal, as shown in Figs. (C) and (D), a drill placed in a tail stock chuck is used to bore a hole through the babbit metal somewhat smaller than the true size of the bearing in order to be able to pass the boring tool through the bearing and machine it to the proper size.

Frequently the shaft itself is badly cut, and there are several ways in which this can be overcome. The first one is to machine the shaft with a tool in the lathe until an even diameter has been reached all along the journal, and finish this with a fine cut file. Then if newly babbited bearings are to be used, they can be bored out the proper size to fit this reduced shaft diameter. In some cases the hole for the oil cup must have a drill run through it, followed by a tap.

The second method of repairing a badly worn shaft is to machine it down about $\frac{1}{16}$- to $\frac{3}{32}$-inch or even more, and then to shrink a steel sleeve on this reduced size shaft journal. These steel sleeves are sold in regular repair shops cut from seamless steel tubing, but may be made for individual jobs from a piece of cold rolled steel rod. The principal point here is to have the inner diameter of the sleeve slightly smaller by a few thousandths than the newly machined diameter of the shaft bearing, so that when the sleeve is heated, it will, by expansion, drive on easily over the shaft. If the shaft is turned too small, as sometimes happens for a stock sleeve, the day may still be saved by thoroughly roughening the shaft surface with a prick punch, so that the sleeve when heated may drive on and get a fair hold after all. The sleeve is then carefully machined down to the proper diameter.

(*To be continued in next issue*)

Making A Sensitive Balance

(*Continued from page* 609)

move the same distance, the balancing screws must be adjusted. When the balance is adjusted so that the pointer moves the same distance when the same weight is placed in either pan, a permanent scale can be plotted and weighing of small amounts can be done by reading the displacement of the index.

For additional accuracy in reading, a peep sight may be placed in front of the pointer as shown in Fig. 6. This is a strip of metal with a hole bored through it and a thread glued across it. It is placed exactly opposite the zero mark on the scale.

(*Continued on page* 645)

EDITED BY JOSEPH H. KRAUS

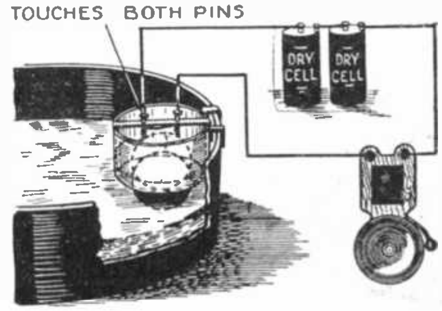
ON this page every month we will give our readers the benefit of our experience on patents and questions pertaining to patent law. Years of our treatment of the subject of patented, patentable (and many unpatentable) devices has proved satisfactory to hundreds of thousands of experimenters. The writer, 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.

Drip Pan Alarm

(9) W. Poley, Montreal, Canada, asks our opinion of an automatic drip pan alarm for ice boxes which is to be electrically operated.

A.—We would most assuredly advise against trying to patent your refrigerator drip pan alarm, because there are many better ones upon the market.

CIRCUIT CLOSED WHEN METAL BALL TOUCHES BOTH PINS



Repulsion Motor

(10) Charles Watson, Cincinnati, Ohio, asks whether we would advise him to apply for a patent on an electric motor which works on a peculiar principle of repulsion. High frequency charges pass off the end of a needle to strike a wheel which is revolved by them.

A. We do not believe that there is any sense in building a device of this nature. In the first place it is doubtful if such a system will operate unless the wheel itself is balanced and suspended between jewel bearings. The device must be very light and must require a minimum of energy to turn it. Fitting the wheel itself with points and then connecting the lead of the high frequency machine to the wheel, will make it revolve more readily. The power that it develops is so slight that a strong breath of air would stop it. The energy on the other hand, which drives this wheel, is comparatively great. Frankly, we would suggest that you forget about the system entirely.

Railroad Crossing Signal

(11) Dr. B. S. Bell, Miami, Fla., submits a drawing of a railroad and electrical railroad crossing signal which closes the circuit to "blinking" lights placed in the middle of a roadway some two hundred feet from the crossing. Orange lights are operated when the train enters the block five hundred or a thousand feet from the crossing. A red light is operated when the train proceeds to the next block, and a combination red light and bell are operated when the train enters the last block. He requests our advice.

A. We do not believe that the railroad crossing signal which you have designed is of any particular value. We have seen a great many devices far more ingenious than the system outlined by you. Some of these devices are in use at the present time. For a crossing signal is not what is desired. What is needed is a railroad gate that will infallibly prevent individuals from crossing the railroad tracks when a train is coming. Nevertheless, these gates must not close to traffic which is already on the rails. They must permit any trucks, wagons, automobiles or pedestrians to pass across the intersection between the two gates, and yet they must effectively prevent coming traffic from entering upon the railroad right of way. They should preferably not project upon government, state or city rights of way. They must be easily and cheaply installed; the maintenance cost must be low. The gates should be entirely automatic in operation, and must work without binding in rain, snow, hail or sleet.

The signal which you have designed is nothing more than an elaboration upon present day signals. We can go anywhere and find bells ringing or lights flashing, and acting in just the same manner as the device designed by you. Some of the modern signals are perhaps superior to the method you have outlined. We consequently do not advocate your working upon this particular device to any greater extent, as it seems to us all in all an extremely inferior product.

Sensitive Galvanometer

(*Continued from page 616*)

also be cut in the underside of the base for the wires to lie in. It might be mentioned that brass screws must be used throughout as iron ones might have some effect on the magnet. The high resistance should be in circuit when feeble currents are being measured, and the low one when more powerful ones are dealt with. As an example of the sensitiveness of the instrument, it was found that one cell from an exhausted flashlight caused the pointer to swing to its farthest limit when connected to the high resistance coil.

The Ark of the Covenant

(*Continued from page 615*)

our cabin, and on Danny's advice the surgeon ordered the sick-bay stewards to put the two to bed to sleep off the effects of the gas.

The cruiser, meantime, had come alongside the liner, and in an excellent display of seamanship had grappled her. It was the *Parnassic* all over again. Sleeping people were huddled about her decks, nor could any efforts of the boarding-party bring them to consciousness. It was decided to take the liner in tow to Madeira, and the bluejackets quickly bent a cable from ship to ship.

At breakfast we had a long discussion with the sailing and flying officers, and we were brought to the conclusion that the raiders had, in addition to the gas, some secret means of disturbing the engines of planes. There was the evidence of the two machines forced to come down in the raid on Paris, these, it will be remembered, like the *Merlin* and the big de Hamiville, showing no lasting engine trouble. Dan's theory was that the raiders had a ray which affected the electrical circuits.

He also had an idea that the raiders had some way of controlling their clouds of anæsthetizing gas, a notion that was supported by the officers who had been watching the show from the cruiser's fire-control top. The pink haze had moved about from position to position in too definite a manner to be haphazard, and Dan and the officers were of the opinion that the gas had been purposely swept from the vicinity of the *Merlin*.

Dan, while the discussion was forward, was back at his old trick of shaking loose change in his cupped hands, but from this demonstration of his interest and excitement he drifted into a mood of silent cogitation, which deepened the wrinkles above his snub nose and gave him the air of a thoughtful child.

After breakfast, Milliken and I went over the *Merlin* on a general overhaul, and found her none the worse for her straining. We took off from the deck of the cruiser just before nine o'clock.

"Where now?" asked Danny.

"Mogador," said I. "We owed the raiders a start for their humanity. They certainly play a clean game. It would have been easy for them to have left the *Merlin* in irons with their gas. But we're going to have another cut at them. First, we must refill our tanks at Mogador, and get a message radioed from the station there to the President and to Sir Thomas Basildon.

"But, Jimmy," Dan objected. "If they can stop your engines once, they can do it again. How are you going to get over that?"

"I'm not quite sure," said I. "I think the notion is to get well above them, then it doesn't matter whether the engine is stopped or not—a glide will do all that's required. Next time, I'm not going to waste ammunition on the envelope—they're using some uninflammable gas—that's plain. I'm going straight for the stern engines. Did you notice that the air-ship's steering was done by them?"

"No."

"Fact, all the same," Milliken put in. "The whole of the stern cabin works on a swivel."

"It's so, Dan," I said. "And that's where I'll bust them, or bust ourselves in the attempt. We might have the luck, too, to take them sitting."

"How do you get there?" Dan demanded.

"It's my notion that the airship we attacked works from a base at the back of Morocco. I'm banking enough on the idea, anyhow, to advise Sir Thomas Basildon to get as many scouts concentrated round the coast as he can. If the airship comes out again, we may be able to crowd so many planes round her that the ray you imagine will have more to handle than it is able. In any case, the place wants going over thoroughly."

In answer to the radios we sent from Mogador, the international scouts came flocking to the African coast. Indeed, we were no sooner at the place than the forerunners of the crowd came after us, brought along by the news of our fight. They came in a big fan-shape move that must have caught her had she doubled back across the Atlantic.

There was little doubt in my mind, after sizing the thing up with Milliken, that he and I had done some damage to the airship with our shell-fire. We had put in enough stuff to have fired her if hydrogen had been used in her ballonets, so it was pretty clear that her lift was got from helium. In the face of the amazingly quick getaway the raiders had made after the engagement, this was puzzling.

From her length, which Milliken and I agreed was about two hundred meters, and from her other measurements, the total fixed weight of the ship was somewhere round thirty-four thousand kilos. Using helium, she could not have a disposable lift of much more than perhaps fifteen thousand. When the weight of her crew, fuel, and armament was taken into account, not much margin was left for carrying extra gas in liquid form. So we reckoned that our puncturing of her must have caused a lot of leakage, and that her spectacular ascent must have exhausted a good portion of her reserve gas. We concluded from this that she could not have had far to go to her base, and that she would have to travel ultimately at a low altitude, which made it unlikely that the patrols making for the African coast would have missed sight of her, had she been making across the Atlantic. Altogether, the three of us worked it out that we were justified in believing the air-ship to be concealed somewhere in the hinterland of the Barbary Coast, and that she would venture out again when the damage we had done to her was made good.

We in the *Merlin*, with numbers of the international scouts, worked on this notion and ventured far into the desert, but without finding any reward for our searching. A cordon of scouts was flung round the coast from the Canaries right into the Mediterranean.

On the Wednesday following our fight with the airship, radio messages were picked up that told of raids on shipping to the north of the Bahamas. The temptation then was to go chasing off in that direction, but we held back, pinning our belief to the idea that our particular air-ship was berthed somewhere in N. W. Africa, and that it was only a matter of patience before one or other of the planes round the coast came upon her. Personally, the news of the raids in the western Atlantic only confirmed my belief that the organization was big enough to have bases on both sides of the hemisphere.

We lay on and off the coast of Africa for ten days, without any luck, and for several reasons I made up my mind to make for home, *via* London. First, I wanted to see Sir Thomas Basildon, with whom we had been in constant communication since leaving Washington. Dan had sent him a long report embodying his ideas of the means used by the raiders for upsetting the engines of attacking planes, and outlining a possible way of circumventing the strange weapon. Already Dan's assistants in New York had drawings of a protective arrangement designed for the *Merlin*, and I was anxious to give the thing a trial and to have it tried out on other machines. It was an elaborate cage arrangement of metallic conductors leading to a series of condensers, and it was meant to collect the supposed electric ray before it reached the engine and to disperse it harmlessly. In the matter of the gas, however, by some unfortunate mischance in landing, whether by a wave or otherwise, Dan's bottle apparatus for sampling the anæsthetic had been smashed on the day of our fight, and he was without a sample for analysis, much to his and my chagrin. Secondly, as a reason for going home *via* London, I had heard that Lord Almeric was intending another visit to America, and I thought if he could make his arrangements suit it would be a good notion to take him over on the *Merlin*.

I radioed to Sir Thomas telling him to expect us, and on the Thursday evening Dan and I were closeted with him and Lord Almeric in the room at Scotland Yard.

The chief of the British C. I. D. had not wasted any time, we found. He had badgered the authorities into fitting up his planes with airtight bodies and supplying them with oxygen, and he had had instrument-makers set to the task of turning out Dan's protective apparatus. Our discussion with him, and our description of the fight, helped to clear up some points that had been puzzling him. We came away from Scotland Yard in the knowledge that our visit there had not been a waste of time.

Business Panic in England and Fall of the Government.

From Lord Almeric we heard that business in Britain was at a standstill, and that factories and commercial houses were closing down all over the country. Prices in the stock markets were lower than they had ever been, good industrial securities which had been regarded as next to gilt-edged being sold at prices that made them look like wild-cat oil stock. The damage to the country in lost trade represented millions, Lord Almeric declared, and the set-back would be felt long after the raiders were scotched. The state of affairs was out of all proportion to the damage done actually in the raids, and could only be attributed to a kind of panic.

As a result of the London raid and of the affair in the House of Commons, the government had fallen. It had been laughed out of office, though ostensibly its fall was due to a defeat on some quite unimportant measure. The press devoted columns to the raids now, and printed the opinions of wise men, foolish men, well-known men, obscure men, of how the outrages were carried out and how they could be stopped, with fantastic theories on both sides. It was even suggested that the raiders had come from Mars. The change of tone from the time of the New York raid was, to say the least of it, remarkable.

Unobtrusively as we had made our entry into London, neither Dan nor I nor Milliken escaped the

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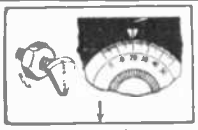
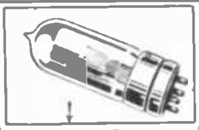
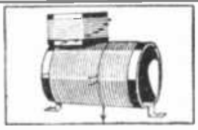


Dial Marker
The big little thing you have been waiting for. Just drill a hole in the panel and mount the marker above the dial. Nickel plated and polished.
L7788 Dial Marker, three for ....$.10

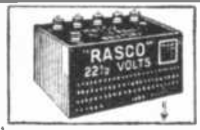


Vacuum Tubes
Only best make tubes carried in stock. Any tube replaced if defective, providing filament lights.
SPECIAL PRICE
L731A 5 v....25 amp.$1.95
L799 3 v...06 amp. 1.95
L72 1½ v...25 amp. 1.95

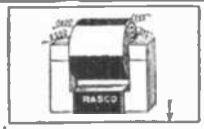
Melotone Loud Speaker
The greatest and most powerful loud speaker phonograph attachment made. If, after five days trial, you do not proclaim it the best and most powerful speaker return it for refund.
L6699 Melotone.....$6.90



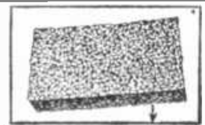
Cockaday Coil
Guaranteed best make. Three windings of No. 18 Magnet wire. Has brass brackets for panel or base mounting. Satisfaction guaranteed or money back.
L2750 Cockaday coil $1.50



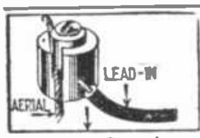
Tapped "B" Batteries
We positively guarantee these batteries to be of long life. We carry only fresh stocks. All with taps.
L2250 Sm. 22½ v....$.85
L2251 Medium Navy size, 22½ volt......1.20
L4500 Medium large size, 45 volt 2.30



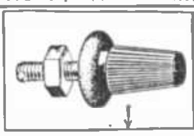
Audio Frequency Transformer
No better Transformer made. Highest class materials. Impregnated coils. Silicon steel stampings used. Save 50 per cent by assembling it yourself.
L1100 Ratio 4½-1..$1.85
L1150 Ratio 6½-1 . 1.85



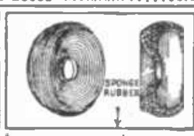
Sponge-Rubber Cushions
Get rid of tube noises due to vibration. Softest sponge rubber made. Size 2½"x3", ⅜" thick.
L8989 Sponge-rubber cushions, each ......$.12
Six for .... .60



Antenna Connector
At last the solderless antenna connector, made entirely of brass in three pieces; clamps aerial and lead-in with vise-like grip, keeping perfect contact at all times. Dia. ⅝", height ½".
L9994 Connector....$0.20

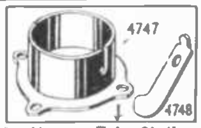


Rasco Vernier
Why use a vernier condenser when a vernier attachment will do anything and everything a vernier condenser accomplishes? Cleverest vernier made. Can be used with any dial. Soft rubber ring engages dial. Nothing to come apart.
L1450 Vernier ......$.18

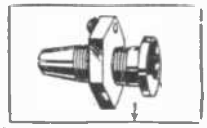


FONEKUSHIONS
Made of sponge rubber. Make wearing your receivers a pleasure. Positively exclude all noises and make reception a pleasure. Sponge rubber will last for years. Light as a feather.
L3550 Fonekushions, set of two ....$.35

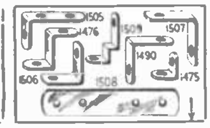
Dial Button
Made in blue enamel and gold, to be worn in button hole. Every radio fan wants one. ⅝" diameter, best gold plate. Perfect reproduction of radio dial.
L7799 Dial Button, each $0.25



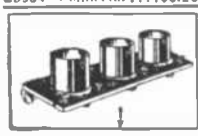
Vacuum Tube Shell
Nickel plated shell for the man who builds his own. 4 holes to attach to sub-base. Each shell comes complete with 4 phosphor bronze socket contacts. See illus. 4748.
L4747 Vacuum Tube Shell and Contacts $0.16



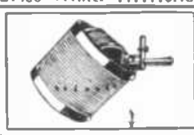
Cord Tip Jack
Takes place of binding posts. Cord tip firmly gripped by jack. Made of brass, nickel plated. Screw to attach lead wire. No soldering necessary.
L1500 Cord tip jack. Each ....$.15



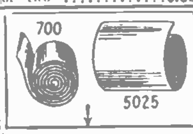
Brass Nickeled Brackets
All illustrations ¼ size.
L1505 Bracket, each $0.05
L1507 Bracket, each .05
L1509 Bracket, each .04
L1476 Bracket, each .05
L1506 Bracket, each .05
L1490 Bracket, each .04
L1475 Bracket, each .03
L1508 Bracket, each .05



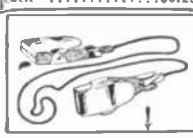
Three-Gang Socket
Aluminum shells, genuine heavy bakelite base, 3 brackets for mounting, 12 nickel binding posts. Length 7⅛".
L5995 3 gang socket $1.50



Rasco 180° Variocoupler
Silk wire wound on bakelite tubes. Six taps. Wave length, 150 to 600 meters. For panel mounting. ¼" shaft. Your money refunded if it is not all we claim.
L3100 Variocoupler prepaid $1.50

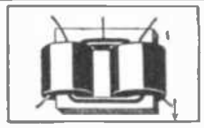


Copper Ribbon
.005" thick.
L700 ⅜" wide; L701 ¼" wide; L702 3-16" wide.
All sizes per foot...$.01
Copper Foil
.001" thick. 4" wide.
L5025 Copper Foil, per foot ....$.10
10-foot length .... .80

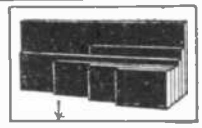


Rasco Clip Leads
Invaluable for experimental work. Clip lead hooks in a jiffy onto any wire, binding post or conductor. Safest experimental connection. Brass clips. 1 foot silk wire, green or red.
L7887 Clip Leads, ea.$.12
Dozen lot 1.35

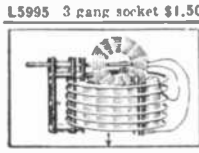
Radio Frequency Transformers
Best Radio Frequency Transformer developed so far. Designed by R. E. Lacault, Inventor of Ultradyne. Air core type. 200-600 meters.
L2800 Transformer, size 1⅞"x2½" $1.35



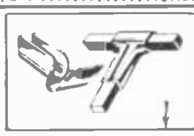
PUSH-PULL
Push Pull Transformer for many new circuits. See any radio magazine. Made of best materials. Coils impregnated. Silicon steel laminations. Save 50 per cent by assembling yourself. Simple instructions furnished.
L1159 Push-Pull Transformer,ratio 6½ to 1 $3.40



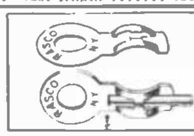
Dilectryte Panels
Highest dielectric strength as per Bureau of Standards. Beautiful high finish.
L7100 7x10x3-16" ..$.70
L7120 7x12x3-16" .. .85
L7140 7x14x3-16" .. .95
L7180 7x18x3-16" ..1.25
L7210 7x21x3-16" ..1.45
L7240 7x24x3-16" ..1.65



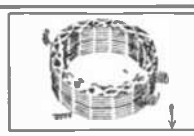
Low Loss Tuner
Same type as used in our LOLOS EXPLORER. Tunes from 200 to 600 meters. Hard rubber insulation throughout. Silver plated primary. Secondary D. C. C. Tickler silk insulated wire.
L2690 Tuner $5.00



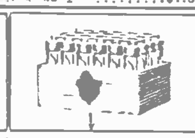
"T" Wire Connectors
This big little article solves all troubles when making "T" wire connections. Made to take 1/16" square or round bus-bar wire. Can be attached with a pair of pliers.
L2975 "T" Wire Connectors, 12 for.....$0.05



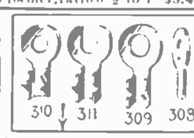
Nosolder Lugs
Finally, a real solderless lug is here. Soldering positively done away with. Takes square or round bus bar, which it holds with a vise-like grip. Perfect connection. Just slide bus bar into slip-grip.
L3727 Lug. 25 for ..$.15



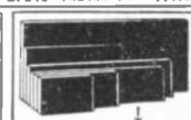
Low Loss Coil
Same type coil as used in Freshman and other Tuned Radio Frequency sets. D.C.C. wire. 200-550 wavelength. 3" diameter. 1" wide. 5-16" thick. 4 connections. 2 primary, 2 secondary.
L2629 Low Loss Coil 85c



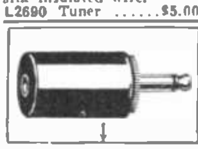
Storage "B" Battery
48 volts. 4½ amp. hours. Buy storage "B" batteries by capacity, not by looks. Charge lasts one month. Rubber tops and vents, wooden tray. Sent Express Collect.
L4480 Storage "B" Battery $14.00



Tinned Nickel Lugs
All our lugs are tinned.
L310 Brass Lugs for No. 8 screw, doz. ......$.10
L311 Copper Lugs for Nos. 6 and 8 screws, doz..$.10
L309 Copper Lugs for Nos. 1, 6 and 8 screws, doz .10
L308 Copper Lug for 6-32 screw, doz. .... .10



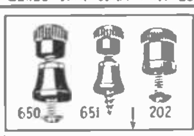
Formica Panels Clearance Sale
As we are discontinuing these particular sizes, this material is now offered at cost. All 3-16" thick.
L352 9x12" each ...$1.25
L354 6½x9½" ea... 1.60
L356 6x14" each 1.20
L357 6x1" each .... .45



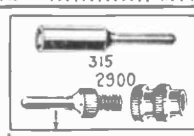
Phone Plugs
Fold from 75c to $1.00 everywhere. Hard rubber composition shell and patented cord tip holder. Finest workmanship throughout.
L1030 Rasco Telephone Plug. Each ....$.35

Bakelite Socket
Octagon shape. Four nickel binding posts, phosphor bronze contact springs. Best brown bakelite.
L6510 Bakelite socket $.40
L6500 Tube Socket. Made entirely of composition. Best made. Each....$.35

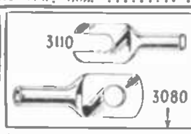
Binding Post Name Plates
Dia. ⅝". These styles: Phones, Ground, —, Output, "A" Bat. —, "B" Bat. —, Loud Speaker, "C" Bat. —, Aerial, +, Input, "A" Bat. +, "B" Bat. +, Loop "C" Bat. +, New! "A" Bat. +, "B" Bat. —.
L6000 Name Plates. Dozen ....$.25



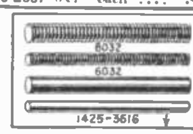
"Rasco" Posts
Made of black composition.
L650-51 Each ......$.08
L202 Has nickel-plated bottom, each ....$.08
Dozen, each style....$.90
L122 Initialed Binding Posts. Six popular styles. Each ....$.06



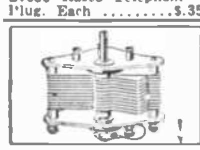
Cord Tips
Standard phone cord tips, nickeled.
L315 Each ....$.03
Separable Cord Tips
No solder required. Wire goes in ferrule. Shank holds it tight. Nickel plated.
L2900 Each ....$.06



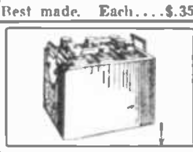
"Perfect" Lugs
These new and improved lugs are brass, nickel plated, flattened on top a. shown. Made of a single piece of metal. Lead wire goes into tube.
L3110, L3080 "Perfect" Lugs. Each $0.02
Dozen lots .... .. .20



Brass Rods
Sold in 6" lengths only.
L8032 Rod 8-32" thread length ....$.08
L6032 Rod, 6-32" thread length ....$.06
L1425 Rod, plain, ¼" round, length ....$.10
L3616 Rod, plain 3-16" round, length ....$.06



Panel Mounting Grounded Rotor Condensers
Positively no better condenser made. Lowest losses, pigtail connection, binding posts, aluminum plates, rugged construction. Used by 9 big set manufacturers.
L2113 13-plate $1.50
L2123 23-plate 1.90
L2143 43-plate 2.85



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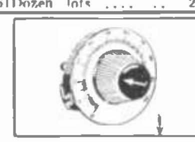

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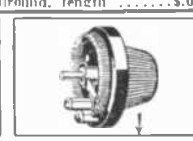

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attentions of the newspaper men. They clung round us like flies, infesting our vicinity at meal times, seeing us to bed and greeting us on our awaking. We were glad when at last on the Saturday morning we could get Lord Almeric aboard and be off across the Atlantic. We made straight for Washington, where my passenger was to meet my father and several other bankers. Our voyage was quite uneventful and placid, and we arrived on the Potomac basin just before seven on the Saturday evening, American time.

II

It was good to get back to Washington and find not only my father but Kirsteen Torrance waiting for us on the landing-stage. Four weeks all but a day had elapsed since our setting out on our venture, and, to me at least, a shadow of failure lay on our return. At any rate, I was a little shy of meeting Miss Torrance's level glance. There was that in her welcome of us, however, after she had greeted Lord Almeric with affection, which quickly swept away all sense of having failed. To Milliken, always her favourite, she had so much to say that he was at his blackest of countenance with embarrassed delight. I thought he would burst something.

The old man, too, seemed to think we had not done badly. In the casual heartiness of his greeting, I thought I could discern something of satisfaction—of pride, even—at our exploit.

Dinner that evening at the White House was a sort of reunion. The President, Kirsteen, Lord Almeric, my father, Danny, and myself, all somehow linked up with the task in hand, composed the party—and one stranger. This was an Englishman, a big fellow named Seton.

Miss Torrance Again

Now in the four weeks we had been away from Washington, I had thought a good deal about Kirsteen Torrance, and I may admit here and now that I had come back to her with an absolute certainty that life without her would for me be incomplete. When the *Merlin* was streaking down on the airship that Sunday morning, it had come to me very clearly just what Kirsteen stood for—and that was pretty nigh everything. I won't elaborate on the theme. I'll leave it just so.

It was with a pang of dismay, therefore, that I heard Commander Seton introduced as an old friend of both Kirsteen and Lord Almeric, and saw the satisfaction the big Englishman and she had in each other's company. When a fellow finds a girl interesting, there's nothing can make him feel so hopeless about his chances with her as to hear her talk with another man. "Do you remember—?" bulking largely in the conversation. Seton and Kirsteen were old enough friends for that.

It would have been a mean thing to get up any dislike of Commander Seton. As he listened to the story that Dan and I had to tell, it became very evident that the stranger was no layman in the matter of aeronautics. His comments were practical to a degree, and his questions shrewdly knowledgable. Not only that, but under the lethargy which sometimes is to be seen in big men of his sort, there lay a mental alertness that promised he could move his big frame with lightning quickness in an emergency. He gave an impression of being very much a man.

The only point that Dan and I held back from the general company was regarding his idea for getting round the electric ray of the raiders. I can't say what it was that moved us to this piece of reticence, unless it was just the presence of Seton. But this was the very point that the big Englishman brought up later in conversation with me, when Kirsteen had brought us together, saying that we should find much in common.

"That is a curious fact about all four machines being sent down with engine trouble, Mr. Boon," said Seton. "It seems indeed to point to some weapon of the kind imagined by your friend Lamont."

"Yes," said I. "The raiders themselves knew our engine would be all right afterwards."

"Makes it conclusive."

"Yes," I said shortly. "Are you remaining long in Washington, Commander Seton?"

"It depends very much on circumstances," he replied. "If the raiders have such a ray, it makes them practically immune from aeroplane attacks."

"Practically," I agreed. I wanted to leave the subject.

"Unless, of course, surprise attack on a vulnerable point from a height."

"Oh, yes," said I. "There's always that. It must be obvious to you as an airman——"

"Ah," said Seton, "you know that about me, do you?"

"I guessed it. Ordinary people do not talk of 'torque' as you do."

"Come, come. A common engineering term like that——?"

"Aren't you, then?"

"My dear man, I have never concealed it. If I did, there would always be *Who's Who?*—and the British Navy List to give me away."

"Fly much these days?"

"A little—but I still retain an interest in the game," Seton said. "I am very interested, for example, in this new machine of yours. From all accounts, she must be a wonder."

"She's pretty good, I'll admit," said I. "Come and see her some day."

"I should like to very much. What day would suit?"

"Tomorrow if you like. We go to my place on Long Island for a refit, but you could see her before we start. Where are you staying?"

"Hotel Maryland—like yourself."

"Then you could come down with me to-morrow."

"Splendid," said he. "I want to see her, especially as she may be the last of the aeroplanes."

I looked at him with some amazement.

"How do you get there?" I asked.

The Lie about Overcoming the Rays.

"I mean the last of the fighting aeroplanes," he explained. "If these raider johnnies have the ray you imagine, and unless some means of protection against it can be devised, the aeroplane will be of no use. Think of dirigibles attacking a town—with bombs—and crashing all machines sent up against them. Their power would be unlimited. But perhaps you and Lamont have devised some means that may make the rays ineffective?"

I looked him straight in the eyes—and lied.

"No," I said, and turned to find the President coming over to me.

"A minute, Jimmy," said Mr. Whitcomb, "if Commander Seton will excuse us. I have been talking with Dan Lamont about that protective cage idea for these rays——"

I got up with a look at the big Englishman. He was smiling blandly, and he shook his head at me in a way that made me feel very small, for I did not know why I had fenced with him all along, to lie to him at the finish.

I saw little of Kirsteen that evening. People drifted in later, and between these, her uncle Lord Almeric, Seton, my father, and Danny, she was kept too busy to spare more than a brief moment or two with me. It was from Lord Almeric that I heard Seton's history.

Commander Seton had done well for his country in the war of 1914-18, and had come out of the struggle with a string of initials after his name, representing the highest honours the Allies and Britain herself could give him. He fought as a sailor and as a flying man, and in the latter branch had handled both aeroplanes and dirigibles. Towards the end of the war, he had gone back to sailoring, and had finally retired with the rank of commander. He then took up business in London City, and in four years had amassed, it was said, a fortune of half a million British pounds sterling. With this behind him, he deserted the City and began to indulge a passion for exploration, often being absent from England for months on end. He was now back, Lord Almeric thought, after over a year's absence.

Seton came to see us off to Gardiner Bay on Sunday afternoon, and he had great praise for the *Merlin*. He was the only airman who ever inspected the machine who grasped the principle of the hovering arrangement straight off. There was something about the big fellow that moved me to a sincere admiration of him, but I did hate to see him standing with Kirsteen as we flew off. I knew it would be days before I could get back to Washington, and I was leaving him a clear field with the girl.

Still, I had my job to do, and in the face of that, personal matters had to stand aside. We had to fit the *Merlin* up with Dan's apparatus, and go over every screw and pin of her. She had been flying for over a month with no more overhauling than Milliken and myself could give her, with the help of chance mechanics. She was due to be taken down and set up again by men who understood her, if her high efficiency was to be maintained.

Home Again at the Battery

We put Dan ashore at the Battery landing-stage on the Sunday evening, so that he could go straight to his laboratory, then we went on to Gardiner Bay, where we found every man jack of the workshop hands waiting to see us arrive. It was their day of rest, and since our departure they had been working at top speed on the making of machines from the *Merlin* design, but the boys had always been keen. They were more than just paid hands. Anyhow, the cheer that went up when the old *Merlin* came to rest by the jetty might have been heard in New York. Nothing would suit them but that I should tell the whole bunch of them, collected in the erection shed, the full story of our toss-up with the airship.

On the Monday, Dan Lamont turned up with two intense-looking assistants and a car-load of materials. We handed over to the three of them a small drafting-office, where they immediately became happy in an outrageous tangle of wire and blue prints. I told Dan I thought they were a messy gang, but by the time we had the *Merlin* overhauled and waiting to be put together again, he and the solemn pair were on the mat with a neat cage affair and a string of black boxes, all ready for fitting inside the engine cover. By Thursday evening we were prepared for our second sally against the enemy, and I had great hope that Dan's fixment would give us a better fighting chance.

We arrived in Washington early on the Friday forenoon, and almost the first person Dan and I met there was Commander Seton. We ran into him in the foyer of the hotel.

"Hullo, Boon! Hullo, Lamont!" said he. "You're just the very men I was hoping to see. I'm off for the south at three o'clock, and I want you to lunch with me. Miss Torrance is coming, and Lord Almeric, if he can get away."

"Why, sure," said Dan, right off. "Very glad to——"

"Delighted," I said. "Where and when?"

"In the hotel here, at one o'clock."

Dan and myself went off to see the President and some of the officials who looked after affairs connected with the raids, and at one o'clock we found Kirsteen and took her to the hotel. Lord Almeric sent his excuses. Talk at lunch-time never seemed to be far from the raiders and our venture.

"I wonder," I said, "just what the game is—the big idea behind the raids?"

"What's wrong with asking?" Seton asked casually.

"Asking!" said I. "Asking whom?"

"Asking the raiders," he replied.

"Christopher!" said Dan Lamont. "Funny nobody's ever thought of that!"

"They have wireless, haven't they?" Seton went on. "It should not be a matter of great difficulty to ask them what they're up to. Why don't you?"

"I will," I said. "Or see that they're asked, anyhow."

III

Seton left Washington at three, and Lord Almeric joined us to see him go. He was going to New Orleans.

"Good-bye, Boon," he said to me, last of all, and gave my hand a grip that nearly brought the blood out under my nails. "I have a feeling that we shall meet again, quite soon."

"How's that?" Kirsteen broke in. "I thought you were leaving America, Jumbo?"

"Well, what of that?" laughed the big Englishman. "Can you say in what part of the globe an ubiquitous fellow like Boon will be three days hence? I shouldn't be surprised to see him turn up with his machine in Timbuctoo."

"Timbuctoo!" I said. "Is that your destination?"

"Timbuctoo! Lord, no. I only mean I have a hunch we'll meet in the most unlikely place sometime."

That evening a message in the name of the President of the United States was broadcast on the wave-length used by the mysterious air-ship:

To the Airship *Ark of the Covenant*: With what object are these raids made on humanity?
B. Whitcomb, President of the United States of America.

Stations all around the Atlantic shores, on our side and in Europe, took up the message and repeated it. Every three hours the message went out. Saturday came and passed. Sunday passed. And still the message was repeated.

News of the President's message, germinated from a chance remark at a luncheon party, got into the newspapers. It was featured with staring headlines, and the people waited in breathless expectancy for the reply, for most of the journals promised a special edition immediately the news came through.

Danny and I waited that Sunday night in the White House, while Milliken stood by with the *Merlin*. Midnight came, and the President still stubbornly believed that the message would come. I thought of going down to the basin and turning in on my boat, ready to take the air as soon as the word came through the aerodrome radio. But Mr. Whitcomb would not hear of it. There would be no delay, he promised us, and if we cared to sleep, he would have the servants make up a shakedown apiece. But I was not thinking of sleep for myself. I was thinking of sleep for the President, and for a too-heavy-eyed Kirsteen who shared our vigil.

The Coast Stations on the Alert to Locate the Raiders.

Now, I would have the situation realized to the full. Every radio station on the shores of the Atlantic waited for the message that might come from the raiders, and every one would take it with the directional detector open. It was a trap of sorts. Some hundreds of stations would pick up the message, and behind these stations planes lay, ready to take the air to the place whence the message emanated.

It was too much to hope that the raiders would reply from a base. None would know better than they the danger that lay in doing so. But it was hoped that their known daring would tempt them to reply from the airship, not realizing perhaps the extent of the secret preparations that had been made for their next appearance. It might chance that they would reply from the middle of an encircling ring, which would at once close down on them.

One o'clock on Monday morning, and still we waited. The hand of the clock slowly crept round to the half hour, and the chimes belled out half an old Lutheran hymn tune. The vibration of the last unsatisfying note still hung in the air when a knock came to the door. It was a messenger with a radio flimsy in his hand.

"I'll read it aloud," said the President. "God bless us and give us mercy! Listen!

"Relayed from the U. S. S. *Pershing*—Message begins—Regret to report total company of the ship rendered unconscious between the hours 23 Sunday 1 Monday. Following message found in radio cabin addressed to President Whitcomb—quoted message begins—To the President of the United States of America from the Airship *Arc of the Covenant*: To stop War!—Quoted message ends—Position 39°N. 73°W.—relayed message ends."

A gasp went up from our little company. Then silence.

"To stop war!" the President repeated at last. "A worthy object indeed! Piracy, robbery, the world's commerce and trade brought to chaos—to stop war! What visionaries, what madmen are these?"

"Shrewd madmen!" I exclaimed. "By this time they are six hundred kilometers from the position of the *Pershing*. We might have known!"

"Not peace, but a sword!" breathed Mr. Whitcomb. "Peace by terror—panic in the night!"

I darted for a chart that lay on a table near by. "Thirty-nine degrees north. Seventy-three degrees west!" I cried. "That's near home, if you like. Six hundred kilometers due west of this city!"

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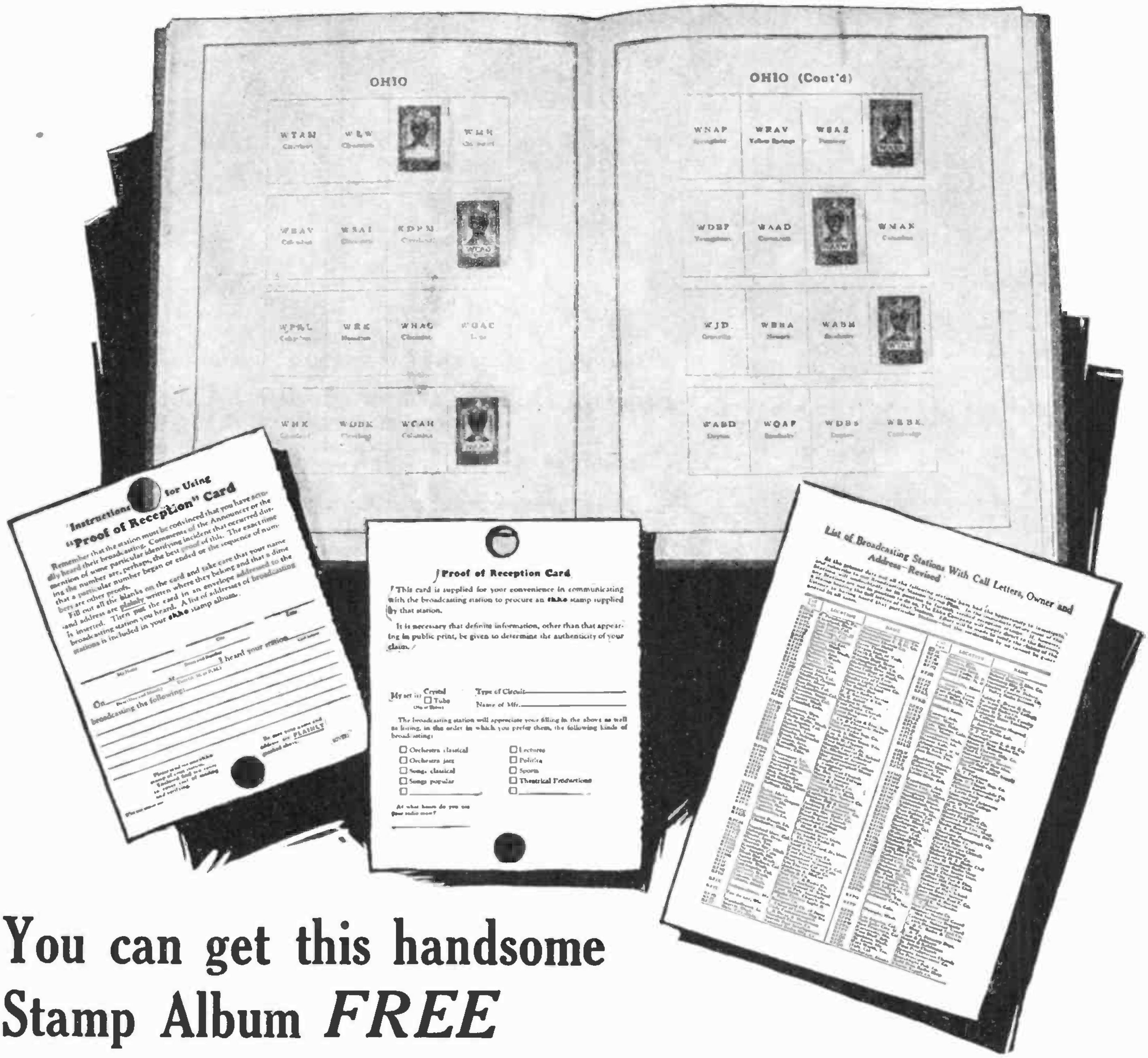
Here is the DX Radio Stamp Album just like the ones we owned in our youth, in which were placed the rare stamps of the countries of the world. Some were hard to get some couldn't be purchased for love or money; but the fun of the hobby was the seeking of rare stamps and the eventual possession. So it will be with the DX Radio Stamp Album. There will probably be some stamps you will never be able to own but there will be many you will be proud to have and be able to show to other radio enthusiasts. It's an interesting game. Below the Album is shown the "Proof of Reception Cards" of which a generous supply is furnished with each Album. A dime placed in the hole in the card and sent to the station you heard brings back a stamp for your Album.



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NAME .... ADDRESS ....

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DON'T FAIL TO USE THIS COUPON.

"Up after them, Jimmy!" cried the President. "Beat the skies for them! Bring them down——!"

I put my hand on my flying-coat which lay on a couch handy, and Kirsteen ran to help me.

A Swoon and an Awakening, and a Communication from the League of the Covenant.

Just then, through the open window, there came a wild shrilling of whistles from the streets of the City, a hubbub and shouting. Transfixed, I stood with an arm in one sleeve of my coat, the body of it hanging loose in Kirsteen's hands, and she by my side, staring at the window with the rest of us.

A faint explosion came from the grounds outside—like the bursting of an electric bulb.

"Quick!" I shouted. "The window, Danny! Shut it quick! Kirsteen—Mr. Whitcomb—upstairs as fast as you can! To the roof!"

But even as I sprung for the door of the room, I saw first Danny succumb to the gas, then the President. I was just in time to catch Kirsteen, swaying, as she fell. By dint of holding my breath, I managed to lower her gently on the couch—then my overwrought lungs gave way.

I sprang from tall cliffs . . . into a balanced dive . . . down . . . down . . . into depths that were dense indigo. . . .

IV

From gross darkness I swam upwards, with a sense of well-being. Into a cavern of deepest blue, through cerulean and emerald, into pearly grey and primrose I swept upwards, to wake with a strange exhilaration in a blaze of light. . . .

Somewhere near me clock chimes belled out half an old Lutheran hymn tune. . . .

I found myself huddled at Kirsteen's feet, as she lay inert on the couch in the President's sitting-room. Some one had thrown my flying-coat over her. By the window, now closed, lay Dan Lamont, and nearer the middle of the room, with his head comfortably disposed on a pillow and with a rug thrown over him, Mr. Whitcomb reposed.

Remembering, I got unsteadily to my feet, and as I looked at the clock and saw that it marked half-past three, my first thought was for Kirsteen. I took her hand and patted it gently. She did not stir, and I half strangled with a fear that she was dead. But she was breathing softly, and I left her to cross to the President. He awoke at my touch.

"What?—what?" he muttered. "What was that noise in the garden, Jimmy?" I helped him to his feet. "I remember now. The raiders!"

"Yes, sir," I told him. "We all have been asleep for two hours."

He went over to Kirsteen in a dazed way, while I crossed to Dan Lamont. The President shook the girl softly by the shoulder, and as I knelt by Danny I saw her wake with a smile. I shook Danny.

"I wasn't smart enough, Jimmy!" he muttered. "It's too quick, that dope—doesn't give you a chance."

I helped him to his feet.

"Gee, Jimmy!" he said with a faint grin. "We've been raided!"

"Looks like it."

I turned to the President and Kirsteen, and found them standing by the table in the centre of the room. On the table lay a paper.

"Boys, come here!" the President said, and all four of us stood by him to read the message that lay before him.

Benjamin Whitcomb (it ran).

You ask us what object we have in making these raids on humanity. Here is our answer once more:

A Strange Message from the Raider

We make these raids on humanity for humanity's sake. Our object is to put an end to war on humanity. If you, as the honest man you are known to be, have a real love for humanity, you will use your power and influence to further that object, by whatever means you think fit.

None knows better than you how near the nations stand to the brink of war. Until they resolve to step aside from the path that leads them to destruction, our power will be used against them on land and sea.

If you have eyes to see, you will see. If you have a tongue wherewith to speak, you will bear witness to the nations.

That is our answer, Benjamin Whitcomb. Look to it that you answer as straightly.

THE LEAGUE OF THE COVENANT.

"The madness of it!" muttered the President. "Do they think that nations can be reformed by the turn of a hand? And yet—the bigness of it! Man, man—if I were only foreman to God Almighty——"

He broke off and paced up and down the room.

"It is a great object if sincere," he said, as if we had not been there, "but these are not the means to accomplish it. Will earthly fear drive out that sin which not the fear of God can subdue? No, no! No wrong can right another. It is a menace—a menace. It has brought the peoples nearer to war than further from it. It is a menace."

He turned to Danny and me, but though he looked at us with blazing eyes, he seemed to see beyond us.

"I will not turn back," he said thickly. "Your task remains, James Boon. Find me the nest of these visionary pirates, and let us test their boasted powers, these evangelists who do not scorn to fill their pockets as they preach. Rout me them out, James Boon. You have behind you the whole of the United States. To it my son!"

"Yes, sir," I said quietly, for I saw with surprise that he was not himself. "Good-bye, sir!"

"Good-bye, Jimmy. Good-bye, Dan."

He turned to finger the paper that still lay on the table, while Kirsteen came with us to the door.

"Don't leave your uncle, Kirsteen," I whispered. "He is not himself!"

"He is better alone," she replied. "He is so terribly self-willed that he hates being dictated to, and he is mad with anger at the indignity of having been sent to sleep. But he's right. The raiders must be caught and punished. Good-bye, Dan. Good luck!" She held out her hand to Dan, who grasped it for a moment, then ran down the steps. "Good-bye, Jimmy. God speed you!"

I retained her hand for a moment.

"Kirsteen!" I blurted. "I caught you as you fell. I know I can't do without you. Is there any chance for me?"

"Jimmy, Jimmy!" she said gently. "You have a man's task before you yet——"

But there was that in her voice made my heart leap. I laughed, and stooped to kiss her hand.

"Well," I said, "it's a man's task to tell a girl he loves her".

I ran down the steps after Dan.

CHAPTER TWELVE

The Plateau of the Red Seer

I

As we made our way down to the basin on the Potomac, Dan Lamont and I came on a number of people still lying unconscious from the gas. They were at about the end of their sleep, and the night was warm and mild, so they could not come to much harm. We stopped, therefore, for no attempt to bring the sleepers round.

At the landing-stage everything was placid and quiet. The arcs were burning brightly, and by their light we could see mechanics walking about or working here and there. Milliken was fast asleep in the *Merlin's* cabin, and when we woke him we found that no news of the raid had yet reached the aerodrome. The message to the President had been picked up by the radio, and on receipt of it several pilots had gone up to make for the position given by the *Pershing*.

"I thought it was a bit like shutting the stable door, myself," said Milliken, "seeing that the radio arrived over two hours after the doping of the battleship. When you didn't turn up, I thought to myself that the plan had been changed, and that you were after some other game. So I just turned in and had a sleep."

"While you were sleeping, Milliken," said I, "Washington was being raided."

He sat up at that.

"Jinks!" he exclaimed. "There wasn't a whisper of it round the aerodrome."

I turned to Dan.

"Looks as if the folk that made the hubbub and blew whistles just before the gas caught us must have been doped, too," I said.

"Looks like it," Danny replied. "It's a clean get-away!"

"What? Were you doped, then?" he asked.

"Yes. The attack was on the White House. The President and Miss Torrance were put to sleep."

For the first time in my experience of him I saw Milliken grow really angry. The blood rushed to his face until it was black.

"Miss Torrance!" he choked. "Here! C'mon after them!"

"Easy, Milliken," I checked him gently. "We don't know yet which way the raiders have gone. I had hopes that the aerodrome knew of the attack, and had some idea of the direction they took."

"Not a scout went up, sir, on account of the raid," he said thickly. "If I'd only known! I'd have given them something—the swine! Dope a girl like Miss Torrance, would they?

"Look here, Mr. Boon—Mr. Lamont," he went on presently in his normal voice. "I've been thinking this thing out in my own way. I've been studying the map a bit, and calculating distances and that. I've worked out times, too. From what I saw of the airship that day, I'm betting she has a fair pair of legs—not up to the *Merlin*, but still fair enough for an airship. Look at this morning. Six hundred kilometres in two hours!

"There's legs for an airship," Milliken insisted. "Here, Mr. Boon—and you, Mr. Lamont—just have a look at this. This map. I figure it like this——"

He had dived into his locker and brought out a small scale map of the Western Hemisphere. On this he had drawn a complicated series of lines, carefully tagging the longitude and latitude of each known raid. It was an interesting piece of work, and it showed that old Milliken was silent to some purpose if he thought the more.

"What do you think of it?" I asked Dan.

"Christopher!" said he. "I think Milliken's got a hot idea. Good for you, Milliken!"

We went over the theory carefully once more, checking Milliken's figures. The idea was more than feasible.

"You're betting, then, Milliken, that the base is somewhere on the Spanish Main?" I said to him.

"The Spanish Main!" he cried. "Why, so it is! I never thought of it so—but so it is! Now wouldn't that be just the place for the dern pirates?"

Off to the Spanish Main on the Merlin.

It was obvious that the romantic associations of the old name had fired the imagination of Milliken, but that did not affect the attractiveness of his notion. A feature of it was that he had worked the whole thing out on the basis of one airship. I thought this point a trifle stretched, myself. It was giving the airship of the raiders a power that was simply miraculous, but even worked out on the basis I held to, that the raiders had stations on either side of the Atlantic, there was a good deal in the idea. I slapped my mechanic on the back, anyhow.

TO OUR READERS—If you are unable to get your magazine from your regular newsdealer kindly notify us. The Experimenter Publishing Co., 53 Park Place, New York.

"Good enough, Milliken," I said. "We'll head south for a start!"

When we flung open the gates of the boat-shed, and floated the *Merlin* out into the basin, we found that the news of the raid had got down to the air-station. It was now a scene of wild activity. From all directions came the hum of engines, and mechanics were running about on all the platforms. When the *Merlin* appeared in the open, we were immediately surrounded by pilots and squadron commanders asking for the latest news. Their news was more up-to-date than ours, and we did not waste time in telling them how we ourselves had been doped. Nor was it necessary to inform them of Milliken's idea. They were all under the central command, and the information would only have made them restless. We left it alone and got ready to take off.

"Where are *you* heading, anyway?" some one shouted, as we swung into the beam of light which gave us our path into the wind.

"Us?" I yelled in reply, with a strange feeling of exhilaration. "Why—we're heading south! Contact, Milliken!"

To the hum of the engine the *Merlin* throbbed, and as my mechanic climbed up through the hatch, we lifted from the surface of the water and climbed, swinging south for the old Spanish Mainland.

It was after four in the morning when we took off from the basin, and day was breaking as we reached flying height. Less than an hour's flight left Cape Lookout behind us, and shortly after seven we were over the Bahamas. The mass of Cuba loomed up on a clear horizon sometime past eight, and by ten o'clock Dan and I were breakfasting in one of the best hotels in Kingston, Jamaica. So it may be guessed in what trim the *Merlin* was that morning.

Off to Maracaybo in the Merlin

Milliken had relapsed back into his usual taciturn self, and would not be persuaded to join us at the hotel. He preferred to remain behind with the *Merlin*, and cook his own breakfast on the gasoline stove. I fancied he was a little astonished at his own eloquence in the early morning, for he was certainly piling up a new record for silence. He woke up enough, however, when we rejoined the *Merlin*, to plead that we make straight for Maracaybo, so redolent of association with the Buccaneers. I had had another notion than to risk the probable discomfort of the Venezuelan town, but I decided that Maracaybo would do for a start, especially as it satisfied some hidden vein of romance in my robust artificer. Let the reader examine Milliken's map of the North Atlantic at this point, and learn what a curious fellow my mechanic is.

"Maracaybo be it!" I said to him. "And let's hope your hunch leads to another slap at this modern Morgan!"

We crossed the Caribbean without mishap in good flying weather, and made Maracaybo an hour after noon. The town has a good harbour, part of the land-locked Lake of Maracaybo, excellent as a shelter for seaplanes—but for reasons which have much to do with a personal bias to that virtue nearest godliness, we decided to sleep on the *Merlin*.

We had filled up with gasoline at Kingston, and had sufficient aboard for a fairly long flight, but it is always a wise plan to keep full tanks if good stuff is to be had. Here we found some difficulty. The stuff the dagoes were willing enough to supply would have been too much for the digestion even of a three-thousand-kilo truck. I was for letting the thing slide until we made another port, but Danny came out with a suggestion.

"What's the matter with trying old Aunt Mandy again?" he asked.

"It's an idea," said I. "Let's try it."

We hunted round until we found a general store and here, sure enough, we were able to buy a packet. On the packet, the name of the local agent was given, and an address, so we looked the fellow up.

Señor Fernando Lopez was a stout and very tired Spaniard, it seemed at first sight, a typical dago who had difficulty with English. He was too polite to yawn in our faces, but he looked as if he would have liked to. And he did not change a hair when I casually flashed the star that was pinned to the inside of my coat. All he did was to waddle over to a door and push it open, with a lazy wave of his yellow hand bidding us step inside. But once the door was closed on the three of us in that inner room, Señor Fernando Lopez spoke idiomatic American.

"Say, boys," he said with a quick smile, "mighty glad to see you! What's the trouble?"

I explained who we were and our present needs.

"Aviation spirit?" said Señor Fernando. "Sure! So you're Mr. Boon and Mr. Lamont? I've been hearing about you. Glad to see you, boys—glad to see you! I have been wanting to see you for a week or two past. I was hoping you'd drop in here one day."

"That's funny to hear, Mr. Lopez," I said in some surprise. "It's the merest chance that brought us to Maracaybo. What made you think we might turn up?"

"Sit down, boys, and I'll tell you," said he. "No—stop a bit. We'd better be comfortable——"

He opened another door. This led into a courtyard, a widish space with palms and flowers, and surrounded by a sort of cloister of old arches. It was clean and sweet and cool, and a surprising thing to come on after the hot and dusty narrow street from which one entered the building. We found comfortable American reclining chairs in the shade, and when we were snuggled down Señor Fernando clapped his hands Spanish fashion. A soft-footed yellow servant appeared, and our new friend jabbered an order at him. Next moment the servant was back with a tray of glasses, a bottle or two, and a bowl of ice.

"I won't ask you what you'll drink," said Fernando, "because I know what's best in Maracaybo. I prescribe!"

He manipulated the bottles, and whisked in the ice. The result was a beautifully coloured, bubbling drink in each of three long glasses.

"Bury your noses in that!" said Señor Fernando. "Say, boys—I'm mighty glad to see you!"

He nodded and took a long pull at his glass, an example that Dan and I were apt enough to follow. I will say that Señor Fernando Lopez could mix a drink!

"And now, boys—I'll tell you one of the reasons why I'm so mighty glad to see you," he said. "That's apart from the fun of seeing your American faces." He leaned forward in his chair. "*I think you're on a hot scent down here!*"

Danny and I, you may be sure, pricked up our ears.

"You mean—the raiders?" I asked. He nodded mysteriously. He had a funny little trick of a backward nod that seemed to call you closer.

"Listen! There are rumours along this coast—from here right along to Port of Spain—aye, and further—of an airship crossing the coast-line. At first, when the news came out about these raids, I thought it was only nigger and dago talk. But the thing has persisted. I've been to the trouble of having the thing—the rumour—followed up, and I'm beginning to think there's something in it. So far, I've only reported it to headquarters as perhaps dago and nigger fiction, but—now—well, I think it would pay you to haunt this coast for a spell. Do you get me, boys? I have nothing definite to give you except my own opinion—and that is, *there is something in it!*"

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(To be continued)

The Pianor

(Continued from page 586)

2. The two effects can be combined; for example, the accompaniment can be played as on an ordinary piano, while the melody is given in continuous sounds, recalling those of the flute or hautboy.

This comparison is not given as an approximate image, but as a rigorously exact expression of the reality, and it is this which is the most curious feature of the pianor. An ordinary piano string of steel stretched to produce its note and which under the effect of the hammer blow gives the regular piano staccato note, changes to a singing tone, reproducing the sound of a wind instrument when it is made to vibrate without mechanical contact, is actuated by electromagnetic attraction, as if it were blown upon, as in the case of the aeolian harp.

The description of the action follows: When the performer presses the key he closes the circuit of two electromagnets, there being two for each note. The principal electromagnet draws the string toward its poles, but instantly the secondary electromagnet attracts the metal brush, which is withdrawn from the tuning fork, the circuit is broken and the cord vibrates, dying away into its initial position.

After the first attraction the metallic brush, which connects the circuit of the secondary electromagnet to the tuning fork by the intermediary of a contact piece of silver, stays in equilibrium, acted on by a damper. The tuning fork, to which a linen thread transmits the vibration of the string, oscillates synchronously with it, and it is this which, opening and closing the circuit at the brush, determines the makes and breaks of the current, which for some notes may exceed 2,000 per second. Each touch, besides, may give a hammer blow to the cord as in an ordinary piano.

Making A Sensitive Balance

(Continued from page 634)

A set of weights for this balance can be purchased of any scientific supply company or can be made of wire as shown in the illustration. Each bend represents a tenth part of the unit, which for small weights may be a centigram and for larger ones a gram.

Carbon Bisulphide Prism Spectroscope

LONG ago, in the good old ELECTRICAL EXPERIMENTER (which I am glad to see revived) there were given directions for making a spectroscope, using for a prism a hollow cell filled with carbon bisulphide. Such a prism is expensive to buy, but one can easily be made. I take no credit for the idea, although I have made modifications.

With a hacksaw cut a ring from a piece of brass tube (about one inch diameter with $\frac{1}{32}$-inch walls). This ring is so cut that the two faces will have an angle of about 60 degrees between them. Drill a small hole of $\frac{1}{16}$-inch diameter at the top for filling. File the cut surfaces smooth and flat. They may be rubbed upon a piece of emery cloth stretched over a board. Clean the metal from oil. Cut some glass rectangles from a piece of clear glass (photo-plate glass). Clean these thoroughly and dry. Apply the cement formulated below to the edges of the brass ring and press against one of the glass pieces. Allow the cement to harden before treating the other side in the same manner. After a few hours the prism may be filled with carbon bisulphide. This liquid is highly refractive and dispersive, but also odoriferous, inflammable and poisonous. Stop the hole with a small wooden plug covered with cement after the prism is filled.

Cement formula (proportions approximate):

Carpenter's glue	5 parts
Water	5 parts
Glycerin	1 part

Heat on water bath or heat gently, replacing lost water. Use hot. Be careful not to overheat if a double vessel or water bath cannot be used.

The prism is most easily filled with a medicine dropper with a fine point. (Don't let the bulb get wet with the bisulphide.)

The spectroscope is an arrangement for viewing an illuminated slit through a prism. The simplest arrangement for our simple apparatus is to place the prism at one end of a cigar box near the peep-hole, and to have a narrow slit at the opposite end of the box through which light enters. An adjustable slit may be made by fastening two safety razor blades near together before a square hole in the end of the box.

To improve the vision a lens may be placed between the slit and prism. This magnifies the image, but requires focusing. The image always appears at one side and should be at the right, with the colors red to blue running left to right.

The instrument is rendered more efficient by blackening the inside of the box.

A more compact form of mounting is to arrange the prism, lens and slit within a cardboard tube, which may be mounted upon a stand.

By using a narrow slit the Fraunhofer lines are seen, using daylight. Many experiments in spectrum analysis are possible with this instrument, which replaces a fairly expensive one.

Contributed by Troy Carney.

A Curious Effect

A Spanish correspondent informs me of a very curious experiment tried with some carrier pigeons at the radio station of Paterna, near Valencia, Spain. Several birds were released near to the aerial mast at the moment when the station was transmitting, and it was observed that the pigeons lost their sense of direction and turned around and around in confusion. The tests were repeated many times, and in all cases the electro-magnetic waves appeared to destroy the pigeons' sense of direction.

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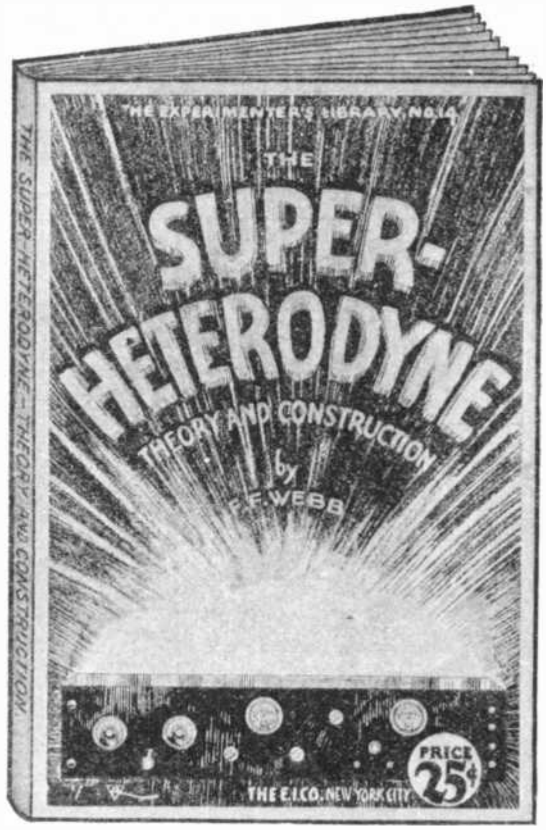

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