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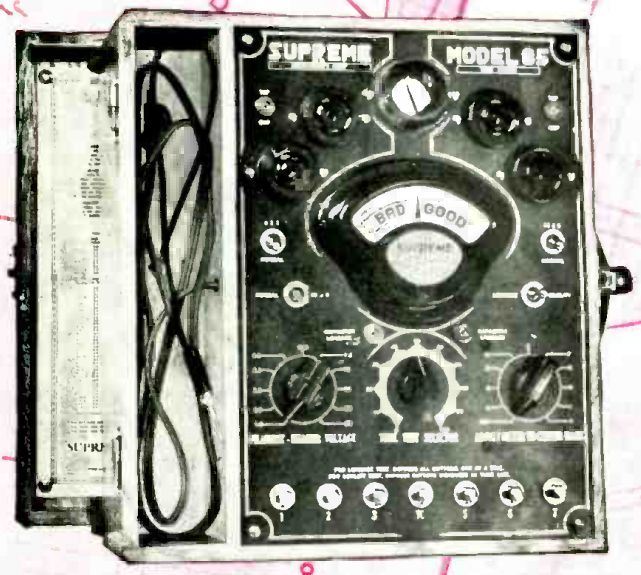

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CONTENTS OF THE APRIL, 1935, ISSUE

Volume VI Number 10

FEATURING PUBLIC ADDRESS IN OUR NEXT ISSUE

Public address has attained not only national prominence but also is rapidly surging to the fore in other countries. In the next issue of RADIO-CRAFT we are going to inform our readers of some of the happenings in the P.A. field, abroad. Then, we'll go over domestic happenings in our own backyard—something about fidelity in phonograph records—the "infinite baffle"—a new electronic-music instrument by that dean in the field, Captain Ranger—an easily-built 100-watt amplifier—and many other interesting items.

Then, there will be the usual departments you look for each month—the DX Listening Post that keeps you and your customers posted on what DX stations to listen for and when—Operating Notes for the Service Man—instructional articles for the beginner in radio—and descriptions of new developments by the commercial labs.

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Editorial Offices: 99 Hudson St., New York, N.Y. HUGO GERNSBACK, Editor Vol. VI., No. 10, April, 1935

THE ELECTRONIC ART

An Editorial by HUGO GERNSBACK

THE electronic art encompasses that branch of radio and allied radio branches which has to do with the motion of electrons in certain electrical devices, such as vacuum tubes.

The radio tube, for instance, is a device which is electronically operated. It functions by the motion of the electrons between the different plates and grids in the interior of the radio tube. But radio tubes are not the only electronic devices. There is a formidable array of devices and instrumentalities in use today which is making the electronic art a big business—one that is growing by leaps and bounds, with a magnificent future before it.

Besides the radio receiving tubes, we have, of course, the transmitting tubes, power tubes for various purposes, rectifier tubes, and tubes with such high sounding names as Thyratron—grid-controlled rectifiers; Phanotron and Kenotron—high-potential rectifiers; Pliotron—oscillators; Magnetron and Axiotron—magnetically-controlled oscillators; Ignitron—mercury-pool controlled rectifiers; Kathetrons—grid-controlled mercury-vapor rectifiers; Cathautograph—cathode-ray pencil; etc.

In addition to this, there are, of course, X-ray tubes, of various types, all electron-operated. Then we have the long, tubular glowing lamp, known as the illuminating neon-type tubes, although many of the newer ones contain other gasses besides neon. Not every colored tube which you see today uses neon; those which give off the red-pinkish light still use neon but others, such as those which give green and blue and yellow, use other gases and metals. Thus, a brilliant yellow illuminating tube is made by using the volatile metal *sodium;* the green illumination is made with *mercury vapor;* blue is made by means of *cadmium*, another volatile metal; while a mixture of vapors of mercury, zinc and cadmium gives a light much like daylight.

The operation of all these tubes, no matter what gas used, is, of course, by means of the ubiquitous electrons.

But the tube which the public associates, perhaps more than anything else, with the electronic art is the photoelectric cell. This electronic device, commonly called the "electric eye," has found hundreds of new uses and the proverbial surface has, as yet, not been scratched. Photoelectric cells are used today for opening doors automatically by intercepting a light beam; they are used even to assort beans, as well as grade different shades of cigars; and the photoelectric cell does this much better than the human eye because it is unfailing and it never tires. Photoelectric cells are used to level off elevators, so they stop exactly at the proper floor height; they turn on street lights at sundown and turn them off at sunrise; they accurately count people in the street, or automobiles in underriver tunnels. They operate garage doors by the light from the automobile headlight; they are one of the most important adjuncts to television in transmitting the light impulses from the televised subject; they check drinking water on shipboard for the presence of oil or sediment; protect the operators of shearing and punching machines in factories; check the humidity of air in a room; align the printing on toothpaste tubes with the "seal" at the bottom; inspect jigsaw puzzles in manufacture; verify the timing of automobiles or runners in competitive races; control automatic machines for making paper bags; record the time of flight of shells from large guns at proving grounds; save electric bills in large industrial plants by correct control of illumination; measure the sand and cement in mixing mortar; measure the acidity or alkalinity of chemicals and, last but not least, permit blind people to "see." An entire book could be written as to the application of the wonderful photoelectric cell itself, and many new and far-reaching uses will be found for it in years to come.

Closely allied with photoelectric cells are such devices as light-sensitive selenium cells and copper-oxide cells. The latter has particularly found a fine field of new endeavor in measuring (by means of an attached meter) the illuminating power of reading lamps, so that the engineer can tell whether your eyes are being strained by a particular type of illumination.

The latter device operates somewhat differently from other electronic devices in that the light falling upon the cell, itself, gives rise to the release of an electronic stream. In other words, the light ray falling upon the cells transmutes the light energy into electric energy inside of the cell—as the result of electron motion, of course.

Dr. Colin G. Fink of Columbia recently declared that photo-cells of this type, producing electricity equivalent to 75 per cent of the solar energy, are not beyond the realms of possibility, though at present they are only a fraction of 1 per cent effective. Considering that there is an equivalent of 150 watts of power in a square foot of sunlight, a roof on your house made of such a photoelectric material would convert, in one short hour, sufficient electricity to supply all your needs for a week.

This research has led many engineers into still another field of electronic devices, and that is the "cold electronic tube." Today, the overwhelmingly larger percentage of electronic devices are dependent upon the radiation of their electrons from a hot wire (filament) or cathode, the temperature rise in which releases the electrons. Without such a hot wire or a hot cathode, the device would not function. But all the time we are getting closer to the new cold electronic tube, where no hot electrode, no hot wire, no hot surface, is used, and where the entire electronic emission is dependent upon the electrical current which, in a number of ways, tears out the electrons from a cold cathode or cold wire. So far, such devices have not been highly successful, and we still must use our heating or "A" power in order to get the energetic electronic flow; but the time will come when all electronic devices will be of the cold-tube variety, and the efficiency of such electronic devices will no doubt be far higher than those with the hot cathodes or hot wires in use today.

THE RADIO MONTH

An experimental set-up of the inverter used in the new power distribution system.

NEW DEVELOPMENT IN POWER DISTRIBUTION

ELECTRONIC tubes have made possible a new highly efficient method of sending electric power over great distances—without the tremendous losses heretofore encountered in such projects. This fact was made known last month in a paper read before the members of the A.I.E.E.—and is the work of Dr. C. H. Willis of Princeton University, and B. D. Bedford and A. C. Sprague of the G.E. Co.

The new system depends on the use of gigantic thyratron and phanotron tubes—half as large as a man—and is briefly dependent on the conversion of high potential alternating currents into direct currents of the same potential, which are transmitted over high voltage power lines, and then the efficient re-conversion of these extremely high "constant currents" into low voltage alternating or direct currents.

The paper read before the A.I.E.E. stated that power losses of 1 to 2 per cent were encountered in these conversions. With such highly efficient distributing systems, huge power plants, such as the Tennessee Valley, Boulder Dam, etc., will be able to supply their power to wide areas in the country—and because of the size of these plants, the power cost will be extremely economical. The importance of this development, cannot be over-estimated.

In addition to great economy in distribution, there are other advantages—complete regulation of power flow is always realized—short circuits cause a drop in power instead of a concentration of flow as with present methods.

The appearance of the Hewlett sun motor which uses four selenium photo-cells.

RAYS OF LIGHT OPERATE NEW MOTOR

ANOTHER step forward in the search for machines which can harness the natural energy received from the sun was demonstrated last month by an eminent scientist—Dr. C. W. Hewlett.

Dr. Hewlett's model which utilized unusually sensitive light-sensitive cells of the selenium type, derived sufficient energy from sunlight or even artificial light to run a small motor.

Four of the selenium cells, connected together, operated a motor rated at four ten-millionths of a horsepower. The speed with which the motor turned depended on the amount of light—direct sunlight turned it about 400 revolutions per minute but even a sky light on a cloudy day was sufficient to turn the motor rapidly.

No practical applications for the sun-driven motor have been undertaken, for its size of four ten-millionths of a horsepower, which might be likened to one flea-power or less—is too low to be of immediate practical value.

It has been pointed out, though, that "each square foot of sunshine continuously delivers energy equivalent to 150 watts of electrical power—enough solar energy falls on the average automobile to drive it at speeds up to the legal limit. More solar power is delivered to the decks of the average steamer than the total power of her engines."

Dr. Colin G. Fink of Columbia University recently declared that photo-cells producing electricity equivalent to 75 per cent of the incident solar energy are not beyond the realms of possibility—though the present efficiency is a fraction of 1 per cent.

The little sun motor made by Dr. Hewlett has no practical value, according to its constructor—but it is probably the forerunner of really practical types.

PROFESSOR LECTURES CLASS FROM HOME

THE dream of every pedagogue to sit comfortably at home and deliver lectures to a classroom, without having to face the yawns of inattentive students, became a reality last month when Dr. C. C. Clark of New York University introduced the use of ultra-short-wave transceivers to his class in science.

Dr. Clark, chairman of the school's science department, seated in his home at 10 Sheridan Square, about a quarter of a mile from the "School of Commerce," delivered lectures and answered questions for more than a week, without once having to attend class.

The means whereby this was accomplished was the use of two transceivers or combination transmitters and receivers which operated on ultra-high-frequency waves. One of the transceivers was set up in the Doctor's home and the other, with a suitable amplifier was installed in the classroom. These ultra-high frequencies, it will be remembered, do not carry over long distances, but are ideal for spans up to 20 miles.

The Professor was so closely in touch with the students during these experiments and so familiar with his students that he even enjoyed the fun of admonishing—"You two in the back of the room—sit up and pay attention."

This practical experiment immediately suggests other uses for which the transceivers might be applied. For instance, they could be used for communication between the school principal and any of the classrooms, thus eliminating the lines and public address equipment otherwise required.

The professor can now sit comfortably at home and lecture his classes.

IN REVIEW

Radio is now such a vast and diversified art it becomes necessary to make a general survey of important monthly developments. RADIO-CRAFT analyzes these developments and presents a review of those items which interest all.

RADIO BUSINESS IN 1934

IN THIS, the beginning of the fifteenth year of broadcasting, it is interesting to look back over the past twelve months and note the financial condition as reported last month by Dun and Bradstreet, Inc.

In addition to the continual encouraging reports during the first six months, an abrupt increase in sales took place when the new all-wave models were displayed early in the fall. In comparison with the totals for the corresponding period in 1933, no losses were reported in any part of the country, while increases ranging from 25 to 100 per cent were recorded. The less expensive sets were bought freely, but the proportion was not as large as it was last season, because of the decided shift to the higher-priced all-wave sets.

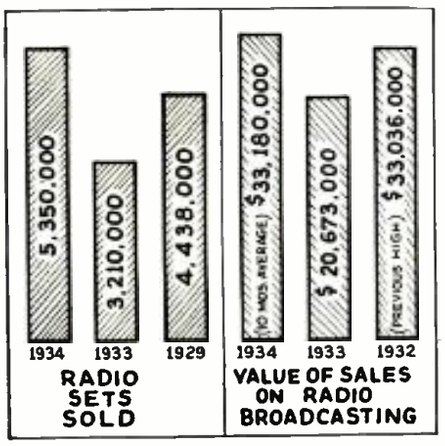
The report of Dun and Bradstreet indicates that the sales averaged 40 per cent higher than the comparative period in 1933—an encouraging report, indeed! The results are shown in the graph here.

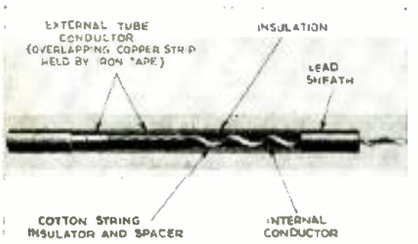
But the advances reported in set sales are nothing compared to the startling figures reported for the radio broadcasting network business.

In October, the highest sales in broadcasting history were reached at $4,527,000, a gain of 59 per cent over the 1933 comparative figures and 49.1 per cent higher than October, 1932. For 10 months of 1934, the sales amounted to 33.8 per cent higher than the 1933 comparative figures and 2.2 per cent in excess of the 1932 total, which was the previous all-time high level.

Let us hope that these encouraging reports continue to pile up!

Some of the encouraging figures reported for the year just past—1934.





A section of the new coaxial conductor showing the inner wire and copper tube.

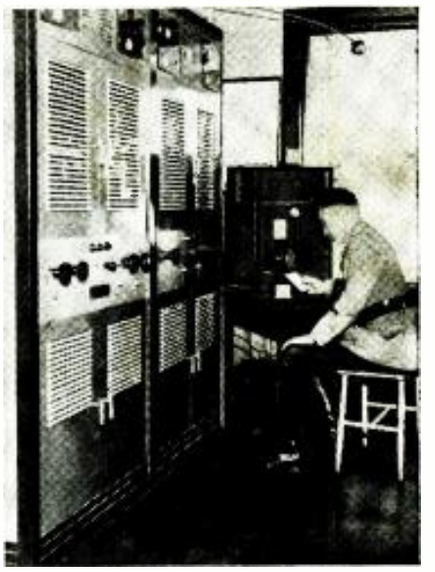
NEW-TYPE CABLE AIDS TELEVISION

A NEW type of electrical transmission line which will provide a television channel (signal) "giving size and clarity for vision hitherto unknown," was announced last month by the Bell Telephone Laboratories. The wire and associated apparatus, it was reported last month "permit the extension of frequency band widths of the order of 1,000,000 cycles or more to be transmitted over long distances."

While existing telephone lines can be worked at frequencies up to the tens of thousands of cycles, the new cable multiplies that capacity by a hundred times. In addition to being useful for the development of television, this new type cable can be applied to telephone work and will carry 200 long-distance telephone conversations simultaneously over a single pair of conductors—by the use of "carrier current" methods. The latter make use of vacuum tube amplifiers and filters so that each conversation covers only a narrow band of frequencies—thus with a million cycle band available, 200 bands each 5,000 cycles wide can be accommodated.

The "coaxial conductor," as the new wire is called, consists of a central solid copper wire insulated by cotton string wound spirally around it. Next comes the outer conductor which is formed of overlapping copper strips held in place with a binding of iron tape. The whole structure is then protected from the weather by a lead sheath.

Thus, a wire within a wire is formed which utilizes what is known as the "skin effect," namely that high frequency currents like to travel on the outside of a wire. In the new conductor, the high frequencies travel on the outside "skin" of the inner wire and on the inside "skin" of the hollow tube surrounding it.



The new 1000 watt transmitter of the New Jersey state police—W3XCW.

POLICE RADIO OPERATES CONTINUOSLY

SOMETHING new in police radio broadcasting was started last month, with the inauguration of the new 1000 watt station of the New Jersey State Police—W3XCW.

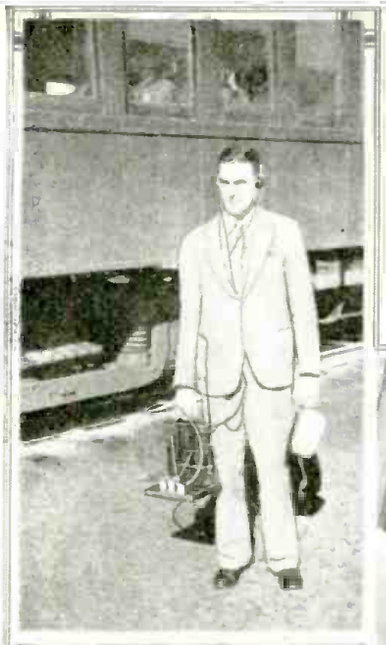
This station operates continuously from 8 a.m. to 4 a.m., giving the time every fifteen minutes and relaying teletype telephone messages received at the police headquarters to six state police cars and a radio equipped motorcycle. The teletype messages are interrupted whenever special instructions are to be given to a particular car.

The receivers in the six cars and the motorcycle are fixed-tuned to 1610 kc. and are operated at all times.

By keeping the transmitter operating continuously, in this manner it is expected that the radio service to the squad cars will be greatly increased. Important instructions can be given to any car at any time without delay, and the teletype descriptions of missing persons, stolen goods, etc., keep the patrolling cars always "on their toes" and instructed as to late happenings, etc.

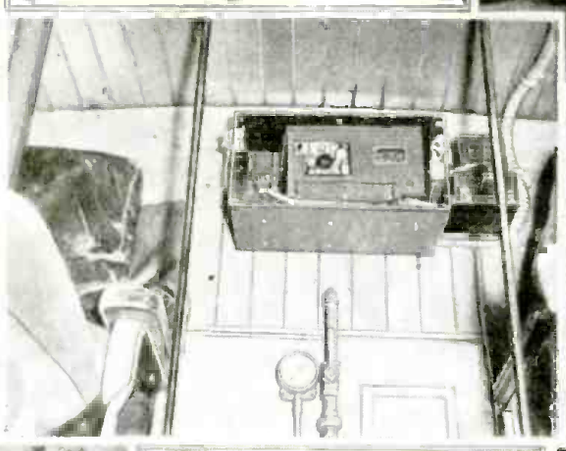
The situation in this installation is somewhat different from the usual police installation, in that the cars are scattered over quite a few miles of territory and they do not report, except by private telephone, for days at a time each car having a certain portion of road and territory to cover.

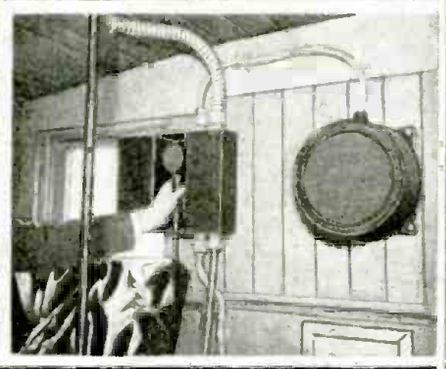
ELECTRONICS RADIO PICTORIAL

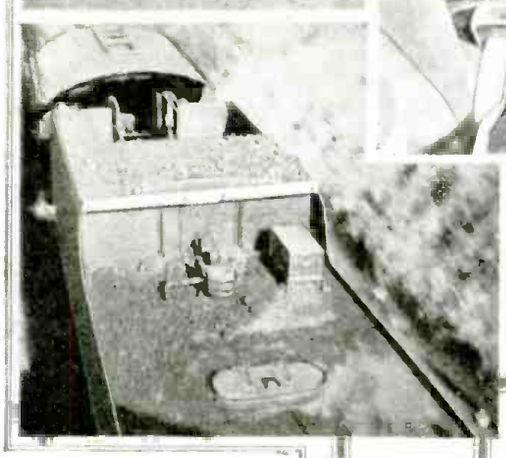


Here are five views of an experimental "engine-to-caboose" radio telephone, recently installed and operated on a freight train. It might be construed at first thought to be a distinct novelty, but such is not the case at all. It has been an ever-present problem, since the first freight train took to the rails, to secure instant and continuous communication between the engineer and the conductor, 50 to a 100 cars behind. Now, using a very practical ultra-short-wave (about 8 meters) "transceiver" at each end, it is easy to maintain constant communication. Each unit is very compact, and readily portable, as can be seen in the view at left. At upper right is shown the rod antenna system installed on a caboose roof. Lower right shows the hand microphone and loudspeaker secured to the caboose wall. Operation is almost as easy as using a line telephone. The center view shows the receiver unit, also in the caboose, out of the way. At lower left is the engine antenna system, installed on top of the tender.

Westinghouse photo.

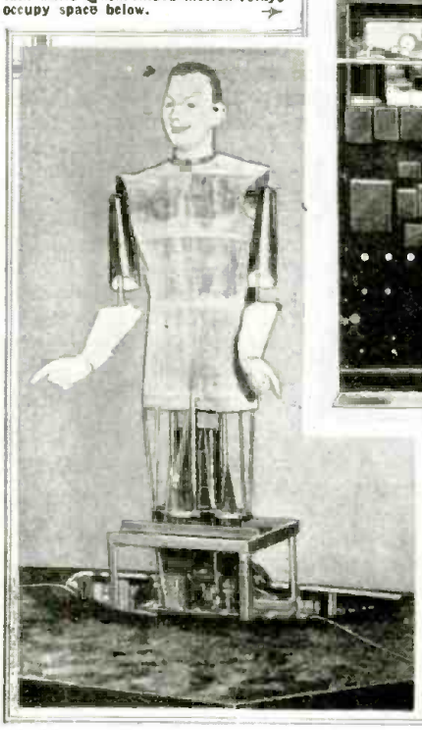




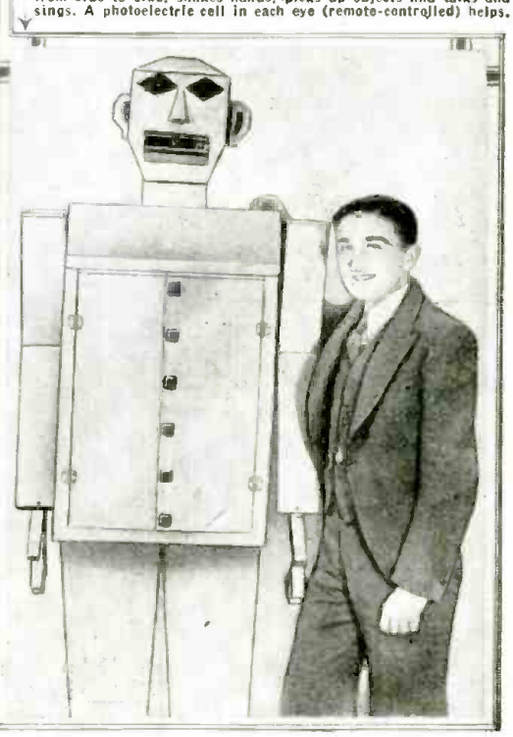


At right is a demonstration tube built to very large dimensions and with a plate coated with a material which becomes luminous when bombarded by electrons. In this way it is possible to see the action in the tube as the grid potential is varied. The action of a "microphonic" tube is also readily seen, such as the variation of luminous areas due to vibrating filament strands.

Operating mechanism of the "Robot." A turntable at top supplies the talk while synchronized-motion relays occupy space below.



This complicated "Robot" smokes cigarettes, turns his head from side to side, shakes hands, picks up objects and talks and sings. A photoelectric cell in each eye (remote-controlled) helps.



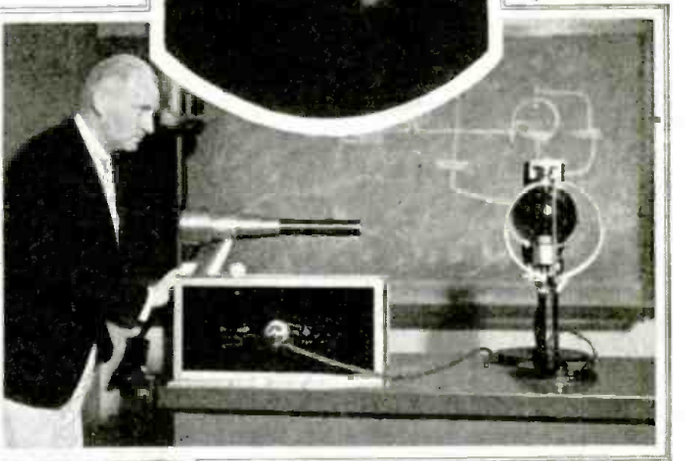
Mechanical men, or "Robots" as they are termed, always attract much attention at fairs and conventions. This one, above and left, is unusual in that his face is mobile (his mouth moves and expressions change in synchronization with his speech). He was designed and built for advertising purposes, and always draws a crowd and gets a hand when he talks, in Fred Allen's best manner, of the wonderful benefits to be derived from using a well-known brand of relief medicine and a tooth paste! Through a few simple mechanical levers and a system of relays, he points over his shoulders, contorts his face in a very life-like manner. These views, together with that shown at right, serve to indicate the great variety of forms these interesting automata can assume.

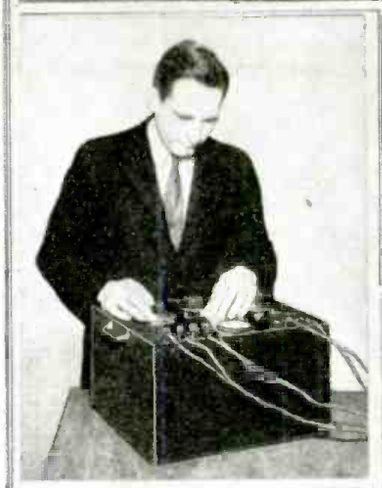
Photos courtesy Andrews & Reullo

In the window of an enterprising New York radio dealer is this interesting device. Passersby are invited to try to stop the wheel on a lucky number. The wheel stops when closely approached by the hand. A metal plate inside the window is connected in a grid-glow tube circuit. The two grids form a balanced bridge. When a hand approaches the plate it changes capacity of one side of the bridge, and a relay opens the wheel motor circuit. When the hand is removed the wheel resumes rotation.

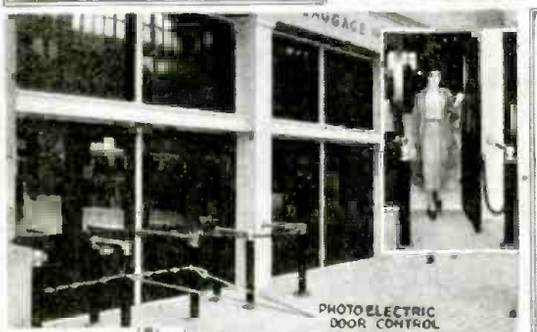
Photo courtesy Blan, The Radio Man, Inc.

This view was made from an actual photograph of the action of an "Ignitron" tube, making a ball, traveling at four miles a minute appear to stand still and pose for its picture! The ball is shown at the instant of breaking a fine wire, concealed in a rubber tube. The time of exposure is about one millionth of a second.





While the automatically opening and closing doors separating the two vast rooms in Pennsylvania Station, N.Y.C., are now a familiar sight to New York's commuters, there are many who look and wonder what it is all about. This view shows how it is done. As a person passes the beam of light (dotted line), he interrupts it, causing the photo-cell in one of the posts to operate a relay, which in turn causes the door operating mechanism to open the door.



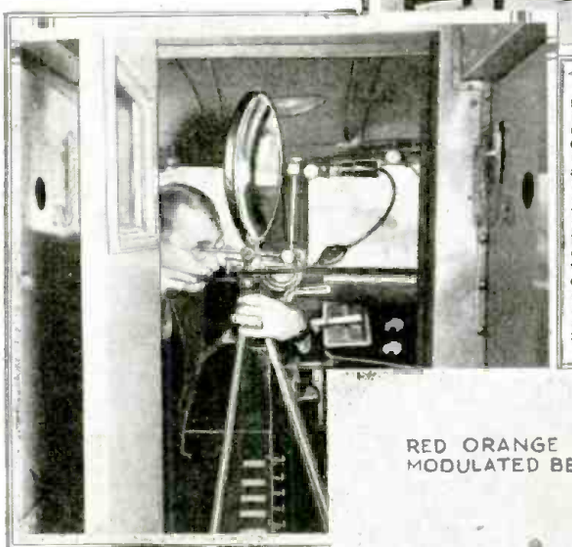
A unique photoelectric tube use—that of judging paper quality with a PE. cell. The more light reflected from book-paper, the better the paper!

This is the actual setup of apparatus used to obtain the striking picture above. It illustrates the manner in which the new ignitron tube, which discharges 1,000 amperes in one-millionth of a second, operates. Recently a large audience was able to see, apparently standing still, a ball shot out of a cannon and traveling at a speed of four miles a minute.

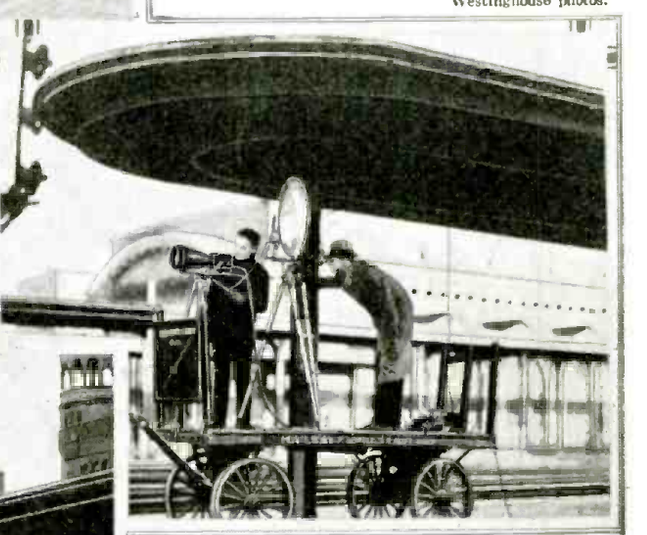
The ball while it was moving through a distance of one inch broke a wire in front of the electron tube in about ten-thousandth of a second. The broken wire sent a condenser discharge through the tube, which then flashed brilliantly for a millionth of a second, during which time the ball moved only about a one-hundredth of an inch, or was practically standing still!

The almost incredible speed at which this new tube goes into action, and the simplicity of the entire setup open a new era in the observation of rapidly moving objects.

Westinghouse photos.



Two close-up views showing how transmitting (left) and receiving stations are operated in conducting conversations over a beam of light in broad daytime! A microphone aboard the train modulates a light beam from the train's headlight. The receiving end picks up the light on a photocell and converts the energy into sound again by means of amplifiers and a loudspeaker.



When the new Union Pacific six-car streamlined passenger train visited Schenectady recently it had a headlight that talked. On the platform of the station stood a handtruck, on which was a tripod-mounted concave mirror, and in back of that a loudspeaker system. The train rounded a curve in approaching the station and, in full daylight, the orange-red beam of a headlight could be seen. The operator on the train aimed the beam of his projector at the mirror; and then, while the train pulled into the station and stopped, persons aboard the train were able to talk, over the beam of light, to those on the platform. The train was stopped briefly at the station and was then backed to a siding, to remain a few hours while thousands of people were given an opportunity to inspect it. While the train was being backed to the siding, the light-beam conversation was continued. The special headlight had been installed while the train was in Albany the previous night, and persons on the platform were unaware of what was being done until a voice was heard over the loudspeaker. He explained the talking light and invited the public to inspect the train while it was at Schenectady.

Aboard the train the voices were converted by the microphone into electrical energy. This was used to modify the light of the neon lamp in the "headlight." At the focus of the concave mirror of the receiving equipment was a photoelectric tube which converted the modulated light into electrical energy. This was fed to an amplifier and then to the loudspeaker system.

General Electric photos.

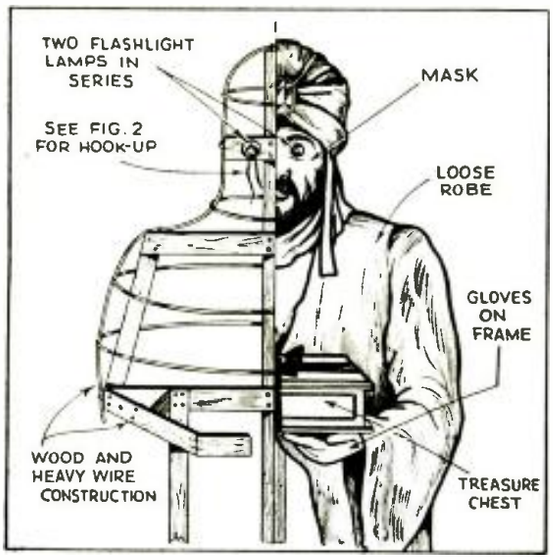


Fig. 3. Details of figure in the closet.

AN ELECTRONIC

A NOTE TO ALL SERVICE MEN—

Every day new ways are found for the wide-awake Service Man to capitalize his knowledge of the fundamentals of radio. One of the most lucrative and profitable of the fields in which the radio Service Man is a "king pin," and which is particularly rich in possibilities, is that of ELECTRONICS. For this reason RADIO-CRAFT has developed a novel means of bringing to the attention of radio men an application of electronics which will appeal to the non-technical person. The electronic "party" treasure hunt (as distinguished from the more serious methods of actual metal-location described in past issues of RADIO-CRAFT) offers to the far-sighted technician an opportunity to stage an entertaining demonstration of the possibilities of electronics in the home. By thus sugar-coating the technique of electronic applications it is possible to interest a great number of people, group by group, who otherwise would never realize just what the Service Man can do for them. YOU, MR. SERVICE MAN, as a member of a great, fast-growing organization, ARE IN DUTY BOUND to do your share toward promoting interest in those fields to which your technical abilities are perfectly adapted. Plan today to stage an electronic treasure hunt!

WHATEVER your experiences have been with "treasure hunts," we have something entirely different in store for you in this "electronic" variety. Whether you are a radio technician or an uninitiated novice—whether you know anything about photo-cells or not, makes not the slightest difference. All that is required to "go to town" on this idea is an elementary idea of electrical circuits. Since you are reading RADIO-CRAFT, it is a pretty safe bet that you have the required knowledge. So—let's get going on a 1935 edition of a search for treasure, minus the long voyages, yard-arm hangings and murders, but *plus* all of the thrills and plenty of excitement!

The only theory you will get in this article is right here in a single sentence. A beam of light striking a photo-cell in a darkened room causes a relay to close circuits. There you are. If you want the theory and technical knowledge of electronics, this issue of RADIO-CRAFT is full of it (see pages 588 and 592). We're on a treasure hunt, so let's get down to business. The idea is this: Hidden around a room are half a dozen photo-cell tubes of the simplest type, costing about a dollar each.

Guests at the party, who should be masked and costumed for a treasure hunt, are armed with flashlights. They go looking for the treasure. The room is dark. After greeting your guests, you disappear to the control room. Just as every show has its stage manager, this one has too, and you are elected. Then the fun begins. From your vantage point you control the circuits with simple switches, leaving the treasure switch open until you want it to be found. In the meantime a beam of light "finds" one of the photo-cells. Immediately a loud alarm bell begins to ring, or the lights flash on and off, or an auto horn blasts out from the family piano—well, you get it! Of course you are not limited to just six effects. Use as many or as few as you like. The more varied the thrills, the better. You can shoot off guns, operate sirens, and do countless other stunts. Your own pocketbook and ingenuity and available time are the controlling factors.

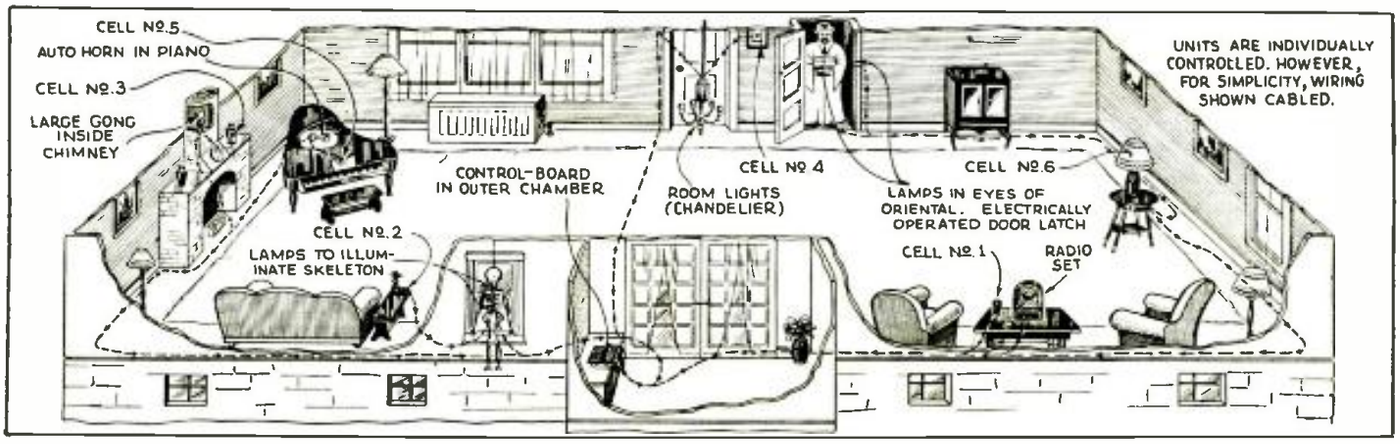
EQUIPMENT NEEDED

The parts necessary for this setup (assuming that you will follow the layout as shown here) are few in number and not at all costly. They can be obtained from any good radio supply house. First you need the six photo-cells. They are of the photo-emissive (selenium) type, the ones most generally used for commercial purposes. The cheapest ones are plenty good enough for this "hunt." Since good relays are pretty expensive, by means of switches you can get fine results using only one relay to work the whole business. The cost varies considerably, but about $3.50 is average. If you can get hold of the bell-ringing mechanism from a telephone box, it will be just the thing for a good relay. Next comes a simple 1-stage amplifier, used to build up the feeble current from the photo-cell to a value to operate the relay. A 90 V. "B" battery, a 6 V. storage battery, some light bulbs, wire, etc., complete the list.

CONSTRUCTING A SENSITIVE RELAY

Making a good relay is a rather painstaking job, but if you want to do it, Fig. 4 gives the details. Wrap the core with a layer of friction tape before mounting coils. Coils must fit snugly. Mounting the armature is an important part of the work. Make sure it is clean and wraps closely but not tightly around the mounting screw. The contact

Fig. 1. This is a typical layout for the "treasure hunt" party. The photo-cells and all wiring should be hidden.



"PARTY" TREASURE HUNT

There are two ways in which a beginner in electronics may acquire the necessary fundamental knowledge. One is to study pure theory from a textbook or in a school. The other, and perhaps the better way, is to actually construct simple electronic devices and to observe their actions by practical operation. This article presents an idea from which beginners may derive education as well as entertainment.

J. H. RENKENS

point can be made by pushing a piece of silver wire (the kind used for short-wave coils, gauge 14) through a hole of like size at the extreme end of the armature. Let it project 1/16 of an inch, and cut it off with side-cutting pliers an equal distance on the other side. Then pound it with a hammer, square up with a fine file, and there you are. The tension spring adjustment is most important, as is the distance between magnet poles and armature.

CONSTRUCTING THE AMPLIFIER

Any amplifier you may have on hand can be used, A.C. or D.C., (connecting the P-E cell leads to plate and grid). It is simply a 3-element tube, with its filament and plate battery supply, and grid-leak condenser unit. If dry cells are used with a type 30 tube, a 30 ohm resistor is connected as shown in Fig. 2. The parts cost about $1.50 including the tube. Two small 45 V. "B" batteries cost about $1.50. Mount the parts on a board in the order shown and hook up to binding posts. For convenience, you can mount the two 6-gang switches and the single relay-cutout switch on the same board with the amplifier. The switches, by the way, are simply strips of brass held down at one end by screws and "floating" above brass wood screws at the other.

FIXING UP THE TREASURE CLOSET

Referring to Fig. 2, you will see that one of the "effects" consists of a magnetically operated door latch in parallel with a photo-flash lamp (the kind used when taking indoor snapshots). This effect takes place at the "big moment" of the party, when the treasure is located. The cover picture

(*Continued on page* 635)

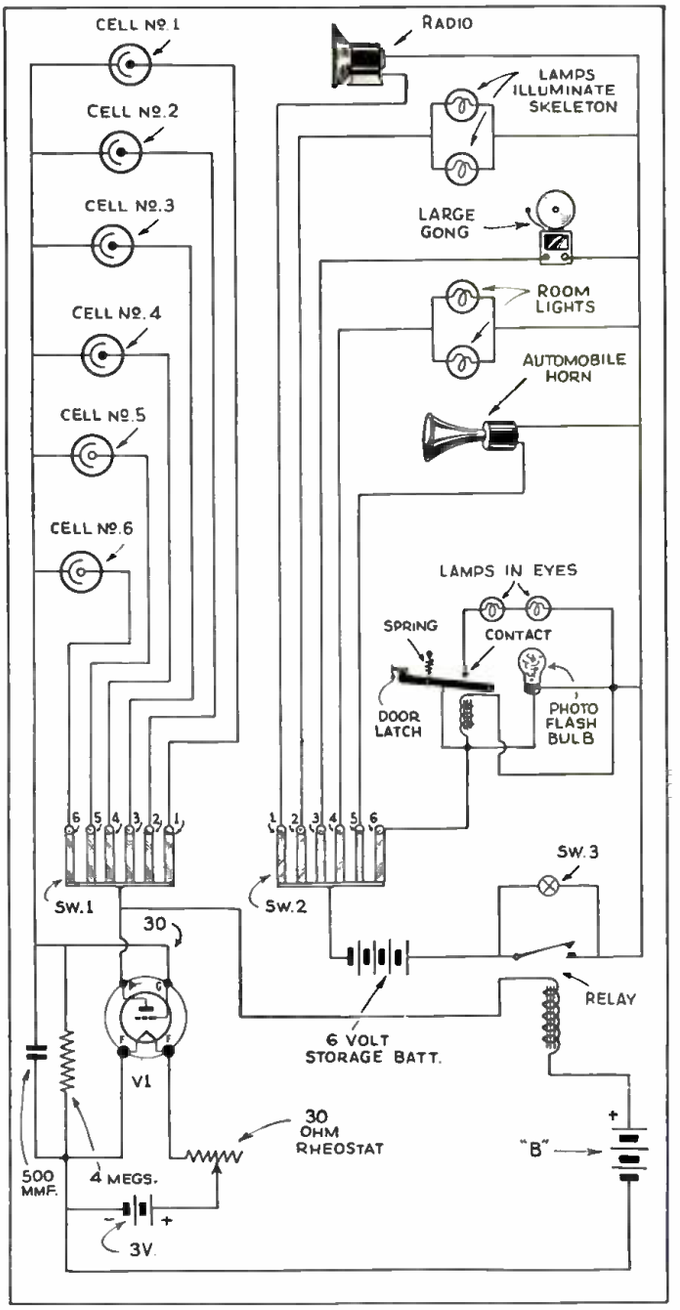


Fig. 2. Schematic-circuit and amplifier picture diagram.

Fig. 4. Construction detail of the relay.

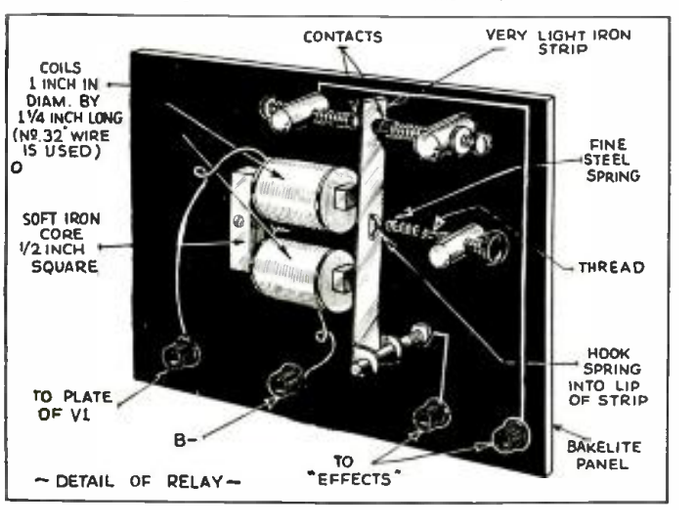
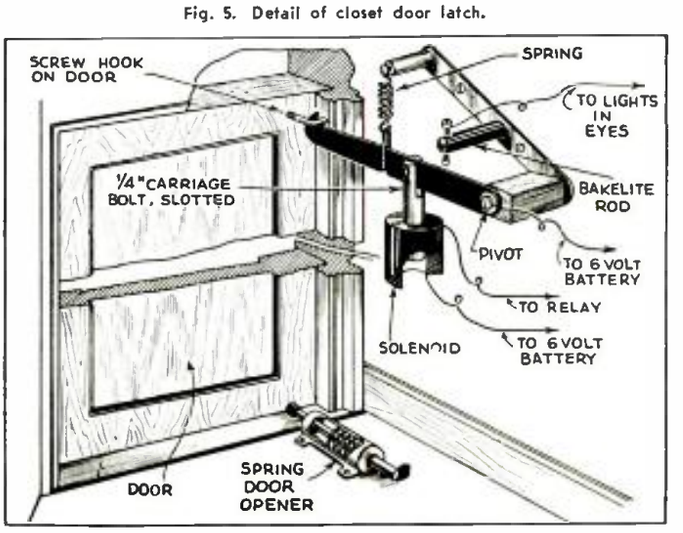
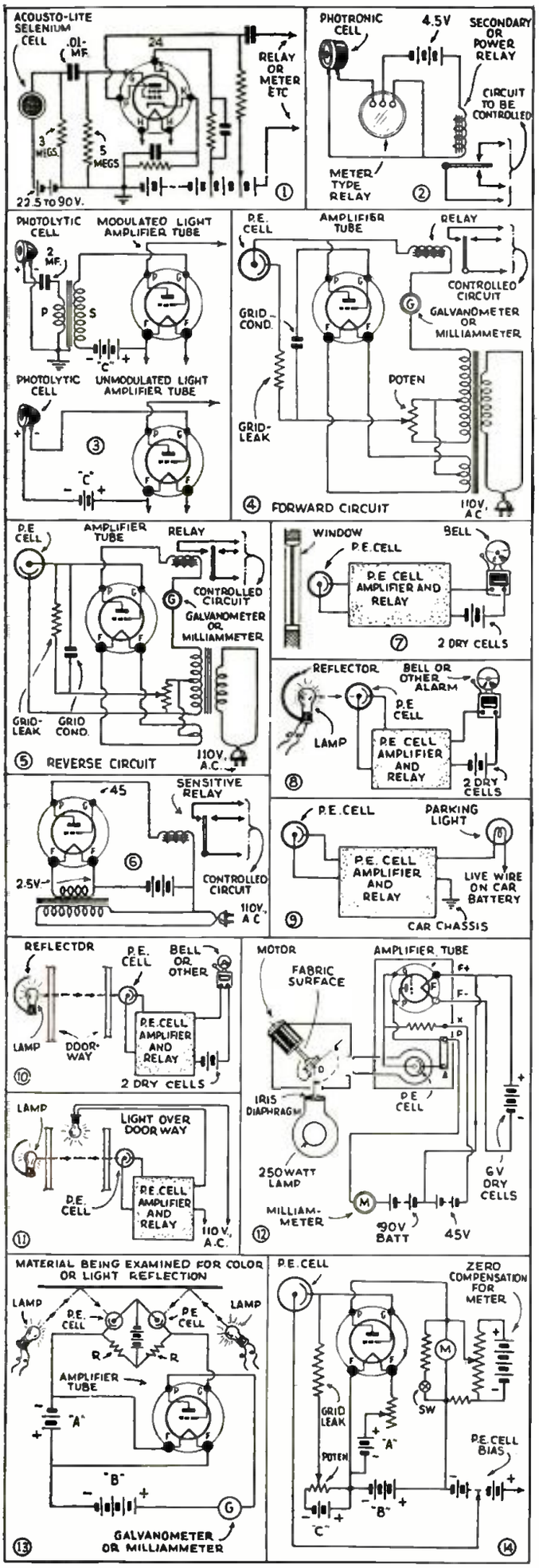


Fig. 5. Detail of closet door latch.





TWENTY WAYS TO USE THE "ELECTRIC EYE"

One of the most interesting fields for experiment—by the radio fan—is the use and application of photoelectric cells.

C. W. PALMER

THE PHOTOELECTRIC effect was discovered in 1889 by Hallwachs—who found that crystals of fluorite not only became electrically charged by heat but also by exposure to sunlight or to the light of an electric arc, both of which are rich in ultra-violet light. It has been scientifically demonstrated that every material is electrically sensitive to light—conductors and insulators alike all emit electrons when exposed to a suitable source of light. Some materials exhibit marked photo-sensitive effects, while others are notably insensitive.

There are many practical uses in everyday life for photoelectric cells (the devices which operate by means of photoelectric effects). In industry they are used for counting, sorting, regulating artificial lighting, protecting workers, and many other such tasks—in the home they are applied to opening doors, turning on lights, announcing guests, smoke and fire alarms, burglar alarms, etc.

Photoelectric cells may be divided into five general classes:

The selenium cell—or photo-conductive cell which is perhaps the oldest practical photo-cell. The fact has been known since 1851 that the resistance of selenium decreases when light falls upon it—though the effect was not understood or applied until about 1890.

Photo-voltaic cells—or light batteries as they are sometimes called. They are of the wet type having electrodes in a suitable liquid. They produce their own voltage when light falls on them.

The photoelectric tube—which consists of an alkaline covered cathode and an anode enclosed in a glass or quartz bulb and either evacuated or filled with an inert gas. By means of a "B" battery a current is caused to flow from cathode to anode and this current is controlled by the amount of light impinged on the cathode.

Semiconducting layers of cuprous oxide similar to the rectifiers used in radio work form the fourth type. This type resembles the dry battery in that it produces a current when illuminated.

Still another type consists of a flat metal plate with a suitably sensitized surface which becomes a generator of electricity when exposed to light. This type is known as the photronic cell.

The last two types are generators, in that they convert light into electricity directly, without an intermediate source of current.

HOW THEY ARE USED

The photo-sensitive cell—whichever type is chosen—may operate a sensitive magnetic relay and so accomplish electrical or mechanical tasks controlled by a source of light. Some types produce current differences sufficient to actuate the relays directly, while others require amplifiers to increase the change in current sufficiently to operate practical relays. (With sufficiently sensitive relays, any type could work directly—but the relays would be too costly and two delicate for practical use.)

(*Continued on page* 622)

[redacted] told the au[redacted]nt to his vast laborato[redacted] to the last corner with expensive television devices: "Television in its principles is well known since Paul Nipkow applied in 1884 for his famous television patent, and thus founded the basis of the television technique of today. We are now looking back upon an evolution of about 50 years, and it should not be taken as exaggeration if I say television is only a question of six or eight months. In case some difficulties so far unknown should occur, it will not be more than a year before television will be in general use."

Since then a great many other well-known experts have called television a device "just around the corner," and if the public, disappointed by statements of this kind, has some doubt about the possibilities of television, nobody will be surprised. In the meantime we have been informed by statements of rather more pessimistic tendency that television is more than only a technical question, because it is also a financial problem, and involves a great many program difficulties. The history of other great inventions, however, has shown that limitations of this kind could not prevent an important technical improvement being put into use sooner or later, and the following consideration about the ripeness of television will show that a little more optimism should be employed instead of the tremendous pessimism found today.

IS TELEVISION AROUND THE CORNER?

There is no doubt that the progress of television technique during the past three years has been much greater than during the entire previous time. We should forget about "foolish statements" made by experts in this field and should pay attention to the fact that approximately more than 5 million dollars have been spent in this country and abroad for television experiments; quite a large sum of money which never would have been spent for an invention considered only as a kind of technical toy!

The number of television systems around the globe—today, in a pretty ripe state of construction—can be counted as 10 without danger of using superlatives. But only a few of them have a chance to be put to work. This, of course, will sound hard in the ears of the investors and inventors who spent a fortune for the progress of television. However, this sharp cut is necessary if difficulties are to be avoided in putting different systems to work. A television receiver useful only for one particular station is taboo because the television enthusiast must have the alternative of switching over to another transmitter if desired. It is, therefore, not worth while to talk about television being around the corner until a so-called "unit" television receiver is created, useful for all of the television stations to be erected.

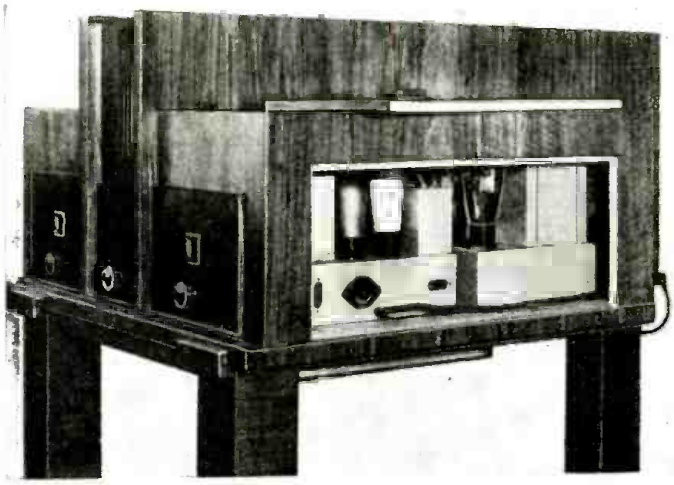
WE NEED COOPERATION BETWEEN THE DIFFERENT PATENT HOLDERS!

There are 20 television stations in this country now in use, and the main reason that 99 per cent of the radio listeners know nothing about them can easily be explained by the fact that at least 18 of the 20 stations are using different transmission methods! This trouble is not limited only to the U.S. The well-known English magazine, WIRELESS WORLD, in an editorial in the December 28 issue of last year, emphasized this dark point in the progress of television, and called attention to the fact that the only way to improve the condition for a general use of television is cooperation between the various patent holders. The magazine states further: ". . . the rival companies should get together and adopt a joint licensing scheme for manufacturers of television receiving sets."

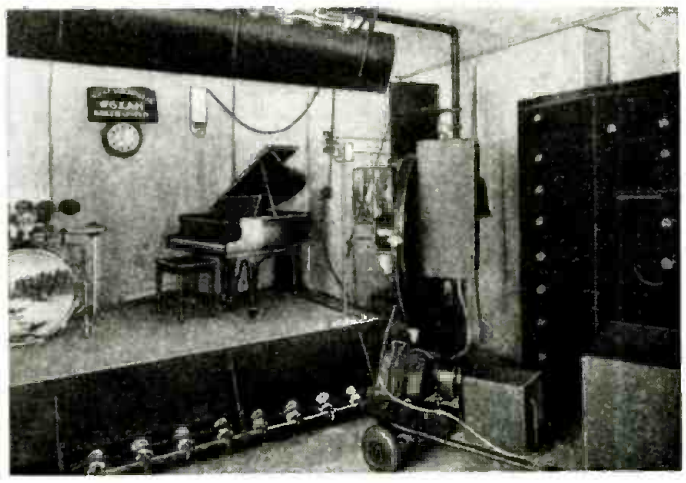
In Germany they have been farsighted, and made a start in this respect a few years ago by founding the so-called "Fernseh A.G.," a company created by cooperation of a few im-

(*Continued on page* 628)

A German television receiver manufactured by "TEKADE."



An American television studio connected with W6XAH.



tion gives a complete and authentic description of the electronic newcomer.

CLIFFORD E. DENTON

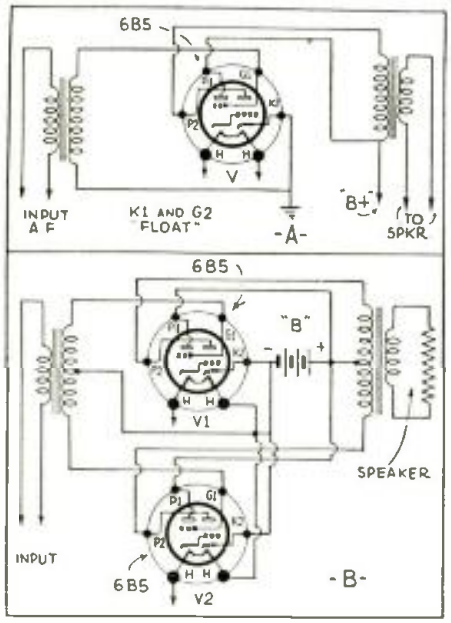
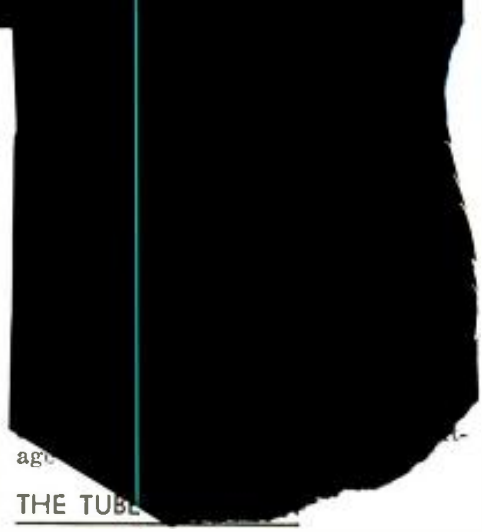


Fig. 1—single and push-pull circuits.

HIGH-POWER output with high-power sensitivity is much to be desired in an audio tube in this day and age. Composite tubes with a dozen elements scattered helter-skelter, but connected according to Hoyle, have gone a long way toward saving space in the R.F. and I.F. end of a receiver, and it is with a feeling of equilibrium that the writer presents herewith advance information, with authentic characteristics, of what promises to be one of the most widely used tubes in the audio-amplifier field.

This new offspring is not one of those "shots in the arm" that appear one morning and disappear the next; it has been long in the making and will remain long in the using. Just mull over these figures: power output, 4 watts with one, and over 10 watts with two in push-pull; harmonic distortion (total), less than 5 per cent; strictly class A, and no grid-bias resistor or bias condenser of any sort, concealed or otherwise; the overload point seems



THE TUBE

The tube is pictured in Fig. A and the schematic circuit in Fig. 1A. There seems little difference in external appearance between this tube and most others in use, but the circuit tells the story. The tube is divided into two sections, the first designated by the subscript 1 and the second designated by the subscript 2. The input section, No. 1, receives the signal, and the out-

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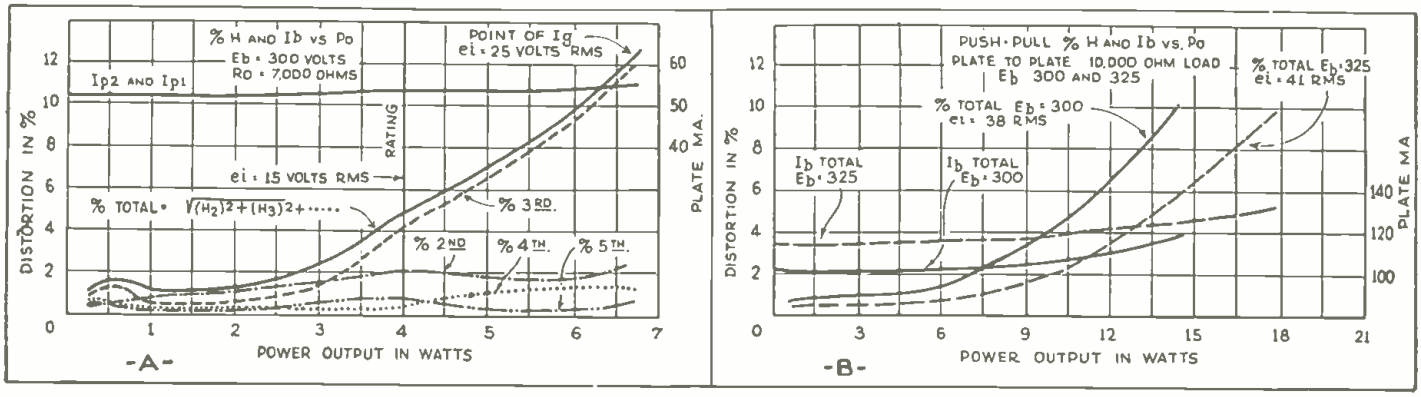
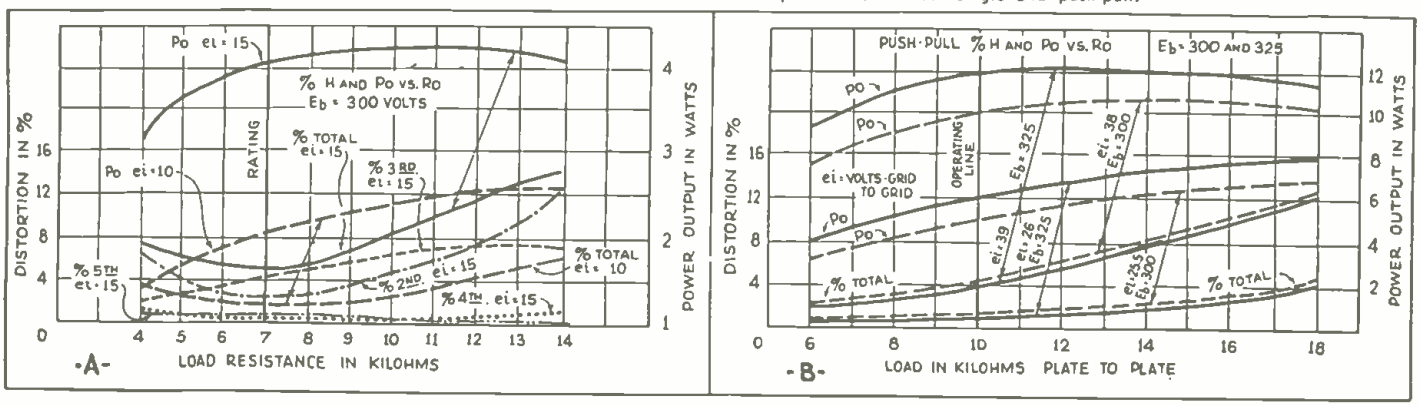


Fig. 3, above
The per cent distortion and plate current values as the power output is varied—single and push-pull.

Fig. 4, below
The power output and distortion values as the load impedance is varied—single and push-pull.



tional institution."

rephoto service.

GIDEON SEYMOUR

days behind the news was overcome or reduced when the newspapers inaugurated a few weeks ago, a wirephoto service bringing to them from 24 cities throughout the country, at the same speed as news, the events of the day in pictures over a 10,000-mile leased-wire system.

A president addresses Congress, and accompanying the text of his message will be a picture of the scene in the national House of Representatives transmitted with all the perfection and detail of the original print.

An intersectional football game in Los Angeles excites the fans of the nation, and an action picture of the winning touchdown appears in the papers beside the final score.

A malefactor is found guilty by a Kansas City court, and riding the wires beside the account of his conviction is a picture of him as he listens to the verdict.

America wins a yacht race in Long Island Sound and a picture of the finish helps the sport writers convey to readers, 3,000 miles away, the graphic story of the last long mile.

A hurricane sweeps Cuba, and views of devastation travel by wire abreast of the news dispatches, to describe what words cannot.

A boxing title changes hands in a Chicago ring, and topping the round-by-round account of the bout is a picture of the knockout blow.

THE NETWORK

Linking in the new newspaper service the cameraman on the spot and the picture in the newspapers is the wirephoto network stretching from Boston to San Francisco, from Miami to Los Angeles, from Minneapolis to Dallas. Costly and highly technical equipment, adjusted to measurements too fine for the naked eye to see, must be disciplined to follow up and down the continent the swift and unpredictable finger of the day's news.

The wirephoto day begins, in each of the 24 equipment rooms over the country, with the pressing of a button which starts a power plant. The equipment room occupies 240 square feet of floor space in which, in addition to the power plant, are sending and receiving machines for pictures and a "bay" or switchboard for each. The "bay" contains a talking circuit with loudspeaker over which any point in the network may talk to the others. The function of the power plant is to furnish an absolutely constant source of voltage to the sending and receiving machines, for no commercial source of electricity is steady enough. It consists of special generators, regulators and storage batteries. The generators are the sources of power; the storage batteries and regulators keep the generators steady.

The operator, having started his power plant, adjusts the sensitive machinery by meter readings and tunes the light valve mechanism of the receiving machine, making the tension on a little ribbon vibrate at a natural frequency of 1,200 cycles per second. This operation takes five minutes or less.

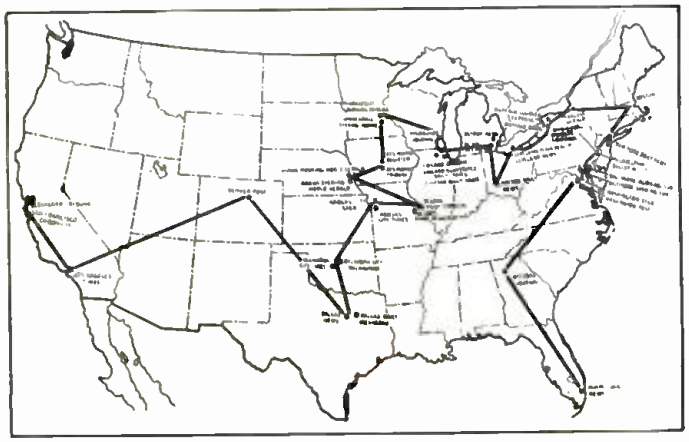
SETTING THE SCHEDULE

Then the control station in the New York office of The Associated Press, which maintains and operates the wirephoto system for the 48 newspapers of the United States cooperating in its use, opens the talking circuit. All points report that they are ready, and each reports what pictures it has for sending.

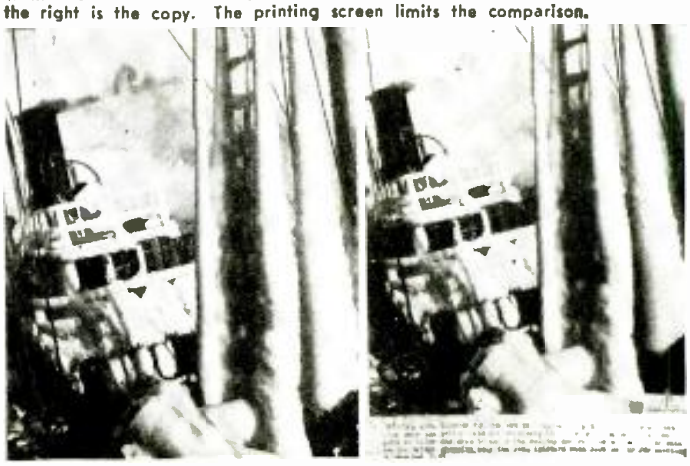
Detroit may have a picture of a serious fire, New York some photographs of celebrities just arrived by ship or an important news photograph from Europe, St. Louis a view of an airplane crash, and Miami, by the morn-

(*Continued on page* 629)

Here are the 24 cities equipped with wirephoto stations which serve 48 newspapers.



The perfection of the photographic copies sent over the wires is evident from the unretouched sample below. The left photo is the original; on the right is the copy. The printing screen limits the comparison.



A RADIO TUBE consists of a cathode and one or more additional electrodes—all enclosed in an evacuated glass bulb—with their electrical connections brought to exterior terminals. The cathode supplies electrons while the other electrodes control and collect them.

The importance of the radio tube lies in its ability to control almost instantly the flight of the millions of electrons supplied by the cathode. It accomplishes this with a minimum of control energy. Because it is almost instantaneous in its action, the radio tube can operate efficiently and accurately at electrical frequencies much higher than possible with rotating machines.

The electronic tube, through the various means of control of the emission of electrons and ions, becomes a very efficient tool in a wide range of applications, as we shall discover.*

The generally accepted conception is that the atom is composed of a nucleus, surrounded by a number of electrons—the number and arrangement depending on the substance.

One of these nuclear particles is the proton, which is the nucleus of the simplest atom known—hydrogen. It has a positive electrical charge equal to the charge of an electron. The proton is very minute, even in this submicroscopic world, but in proportion is extremely heavy, weighing about 1,850 times as much as an electron.

Another particle found in the nucleus is the neutron, which weighs as much as a proton, but has no electrical charge on it whatever. Scientists believe that the neutron is really an intimate combination of a proton and an electron—in short, a complete hydrogen atom in which the planetary electron has fallen into the central "sun," neutralizing its electrical charge.

The positron is the third kind of subatomic particle now known. It is a particle of electricity, has the weight of an electron, but with a positive instead of a negative charge. It was first predicted by the Nobel Prize winner Dirac and was later discovered by Dr. Carl D. Anderson of the California Institute of Technology.

Physicists have been able to determine the charge and size of electrons and protons quite accurately even though the individual electron or proton has never been isolated for measurement.

Zworkin and Wilson in their book—Photocells and Their Applications—say, "To realize how small the mass of an electron is, imagine an electron speeding through space at the rate of 100 miles an hour or about 150 ft. per second. Let us calculate the force of a blow it would give to an obstacle placed in its path, assuming the electron was brought to a dead stop in 1/10 second. We will find the average force experienced by the obstacle would have the amazingly small value of one one-hundred-thousand-million-billion-trillionth of a pound, or

$$\frac{1}{100{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000 \text{ lb}}$$

A particle possessing such small mass will, of course, present no appreciable inertia to any applied force. Thus an electron starting with zero velocity at the cathode and traveling to the anode under a field of 1 V. will acquire a velocity of nearly 25,000 miles per hour." (!)

In electronic tubes electrons can be made to detach themselves from metal electrodes, commonly called cathodes,

(*Continued on page* 624)

BUILDING-BLOCKS OF MATTER

Atom—One of the tiny physical units of which all matter as such is composed.

Nucleus—The core or heart of an atom.

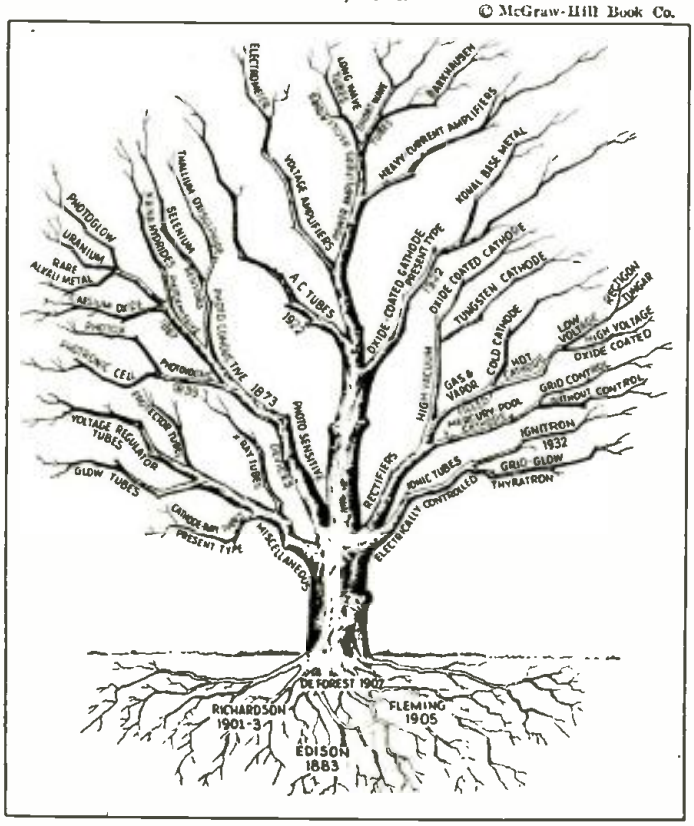
Electron—The smallest unit of negative electricity.

Positron—The smallest unit of positive electricity.

Proton—The positively charged core of the atom of hydrogen.

Neutron—A nonelectrical particle, possibly a close-packed hydrogen atom.

Fig. 2
The history of electronics from the Edison Effect in 1883 to the most recent developments.



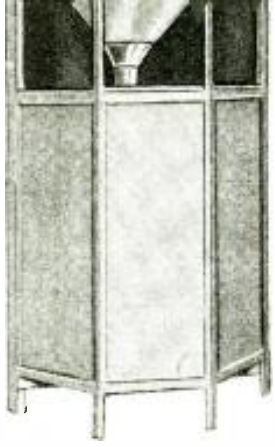


Fig. A
The "corner-type" exponential horn.

reviews of all the really important, new developments illustrated and described each month in these publications.

NOTE that the only available information is that which is published; the experimenter must adapt the ideas to whatever equipment he has on hand.

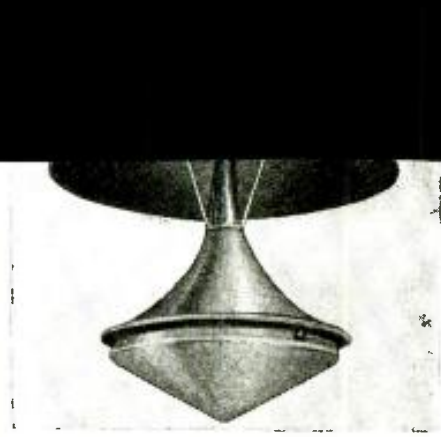


Fig. B
A combination reproducer and light.

NEW REPRODUCER DEVELOPMENTS

THE demand for high-fidelity equipment has not been limited to the U.S.; its effects are found also in foreign publications.

In line with the developments of new amplifiers and receivers, several new reproducers have made their appearance. One of these which appeared in WIRELESS WORLD magazine, is shown in Fig. A and consists of a horn-type unit which is designed to fit into a corner. By this means, the walls form an extension of the exponential curve taken by the sides of the horn. The dimensions have further been reduced by the judicious use of reflectors and the low frequencies which might be attenuated by the restricted dimensions of the horn are strengthened by a special "bass chamber" with an outlet in the floor of the cabinet. This speaker has the characteristics of a straight horn four times its volume. It is applicable particularly to public address installations.

The second reproducer is made particularly for permanent installation in halls and similar places, where there is need for overhead lights as well as sound distribution. The unit is shown in Fig. B; it was described in a recent issue of BASTELBRIEFE DER DRAHTLOSEN.

It is evident from the view of this reproducer just how it is made—with its multiplicity of sound deflectors and the electric light below.

Because of the special design of the drive unit in this reproducer, a flat frequency characteristic of 50 to 15,000 cycles is claimed for it. Three models are made having output ratings of 2, 8 and 20 watts.

A NEW ELECTRONIC ORGAN

ELECTRONICS has been applied to the development of musical instruments and several different types of these instruments have been described in magazines, both in the U.S. and abroad.

A new organ depending on electronic tubes was recently described in FUNK TECHNISCHE MONATSHEFTE, a magazine published in Berlin, Germany.

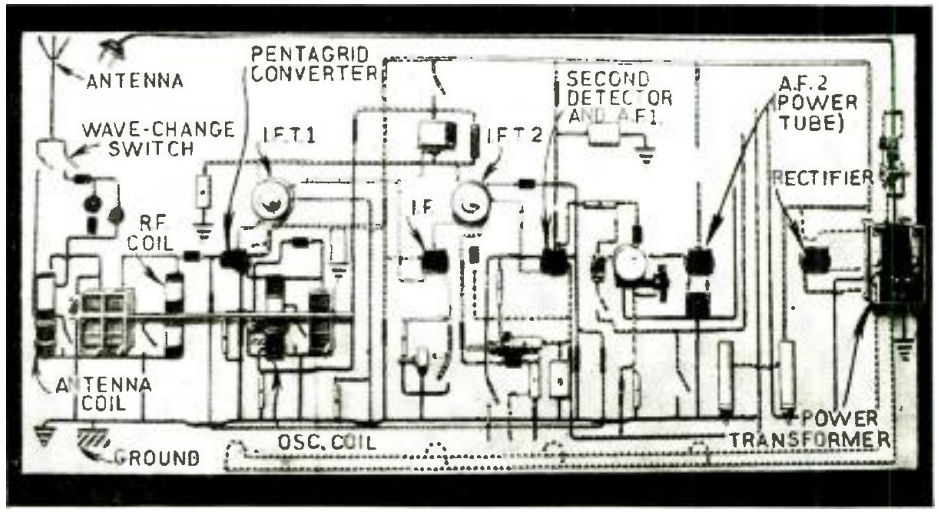
This instrument, shown in Fig. C depends on the use of neon glow tubes for the generation of the tones. These tubes are arranged in oscillatory circuits tuned to the desired frequency and feeding into a bank of condenser-type reproducers which produce the actual tones.

By the use of frequency control circuits, the harmonics of the fundamental tones produced by the glow-tube oscillators may be varied to change the "overtones" or quality of the notes. By this means, the organ can be made to imitate many different instruments. The tone quality is controlled by "stops"

(*Continued on page* 615)

Fig. C, below
The glow-tube electronic organ.

Fig. D, right
The "visible current" radio set.



and "why" these operations are made possible.

THE *cathode-ray tube* is an instrument which has as its moving part a stream of electrons. The stream may be considered as a flexible wire in which current is flowing. In the cathode-ray *oscilloscope*, the ray is deflected by electric or magnetic fields and its travel is observed on the "fluorescent" (glowing) screen at the end of the tube; in the *oscillograph*, this image on the screen is recorded (usually, on photographic film). Both instruments are of great value in all branches of engineering work, wherever alternating electrical currents are involved.

A 19TH CENTURY DEVELOPMENT

The cathode-ray tube has been known for many years and Professor F. Braun is credited with first applying the tube for measurement purposes—about 1897. In the same year of Braun's early experiment, Sir J. J. Thomson showed the rays were deflected by electrostatic and electromagnetic fields; further, the direction of deflection proved the particles in the rays were negatively charged.

The latter part of the 19th century thus was a banner period in that it saw the birth of commercial radio, the determination of the value of the electron charge, and the birth of the cathode-ray tube and its cousin, the Fleming "valve" (tube)!

*Engineer, RCA Mfg. Co., Inc., Victor Div.

THE ELECTRON BEAM A "WEIGHTLESS POINTER"

Now, the mass of an electron, being electrical and due only to the charge which it carries, is of very low order compared to the moving parts of a Dudell galvanometer with its mirror and strips, or a fibre of the Einthoven instrument. Consequently, the cathode-ray oscilloscope, utilizing this electron-beam as a "weightless pointer" having practically no inertia, has been hailed by technicians as an instrument especially suitable for use at the higher frequencies (where former oscilloscopes were useless); further, the development of new, inexpensive cathode-ray tubes has greatly accelerated interest in the application of this type of equipment. Service Men, and in fact technicians in every walk of engineering, are rapidly realizing the usefulness and increasing low cost of this tool.

The cathode-ray tube is extremely useful in frequency determination and phase relations; Lissajous' discovery in the field of sound, some years before the advent of cathode-ray tubes, is useful in this connection.

LISSAJOUS' FIGURES

Jules Antoine Lissajous showed an exact relation between the vibratory motions of two sounding bodies. The equipment in his classical experiment

(*Continued on page* 639)

Fig. 2, right
Phase relations and the results obtained with multiples of frequency with respect to sine-wave voltages are illustrated. These waveforms should be carefully noted as being the most common.

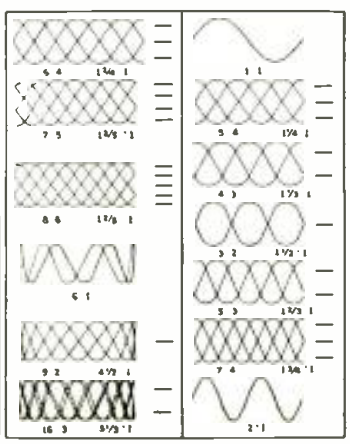


Fig. 1, below
A mechanical oscilloscope, as contrasted with the cathode-ray instrument illustrated and described in (succeeding) Part II.

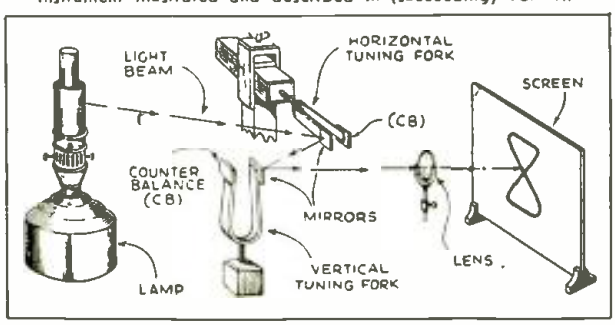


TABLE I
APPLICATIONS OF THE CATHODE-RAY OSCILLOSCOPE

(1) *Oscilloscope* and power supply but without amplifier or sweep circuit.

a. Modulation Meter trapezoidal pattern.
b. Polarity and Amplitude in D.C. circuits.
c. Frequency Comparison Meter.
d. Phase Indicator and Amplitude in A.C. circuits.
e. High-Voltage Peak Voltmeter for low and high frequencies.
f. Bridge Balance Indicator for phase and amplitude.
g. Speaker Impedance Characteristic Measurement.
h. Synchronization of Alternator phase and amplitude.

(2) *Oscilloscope* and power supply *with amplifier* but without sweep circuit.

a. Peak Voltmeter and Ammeter amplifier with as wide a frequency range as practical.

(3) *Oscilloscope* and power supply *with amplifier* and linear *sweep circuit*.

a. Waveform and distortion studies.
b. Receiver Test Equipment indicating stage gain output and distortion.
c. Detector Performance Tests.
d. Study of Static and Stray Electric Noise.
e. Monitoring in a Radio Station.
f. Study Voice and Music Waveforms in conjunction with a microphone.

(4) *Oscilloscope* and power supply with linear *sweep circuit* but no amplifier.

a. Check on Code Signals.
b. Waveform studies on Alternators, Transformers, Generators, and Rectifiers.
c. Study of dynamic characteristics of circuit breakers and fuses.

(5) *Special Equipment* in conjunction with oscilloscope assemblies outlined above.

a. Resonance Curve Tracer—use case (1) with extra equipment.
b. Audio Frequency Response Tracer or Sound Prism—use case (1) with extra equipment.
c. Frequency Comparison Meter with standard frequency source enclosed—use case (1) with standard frequency oscillator.
d. Electrocardiograph—use case (1) with extra equipment.
e. Vibration and Noise Apparatus—use case (3) with extra equipment.
f. Pressure Measuring Apparatus with Piezo Crystal—use case (4) with extra equipment.
g. Ignition Test Indicator—use case (4) and extra equipment.
h. Power Factor of Dielectrics—use case (1) with extra apparatus.
i. Magnetic Hysterisis Indicator—use case (1) with extra equipment.
j. Trace Vacuum Tube Characteristics—use case (1) with extra equipment.
k. Check Tube Noise—use case (1) with extra equipment.
l. Chemical Analysis by Dielectric or Resistance Properties—use case (1) with extra equipment.
m. Circuits for locating ore deposits, locating concealed weapons on persons, etc.—use case (2) as balance indicator on extra bridge circuit equipment.
n. Radio Beam Direction Indicating as used in navigation or airplane landing—use case (2) with extra equipment.

HOME ELECTRONICS

Modern Scientific advances tend more and more to make life easier and more enjoyable. In this article, a description is given of the residence of a well-known radio authority who has made a hobby of applying electronic devices to his home life. Some of these applications are easily duplicated—they will be fine fun for the experimenter and a profitable source of income for the professional. Most of these examples use the PE. cell.

(Photos, except Fig. C, McGraw-Hill.)
Fig. A, PE. cell switches lights.

THE MODERN home is an ideal place to experiment with applications of electronic devices. The better known devices are the garage-door opener and a photo-cell-controlled lighting system which turns the house lights on when dusk approaches. But these by no means exhaust the possibilities of light-controlled equipment. This was made plain recently in an amazing "electric home" where even the weather is controlled electrically to suit the likings of occupants in each room! Dr. Orestes H. Caldwell, former Federal Radio Commissioner and well-known radio authority, has his estate near New York hooked up with many ingenious gadgets. There will be no kidnapping in *that* home. As soon as a prowler attempts to enter a window, he interrupts a beam of light. The result is immediate. A loud gong rings, the window is illuminated by a photo-flash bulb, and a camera takes the startled chap's picture!

At dusk an "electric eye" turns on the all-night lights of the estate and illuminates an outdoor clock on the garage. At dawn it just as surely puts the lights out, Fig. A.

A very novel idea is shown in Fig. B. With the radio set playing soft music, the hearer is apt to feel like dozing. With this set-up, as soon as he nods his head, the radio set obligingly shuts off, preventing shocks to the nervous system if a loud program should take the place of slumber music.

Those habitual "foulers" in bowling are reminded of their fault by the PE. cell arrangement shown in Fig. C. When a foot slides over the line, it interrupts a beam of light, causing a bell to ring or a red light to flash.

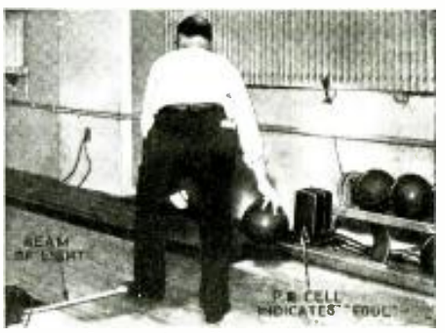
PE. cells are admirably suited to the tired and lazy folks. If you feel too "tired" to turn your drinking water on, just rig up the device in Fig. E. As you bend your head, the shadow turns on the valve. When your thirst is quenched and you stand erect, the water flow stops. Ho-hum!

Of more practical use is the garage-door opening mechanism. It may be operated in two ways. The simplest method is shown in Figs. D and F. The headlights of your car operate the PE. cell opening mechanism. A safer way is the use of a short-wave radio transmitter mounted in the car. A receiver tuned to the same frequency picks up your signal when you approach and the door opens.

If you don't like to jump out of bed on a cold morning (who does?) to close your window, let the first rays of

(*Continued on page* 627)

Fig. B
"Doz-o-Dyne" shuts off radio set when listener dozes.



© International News Photos Inc.
Fig. C
PE. cell indicates bowling "foul."

Fig. E
PE. cell provides automatic drinking service.

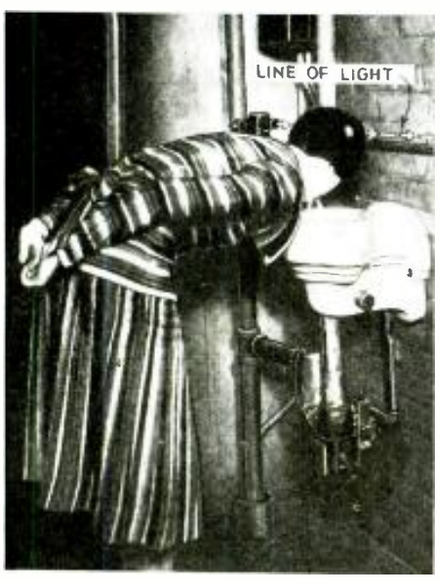


Fig. F
Garage-door opening mechanism, PE. cell operated.

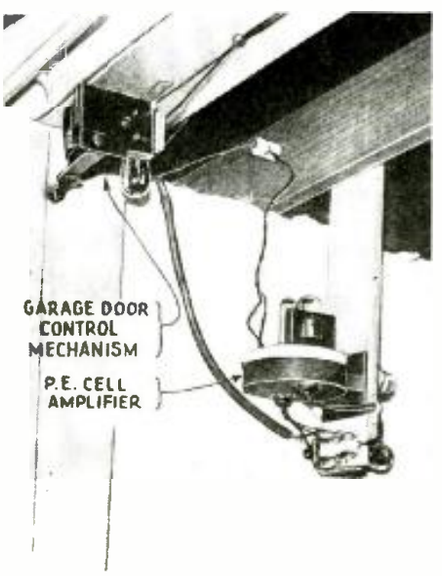


Fig. D, below
Cleverly concealed PE. cell lights up grounds.

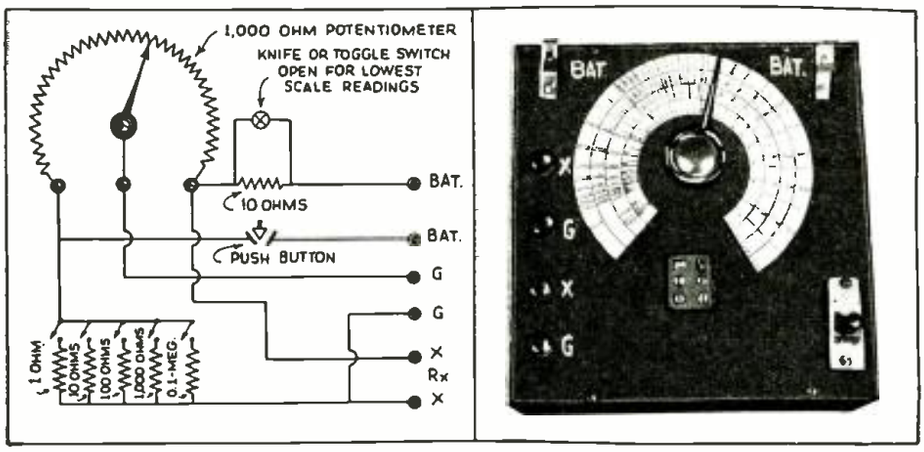
SHORT-CUTS IN RADIO

FIRST PRIZE $10.00
SECOND PRIZE 5.00
THIRD PRIZE 2.50

Honorable Mention

EXPERIMENTERS: Three cash prizes will be awarded for the best "short-cuts" — time- and money-saving ideas—submitted by readers of RADIO-CRAFT; Honorable mention will be given for all other published items concerning radio and its allied fields.

Send us your "kinks" right away.



The circuit of the resistance bridge—and a view of the device.

FIRST PRIZE

BEING in need of a reasonably accurate instrument for measuring resistances, I worked out the simple bridge arrangement shown. It consists of a 1000-ohm wire-wound potentiometer, five fixed resistances and 6 binding posts.

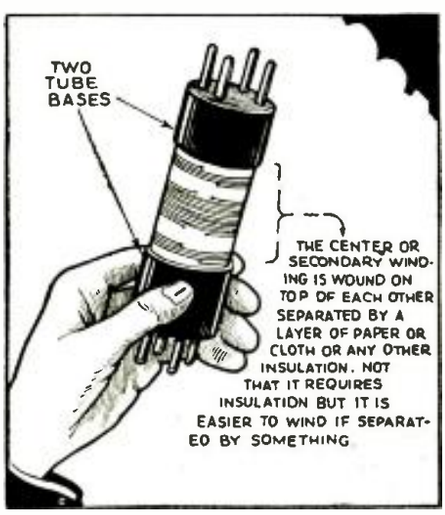
After connecting the parts up as shown in the diagram, connect the points G-G to some current indicating device such as a galvanometer, 0-1 milliammeter or voltmeter. A 1½ volt dry cell serves well for all resistances up to 10,000 ohms. It is wise, however, to insert a series resistor in the battery circuit when used with the one ohm resistance. For the higher ranges from 10,000 ohms to 1 meg., a higher voltage source is needed. A 4½ volt "C" battery works nicely if the indicating instrument is sensitive.

The instrument is calibrated by borrowing from a high-school physics laboratory a resistance box—or by reference to precision resistors (those guaranteed accurate within 2 per cent).

Attach the standard resistance to X-X and adjust the potentiometer until meter reads zero.

H. C. POULSON

One of the 2-in-1 coils ready for use.



SECOND PRIZE

HERE is a kink for the short-wave fan. By using the construction shown in the sketch, the cost of a set of coils will be saved and instead of the usual 4 coils to cover the short waves, only two will be needed.

The coil form is made by winding thin cardboard to fit tightly into the tube socket—which supplies the connection prongs for plug-in purposes. One of these sockets at each end of the cardboard makes a rigid winding form and if the coil is made sufficiently long two sets of windings may be placed on the same form and connected to opposite ends. Thus one coil covers two wave-bands.

The coils containing two windings and four prong sockets, for simple regenerative sets may be made about 4 in. long to accommodate the two sets of windings. The coils containing three windings and six prong sockets should be 5 ins. long to accommodate the extra wire.

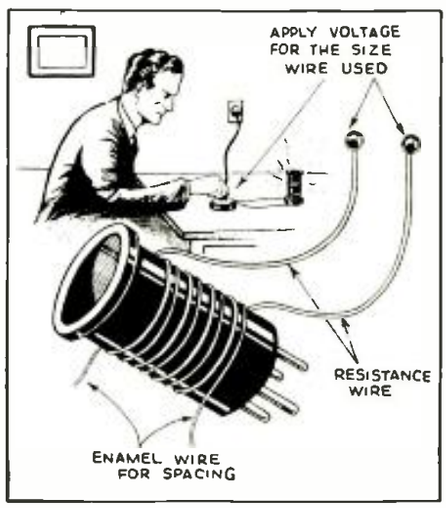
When the coils have been wound they should be soldered to the tube base prongs and then cemented into the bases to make the assembly rigid.

J. O. FRIED

THIRD PRIZE

THE RADIO experimenter who has need for space-wound coils will find this scheme particularly effective.

Wind resistance wire on the coil form along with a size of enamel covered



Cutting grooves in coil forms.

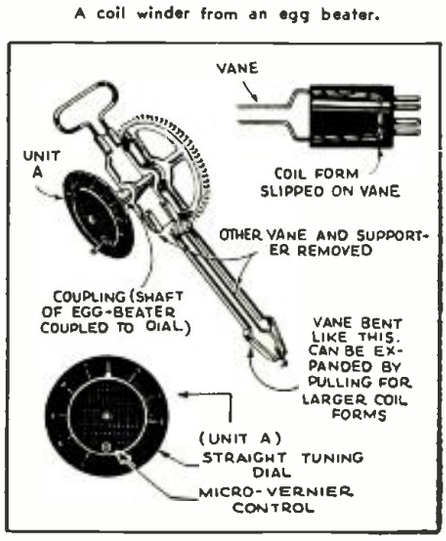
copper wire of a size correct to supply the desired spacing between turns. Secure the ends of both wires and then apply sufficient voltage to the resistance wire to make it glow red. Then disconnect and remove the wires.

If a hard rubber or fibre form is used, the hot resistance wire will have burned a groove into the form which can be used conveniently to space out the wire on R.F. tuning coils, chokes, etc. This method will not work with ceramic forms which cannot be burned by the hot wire.

NORMAN CURL

(*Continued on page 622*)

A coil winder from an egg beater.



HOW TO MAKE A GRID-GLOW TUBE CONTROL UNIT

The grid-glow tube is finding innumerable uses in industrial work—because of its flexibility as a relay for counting, sorting and protective applications. The electronics experimenter will find in this tube a wide field for experiments which are not only interesting but may be highly profitable.

CHARLES D. SAVAGE

THE thyratron and the grid-glow tube are growing in industrial importance and the alert radio man will find them useful tools. If he will build a control unit of the type pictured, he will find his experiments greatly facilitated and at the same time he will gain some experience with phase-shifting circuits, such as are now being used in cathode-ray television. This unit is built around a Westinghouse type KU-610 "power" grid-glow tube (neon filled) but it can also be used with thyratons with perhaps a change in filament voltage.

When the jack switch S1 is thrown to the right, the unit operates as a grid-controlled rectifier, supplying D.C. power from the 110-volt line. With the switch thrown to the left, the elements of the tube are brought out to separate terminals for any desired experiment,—such as obtaining a time axis in oscillograph work, as a D.C. to A.C. "inverter," as a sensitive relay-tube, etc. The experimenter will find many other uses as he becomes familiar with it.

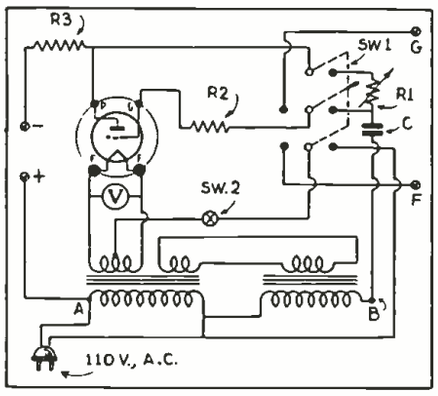
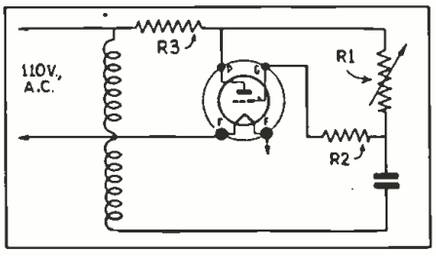


Fig. 2, below
The phase shifting arrangement of the device.



THE CONTROL UNIT CIRCUIT

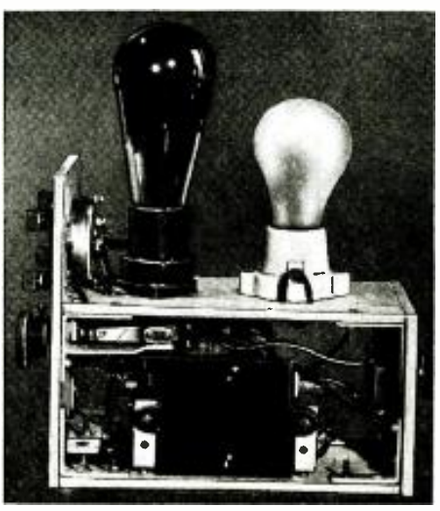
The complete circuit appears in Fig. 1, but Fig. 2 shows the phase-shifting feature more clearly. Unlike ordinary radio practice, the grid voltage remains fixed in magnitude, but its phase angle varies over a range of nearly 180 degrees. As R1 is decreased, the grid voltage swings into phase with the plate voltage. The plate current picks up earlier in the cycle and the average plate current increases. Thus the rectified current delivered from the 110-volt A.C. line can be varied smoothly and efficiently. A small direct current motor could be connected to the binding posts at the left and its speed accurately controlled by R1. Incidentally, the protective lamp R3 can be dimmed or brightened in exactly the same way as the most modern theater lighting systems.

The 110 volts needed for the grid circuit could be obtained from an auxiliary winding on the filament transformer. If the transformer has no such winding, but does have an extra 5 or 7.5 volt winding, connect this to the low voltage side of a bell-ringing transformer. The 110 volts induced in the primary of the latter transformer is added to the line voltage to give a total of 220 volts between points A and B. This was the scheme adopted by the writer and shown in Fig. 1.

R1, the phase control, is a carbon rheostat having a range of 100 ohms to several megohms. A 100,000 ohm resistor, R2, protects the grid from excessive current and a 40-watt lamp, R3, does the same for the plate circuit. The condenser is rated at 0.5-mf, at 500 volts. While not absolutely necessary, the filament voltmeter gives a useful check, as all gas-filled tubes are critical as to filament voltage. For the same reason, switch S2 controls only the plate circuit and the filament is kept hot as long as the unit is connected to the 110-volt supply.

Fig. 1, left
The complete circuit of the grid-glow control unit with the change-over switch which makes it so flexible for experimental work.

Fig. 8, below
The side view of the unit, ready for operation—note the tube and lamp.



HOW IT OPERATES

When used as a grid-controlled rectifier, the output of the device may be filtered and used around the laboratory or test-bench as a source of variable D.C. The unit is extremely versatile, and as a guide to experimenters, the following suggestions are offered:

The grid-glow tube has the peculiar property of not passing any current until the plate voltage exceeds a critical value determined by the grid bias. Hence, a grid current of the order of microamperes can control a D.C. plate current of 0.4-A., giving an extremely sensitive relay effect. The tiny grid currents required are readily passed by small capacities or high resistances.

In cathode-ray sweep circuits a condenser is charged at constant current through a suitably biased pentode. The voltage across the condenser (and across the oscillograph deflecting plates to which it is connected) rises linearly until it reaches the critical voltage of the grid-glow tube. The latter then breaks down, discharges the condenser, and the cycle is repeated.

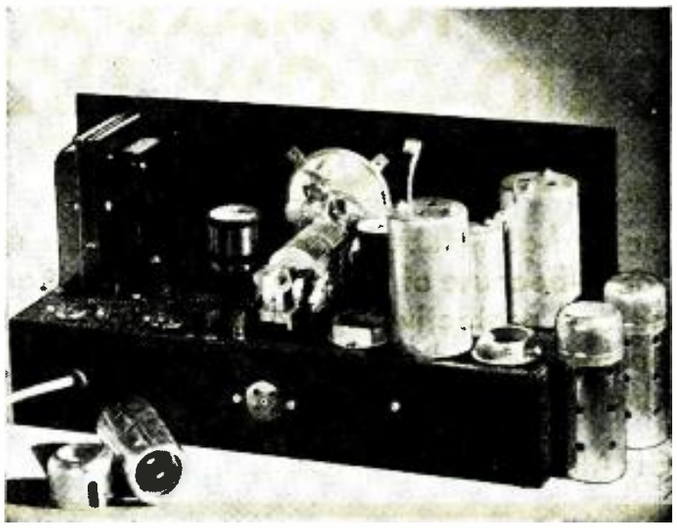
Since a condenser discharge through the neon gas produces a brilliant orange-red light, the tube may be used in stroboscopic work. An alternating

(*Continued on page* 630)

BUILD THIS 5-TUBE ALL-STAR "JUNIOR"

PART II

We continue here the construction of this interesting A.C. powered kit set—for the all-wave radio enthusiast. Blueprints and full-size layouts may be obtained by addressing an inquiry to RADIO-CRAFT.



THE FIRST operation in the construction of the All-Star "Junior" is to mount the wafer sockets on the subbase in the positions indicated in the layout view. When mounting the sockets for the 6A7, 6F7, and the 77 tubes, the shield bases should be fastened with the same bolts which hold the wafer sockets for those tubes. The 6-32 ⅜-in. bolts are suitable for mounting these sockets. Lock washers should be used between the nut and the under side of the wafer socket. While mounting these sockets observe on the layouts (Figs. 2 and 3) which show the under side of the sockets, those which have soldering lugs. These soldering lugs should be installed at the same time the sockets are installed. The volume control and the speaker socket are the only pieces which may be mounted on the sides of the subbase at this time. Install the I.F. transformers so that the lead from the top is close to the tube to which it connects. Solder grid clips to the wires which connect to the tops of the tubes. Keep these leads short.

Fig. 1—The top side of the chassis layout.

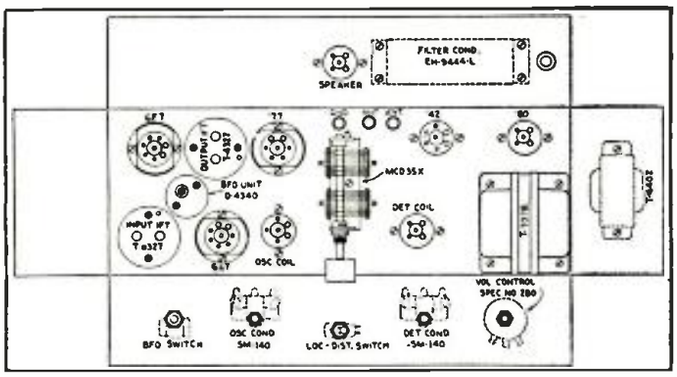
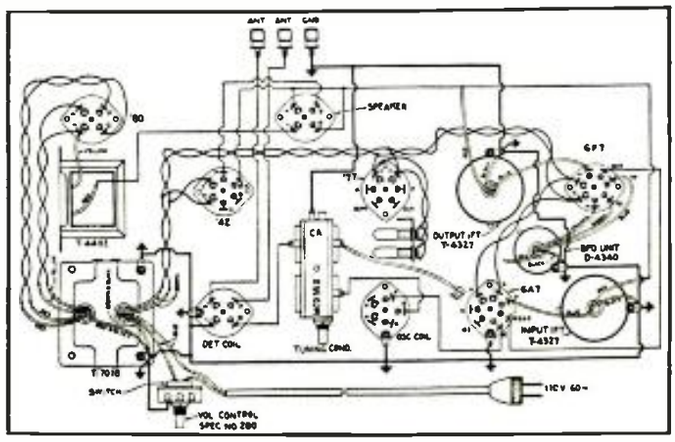


Fig. 2—The beginning of the wiring—pictorially. The twisted filament wires are first, followed by the other connections shown—the wiring is finished according to fig. 3 at the right.



Mount the dial on the dual condenser before fastening the one bolt which holds the dual condenser in place.

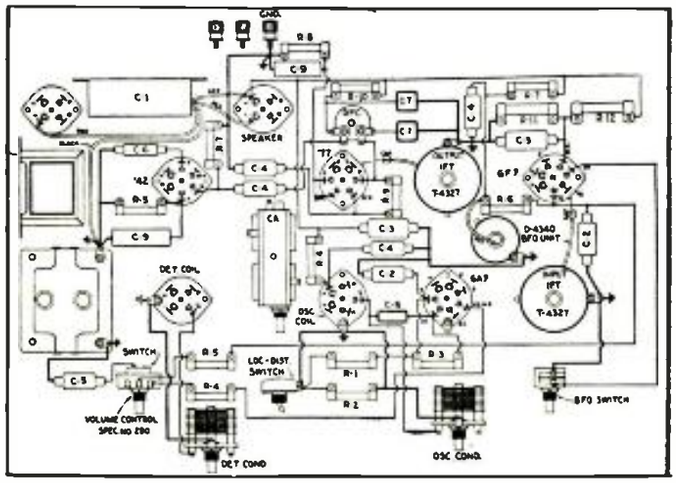
The twisted leads which supply the filament voltages to the tubes and the plate circuits of the type 80 tube constitute the first wiring which should be installed. (Fig. 2.) The twisted leads which connect to the dual pilot lights need not be connected until the dial is installed after the rest of the wiring is complete. Exercise care in selecting the correct colored leads from the power transformer so as to avoid any possibility of burning out the tubes or equipment. The tools you will need are a good electric soldering iron with a supply of rosin core solder, a screwdriver, and a pair of short-nose wire cutting pliers. If you have any difficulty distinguishing color, secure assistance when selecting the proper colored wires from the transformer. The ground wire which appears in the layout may be run immediately after the filament wiring, and should be one continuous length.

At this time the choke coil should be mounted as shown in Fig. 1. The colored wires from the I.F. transformers and the BFO unit should be connected at this time. The red wire from the BFO unit will not be connected until later.

In making connections to the two antenna binding posts use fiber washers to insulate these posts from the metal chassis. The ground binding post should have a lock washer and be tightened sufficiently to assure good electrical contact with the metal subbase. Sandpaper the base wherever connections are made to the metal. The flexible rubber-covered power cord should be threaded through the hole on the back of the base and looped in a knot to prevent it from pulling out. The junction of one lead of the power cord with a blue wire from the transformer should be covered with tape. A serving of tape around the wire

(*Continued on page* 634)

Fig. 3—The remainder of the under-chassis wiring.

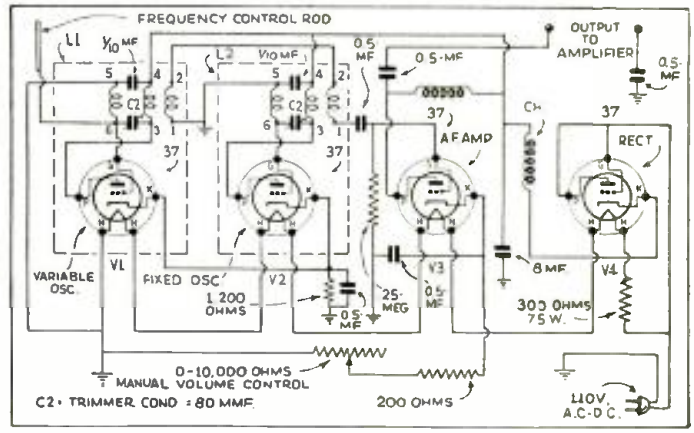


enjoy-
mple to
ed units.

E. L. DEETER

The appearance of the home-built Theremin which will afford the experimenter many hours of enjoyment in making it and learning to play it.

The circuit of the Theremin showing coil connections and power supply circuit.



IN EVERY field of art and industry we constantly find new developments, involving new principles to replace the old or to improve the present ones.

For the past fifty years there have been very few appearances of new ideas in the field of musical instruments. Outstanding among these few newcomers are the electrical instruments of the Theremin type utilizing oscillating circuits of electronic tubes.

Professor Theremin made use of two oscillating circuits, one beating against the other, to produce audible tones covering in a continuous manner the entire musical scale. Of special interest is his space-controlled instrument wherein the capacity of the hand is utilized to produce changes in one of the oscillating circuits. Bringing the hand closer to an antenna rod (*Continued on page* 617)

THE LATEST ELECTRONIC ORGAN

An advanced type of electronic musical instrument—developed by Ivan Eremeeff—a noted Russian physicist. It is based on photoelectric tubes—and is more flexible in "tone quality" than the standard pipe organ consoles.

EDWARD E. KASSEL

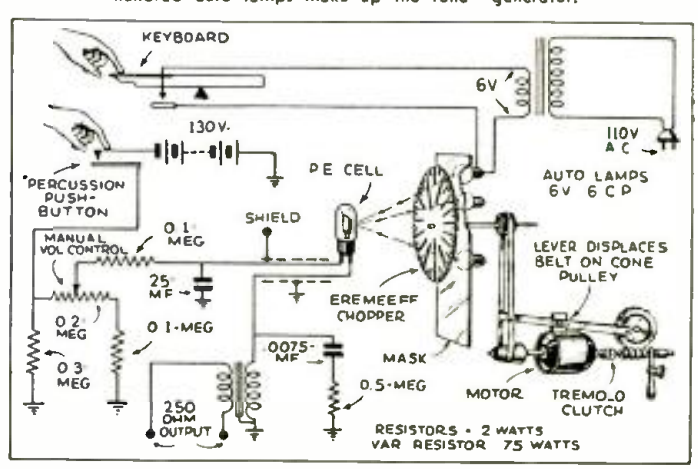
The Eremeeff organ in its complete form.

THE LATEST Eremeeff electronic organ, shown in the accompanying photographs, was invented, designed, and built by Ivan Eremeeff, Russian physicist and craftsman, in the Eremeeff-Stokowski Electronic Musical Laboratories established by the WCAU Broadcasting Station in Philadelphia. This modern instrument has two manuals, twelve interdependent stops for each manual, a volume control pedal, and a tremolo pedal which can also be adjusted by the small knob seen below the keyboards.

This instrument is entirely A.C. operated, without the use of rectifiers, having an outlet for 110 volts A.C. and a three-way wire lead to an amplifier and loudspeakers. The modernistic console is of compact size in order that it may be moved easily through standard-size doors.

The lower manual is provided with stops for combining harmonics and sub-harmonics to the fundamental tones, and the upper manual is provided with stops for combining fractions of the harmonics and sub-harmonics to the fundamental tones, in accordance with the Eremeeff-Helmholtz methods of tone synthesis, which have been described previously in the November, 1932, and August, 1934 issues of RADIO-CRAFT. *(Continued on page 621)*

A simplified circuit of the organ. The methods of obtaining tremolo and "piano" like tones are illustrated. Twelve photo-electric tubes and nine hundred auto lamps make up the tone "generator."



Studio of the 120kw. station at Warsaw, Poland.

C. A. MORRISON

DX-ers' Award

Here's the winner of the current award in the DX contest for All-wave DX-ers—Mr. H. S. Bradley of Hamilton, New York. DX-ers here is your chance to win a valuable prize by submitting your 10 best "veri's." See rules in January, 1935, RADIO-CRAFT.

SINCE starting this series of DX articles, we have taken up in consecutive order, "General Rules to Observe in DX-ing." "The Importance of a Good Log Book," and "Securing and Displaying Verifications." In this issue we propose to give you some very practical, and helpful pointers on *choosing a receiver for DX-ing.*

No one receiver, even the most expensive custom-built receiver, incorporates every desirable feature, and often a very cheap receiver will incorporate at least *one* unique feature that makes it deserving of attention. As the popular priced receiver does not include everything, we must choose (from the standpoint of practicability) a receiver which incorporates the most important DX features, in that price class which we feel able to pay. We suggest that all blatant and ballyhoo advertising be "taken with a grain of salt," as certain highly publicized features are nothing more than glorified names for common receiver functions.

The International station at Shanghai—jointly owned by the U.S. and China. Note the peculiar construction of the towers.

Here are the questions you need to be primarily concerned with: (1) *Is the receiver all-wave,* covering all useful channels from 22,000-kc. down to 540-kc. or is it in reality a short- and long-wave set covering only a small part of the short-wave spectrum? No one today should consider buying anything but an all-wave receiver, since fairly good all-wave receivers may now be had at very reasonable figures and a set, for broadcast band use only, will soon be as out of date as a "horse and buggy on Broadway."

(2) *How selective is the receiver?* A receiver cannot be too sharp in tuning, for the "dyed-in-the-wool" DX-er. A model superheterodyne should give better than 10-kc. selectivity over the whole broadcast band. Does the set bring in a distant station clear and sharp, with no station splash, between two powerful locals? This is absolutely essential for DX-ing. Much DX reception is even sharper than this, as Cubans, Mexicans, and Europeans work on split frequencies, only 5-kc. or less from a local station. With good conditions of reception, split frequency tuning will reward the DX-er with many rare catches. In some of the more expensive receivers *crystals* are incorporated which make 5 kc. tuning easy. These crystals may be switched out for better tone quality. Will the receiver give you adequate selectivity on the 49 meter band? If the receiver is sharp in tuning on these crowded channels such stations as YV2RC, CJRO, VE9GW, or IRA should be brought in without perceptible interference. There is no excuse for poor selectivity today as even a cheap set if carefully designed will be selective enough for the ordinary DX-er.

(3) *What degree of usable sensitivity does the receiver possess?* We are not particularly interested in the highly advertised claim of fractional microvolt sensitivity unless this also means a high ratio of signal strength to noise. Nearly every all-wave receiver at the present time is too noisy, part of which is due to inherent receiver noises, and part of which is local electrical interference. Correctly designed antennas will do much toward reducing the latter type of noise. As I write this article, I am listening to GSE, Daventry, England. I have two

The world's highest transmitter—station CP4, of Radio Illimani at La Paz, Bolivia. It is 12,000 ft. above sea level.

all-wave receivers on test. One is a highly complicated, and technical commercial set embodying all of the supposed gadgets that improve reception. The other is the common stock factory production model of a well-known manufacturer, and has only six tubes. As I turn from one to the other I can detect little difference in the signal strength, although the commercial job is more intelligible on account of the tone pitch which is very high. (When DX-ing your tone control should always be turned to its highest pitch, as weak carriers are more easily distinguished with the tone control in this position.)

(4) *Is the receiver equipped with some device to denote when a signal is tuned to exact resonance?* This may take the form of a beat oscillator, a tuning meter, or a neon glow indicator of some sort. Although some DX-ers still prefer the delicate swish-swish of a carrier heard by the ear alone to any of these mechanical devices, personally I have found these devices are a definite aid in working a weak signal in to its maximum strength, and in locating new stations that might be lost in noise, and thus inaudible to the ears as a carrier wave.

(5) *Is the receiver equipped for headphone operation, or may they be installed without disturbing the balance of the circuits in the receiver?* Many DX-ers still prefer headphones for working with weak signals, or for using their receiver in the wee hours of the morning without disturbing less enthusiastic members of the family. If this is an important factor in your con-

(*Continued on page* 633)

HOW TO READ GRAPHS and CHARTS IN RADIO WORK

Are you frightened by the appearance of a graph in reading a radio book or magazine? If so, this clear explanation of the mechanics of graph making will assist you materially.

W. EGLIT

PART I

THE RADIO experimenter, when reading articles pertaining to his hobby, is frequently confronted with graphs that illustrate the electrical performances that are discussed in the text. All too often the reader shies at these charts and skips by them without studying them, consequently losing much of the value of the article because of his poorly grounded fears of a very simple method of representing facts. The purpose of this article is, therefore, to aid such a reader in acquiring an understanding of the full significance of the graphs that he is likely to meet in future articles.

The commonest form of graph is of the rectilinear type. It is built upon a frame of two reference lines, or coordinate axes, which in Fig. 1 are X'X and YY', intersecting in a zero point, O, called the origin. These lines are at right angles to each other and the vertical line, YY', is called the axis of ordinates, while X'X, the horizontal line, is called the axis of abscissas. If you prefer, you may simply call them the Y axis and the X axis, respectively; or you may dismiss these names from your memory altogether and just retain what they imply. OY determines positive values or distances measured vertically from the zero line X'X, and the higher a point lies above X'X, the greater its positive value. OY' likewise determines the extent of the negative values of points lying below X'X. Points lying on the graph sheet to the right of YY' are positive when measured horizontally from YY' and the further from this axis, the greater the value. Similarly, points lying to the left are negative, that is, at least as far as horizontal measurement is concerned.

THE FOUR QUADRANTS

The graph sheet is divided by the coordinate axes into four quadrants, labeled I, II, III, and IV in Fig. 1. In the first quadrant the Y or vertical values and the X or horizontal values of any point lying in that quadrant are both positive. In the second quadrant the Y value is positive and the X is negative; in the third quadrant the X and Y values are both negative; and in the fourth quadrant X is positive and Y is negative. For example: the Y value of point A is plus 2 and the X value is plus 3; for point B, Y = plus 3 and X = minus 3; for point C, X = minus 2 and Y = minus 1; and for point D, X = plus 4 and Y = minus 4. Since the majority of electrical graphs occur in the first quadrant, we shall give this type of graph the most of our consideration.

Figure 2 illustrates a graph of this type, where OY and OX are the coordinate axes or reference lines, representing amperes and volts respectively, zero voltage and zero current occurring at the origin, O. It is seen that lines are drawn parallel to the axes at equal distances apart. Each of these lines represents a particular value, the horizontal ones for current and the vertical ones for voltage. It is seen that every fifth line is drawn heavier in order to make the chart easier to read. For instance, at intervals of 50 volts and at intervals of one ampere the lines are heavier than for intermediate values. We notice that as we start from the origin and read along the X axis (carrying the voltage scale) we count five lines to the line marked 50 volts; therefore, since an interval of five lines represents 50 volts an interval of one line represents 10 volts. Likewise, each horizontal line measured from the origin

(*Continued on page* 620)

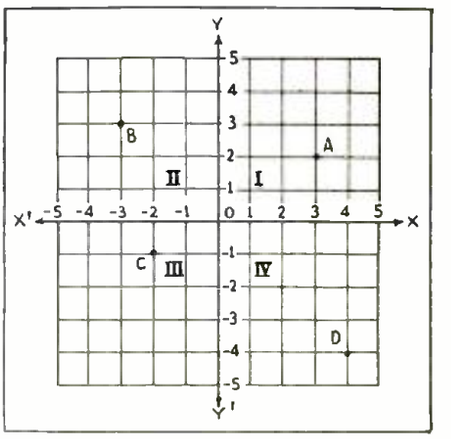


Fig. 1—A graph of the rectilinear type.

Fig. 2, below
A graph in the first quadrant showing a uniformly increasing value of current and voltage.

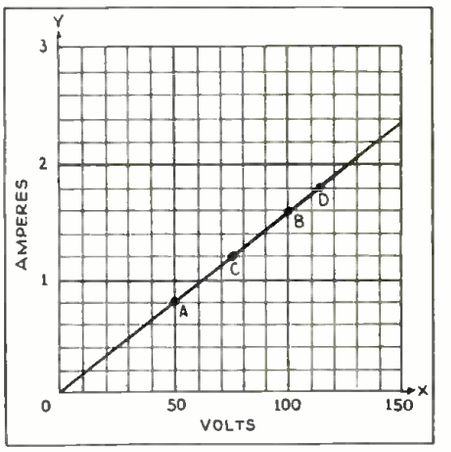


Fig. 4, below
An extension of Fig. 3; the line extends into the second and third quadrants.

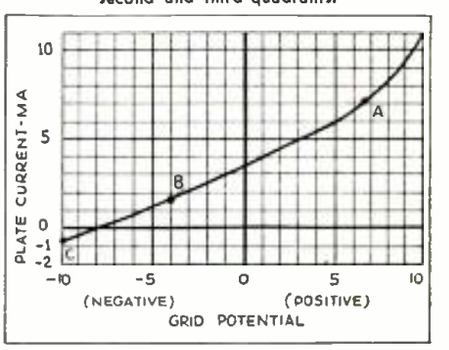


Fig. 3
An increasing value—of more than uniform rate—compare this with Fig. 2.

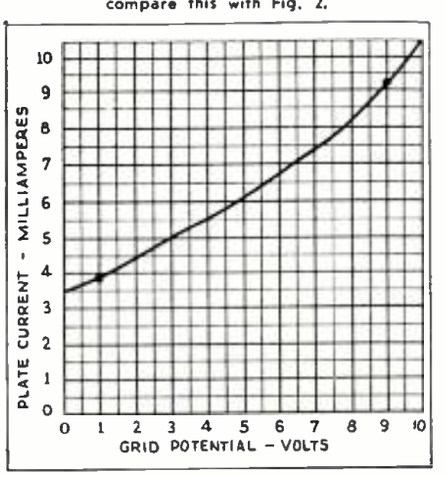
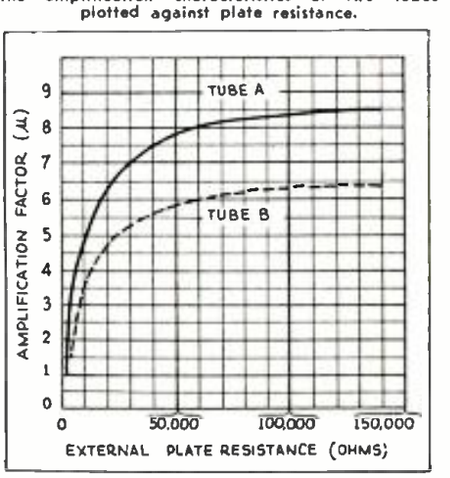
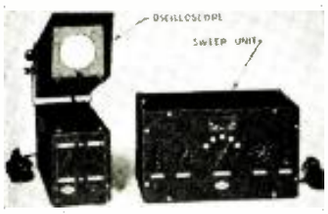


Fig. 5, below
The amplification characteristics of two tubes plotted against plate resistance.



THE LATEST RADIO EQUIPMENT

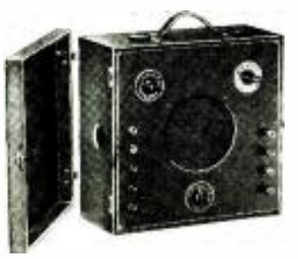


Cathode-ray oscilloscope. (674)

Portable "crystal" P.A. system. (675)

New rectifier-filter unit. (676)

Adjustable pickup-recorder. (677)



Variable-field dynamic speaker. (678)

CATHODE-RAY OSCILLOSCOPE AND SWEEP UNIT (674)

(The Clough-Brengle Co.)

THIS cathode-ray equipment is new in mechanical development—yet it employs a proven type of cathode-ray equipment and sweep-unit type tube, is a fully standardized, portable, and suited for field-service work, as well as production and laboratory use.

Brilliancy is sufficient to allow photographic records when desired. Furnished complete in crackle-finished metal housing, dimensions 11½x6½x16½ ins.

TWO PORTABLE P.A. OUTFITS (675)

ANNOUNCEMENT has been made of two compact, portable P.A. systems using crystal microphones. The smaller model is designed to feed 3.5 W. to the dynamic speaker mounted in front of case. The larger unit (7.5 W. output) can handle as many as 6 permanent magnet speakers.

NEW RECTIFIER-FILTER UNITS (676)

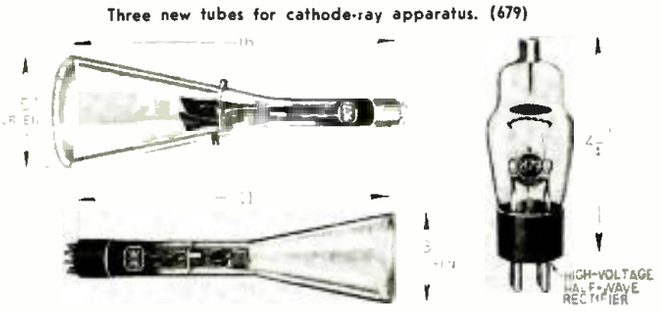
RECTIFILTERS are devices for changing A.C. to D.C. with no moving parts. They consist of transformers, rectifying elements, choke coils, and condensers. Rectifilters are designed for operation from an A.C. power circuit and, by appropriate design of the transformers and rectifying elements, can be made to deliver D.C. at almost any combination of voltage and current. Both copper-oxide and bulb rectifiers are employed depending upon the rating.

ADJUSTABLE PICKUP-RECORDER (677)

(Universal Microphone Co.)

THIS latest combination pickup and recorder is so assembled that pressure can be decreased to a featherweight on the needle groove; minimizing groove and needle wear. As a recording cutting head, it matches all standard line-to-line mixers, tube-to-line and line-to-line transformers. The arm is long enough to play up to 16-in. records.

Three new tubes for cathode-ray apparatus. (679)



A VARIABLE-FIELD DYNAMIC REPRODUCER (678)

(The Radolek Company)

SOMETHING new on the market is a special 6¼-in. electro-dynamic speaker with a multi-tapped field winding having a total resistance of 11,000 ohms with an 8-point tap-selector switch adapting the speaker voice coil to any power tube circuit or to any output transformer secondary. The speaker and transformers are contained in a fabricoid-covered portable carrying case. 12x12x6 ins.

NEW TUBES FOR CATHODE-RAY APPARATUS (679)

(RCA Mfg. Company, Radiotron Division)

CATHODE-RAY TUBES

NEWCOMERS to the list of tubes—The 907 and 908 are of the hot-cathode, high-vacuum, electrostatic type, and employ a fluorescent viewing-screen material especially suited for recording on moving film and for rotating-mirror timing methods. The 907 has a 5-in. diameter screen, while the 908 has a 3-in. diameter screen.

HIGH-VOLTAGE RECTIFIER

The 879 is a high-vacuum, half-wave rectifier tube of the hot-cathode type for use in suitable rectifying devices to supply the D.C. voltage requirements of cathode-ray tubes.

A NEW 8-IN. DYNAMIC SPEAKER (680)

A SPECIALLY designed reproducer, built to supply the need for a good, dependable unit, selling for a low price. It is an excellent replacement unit for many types of sets.

ULTRA-COMPACT REPLACEMENT ELECTROLYTICS (681)

(The Aerovox Corp.)

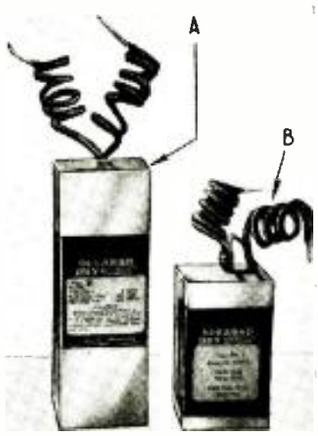
THESE units (B) are the most compact electrolytics yet offered. Each section is enclosed in two wax-impregnated cardboard boxes. The unit remains positively dry, free from leakage, seepage or corrosion. One type is rated at 525 V. surge peak, 450 V. D.C. working. The other is rated at 600 V. surge peak, 475 V. D.C. working. Both types are offered in single and dual capacities.

AN IMPROVED DIAL (682)

THIS new model eliminates vernier at the opposite end of pointer of old model. Open vision pointer permits fast location on any of the 7 scales. This is just the dial for oscillators, short- and all-wave receivers. Outside diameter is 3¼ ins. Ratio is 6½ to 1.

(*Continued on page* 631)

A new 8-in. dynamic speaker. (680)



Smallest electrolytic condensers. (681)

An improved 7-scale dial. (682)

New "dry-cell batteries." (683)

Name of manufacturer of any device will be sent on receipt of a self-addressed, stamped envelope. Kindly give (number) in description under picture.

the professional Service Man. In it will be found the most unusual troubles encountered in radio service work, written in a practical manner, by Service Men for you.

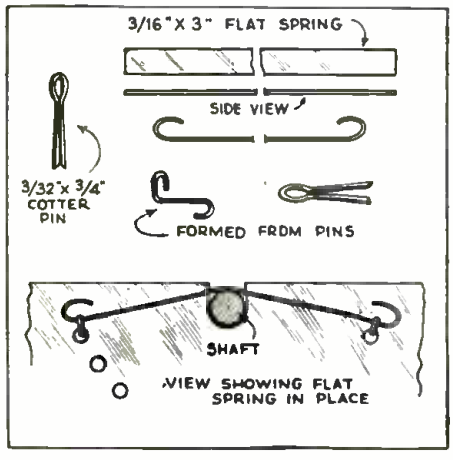
Have you, as a professional man, encountered any unusual or interesting Service Kinks that may help your fellow workers? If so, let us have them. They will be paid for, upon publication, at regular space rates.

PHILCO 16, 17, 17X

A GREAT number of variable condenser gangs of the type used in Philco radio sets go so tight after some months' use that they are difficult to turn for station selection. This is due to the strong wire springs at the ends of the condenser gang frame cutting into the shaft. It would appear that a new condenser gang would be the only remedy. However, not only can a repair be made quickly but also it will improve the mechanical construction. The method of repair is as follows:

First, remove the rotor section of the condenser gang and sandpaper the roughened parts, then, replace. Discard the two end wire springs which are the ones where the wear takes place. Procure a flat spring about 3 ins. long and about 3/16-in. wide (See Fig. 1). This can be obtained from a discarded butcher's saw blade or hacksaw blade, by cutting lengthwise

Fig. 1
Here is how one Service Man solved the problem of preventing "sticking" condenser shafts in Philco sets.



cotter pins and cut and shape as shown in the drawing. Slip the newly formed pins over the ends of springs and place springs in position; the flat side of spring bears against shaft. One end is fastened with cotter key permanently and other end is hooked in hole that gives proper pressure on shaft. This is a quick solution of a perplexing problem and makes a better job as the flat spring will not cut into the shaft like the wire does. Of course, a phosphor bronze spring would make a better contact; however, you still have the center wire for that, and with the flat springs we have never experienced any trouble in lack of contact. Note: After cutting a spring from a blade, smooth any rough edges with a file or emery wheel.

GEO. A. AUBLE, JR.

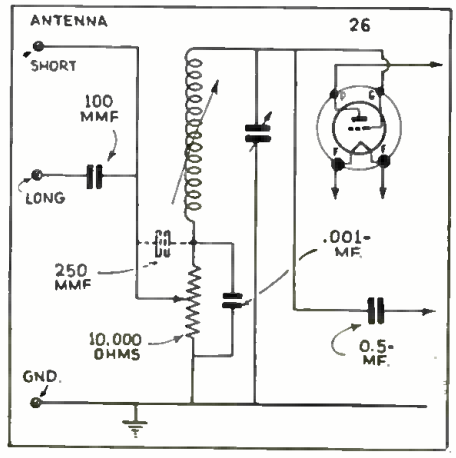
MAJESTIC MODELS 60, 70, 80

AN EFFECTIVE method of increasing the sensitivity and volume of the above models is to place a 250 mmf. mica condenser between the contact-arm of the 10,000 ohm volume control and the low end of the variable R.F. coil in the first R.F. stage. This will have the effect of bypassing some signal directly to the coil without affecting the action of the volume control.

Various condensers were used at this point in the circuit (see Fig. 2), ranging from .01 mf. to 100 mmf., but best results were obtained with a mica-insulated condenser of 250 mmf. Incidentally, noise was reduced considerably. In the case of a particularly dirty volume control, a once-over with chamois cloth on the contact-arm wiper and shaft will work wonders.

BERNARD SUNSHINE

Fig. 2
A single 250 mmf. condenser improves Majestic volume.



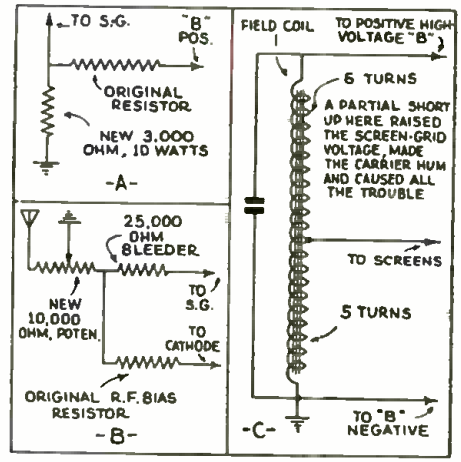
the subject for an Operating Note. It is assumed that all Service Men test tubes when making a service call. Their experiences on the subject of testing tubes, unless most unusual, are not of sufficient interest to other Service Men. Operating Notes should be confined to those faults which are characteristic of, and repeatedly occur in connection with a particular model of radio receiver.

AUDIOLA 30-B

ONE 24 tube was burned out in an Audiola 30-B and the customer mentioned the fact that he was never able to get the volume low enough on powerful local stations without detuning, or turning the local-distance switch to local. The volume control was noisy, too, and so I recommended adapting the receiver to type 35 tubes. I pointed out that the cost would be very little extra, since they had to buy a new volume control and one new 24 anyway.

(*Continued on page* 632)

Fig. 3
Correcting defective volume control and adapting Audiola to 35's (A,B). Locating defective speaker field in Zenith 410 (C).



AN INVALUABLE addition to any experimenter's laboratory, is a vacuum-tube voltmeter. This is an instrument which many have desired to possess, yet have been deprived of owning, because of the costly, delicate meters and elaborate apparatus required in one as dictated by most of the available circuit requirements and by the high cost of upkeep of such an instrument due to the use of batteries for supply purposes.

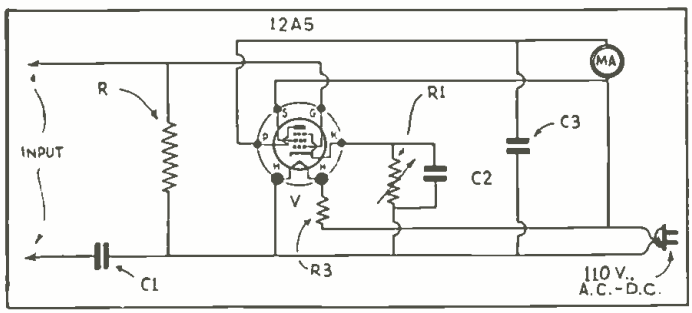


Fig. 1. The circuit of the A.C.-D.C. V.T. voltmeter.

To surmount both of these difficulties, yet to produce an instrument of sufficient precision to meet most of the experimenters' requirements, the following circuit has been developed. In this, low cost and simplicity of operation and construction have been the dominating factors considered in its design.

Since most D.C. meters available to the experimenter are usually of the insensitive type, having a range in the order of 20 ma. for full scale deflection, such a meter was employed in the circuit.

In order to obtain high-power sensitivity, as is necessary because of the use of such a high-range plate milliammeter, a 12A5 tube was selected, due to its high transconductance and also to its low filament current consumption; which enabled the selection of a convenient filament divider resistance and in addition the losses in this divider were minimized. The divider employed, R_3, was a 35 W. standard mazda lamp. Condensers C_2 and C_3 comprised the sections of a dual 8 mf. electrolytic condenser, while C_1 was a 1 mf.

(*Continued on page* 625)

MAKE THIS VARIABLE-TONE CODE PRACTICE SET

The secret ambition of most radio fans is to own and operate an amateur radio transmitter—but learning the code stumps many of them. A practice set of many uses.

H. LEROY FLESH

THIS CODE practice oscillator is designed for the beginner or even the licensed ham. It can be made into a very compact job, having a variable tone which can be controlled by the variable grid resistor. If one likes to copy a high-pitched note it can be so adjusted; or a low tone can be obtained or any pleasing tone the operator wishes to copy.

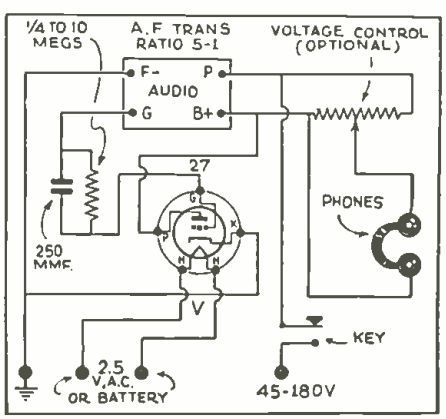
If one doesn't have a variable grid-leak, the tone can be varied by using a variable grid condenser instead of a fixed condenser. In this case a fixed grid-leak should be used, ranging anywhere from three to ten megohms. The variable condenser should be about 250 mmf. maximum.

Either one of these arrangements can be used depending on what parts the builder has or if he wants a compact job.

This all-A.C. oscillator was designed for beginners unable to buy expensive batteries. One can purchase an old "B" box at a reasonable price and filament transformers can also be obtained very cheaply, or if one has a small receiver the "A" and "B" supply can be tapped from its powerpack.

The oscillator in the picture is made on a 3½-in. x 4-in. aluminum pan ¾-in. deep. The binding posts on the end are for power-supply taps. The two small ones are for the filament supply, and the two large ones for the positive and negative "B" supply. The audio transformer is of the midget type with a ratio of one-to-five, but almost any old transformer will work. The variable grid-leak has a range varying from ¼ to 10 megohms and the grid

(*Continued on page* 619)



knows—maybe the 1-tube job will soon make its appearance on the market!

R. D. WASHBURNE and N. H. LESSEM

QUESTION: "Why should I build a 1-tube superheterodyne?"

Answer: No. 1—If you are an honest-to-goodness "old-timer," you will know what we mean when we say you have a thrill in store, if you build this set. No. 2—If you are a beginner in radio, you are urged to construct this receiver and learn the fundamentals, from a practical standpoint, upon which is based the operation of every modern set of the high-gain, selective type.

It will be noted that in the heading the "1-tube" is placed in quotations. This was to call attention to the fact that the use may be considered colloquial, in that although there is only one tube used, insofar as external appearances are concerned, actually there are two effective tubes; the 6F7 used in this receiver incorporates a pentode and a triode in one envelope.

WHY THE CIRCUIT WAS DEVELOPED

The authors designed this 1-tube superneterodyne partly as an answer to the challenge of those who said, "It can't be done"; partly to satisfy personal desires to produce a set of this type as a matter of completeness in connection with a series of so-called 1-tube sets (crystal detectors were used; the tube functioned as the oscillator) dating back to 1925; and partly to furnish experimenters with something *different* on which to try out their ingenuity in the matter of parts arrangement and circuit modifications.

The theory of the superheterodyne has been adequately treated in the article, "The Beginner's '1-Tube' Crystal Superheterodyne," by Francis R. Harris, in the September, 1933, issue of RADIO-CRAFT (incidentally, the previously-mentioned circuits of 1925 are reproduced in this article), and rather than attempt to repeat this lengthy and detailed description, we will content ourselves with a thumbnail resumé of the subject.

The incoming or "signal" frequency is fed to a *first-detector* (or, more correctly, a "modulator"). The purpose of this unit is to mix the incoming signal frequency with a second frequency generated by an *oscillator*. The resultant or third frequency thereby produced is fed to a *second-detector* (or, more correctly, a "de-modulator"). The output of the second-detector is the desired audio frequency that originated in the broadcast studio.

We could have secured this A.F. at the output terminals of the first-detector, but by juggling it a bit, and playing a sort of technical hide-and-seek with it we secured additional selectivity and, to a certain extent, sensitivity; in addition, in our new circuit, this sort of radio legerdemain permitted us to secure several desirable effects.

FEATURES OF THE SET

Our little 1-tube set combines in the single glass envelope, or bulb, of a type 6F7 tube (see Fig. 1) pentode and triode elements that permit the above operations of the *first-detector*, *oscillator*, and *second-detector*, to be secured without recourse to a second tube.

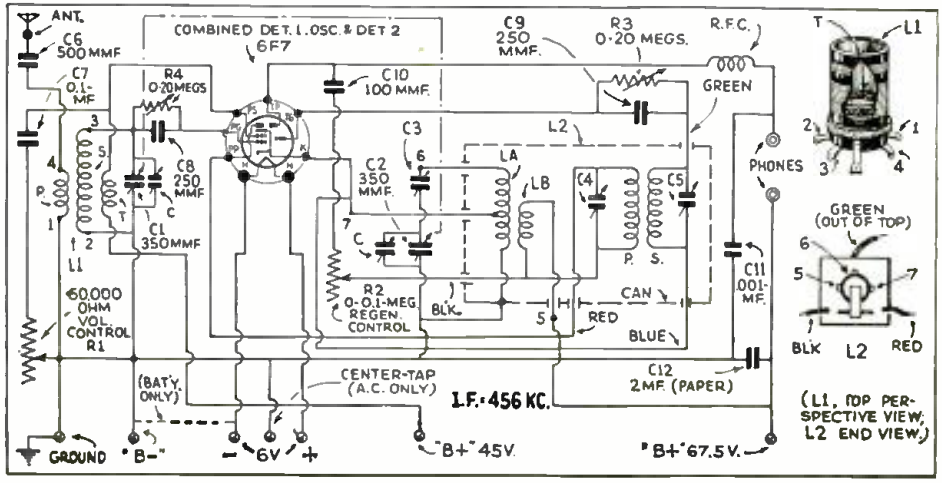
In addition, both detectors are made independently regenerative; the first-detector regeneration within the signal frequency range of 550 to 1,500 kc. does not interfere with the second-detector regeneration at the intermediate frequency of 456 kc.

The pentode section of the 6F7 is excellently adapted for use as a combined first-detector (of the grid-leak type) and electron-coupled oscillator; the triode section functions admirably as a grid-leak second-detector, the plate circuit of which is a good match for headphones,

(*Continued on page* 632)

Fig. 1

All the fundamental functions of the tubes in a superhet. are performed in 1 tube!



IT WAS stated in these columns last month that trying to use new type tubes in sets designed for earlier types can cause a lot of trouble and usually produce results of doubtful benefit. Nevertheless tube changes are often attempted because it is desired, for instance, to increase the audio output of a set, or to change an A.C. set for operation on a D.C. power supply. In the following discussion of these tube changes, a description of the difficulties involved may serve to caution those who think that the changes are usually simple, and the information given may be helpful to those with sufficient knowledge and experience to have a fair chance of success in making changeovers.

It should be noted that when the new type takes a different socket than the tube for which it is substituted, an adapter may be used in A.F. stages but this is unsatisfactory in an R.F. or I.F. stage. The losses and capacity introduced by the adapter usually spoil the set's tuning, and the elevation of the tube above the chassis makes tube shielding difficult.

SUBSTITUTIONS AMONG THE 2.5 VOLT TUBES

Voltage Amplifiers

24A by 57
35 by 58 Socket Differences: 24A and 35 have 5-pin base; 57 and 58 have 6. These substitutions are often attempted because the new tubes have a higher mu. But if any increased gain is realized, feedback through the power supply, and electrostatic coupling between the tube's plate and the grid circuit can both become troublesome. This necessitates more R.F. filtering and the addition of tube shields. The difference in shape of the grid-plate characteristic curve sometimes means that a change in the A.V.C. system and the taper of the volume control is necessary. Grid bias usually must be changed. The difference in inter-electrode capacity may mean that the tuning condensers have to be realigned. In I.F. stages, the higher plate resistance of the new tubes puts less loading on the transformers, so looser coupling may be required.

27 by 56 Socket Differences: None. In R.F. and detector stages this substitution requires tube shielding and additional R.F. filtering if any increase in gain is to be realized. In detector stages no other change is necessary. In R.F. and A.F. stages with fixed bias, the bias should be made less negative; if a cathode bias resistor is used it need not be changed.

Power Amplifiers

45 by 2A3 Socket Differences: None. In a single-ended stage the control-grid bias should be changed and an output transformer with a smaller step-down ratio should be used. In self-biased push-pull circuits, 2A3s can sometimes be substituted without any changes. In all cases, the set's power supply must be able to deliver the extra

5. This substitution requires an output transformer with more step-down ratio. In order to suppress the shrill tones which are characteristic of the output of an improperly installed pentode it may be necessary to add a filter network to the output. (A .03-mf. condenser and A 10,000 ohm resistor in series, and connected from plate to chassis, is one inexpensive expedient that may be tried.—Editor)

45 by 46 or 59 Socket Differences: 45 has 4-pin base; 46 has 5; 59 has 7. This substitution can be made if the new tubes are connected as *triodes*. The output of the 59 is more hum-free than that of the 45 be-

(*Continued on page* 639)

CHARACTERISTICS OF NEW AND OLD TYPES AT TYPICAL OPERATING VOLTAGES

TABLE III

VOLTAGE AMPLIFIERS

2.5 Volt Types

Tube Type	Amplification Factor	Plate Resis. Megs.	Grid Bias Volts	Grid to Plate mmf.	Input mmf.	Output mmf.
24A	630	0.6	− 3	0.007	5.3	10.5
57	1,500+	1.5+	− 3	0.007	5.0	6.5
35	420	0.4	− 3	0.007	5.3	10.5
58	1,280	0.8	− 3	0.007	4.7	6.5
		Ohms				
27	9	9,250	−21	3.3	3.1	2.3
56	13.8	9,500	−13.5	3.2	3.2	2.2

6.3 Volt Types

		Megs.				
77	1,500	1.5	− 3	0.007	4.7	11.0
6C6	1,500+	1.5+	− 3	0.010	5.0	6.5
39/44	1,050	1.0	− 3	0.007	3.5	10.0
78	1,160	0.8	− 3	0.007	4.5	11.0
6D6	1,280	0.8	− 3	0.010	4.7	6.5
		Ohms				
37	9.2	8400	−18	2.0	3.5	2.9
76	13.8	9500	−13.5	2.8	3.5	2.5

TABLE IV

POWER AMPLIFIERS—SINGLE TUBE CLASS A

2.5 Volt Types

Tube Type	Power Output Watts	Grid Bias Volts	Plate Current Ma.	Plate Load Ohms	Output Trans. Ratio*
45	1.6	−50	34	3900	20:1
2A3	3.5	−45	60	2500	16:1
47	2.7	−16.5	31	7000	27:1
46	1.25	−33	22	6400	25:1
59 (t)	1.25	−28	26	5000	22:1
47	2.7	−16.5	31	7000	27:1
2A5 (p)	3.0	−16.5	34	7000	27:1
59 (p)	3.0	−18	35	6000	25:1

6.3 Volt Types

38	2.5	−25	22	10000	32:1
41	3.4	−18	32	7600	28:1
42 (p)	3.0	−16.5	34	7000	27:1

(*)—Step-down ratio of output transformer for 10 ohm voice-coil load.
(t)—Triode. (p)—Pentode.

*RCA Manufacturing Corp., Radiotron Division.

THE KNOWN FREQUENCY SPECTRUMS

In this fast-moving age we are prone to use the tools available to us, with no regard for their principles of operation —we glibly refer to "light rays," "heat rays," "radio waves," etc., without much realization of their relative status. The author interestingly clarifies the subject.

JOHN J. GLAUBER*

ALMOST daily we either hear or speak about radio waves, light rays, heat rays, and sound waves. It is frequently asked if some relationship exists between these waves or rays, seemingly so different in their effects. To some extent a similarity exists. First, all are of a wave motion.

THE AUDIBLE SPECTRUM

Second, radio waves, light rays and heat rays all require an ether medium for transportation. Sound waves require a material substance such as air or a liquid or solid matter for transportation. Sound waves may be thought of as alternate condensation and rarefaction of material conducting the sound; that is, it is a series of pressures. Sound waves travel much slower than do waves of radio, light, or heat. The latter waves travel at a speed of about 186,000 miles or 300,000,000 meters per second. Sound waves travel through air, at normal temperature and pressure, at about one-fifth mile or 335 meters per second.

THE ETHER SPECTRUM

The sound waves form what is known as the audible spectrum because they affect our aural senses, while the radio, heat, and light waves form the electric wave or ether spectrum. Figure IA is a chart showing the ether spectrum, beginning at the left with the long radio waves to the short cosmic rays at the right. Included between these extremes are the infra-red radiations, the visible radiations, the ultra-violet radiations, the Roentgen or X-rays and the gamma rays. These are all similar as to their speed and the medium transporting them. Their only difference lies in their frequency or wavelength, those of lowest frequency (the radio waves) having the longest wavelengths and those of highest frequency (the cosmic rays) having the shortest wavelength.

METERS AND ANGSTROM UNITS

A 1,000,000 cycle (1.000 kilocycle) radio wave has a wavelength of 300 meters. If we imagine a wave motion such as is produced on the surface of a pool of water, the distance measured from the crest of one wave to the next crest would, in the case of our radio, measure 300 meters. The average length of visible light which, as we can see from the chart, are by no means the shortest waves, have a wavelength of .00000033-meter (violet) to .00000081-meter (red). Because of the awkwardness of such figures, the "Angstrom unit" is used when these minute waves

*Chief Engr. Arcturus Radio Tube Co.

(*Continued on page 636*)

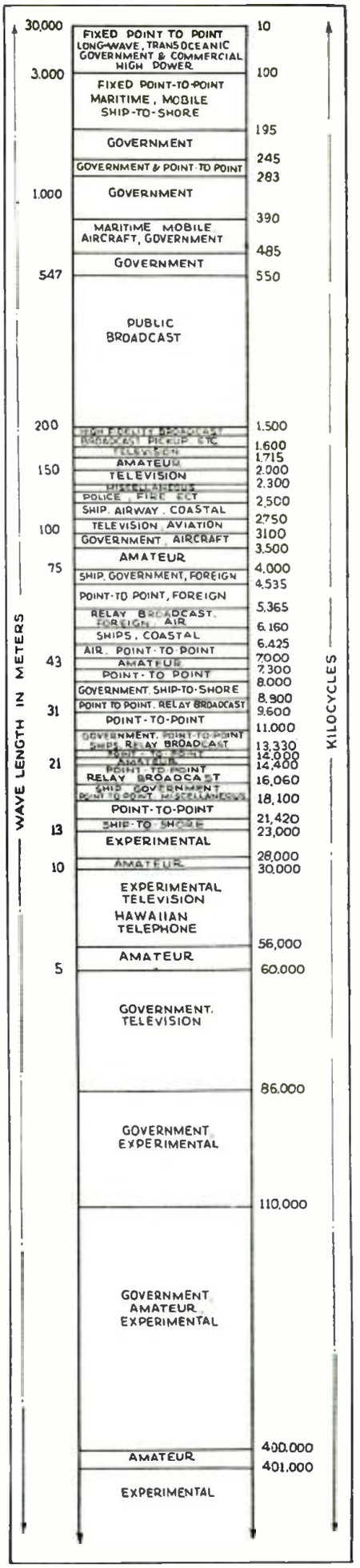
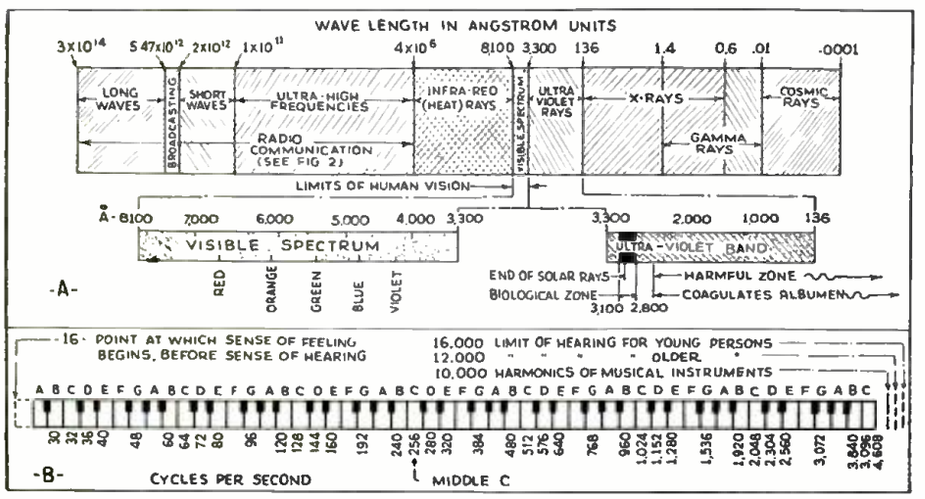


Fig. 1, below
Frequency spectrums in air and ether.

Fig. 2, right
"Radio" portion of ether spectrum.



AN ELECTRONIC AND P. A. AMPLIFIER

A new amplifier with many departures in design, making it suitable for a wide variety of P.A. and electronic applications.

CHARLES R. SHAW*

IN DESIGNING a combined electronic and public address amplifier our first assumption was that the typical experienced buyer of amplifiers has passed the stage of purchasing amplifiers merely for the restricted amplifying properties of the unit itself. Although it is true that it was the original purpose of all audio amplifiers to build up weak audio signals, and as all of them do this, amplifiers and particularly general utility amplifiers are no longer bought entirely from this standpoint. Public address men now consider details of gain, power output, operating economy, frequency response, operating power, input impedances, number of channels, class of output stage, mixing and fading facilities, type of interstage coupling, bias circuits, speaker field supply, frequency control, simplicity of installation and operation, plus innumerable details which one might say are more or less insignificant within themselves, but when taken collectively, might mean the difference between a poor and profitable investment—particularly when an amplifier is bought with the idea of using it for three, four, or five years, or even longer.

Considering the fact that amplifiers are (or can be) used in practically every phase of industrial, commercial, recreational, and political activity, one wonders why the technicians engaged in renting, selling and installing amplifier systems have not long before demanded a truly versatile device, suitable for all practical applications designed and built to compete with other amplifiers which are definitely restricted to one or, at the most, two uses.

To meet the demand for such an amplifier of surprising versatility, the laboratories of a well-known manufacturer have developed a combined electronic and P.A. amplifier, Fig. A. A study of Fig. 1 will disclose the following interesting design details; the device is essentially composed of a dual channel amplifier powered and biased by a common high voltage and low voltage supply system. Each of these clear channels combine a high gain pre-amplifier (for use with ribbon (velocity), condenser, dynamic, crystal microphones, low-level phono. pickups, and photocells for sound-on-film work), a voltage amplifier, a phase inverter, a class A fixed bias output stage with universal output impedances, complete mixing and fading controls, selective high and low gain universal input circuit, high and low frequency cut-off tone control, as well as innumerable optional electronic features too numerous to mention in this brief resumé but which will be subsequently enumerated.

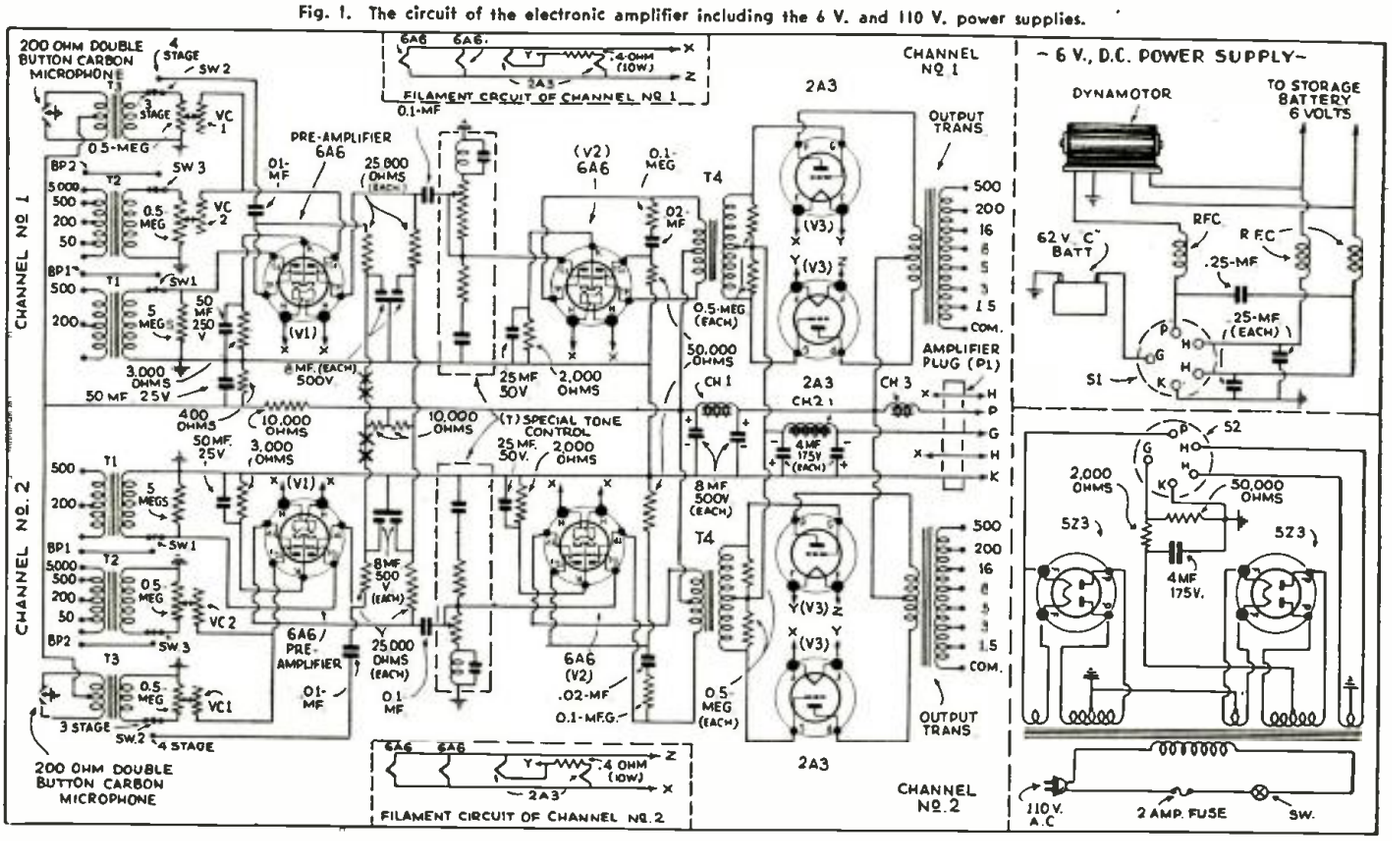
*Design Engineer, Columbia Sound Co., Inc.

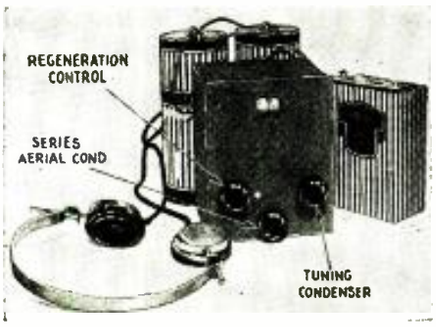
WHAT IT CAN DO

Besides serving all of the prosaic

(*Continued on page* 623)

Fig. 1. The circuit of the electronic amplifier including the 6 V. and 110 V. power supplies.





NEW "1-TUBE" ALL-WAVE BATTERY SET

Here is a battery companion to the 1-tube electric receiver which appeared in the last issue—it has 2-tube performance with 1 tube. Wavelength range—15 to 625 meters.

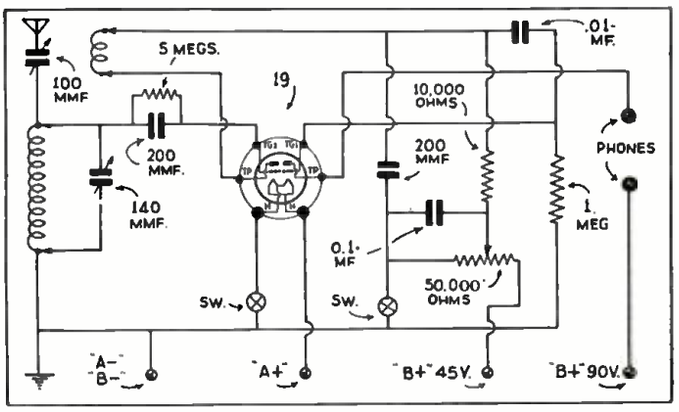
W. GREEN*

LAST MONTH we described a simple 1-tube all-electric set. The 12A7 tube was used, thus really making it two tubes in one. The use of the type 19 tube, a twin triode, makes possible the battery operated version of this remarkable set. Full 2-tube performance is obtained by using both sections of the type 19 as separate circuits; one section as the detector tube and the other as a stage of audio.

As you may see from the illustrations, the layout is as simple as can be. Two sockets, one for the tube, and one for the coil and the tuning condenser are the only major parts on the chassis. The regeneration control and the antenna coupling condenser are mounted on the panel. In the space of a few hours the set can be completely assembled, wired and set up for operation. Its smooth performance and easy handling are a pleasure even to the experienced ham. You will find the set brings in the nearby as well as the distant stations with unusual ease. All components are well insulated, and the parts are laid out so that all wiring (especially high frequency connections) are very short. Potentiometer type of regeneration control, though a little more costly, makes the operation of the set positive. The appearance of "dead spots" is eliminated by the use of a small variable coupling condenser in series with the antenna. The switch is attached to and is part of

(*Continued on page* 628)

*Chief Eng., Harrison Radio Co.

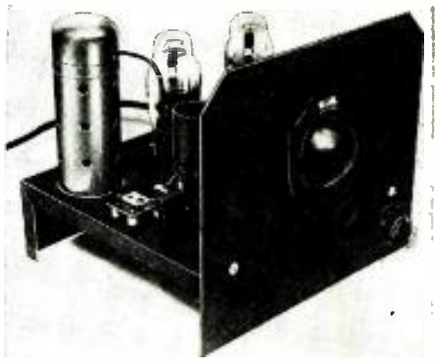


The circuit of the 2-in-1 all-wave set

A 10 TO 600 METER 3-TUBE A.C.-D.C. KIT SET

This easily built set supplies 4-tube performance with three tubes—it is an all-wave receiver operating from any power line.

L. J. MILES*



The kit set completely assembled.

THIS all-wave receiver has been designed to meet the present demand for a simple, inexpensive, and completely electrified short-wave receiver that is capable of world-wide reception. There are many problems involved in the design of such a receiver. These problems are concerned with the attainment of sufficient oscillator stability, sensitivity, selectivity, and hum attenuation, and still employ only the absolute minimum number of parts. The present design, in the opinion of the author, represents the greatest value per unit of investment that it is possible to attain in designing such a simple receiver.

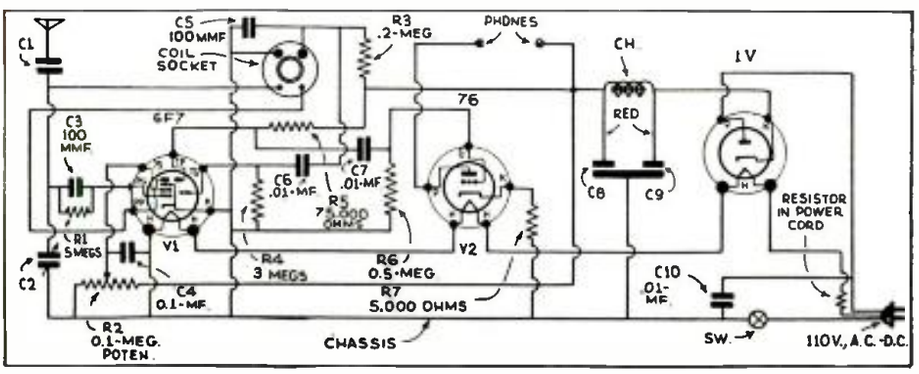
The nucleus of this set is a special circuit that is built around the high gain 6F7 tube. Originally designed for superheterodyne use, this tube is readily adapted to other services. It is in reality two tubes in one bulb, i.e., an R.F. pentode and a medium-mu triode. Used in conjunction with types 76 and 1V tubes we have 4-tube performance from 3 tubes.

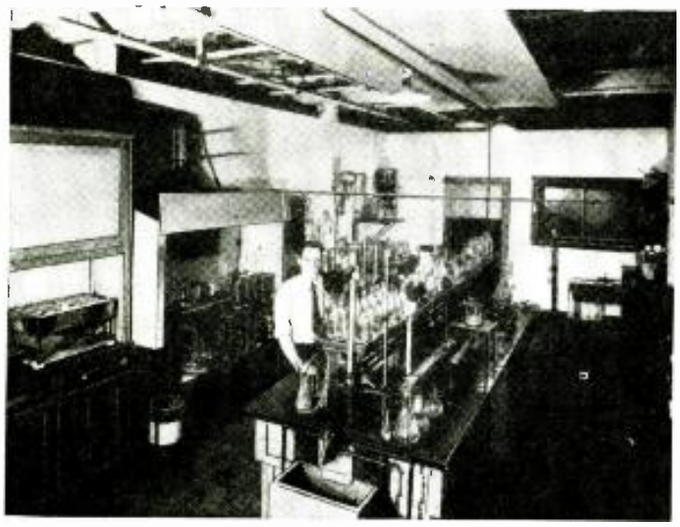
Inspection of the circuit diagram reveals the use of the R.F. pentode section of the 6F7 tube as a screen-grid regenerative detector, the output of which is resistance-capacity coupled to the triode section of the same tube which serves as a first audio frequency

(*Continued on page* 630)

*Ellen Radio Laboratories.

The circuit of the receiver—which is rather unusual.

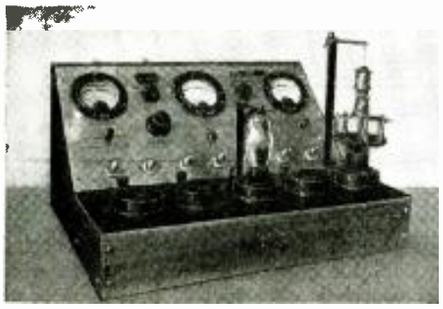




NEW TUBES VS. OLD

While few new tube models of startling interest have been announced recently, the tube development laboratories have been hard at work modernizing the older types—to keep abreast of the later methods of manufacture. Thus all tubes, even the oldest types have been improved tremendously both in operation and working life.

AUSTIN C. LESCARBOURA



An elaborate "third-degree" test for tubes which indicates any defects or weaknesses. Neon glow tubes indicate the conditions in addition to the usual meters.

These vibrators give tubes as much shaking in a few minutes as they receive in thousands of miles of use in auto radio sets. Any rattles or poor welds soon show up.

Filament and heater wire is critically examined before being accepted for radio tubes; its diameter is checked—its composition is examined microscopically for structural features.

Photos—Hygrade Sylvania Corp.

FOR CERTAIN reasons best known to themselves, tube manufacturers select an exceptionally obvious bushel basket under which to hide the blazing light of their research, engineering development, and production achievements. In their advertising and sales messages they usually resort to meaningless generalities and empty superlatives. Because they fail to announce the specific merits of their wares, therefore, a disinterested observer may be pardoned for stepping forward and telling the behind-the-scenes story solely with the reader's interest in mind.

To begin with, tube appearances mean little or nothing. The best tube and the poorest tube look pretty much alike. Even momentary performance in any given circuit may fail to reveal superior design, production and inspection; for it is a fact that poor tubes frequently excel in just one particular, usually to the extent of being unbalanced or useless for normal and general functions. But in all-round practice, over a protracted service life, inherent quality is bound to tell its own story. And that story can be anticipated, perhaps, by taking a peek in the research laboratories and manufacturing plants where tubes are conceived and brought into being.

Really a surprising amount of research and engineering development is lavished on certain brands of radio tubes. Some manufacturers maintain extensive development sections, for while general types may be set by one or two leaders, other manufacturers have pretty much their own ideas as to how to attain the standard characteristics. Engineering staffs of several dozen men are by no means unusual. One tube manufacturer, for example—and not the leader of the industry, either—has over 150 graduate engineers constantly at work on research, design and production problems. The day of sitting on the door step of the leader and waiting for ideas to copy, Chinese-like, has passed.

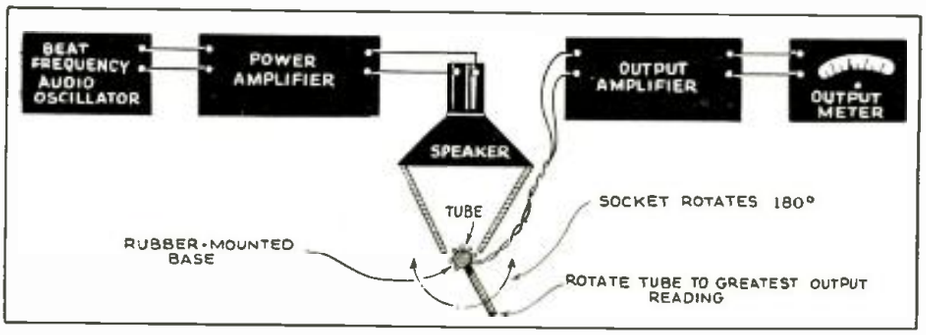
MECHANICAL IMPROVEMENTS

The rapidly expanded variety of tube types absorbed the major efforts of engineers during 1931, 1932 and 1933. The record shows that the growing multiplicity began in 1931, with 10 new types, followed by 32 types in 1932 and 15 in 1933. The enormous amount of detail work represented in designing, tooling and putting into production so many new types can hardly be appreciated outside tube manufacturing circles. By 1934, however, with upwards of 80 standard types to choose from, the radio industry no doubt is well taken care of in the matter of tube variety. New types have been coming along more sparingly. So engineers seemingly have had a breathing spell, but beneath the calm they have been hard at work on numerous refinements and improvements well worth the telling.

It is in innumerable details, rather than in anything startling, that radio

(*Continued on page* 626)

Testing tubes for microphonic sounds at different frequencies and amplitudes—generated by the A.F. oscillator.



OFFICIAL RADIO SERVICE MEN'S ASSOCIATION, INC.

MEMBERS' FORUM

This department is devoted to members and those interested in the Official Radio Service Men's Association. It is the medium for exchanging ideas, kinks, gossip and notes of interest to those who comprise the membership.

CANADIAN RADIO NEWS

RADIO-CRAFT, ORSMA *Dept.:*

Just a few lines to let you know of the latest "doings" in Canadian radio sets. There is no use to mention the new Victor, G. E., or Westinghouse, because you have them down there, also Stewart-Warner with its Magic Dial, but up here we have the largest radio firm in the British Empire, namely The Canadian Radio Corporation which is a group consisting of DeForest-Crosley and Rogers-Majestic. (It must not be forgotten that Mr. E. S. Rogers gave us the first batteryless radio set by perfection of the A. C. filament tube.)

The tubes manufactured by the Canadian Radio Corporation are of the lead-shielded type; two new tubes are as follows:

(1) A full-wave rectifier and an output power pentode of 1.8 W. in one envelope.

(2) A combined high-mu triode and output power pentode, of 2.3 to 3 W. I will now give you a short description of these tubes because there is not much data available on them as yet, but I believe that if anyone will write directly to the company at Toronto they can obtain the characteristics.

Tube 1: full-wave rectifier; output power pentode; 1.8 W.; lead-shielded; 6.3 filment; 7 prong base; numbered 89RS last year but changed to 6G7, also tube is improved in regulation.

This tube used with a 6A7 and a 6F7 makes a very efficient and compact radio set.

Tube 2: High-mu triode, output power pentode, 2.3 to 3 W.; lead-shielded; 6.3 filament; number 6H7.

At the present time no further data is available, but this tube is being used along with 3 others in a 7-tube, 18-60 m., 550-1,500 kc. receiver and it sure does its stuff.

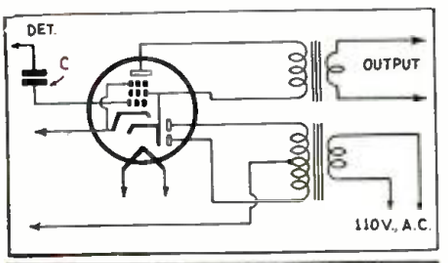
As a radio Service Man for 7 years and a reader of your magazine for nearly the same number of years I have seen very few letters from Canadian radio men; also, very few schematics of the lesser known Canadian-made sets. There is no need of publishing schematics of well-known makes because their service data is available to every Service Man who can make himself known to the radio trade. Many radio Service Men, radio technicians, radio experimenters, etc., when they write to a radio manufacturer for service data do not give the reason for doing so, their experience in the radio field, etc.

If your Canadian readers have trouble in this line of radio work I will be glad to help them out. I can also give them the address of a place where they may obtain any schematic of radio receivers made in Canada at a moderate cost; in some cases the cost is nothing compared to the headaches one gets upon working on an old set with no service data.

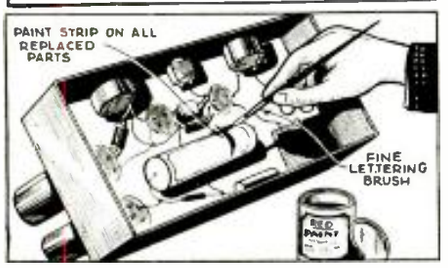
I will be obliged, however, to have them enclose a stamped envelope for a reply.

ROBERT ROGERS

The service bench of Mr. Verson, in Havana, Cuba. It is constructed entirely of maghogany.



A Canadian tube, the 6G7, combines a power pentode with a full-wave rectifier—it makes a fine 3-tube superhet.



One Service Man uses this method of identifying replacement parts put into a set—it avoids misunderstandings.

IDENTIFYING REPLACEMENT PARTS

RADIO-CRAFT, ORSMA *Dept.:*

I practice the following kink (*Continued on page* 619)

RADIO-CRAFT'S INFORMATION BUREAU

CONDENSERS IN SERIES FOR HIGH VOLTAGES

(318) Mr. C. R. Delehanty, Indianapolis, Ind.

(Q.) Recently, having an urgent need for several high-voltage electrolytic condensers (900 V.) and being unable to obtain same, I thought of connecting several 500 V. units in series. To play safe, I used three 8 mf. condensers rated at 500 V. each. I found they worked perfectly in a filter circuit. Is this practice recommended for general service work?

(A.) With condensers of the same make and capacity and the same voltage rating, you are safe in using such an arrangement. However, don't be too free in coupling units of different ratings in such circuits. By way of example, if a 5 mf. condenser were put in series with a 2½ mf. unit, and the arrangement subjected to 900 V., the smaller condenser would be forced to take 600 V., as against only 300 V. for the 5 mf. This is true and provable by reference charts showing the effect of condenser reactance upon applied voltage. While such hookups will work satisfactorily (assuming the leakage to be the same for each unit), following the above precaution, they should be followed only when units of prescribed voltage rating are not obtainable. Always use standard condensers when available.

CATHODE-RAY OSCILLOSCOPE USES

(319) Mr. Joshua Colbin, Lucerne, Pa.

(Q.) I have read about cathode-ray oscillographs (or, more correctly, oscilloscopes). Just what are they used for, and how do they compare with the "standard" mirror type?

(A.) The cathode-ray instrument is particularly suited to high-frequency work, due to the practical absence of inertia of a cathode-beam, compared to the high inertia at high frequencies of the moving elements of string or mirror types. Thus the upper limit of the cathode type is about 200,000 kc. (You may recall that mirror types become inoperative above 10 kc.) Since the cathode-ray oscilloscope operates quite as well at low frequencies, and since it is sturdy in construction, it is more and more becoming the general handy-man in the laboratory. Mention is made here of a few uses for the instrument.

"In Fig. Q319-B is sketched a means for measuring the percentage of modulation of a radio-frequency oscillator. The modulated radio-frequency voltage under observation is impressed across the two vertical deflecting plates of a cathode-ray "oscillograph." Across the horizontal plates is impressed a voltage of the modulating-oscillator frequency. For the sake of simplicity, the schematic is drawn with the same audio-frequency source modulating the radio-frequency oscillator and deflecting the beam horizontally. The amplitude of oscillation of the radio-frequency oscillator varies at the same rate that the spot is swept back and forth across the screen by the audio-frequency current. Therefore, there results a trapezoidal pattern on the screen which has a maximum amplitude proportional to the peak of the radio-frequency wave and a minimum proportional to its lowest amplitude. The actual degree of modulation can then be determined by comparing the two amplitudes with a pair of dividers. A perfectly modulated oscillator will show an almost perfect trapezoidal pattern. The cathode-ray oscillograph makes an excellent peak voltmeter or ammeter.

"This oscillograph is excellent for aligning receivers. In the example shown in Fig. Q319A the tuned circuits of the receiver are slightly out of line, which accounts for the double hump in the output resonance curve. By the observation of the pattern during the adjustment of the alignment condensers, the set can be brought into adjustment with considerable speed. The

(*Continued on page* 638)

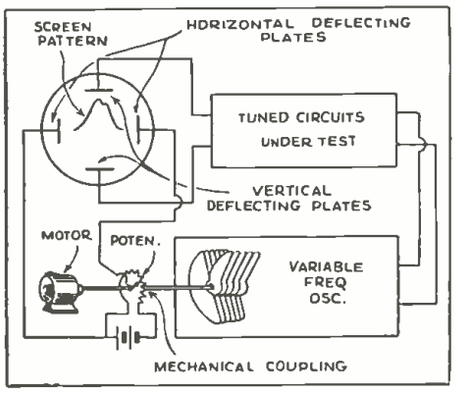


Fig. Q. 319 A, above
Oscillograph testing receiver alignment.

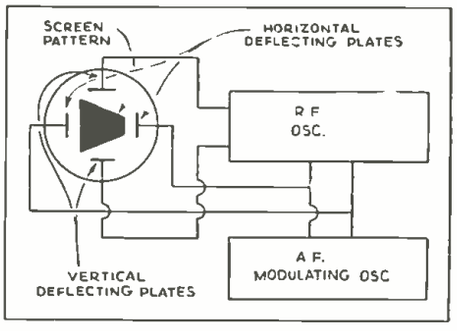


Fig. Q. 319 B, above
Testing transmitter modulation with oscilloscope.

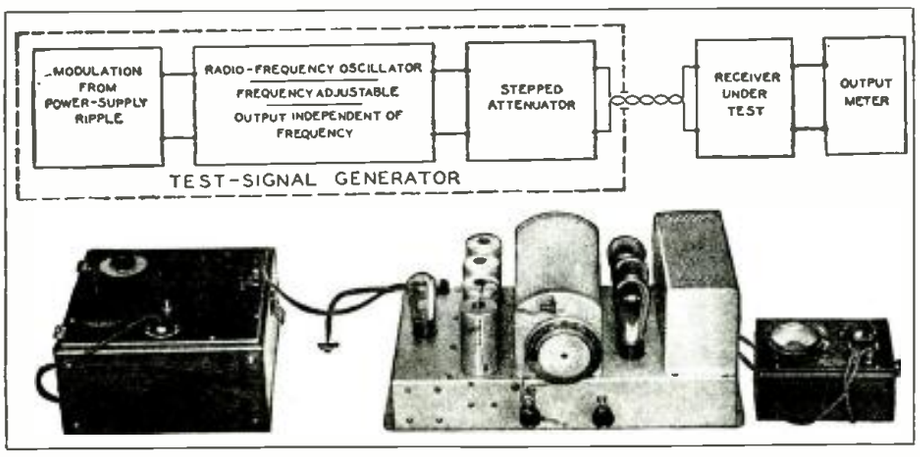


Fig. Q.319 C, below
Set-up for testing receiver circuits.

SPECIAL NOTICE

Those questions which are found to represent the greatest general interest will be published here, to the extent that space permits. (At least 5 weeks must elapse between the receipt of a question and the appearance of its answer here.) Mark such inquiries, "For Publication."

Replies, magazines, etc., cannot be sent C.O.D. Back issues of RADIO-CRAFT prior to December, 1932, are available at 50c per copy; except the following issues: 7/29, 2, 3, 4, 6, 7, 9 and 11/'30; 5, 8 and 9/'31; and 10/'32, which are out of print. Succeeding issues are still available at the regular price of 25c per copy.

Inquiries to be answered by mail MUST be accompanied by 25c (stamps) for each separate question; answers are subject to subsequent publication if considered of exceptional interest.

Furnish sufficient information (in reference to magazine articles, be sure to mention issue, page, title, author and figure numbers), and draw a careful diagram (on separate paper) when needed to explain your meaning; use only one side of the paper. *List each question.* Be SURE to sign your name AND address.

Enclose only a STAMPED and self-addressed envelope for names and addresses of manufacturers; or, in connection with correspondence concerning corrections to articles, as this information is gratis.

Individual designs can be furnished at an additional service charge. The fee may be secured by addressing the inquiry to the SPECIAL SERVICE department, and furnishing COMPLETE specifications of desired information and available data.

ELECTRONIC TUBE ARTICLES IN RADIO-CRAFT—FEBRUARY, 1933 TO FEBRUARY, 1935

(*Continued on page* 638)

Radio Service Data Sheet

AMERICAN-BOSCH MODEL 376 5-TUBE AIRCELL-OPERATED 540 TO 1,600 K.C. SUPER-HET.

(376 BT, table model; 376 S, console model; 376 F, console model. Incorporates magnetic reproducer, A.V.C., tone control, interference wavetrap.)

Above, Exterior of the table-model set. Extreme right, battery arrangement.

Although generally referred to as an "aircell" receiver. this set, which is supplied without batteries, may use any of the following three types of "A" supply.

(1) Dry-cell pack: a ballast tube (No. 107042) is provided with the receiver to accommodate the voltage drop of the dry cell pack which varies from slightly over 3 v. for a fresh battery to less than 2 v. for a battery near the end of its useful life.

(2) Storage battery operation: when using a single cell of storage battery whose terminal voltage is 2 volts, it is important that the ballast tube be replaced by an accessory which serves to short-circuit the ballast tube socket terminal. (Such an accessory will be supplied as service part No. 108015.) Greater satisfaction will result when using the new low-discharge type of battery which has been specifically developed for radio receiver use.

(3) Aircell operation: the aircell, unlike the dry-cell pack, does not vary greatly in terminal voltage during its useful life. and while the ballast tube may be used. it does not allow the total life of the aircell to be realized because its use results in low filament voltage. (Service accessory No. 108014 which consists of a low-value fixed resistor should be used to replace the ballast tube when using the aircell.)

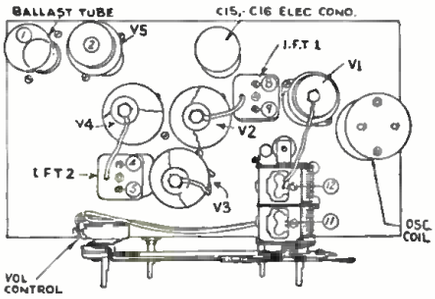
(Replace the Ed. 1 polarized electrolytic condenser, if used. with an Ed. 2 nonpolarized unit. This tends to prevent damage due to an incorrect battery connection.)

The following grid bias voltages are measured to chassis, from A or B as indicated on the schematic circuit, using a 1,000-ohms-per-volt meter; plate and screen-grid measurements are made on a 250 V. scale.

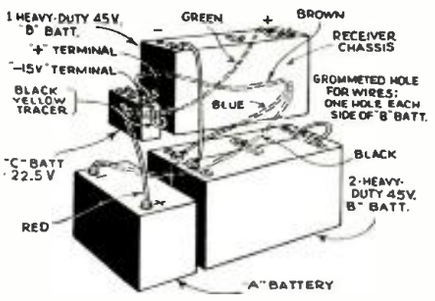
Tube Type	Plate Volts	S.-G. Volts	C.-G. Volts	Chassis To
V1	135	140	15	A
V2	135	12	25	B
V3	140	70	2.5	B
V4	140	70	2.5	B
V5	145	70	2.5	B

I.F. Aligning Procedure

The first step is to align the I.F. at 456 kc., connecting a high-quality service oscillator through .25-mf. to the control-grid cap of V3. with volume full on, tone control in bass position, and antenna and ground leads connected together. Use a sensitive output meter of high sensitivity and a resistance of at least 4,000 ohms. connected across the windings of the magnetic reproducer. Adjust condensers 4 and 5 to maximum output; then connect the service oscillator to the control-grid of V1 and adjust condensers 8 and 9 to maximum output.

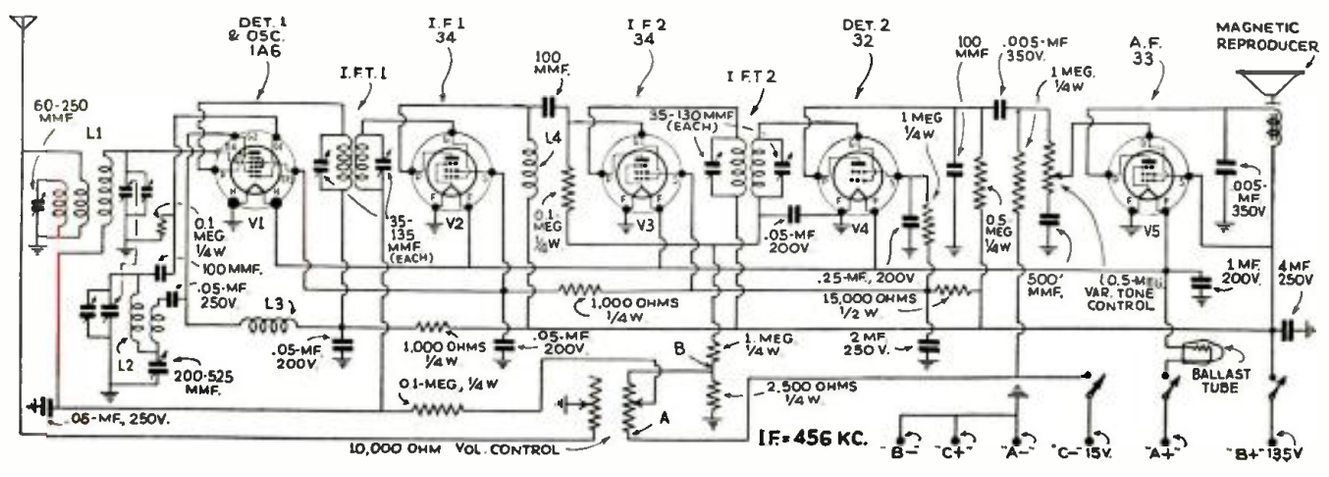


Above, locations of trimmers.



Above, the connections to the batteries.

Below, circuit of aircell superhet.



Aligning Wavetrap (Direct Signal, 456 kc.)

An adjustable wavetrap is provided in series with the antenna circuit to prevent interference due to direct transmission of telegraphic signals at the I.F. of 456 kc.

(1) With the service oscillator remaining at 456 kc., connect oscillator leads to the antenna and ground terminals through a 200 mmf. antenna condenser.

(2) Set the dial scale to 540 kc., and adjust the service oscillator output to obtain full-scale reading on the output meter.

(3) Adjust the wavetrap trimmer 14 until a null or minimum reading of the output meter is obtained.

Aligning Oscillator and R.F.

(1) Connect the service oscillator to the control-grid of V1 and set the service oscillator for an output of 1,500 kc.

(2) Set the dial scale to the maximum mark beyond the 540 kc. calibration point when the gang condenser is entirely closed.

(3) Set the dial at 1,500 kc. and adjust condenser 11 to maximum output.

(4) Connect the service oscillator to the antenna through a 200 mmf. fixed condenser and, with the scale still set at 1,500 kc., adjust condensers 11 and 12 to max. output.

(5) The padding condenser is next adjusted. Set the scale and service oscillator to 600 kc. and adjust condenser 13 simultaneously, then change this adjustment and the station selector of the chassis for maximum output.

Radio Service Data Sheet 136

STEWART-WARNER MODEL R-123 4-TUBE "EXTENDED WAVELENGTH" SUPERHET.

(Receiver models 1231 to 1239; Tuning range: 530 to 1,720 kc. Model R-123-A chassis: 105-125 V., 50-60 cycles; R-123-B, ditto V., 25-133 cycles; R-123-W, 100-260 V., 40-133 cycles.)

The I.F. of 456 was chosen to prevent image-frequency interference. The volume control is of the "double-acting" type, inas much as it attenuates the energy in the antenna circuit at the same time it increases the bias applied to the control-grid of pentagrid converter V1.

Use a voltmeter of 1,000-ohms-per-volt type to obtain voltage readings. (Readings will vary depending upon voltage range of meter, being higher for higher-range instruments. This variation will be most marked for the second-detector, V2.)

Chassis operating voltages are as follows:

Tube Type	Plate Volts	S.-G. Volts	C.-G. Volts	Cath. Volts
V1	275	95	—	3
V1*	95	—	(*)	—
V2	275	95	−10	12.5
V2**	93	—	(**)	—
V3	260	275	—	18

(*) Oscillator section; the oscillator control-grid voltage with the dial set at 530 kc. and the volume control full on is —4 volts (on 300 V. scale).

(**) Triode section; C.-G. voltage from cap to chassis is —10 V.

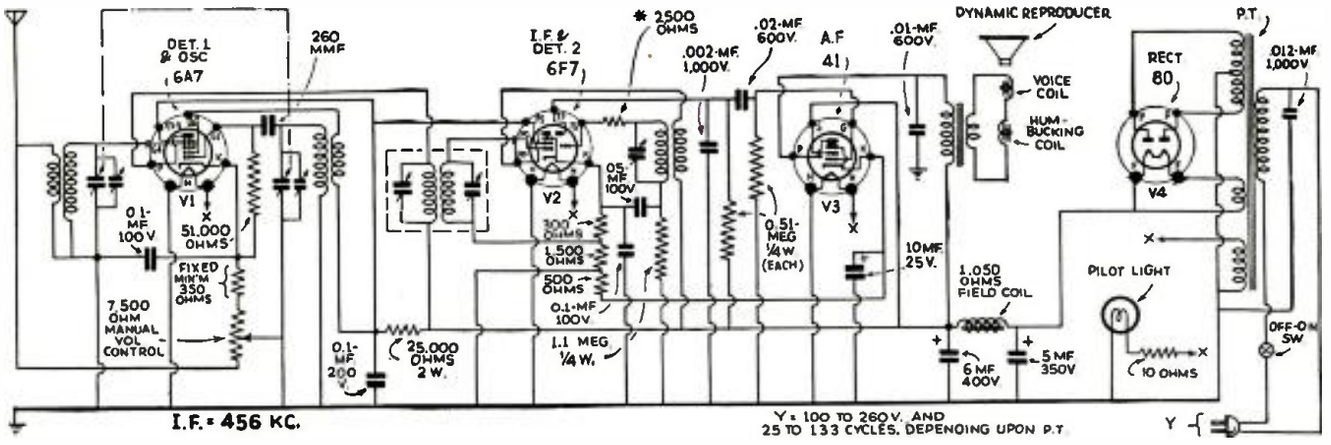
The voltages in the tabulation are measured between chassis and socket terminals. All bias voltages change with the position of the volume control. Use max. position.

Speaker field voltage with coil warm is 65 V., D.C.

The voltages in the tabulation are measured between chassis and socket terminals, with a line potential of 115 V., with the antenna grounded, and dial set at 530 kc.

This set is an interesting design of a "straight forward" superheterodyne utilizing only 3 "multi-purpose" tubes.

(*, on diagram)—used in only a few sets.

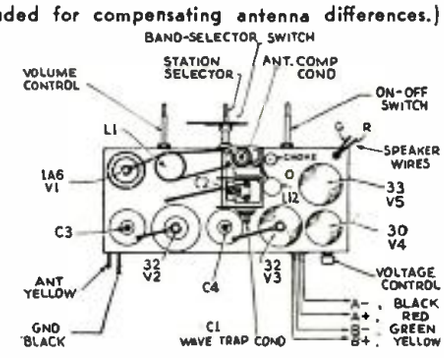


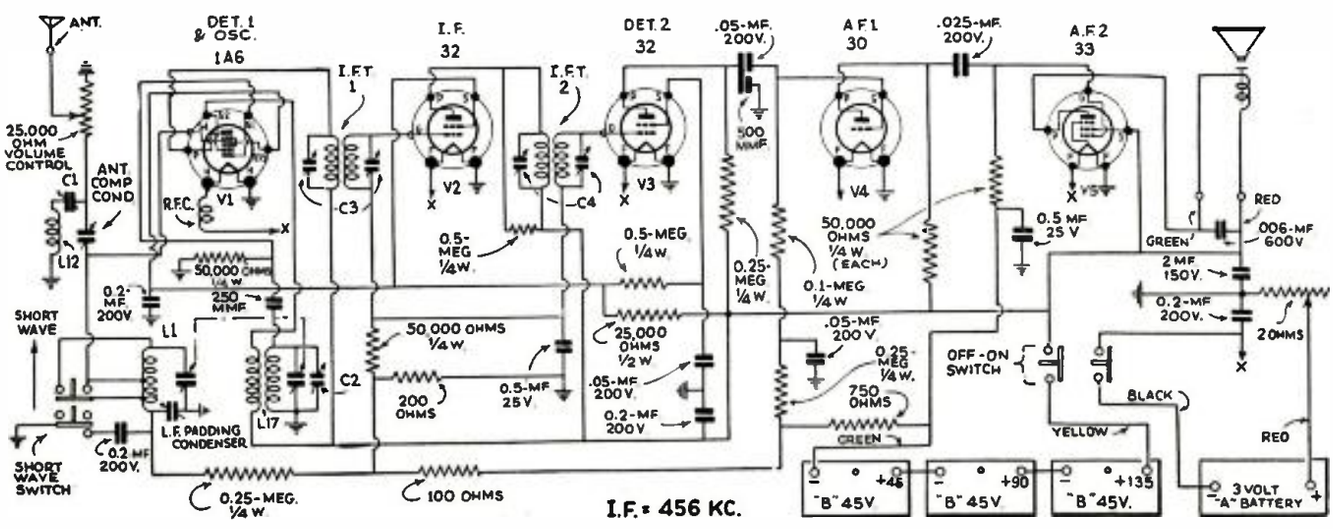
SPARTON MODEL 81-A "COUNTRY HOME 5-TUBE DUAL-WAVE BATTERY SUPERHET.

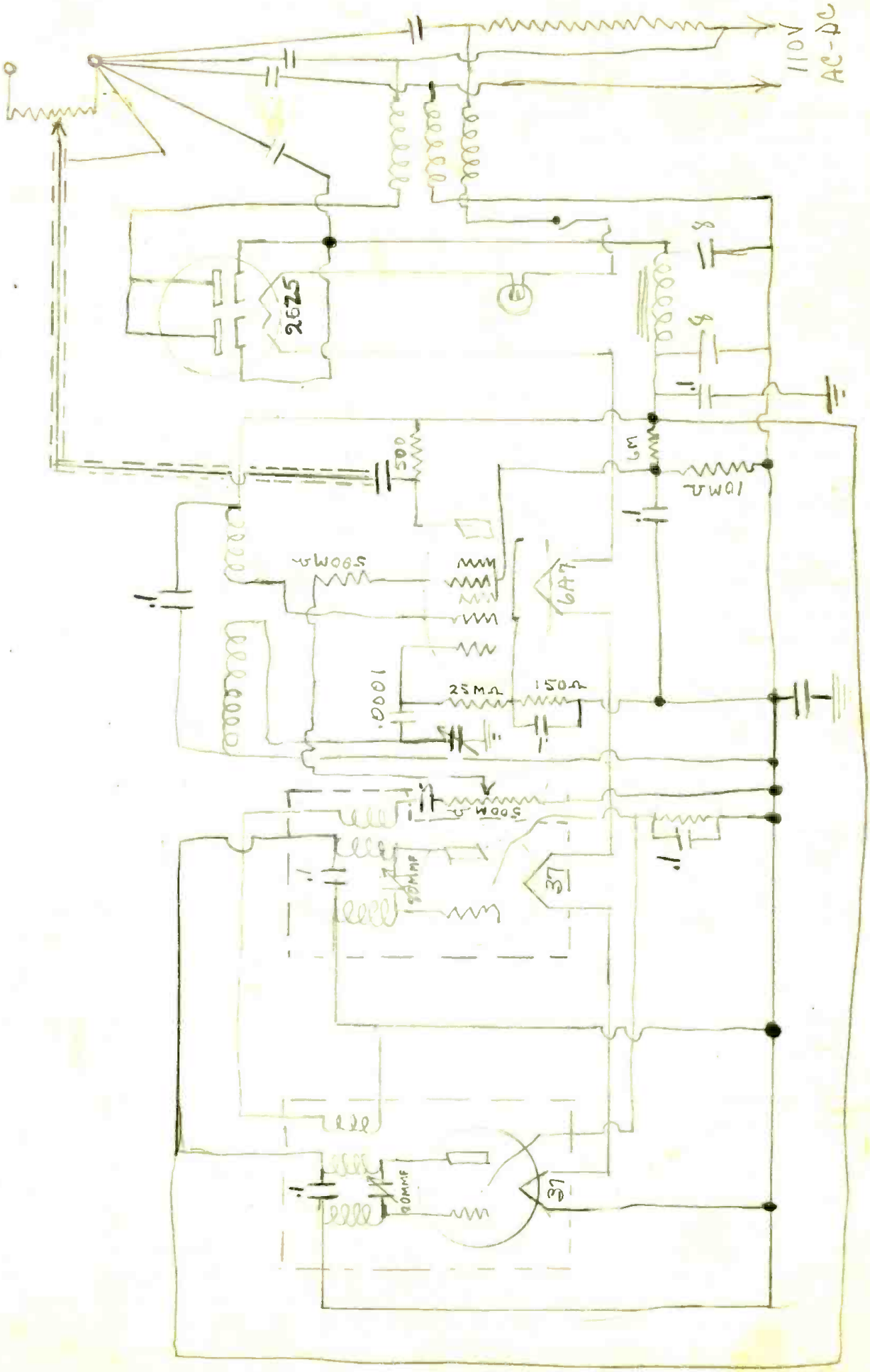
(A magnetic reproducer is used in this set. An antenna equalizing condenser is included for compensating antenna differences.)

Tube Type	Measurement	Prong No. 1	Prong No. 2	Prong No. 3	Prong No. 4	Prong No. 5	Prong No. 6	C.-G. Cap
V1	Volts	0	120	120	*	46	2	*
V1	Megs.	0	0.1	0.1	.07	.15	0	.25
V2	Volts	0	120	46	2	—	—	—
V2	Megs.	0	0.1	.15	0	—	—	—
V3	Volts	0	*	*	2	—	—	—
V3	Megs.	0	.75	.85	0	—	—	—
V4	Volts	0	24	0	2	—	—	—
V4	Megs.	0	0.2	0.5	0	—	—	—
V5	Volts	0	100	*	120	—	—	—
V5	Megs.	0	0.2	.05	0.2	—	—	—

Prong 1 is grounded. All measurements made with Weston Selective Analyzer Model 665, type 1; (*) cannot be measured with the model 665 instrument. (The above table permits fault-analysis by the resistance-measurement method.) The "A" and "B" batteries must be in good condition. Readings are given for the full-on positon of the volume control, with the antenna disconnected, and with band-selector in the Broadcast position.







WATER PLANT OPERATION DAILY REPORT

STD. FORM 930-55

COMPANY _____

PLANT _____

DATE _____

Note: Show hours of equipment operation by heavy line.

PUMP NUMBER	HOURS OPERATED																								
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
NO. 1 DEEP WELL																								
NO. 2 DEEP WELL																								
NO. 3 DEEP WELL																								
NO. 4 DEEP WELL																								
NO. 1 CIRCULATING																								
NO. 2 CIRCULATING																								
NO. 3 CIRCULATING																								
NO. 4 CIRCULATING																								
NO. 5 CIRCULATING																								
NO. 6 CIRCULATING																								
NO. 1 FIRE																								
NO. 2 FIRE																								
AIR COMPRESSOR																								
FIRE ALARM BOX NUMBER																								
FIRE ALARM BOX NUMBER																								

	METER NO. 1	METER NO. 2		METER NO. 1	METER NO. 2
WATER METER 12 A. M.			ELECT. METER 12 A. M.		
WATER METER PREVIOUS 12 A. M.			ELECT. METER PREVIOUS 12 A. M.		
DIFFERENCE			DIFFERENCE		
CONSTANT			CONSTANT		
WATER PUMPED (GALS.)			K. W. H. USED		

FILTRATION PLANT

FILTER NUMBER	EFFLUENT		RUN		HEAD LOST (FT.)		CONTROLLER G. P. M.	GALLONS FILTERED	WASHING FILTER				
	ON	OFF	HOURS	MIN.	START	FINISH			START	FINISH	LENGTH MIN.	GALLONS	PER CENT
1													
2													
3													
4													

COAGULANT TANK	NO. 1	NO. 2
TIME CHARGED		
TIME IN SERVICE		
SOLUTION DEPTH		
TIME OUT OF SERVICE		
SOLUTION DEPTH		
ORIFICE OPENING		
SOLUTION STRENGTH		
AVERAGE NORMAL PRESSURE		
FIRE PRESSURE		

MISCELLANEOUS

POUNDS CHEMICALS USED	
	CHLORINE
	ALUM
	LIME
	SODA ASH

TURBIDITY RAW WATER

TURBIDITY FILTERED WATER

TEMPERATURE AIR WATER

SIGNED _____

CHIEF ENGINEER

INTERNATIONAL RADIO REVIEW

(*Continued from page 593*)

above the manual.

This electronic organ is a product of the Heinrich-Hertz Institute of Berlin.

"VISIBLE CURRENT" RADIO MODEL

THE average man who looks at the under side of a radio chassis gets the impression of a jumbled mass of wires and parts which is confusing and possibly mystifying. As a means of clearing up these mysteries, the Marconiphone Company, Ltd., of England has made a most ingenious model of a five-tube radio receiver.

As shown in the illustration, Fig. D it is made bread-board style, with the parts mounted on a panel, "connected" by glass tubes, in which bubbles of differently colored liquids flow.

By means of the colored bubbles in the glass tubes, the current is seen entering vacuum tubes, leaving transformers and passing through resistances. In the case of the latter, the effect of resistance is produced by a change in the size of the bubbles.

This interesting model made by the Marconiphone Co. was demonstrated at a recent radio show, in England.

THE RAILWAY BROADCASTER

VICTORIA, the smallest and most densely populated state in Australia, is credited with having the first commercial broadcasting station on wheels in the world.

This station, 3YB, is installed in a specially equipped railway car and travels from place to place over the 5,000 miles of railroad tracks in Victoria.

The nature of the mobile station, according to WIRELESS WEEKLY, permits a unique service to advertisers. The listening public is told why they should buy and where to buy locally, the advertised product. Radio set owners look forward to the periodical visits of the station which have been made for three years, as they know from experience that they will receive radio entertainment of the best, without the annoyance of fading, static and distortion encountered in receiving the regular stations which are many miles way.

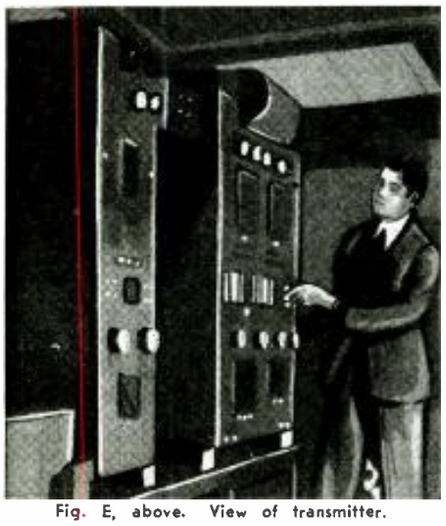


Fig. E, above. View of transmitter.

Fig. F, below. The railway "studio."

TECHNICIANS' DATA SERVICE

JOSEPH CALCATERRA DIRECTOR

The literature listed in this department contains a wealth of very useful information.

A special arrangement between RADIO-CRAFT magazine and the publishers of this literature, which permits bulk mailings to interested RADIO-CRAFT readers, eliminates the trouble and expense of writing to each individual organization represented in this department.

To obtain any of the material listed in this department, simply draw a circle around each booklet number in the coupon, corresponding to the numbers of the items you would like to have, fill in the coupon and mail it to RADIO-CRAFT Technicians' Data Service.

2. HAMMARLUND 1935 CATALOG. Contains 12 pages of specifications, illustrations and prices on the new line of Hammarlund variable, midget, band-spread and adjustable condensers; trimming and padding condensers; R.F. and I.F. transformers, coils and coil forms; sockets, shields, chokes and miscellaneous parts for ultra-short-wave, short-wave and broadcast reception and transmission.

3. HOW TO GET A HAMMARLUND 1935 SHORT-WAVE MANUAL. A circular containing a list of contents, excerpts and illustrations from the new 16-page Hammarlund Short-Wave Manual, together with instructions on how to obtain a copy of it, containing construction details, wiring diagrams and lists of parts of 12 of the most popular short-wave receivers of the year.

4. THE "COMET PRO" SHORT-WAVE SUPERHETERODYNES. Describes the outstanding features of the standard and crystal-type Hammarlund "Comet Pro" short-wave superheterodynes designed to meet the exacting demands of professional operators and advanced amateurs for a 15 to 250 meter code and phone receiver, but which can be adapted by anyone for laboratory, newspaper, police, airport and steamship use.

5. ELECTRAD 1935 VOLUME CONTROL AND RESISTOR CATALOG. Contains 12 pages of data on Electrad standard and replacement volume controls, Truvolt adjustable resistors, vitreous wire-wound fixed and adjustable resistors and voltage dividers, precision wire-wound non-inductive resistors, center-tapped filament resistors, high-quality attenuators, power (50- and 150-watt) rheostats and other Electrad resistor specialties.

6. AMPERITE LINE-VOLTAGE CONTROL. Characteristics and uses of the Amperite voltage regulator and chart showing the correct Amperite recommended by set manufacturers for their receivers.

25. LYNCH NOISE-REDUCING ANTENNA SYSTEMS. Complete descriptions and instructions issued by Arthur H. Lynch, Inc., for making all kinds of antennas for broadcast and short wave reception, with a special supplement covering Ham Antenna Design for transmitting as well as receiving on all the amateur bands, including the ultra-high frequencies.

26. LYNCH AUTO RADIO ANTENNAS, FILTERS AND NOISE SUPPRESSORS. This folder describes a complete line of Lynch antennas, filters and ignition noise suppressors designed for auto radio installations. The antenna system is of the under-the-car type for easy installation. It includes data on Hi-Gain matched-impedance transmission lines which make the under-car antenna highly desirable for use with the new "Turret-top" cars.

28. LYNCH SUPER-FILTASTATS FOR AUTO RADIO INSTALLATIONS. Describes and illustrates, with instructions for using, the new Lynch Super-Filtastats which do away with the need for suppressors in auto radio installations, giving better performance in operation for both the car and the radio set.

34. SERVICE MAN'S 1935 ELECTRAD REPLACEMENT VOLUME CONTROL GUIDE. A 52-page vest-pocket size booklet containing a revised, enlarged and complete list, in alphabetical order, of all old and new receivers showing model number, value of control in ohms and a recommended Electrad control for replacement purposes. Contains specifications and volume-control circuits for over 2,000 receiver models.

57. HOW TO BUILD A HIGH-QUALITY AMPERITE CONDENSER OR RIBBON MICROPHONE. A circular which describes the Amperite microphone kits with which it is possible to build, easily and quickly, high-quality condenser and ribbon microphones.

65. SUPREME 1935 LINE OF TESTING INSTRUMENTS. A 20-page catalog which gives complete information on the entire Supreme line of testing instruments, including the new 5-in. Supreme fan-shape meter, the new Model 333 De Luxe and low-priced analyzers, the improved Model 85 tube tester, the Model 61 oscillator and the Model 180 precision multi-wave signal generator.

66. A SUPREME A.C.-D.C. TESTER WHICH CAN BE BUILT AT HOME AT LOW COST. Gives complete information about the Supreme 5-in. fan-shape meter, rectifier and resistor kit for the home construction of an inexpensive A.C.-D.C. tester.

67. PRACTICAL MECHANICS OF RADIO SERVICE. Information, including cost, features and outline of lessons of the Frank L. Sprayberry course in Radio Servicing, and list of Sprayberry Data Sheets for modernizing obsolete test equipment and receivers.

68. HOW TO MODERNIZE THE SUPREME 400-B. This is Data Sheet No. 4 of the Frank L. Sprayberry series of data sheets on how to modernize obsolete test equipment and receivers.

69. CASE RECORDS OF BROADCAST RECEIVER REPAIRS. Gives plan, contents and price of the Capitol Radio Research Laboratories' loose-leaf case records of 1,500 service jobs showing how actual troubles were corrected. Serves as a guide in correcting troubles in all types of receivers and power-supply units.

(*Continued on page* 637)

Radio-Craft Technicians' Data Service
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AN EASILY BUILT "THEREMIN"

(Continued from page 600)

raises the pitch of the audible note until it finally runs so high as to be inaudible. Removing the hand lowers the pitch to the bottom of the scale, where the tone cuts off and the instrument becomes silent.

Use is made of the other hand in a like manner to control the volume of the notes produced by varying the distance between the hand and another rod or ring.

Because of their cost these instruments have not achieved the popularity they deserve. However the radio experimenter need not let the price interfere with his desire to own a Theremin, for he can, at low cost, construct one himself.

Herein is described a Music Box built for use in conjunction with a public address amplifier. Although designed with this use in mind it will do quite well when coupled to the audio end of a good radio, having ample audio amplification.

Because of its complications the capacity volume control is not incorporated in this model. Instead a manual volume control is used as in some of the earlier models of the original Theremin instruments. This volume control is held in the operator's hand or attached to the side of the instrument.

In building instruments containing oscillating circuits it is important to provide good shielding if stability is to be expected.

The oscillator coils are Remler, type 620, used in the early superheterodyne sets. (Any superheterodyne oscillator coils having a "coupling coil" or any good three-circuit tuners can be used with equal success.—Ed.) These coils contain two windings on the main form and one on the inner movable form. Shellac the windings on the main form and after they are dry remove ten turns of wire from the outer side of each of the two windings. Follow this procedure with each of the two coils. Also cut off the control shaft flush with the mounting plate on each coil as it will not be necessary to rotate these coils. They are used as pick-up and mixer coils in the circuit.

Impedance coupling is used in the audio circuit of the output tube. The choke is the primary of an audio transformer. Likewise the primary of an audio transformer is used as a choke in the power filter circuit.

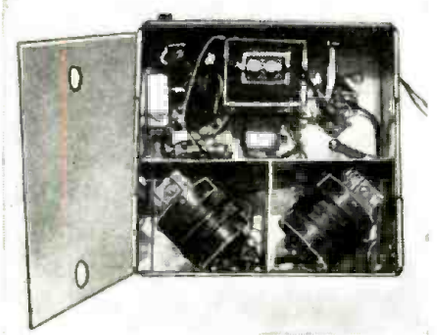
The operating rod is a piece of heavy wire about two feet in length. It fits into an insulated pin-jack in the chassis. A small plate is seen fastened to the rod just above the chassis and is rotated to secure final adjustment of the instrument.

With the plug in and the resistance cut out on the volume control, adjust the trimmers until a squeal is heard. Set carefully until the squeal runs the scale and disappears at the low end. It may be necessary to make use of the plate on the antenna rod, which should be turned out away from the chassis to start.

Now as the hand approaches within about a foot of the rod, the oscillating circuit to which the rod is attached will be thrown off balance by the capacity of the hand and a low audible sound will be produced, increasing its pitch as the hand is brought nearer.

With the output properly coupled to an amplifier system, a little practice (more or less) and we have the latest in music.

Fig. B.—Bottom view of the unique electro-musical instrument, showing distribution of parts. Note the "bias" coil layout.



THE NEW 6B5 DYNAMIC-COUPLED A.F. TUBE

(Continued from page 590)

put section, No. 2, feeds it, duly amplified, to the speaker.

The secondary of an audio transformer feeds the rectified signal to G1 and K2; the cathode of the input section connects only to G2. The input plate, P1, connects directly to "B plus," and the output plate, P2, feeds the "soup" to the usual output-transformer primary. The first thing that strikes the eye is the apparent lack of bias on the input grid; the second thing that stirs the imagination is the load (or apparent lack of it) of the first tube; and the third effect is, "Well, what about it?" But to complete the story, the input section is built below the output section as may be seen by the photograph, Fig. A and the sketch, Fig. 6, with a common heater and separate cathodes, so that the signal starts from the bottom and works its way up—in intensity as well as in physical level!

THEORY OF OPERATION

With no signal impressed on the grid of the tube, plate current flows from the "B plus" to the input plate P1 to K1, to the output grid G2, through the grid-cathode resistance of the output section to ground, the inevitable stopping point for all signals. The voltage drop across the plate-cathode of the input section is, therefore, the "B" voltage minus the voltage drop from G2 to K2, which in this tube is about 15 volts; the remainder is good plate voltage for the input section.

The first important conclusion, therefore, is that the cathode of the output section is negative with respect to the grid G2 (or the grid of the output section is positive with respect to its cathode) by the amount of the voltage drop from this grid to cathode—15 volts. The sweeping conclusion, therefore, is that the input grid is negative with respect to its cathode by this same voltage—15 volts, the normal bias on this tube. The simple circuit of Fig. 2 will clear this up, since the resistances take the place of the apparent "space" inside the tube. This, I believe, will clear up that little matter of bias.

Now let us apply a signal to the grid of the input section. The grid becomes positive and negative alternately because of this signal and raises and lowers the plate current of the input section. This varying plate current (the signal, no less) must flow through the G2-K2 resistance, and so the voltage drop from G2-K2 varies, which, in turn, varies the plate current of the output section, and the signal flows out of the faucet—the speaker—by the usual route. Thus, the same grid-cathode resistance that acts as a grid-bias resistance also acts as the plate load of the input section, and no coupling transformers, resistors or condensers are needed.

But the usual grid-bias resistor in a single-tube amplifier has a bypass condenser across it, and ours has none. The reason is simple: if a bypass were connected from G2 to K2, we would bypass our signal, just as if a big condenser were connected from plate to cathode of any tube. Without a bypass condenser, the first grid is affected by the fluctuations in plate current—the more positive the signal the more negative the bias—degeneration, in other words.

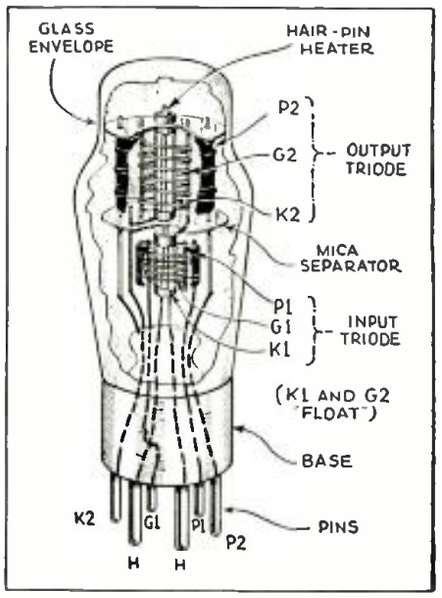


Fig. 6.
Cut-away view, showing 6B5 construction.

True, degeneration does take place; but the point is that it is not harmful in this tube, because in order for degeneration to take place the G2-K2 voltage must be high, and increase with signal. But it is precisely this same voltage that actuates the output section, so that regardless of the amount of degeneration the first tube receives, the final signal is unaffected. The degeneration has another advantage—the first grid, G1, can never go positive, because the greater the signal, the greater the plate current, the greater the voltage drop from G2 to K2, and the more the negative bias applied to the input grid. It is, this G2-K2 bias *that is the signal* applied to the input of the No. 2 section, as previously explained. So you see, it's ring around the rosy: the more signal, the more bias and the more output. Why worry about degeneration?

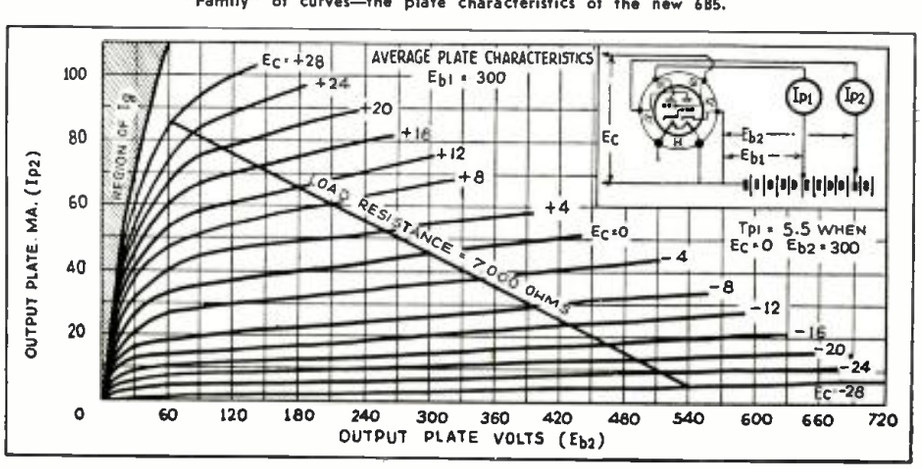
Another way of looking at the theory of the tube is that the output grid section requires power, *all* of which is supplied by the input tube. So long as this input tube can supply power enough to keep the G2 section satisfied, all is well.

SOME CURVES

And now some curves for you technical boys. Figure 3A shows the per cent distortion and plate current as the power output is varied with the plate voltage at 300 volts. Note that at 5 per cent distortion, 4 watts can be obtained with an input signal of 15 volts r.m.s. The dotted curves merely show the per cent 2nd, 3rd, 4th, and 5th harmonics.

Figure 4A shows the power output and per cent distortion with 300 volts on the plate for different values of load impedance. Note that with 5 per cent distortion, over 4 watts are obtained with a load impedance of 7,000 ohms.

Fig. 5.
"Family" of curves—the plate characteristics of the new 6B5.



Maximum output power is obtained with a load impedance of about 10,000 or 11,000 ohms, but the distortion is high. One set of curves is for an input signal of 10 volts and the other for a signal of 15 volts. Those diagonal lines with arrowheads on both ends merely tell you which curves correspond.

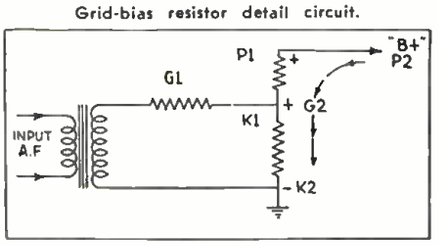
PUSH-PULL CIRCUITS

Figure 1B shows the connections for a push-pull circuit and Fig. 3B the distortion curves for two values of plate voltage, 300 and 325 volts, as marked. The total plate current is also shown on this as well as on other curves. For about 10 watts output, a signal of 38 volts r.m.s. (between outside terminals of the push-pull transformer) are required. For the same distortion, we can get about 13 watts output with 325 volts on the plate.

Figure 4B is a nice bunch of curves which give the power output and per cent distortion for the push-pull connection with 300 and 325 volts on the plate. The arrows tell you what curves correspond. Note that a plate-to-plate resistance of 10,000 ohms has been officially selected by the designers of the tube as the best value for 5 per cent distortion, just like 7,000 ohms was selected as the optimum value for a single tube.

And Fig. 5 is our good old reliable plate voltage—plate-current family with which we are so familiar. A 7,000-ohm load line is drawn, terminating at about 550 volts. Thus, when the plate current is about 50 ma., the plate voltage is about 300 volts, one of the rated values.

Fig. 2.
Grid-bias resistor detail circuit.



USING THE TUBE

The base pin connections are as shown in Fig. 1A and B. When you finally dope the thing out, you will find that this tube can replace the type 41 or 42, without any socket changes, merely by short-circuiting the grid-bias resistor normally used with the 41 or 42. Just short this resistor and slip in the 6B5—and watch that speaker hop off the table!

CONCLUSION

The power sensitivity is high, as in a pentode, and this tube will give class B power with class A quality. The design of the power unit is not critical, since, as shown in the curves, the plate current remains practically constant from no load to full load. You don't have to worry about low-resistance chokes or saturated cores. And you can dispense with one audio stage in that new receiver of yours and still hold up the volume.

●

MAKE THIS VARIABLE-TONE CODE PRACTICE SET

(*Continued from page* 603)

condenser has a capacity of about 250 mmf. The tube used is a type 27. (Note—A 27 with poor filament emission will operate much more satisfactorily than a new tube, so any old tube will do that isn't shorted.) This oscillator will give a pure D.C. signal.

This rig was designed through necessity of being unable to use batteries for a regular D.C. set and it has enabled the author to increase his code speed considerably. The would-be amateur probably knows what a job it is to learn to copy code from a receiver; there is always static or interference and it is too inconsistent to make any real headway in code speed.

●

ORSMA MEMBERS' FORUM

(*Continued from page* 611)

when I install new parts in a set. I show the customer the replacement part installed in his set. I then take a fine lettering brush and run a red stripe on the part, at the same time calling the customer's attention to it and giving a 90-day guarantee.

Should anything else go wrong after service and the customer complains that I did a poor job, I call his attention to the fact that the part with the red stripe is still good. This prevents the customer from demanding free service or telling the neighbors that I am a "gyp."

I find that this method of procedure prevents much trouble and helps to maintain the prestige I have built up over years of effort.

W. J. RYAN

A CAREFULLY PLANNED SERVICE BENCH

RADIO-CRAFT. ORSMA *Dept.:*

While making a trip around the United States with the view of improving my studies in radio and also acquiring new equipment for my shop in Havana, Cuba, I wish to take this opportunity to send you a photo of my service bench.

It consists principally of one set analyzer; one tube tester; one service oscillator; one grid-dip oscillator and signal generator; and one power pack for different voltages, as well as speakers, condenser-resistance box, etc. All drawers are different in size and are divided in sections to have all replacement parts handy.

REINALDO D. VERSON

HOW TO READ GRAPHS AND CHARTS IN RADIO WORK

(Continued from page 601)

along the Y axis (carrying the current scale) represents two tenths of an ampere, since there are five such lines to one ampere.

The curve plotted in this system of co-ordinates represents the currents flowing in a certain resistance for different voltages, or vice versa. If we wish to find what current flows through this resistance at 50 volts we find the point A on the curve where the 50-volt line cuts the curve and then read horizontally from this point to the current scale and find that it is 0.8-ampere. In like manner where the voltage is 100 the current is read from point B as 1.6 amperes.

PRACTICAL APPLICATIONS

Suppose now, that the voltage is 75 and we wish to find the current. The procedure is first to find where the 75-volt line crosses the curve. Since this line is not drawn, we must imagine it to lie midway between the 70-volt line and the 80-volt line, and then we find that it cuts the curve at C, which apparently lies on the 1.2-ampere line. Again, let us find the current when the voltage is 112.5. We must imagine the voltage line to lie one quarter of the distance between 110 and 120, because 112.5—110 = 2.5, which is one quarter of 10, the voltage between adjacent lines. Thus from D we read the current as 1.8 amperes.

We may obviously reverse the process and use the graph for finding what voltage drops correspond to various known currents. We find the point on the curve where it is cut by the known current line and project downward from this point and read the desired value on the voltage scale.

This graph, incidentally, gives us an additional bit of information, namely, the resistance of the circuit from which the curve was derived. Take any point on the curve, say A, where the voltage is 50 and the current is 0.8, and by applying Ohm's law the resistance will be found to be 62.5 ohms.

AN IMPORTANT APPLICATION

Curves not only indicate what values of one kind exist for different values of another kind, as does the foregoing, but also indicate rates of change of increase or decrease. Figure 3 is an example of this. It shows how the plate current of a certain three element vacuum tube varies as we add a positive bias on the grid. We see that the slope of the curve becomes greater, as it progresses away from the origin. In Fig. 2, because the curve was a straight line, the slope was uniform and the Y values increased at a uniform rate; but here we have more than that—we have a greater *rate* of plate current increase as we increase the grid voltage. Let us check on this and see what increase in current we have at either end of the curve for an increase of one volt of grid potential. When we increase the grid voltage from zero to 1.0 the plate current increases from 3.5 ma. to 4.0 ma.—an increase of 0.5-milliampere. However, when we increase the grid voltage from 9 to 10 the current increase is from 9.15 ma. to 10.5 ma., an increase of 1.35, which is more than two and a half times the increase at the beginning of the curve.

It might be desired to know what happens to the plate current when we put negative bias voltages on the grid. Figure 4 is an extension of the curve in Fig. 3 and it is seen that the curve runs from the first quadrant into the second and third quadrants, the zero current line and the zero voltage line being the coordinate axes (represented in Fig. 1 as X^1X and YY^1). Point A lies in the first quadrant where the grid voltage is +6.5 and the plate current is +7.1 ma.; point B is in the second quadrant where there is a negative grid bias of —4.0 volts and a plate current of +1.7 ma.; and point C lies in the third quadrant where the grid potential is —10 and the plate current is —0.7, the minus sign before the plate current value indicating that the direction of current flow in the plate circuit has reversed. A potential of 100 volts was maintained on the plate in deriving this curve.

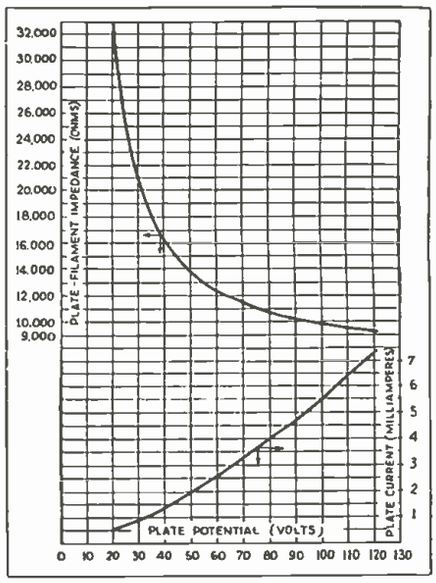


Fig. 6.—Plate voltage-current curve.

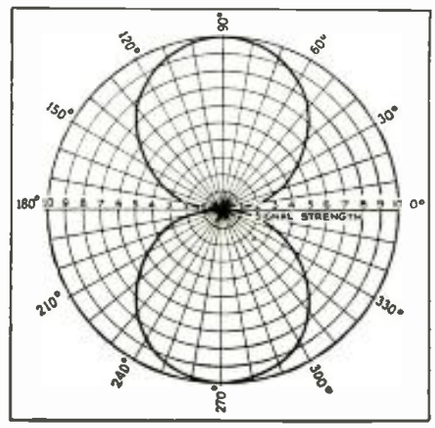
It may be observed that the scales for Figs. 3 and 4 are different. In Fig. 3 there are two divisions per volt and per milliampere, while in Fig. 4 there is one division to each one of these units. Compare the first quadrant of Fig. 4 with Fig. 3.

THE RATE OF CHANGE

We have seen that the change of slope of a curve denotes the rate of change of increase (or decrease, if the slope is down hill) of the particular phenomenon represented in graph form. These sound like so many idle words but a knowledge of rate of change can often be of practical use to us. Figure 5 will bear out the value of this kind of information. The curve labeled "Tube A" is the graph of the amplification factor of the tube we have been considering versus external plate-circuit resistance. We wish a tube to operate on as high an amplification factor as practicable; hence according to the curve we would use a high resistance in the plate circuit. We can see that 20,000 ohms is much better for our purpose than 10,000 ohms, the amplification factor (ratio of output to input) being increased by 1.4. When it comes to a choice between resistances of 110,000 ohms and 120,000 ohms, again a difference of 10,000 ohms, the final result would make little difference, as the amplification factor is increased by only about 0.05. It is also evident that there is no advantage whatever in having an external plate resistance higher than 130,000 ohms, for here the curve has practically leveled out. In fact half that value gives almost as much amplification.

There are times when two or more similar curves are plotted on the same coordinate sheet. They are generally distinguished by appropriate labeling or by being drawn with different types

Fig. 7.—A polar graph.



of lines, as illustrated in Fig. 5. Here they employ the same scales and are particularly useful for making comparisons of the two tubes.

There are other occasions when we come across a pair of curves of associated concepts plotted to three scales on the same chart. Figure 6 is of this class and in such instances one scale is common to both curves and the directions of the small arrows on the individual curves show which scales apply to them. The arrows, though they often appear on such curves, are not always necessary, for the curves and their scales may be identified by their general locations on the graph sheet. It will also be noted in this illustration that the plate-filament impedance scale is not extended down to the origin because no values near the origin are plotted. Incidentally the origins for these curves are not coincident, for although the Y axes coincide, the X axes do not.

THE POLAR COORDINATE GRAPH

Finally, in this brief treatment, there is the polar coordinate graph which the experimenter in all probability encounters at some time or other. For some obscure reason a great deal of mystery has been attached to this system of graph plotting, when it is, as a matter of fact, no more complicated than the rectilinear system. It is used where rotation is involved and is illustrated by Fig. 7, which is a graph for signal strength in a loop antenna as it is turned through a complete revolution. The radial lines signify the angles through which the loop is trained and the distances from the center of the chart, as measured by the concentric circles, represent signal strength, 10 being considered as full strength. Here we have taken the zero angle as that in which the plane of the loop is in the direction of wave propagation. As the loop is rotated the signal strength increases until it reaches a maximum at 90 degrees, after which it decreases to zero at 180 degrees. Further rotation again increases the signal strength until it is again at a maximum at 270 degrees and finally back to zero strength at 360 degrees which corresponds to zero degrees, the starting point.

It will be observed that changing the loop direction from 0 degrees to 5 degrees causes a considerable change in signal strength, whereas changing the loop direction from 90 degrees to 95 degrees makes only a slight difference in strength. In other words, the loop is sharper in the vicinity of the angle for minimum signal strength than it is around the maximum.

In closing, a few words of warning may be issued to the prospective graph maker. If in plotting a chart from a set of data, the points lie in a more or less scattered fashion, as shown by the small circles in Fig. 8, do not attempt to connect them as has been done by the broken line, but instead draw a smooth curve through them, as has been done with the solid line. Of course, if the matter plotted is of such a nature that it has no intermediate stages between the points plotted, as would be a weekly graph for the closing prices of a certain stock, the points would be connected with a series of straight lines. When points cannot be connected with a fair curve it generally means that the data was not of sufficient accuracy and if a smooth curve were drawn through their averages, as it were, it would be a reasonably good representation of the actual facts of the case; provided, of course, that the points are not too widely scattered.

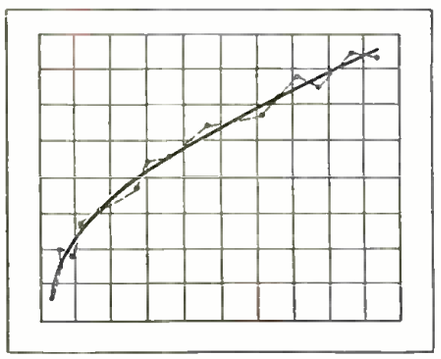


Fig. 8.—Right (solid) and wrong (dotted) methods.

THE LATEST ELECTRONIC ORGAN

(*Continued from page* 600)

The small push-button which can be seen at the right of the lower manual frame is provided for producing staccato effects or percussion tones, similar to those of a piano. By means of this device, the tonal effects of bells can be produced, as well as the tones produced by the picking and strumming of string instruments. The tones may be sustained as long as desired, with and without tremolo. The tremolo operates purely on a slight fluctuation in pitch, as in a violin. Inside of the instrument, supported by a special panel board, are twelve rotating Eremeeff-type light choppers, which are driven by a single endless belt from a single synchronous induction repulsion motor. For each light chopper, there are seventy-five ordinary automobile lamps, making a total of nine hundred lamps connecting with different circuits to the keyboards and stops.

Twelve parallel-connected photoelectric cells are in the line to the preamplifying coupling as shown in the accompanying simplified diagram, which shows in general the operation of the Eremeeff electronic organ. Raw A.C. is used for keying light from the lamps to the photoelectric cells! When the clutch is engaged with the motor shaft, shown in the diagram, the speed of the light choppers is slightly varied for producing tremolo. When a key in the manuals is depressed, a corresponding lamp is lit, and the light beam from the filament is thrown through the rotating light chopper onto the photoelectric cell which cooperates with that particular light chopper for producing the corresponding musical tone of the frequency produced by the row of apertures in the light chopper.

When the percussion push-button is depressed, a sudden rush of polarizing current for the photoelectric cells produces the effect of cracking or striking, similar to the tones produced by striking a piano key. When the percussion push-button is released, the key in the manual continues to produce the tone at a low intensity, although the polarizing current is disconnected, thus producing diminishing effects.

The tones produced by this instrument are so powerful that their force is felt by a listener who is standing even a good distance from the loudspeakers. The fundamental tones are not merely uninteresting pure tones, as in most electronic musical instruments which the writer has heard, but each tone is already rich and round, even before the additional partials are annexed. Of course, each added partial can be adjusted in volume, for which each stop is provided with a small knob, which can be seen in the photograph just below each stop, for increasing and decreasing the current feeding each lamp. Due to the short time duration of usage of each lamp, the percentage of burned out lamps is so small as to be negligible.

The volume control pedal is connected to a potentiometer which is connected after the preamplifying coupling. When typical organ pedals for bass tones are required, these are attached to the organ in the form of a small platform containing them, on which the entire instrument is set, and a contact bar of the pedals is connected to the organ with the aid of a multi-plug.

The electronic organ never goes out of tune, since the tuning depends on the revolutions of the light choppers, and the tuning is mathematically perfect. The response of the keys is instantaneous, and the writer has witnessed the playing, and has questioned reputable organists who stated that the organ responds quicker than any of the latest pipe organs with electrical actions, since in a pipe organ there is still a time lag in the pipes for building up air pressure.

A recording and transcription turntable, operating from the same synchronous induction repulsion motor which is used in the instrument, will be added, as will also the use of the amplification system and the loudspeakers, so that other music can be played synchronously, with the organ music as accompaniment.

Plans are in preparation with engineers and noted organists of Philadelphia for broadcasting this electronic organ over a network of stations all over the United States and abroad in the near future, so that readers can enjoy listening to it.

TWENTY WAYS TO USE THE "ELECTRIC EYE"

(*Continued from page* 588)

The circuit in Fig. 1 shows how a selenium cell is connected to an amplifier tube. This type of cell can actuate a relay directly and, in fact, it is usually used in this way. The device shown is a rather specialized use of the cell for indicating the intensity of light—such as the light in a room. It is used (practically) for regulating the amount of artificial light used. The circuit may also be applied to other control applications where unusual sensitivity is needed.

The circuit in Fig. 2 illustrates the normal way of connecting up a photronic cell to other equipment. Fig. 3 shows two ways of connecting the photolytic cell (this is a photovoltaic cell) where uninterrupted light is used to actuate it and also when a modulated light —such as that found in talking movies—is the controlling means.

The circuits in Figs. 4 and 5 are practical ways of connecting gas-filled or "hard" phototubes. Fig. 4 is known as a "forward" circuit in that when the tube is dark, a minimum plate current flows and the relay is inoperative. Then when light falls on the cell, plate current of the amplifier increases and actuates the relay. Fig. 5 is a "reverse" circuit in which maximum plate current flows when the cell is dark and a decrease occurs when the cell is illuminated. Thus the relay opens when light falls on the cell. The contacts on the relay may be selected to open or close the circuit for either forward or reverse arrangements.

It is interesting to note that A.C. is applied to both the photo-tube and amplifier—as both act as rectifiers.

Certain radio tubes exhibit marked photoelectric effects and may be used by the experimenter in this field with fine success. We refer particularly to the type 45 with the common "black-plate." The grid is left floating—by cutting off the grid prong, as shown in Fig. 6 and the plate is connected in series with a battery to the relay or an amplifier tube. A tube should be chosen which is clear at the top so that light can reach the plate easily.

HOW TO USE THE PHOTO-CELLS

There are numerous interesting experiments that can be performed with photo-cells connected in the ways described. For example, Fig. 7 shows how a bell or alarm can be sounded by the rising sun in the morning. By reversing the relay contacts, a lamp or light can be turned on when the sun sets. Fig. 8 shows how a practical burglar alarm is made up. In this application, of course, it is preferred to use an ultra-violet or infra-red ray which is not visible to the human eye but will actuate the PE. cell. An arclight or a strong spotlight with a sheet of thin hard-rubber over the front is fine for this "invisible light" (sometimes called "black" light).

The arrangement in Fig. 9 shows how a parking light can be turned on a parked car either by the headlights of another approaching car or by the setting sun. For the former use, the photo-sensitive cell should be mounted low on the car—in the direct path of the beam of an approaching vehicle. Two are needed—one for the front and one for the back.

The applications in Figs. 10 and 11 show how visitors can be announced and welcomed by PE. cells. The arrangement in Fig. 10 shows a spot of light across the doorway which is interrupted by the visitor thus ringing the door bell automatically. The one in Fig. 11 automatically turns on a light over the door when anyone approaches it.

COMMERCIAL APPLICATIONS

The circuits in Figs. 12 and 15 show some interesting industrial applications of the photocell which show the methods used and are thus of interest to the experimenter who may apply them to his own needs.

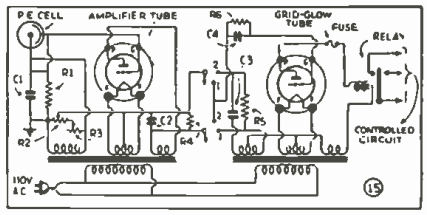


Fig. 15

Control circuit using a grid-glow tube. Use this connection for past actions.

Figure 12 is a method of testing the lustre of fabries by revolving them very fast in the path of a light beam and registering the reflected light impinged on a PE. cell. A sample of the cloth is secured to the disc on the motor. Fig. 13 shows how two cells are employed for comparing colors or light intensities. The cells are connected as two arms of a wheatstone bridge and any difference in the light recorded by the cells causes an unbalance to occur between the cells which is recorded on the milliammeter. Different colors reflect differently. This arrangement is also used for examining paper on rolls for breaks or thin spots, etc., and for many other applications.

The set-up in Fig. 14 is a practical device for measuring light intensity. This is applied to the control of light in industrial plants —to the examination of translucent objects and to similar commercial uses. One of these devices can be applied to photography as an experimental "exposure" meter. A battery is connected with a suitable high variable resistance to oppose the plate current from the "B" battery, so that the milliammeter reads zero when the cell is dark.

For certain specialized tasks, the speed of operation is an essential factor. Ordinary circuits such as those given above are not quick enough in action to serve the purpose. Such applications as the control of hot steel to respond to the radiant energy of the bars —to the control of package wrapping machines to insure the correct register and the printed matter on the wrapper, and for aligning properly the end crimp on tooth paste tubes with the printed matter on the tube—require unusual sensitivity and greater speed than normal. The circuit in Fig. 15 shows a commercial unit which has the necessary speed. The PE. cell actuates an amplifier of the triode type and this in turn triggers a grid-glow relay tube into action.

The applications and methods presented here are by no means a complete summary of the possible uses for PE. cells Such a survey would require a complete volume to cover, in even a sketchy manner. However, a few of the most interesting applications for the experimenter and radio enthusiast are outlined. They may help those who are interested to apply these interesting devices to their own particular needs. The values of voltage and resistors, etc., required for the experimental circuits (Figs. 1 to 6 inclusive) are not at all critical but depend upon the sensitivity needed. A little trial and error will soon show the correct values for the particular tube and experiment undertaken.

If this brief article results in stimulating interest in electronic devices, the author will feel genuinely gratified.

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SHORT CUTS IN RADIO

(*Continued from page* 596)

HONORABLE MENTION

AN EGG BEATER and a micro-vernier dial form the basis of an effective, inexpensive coil winder and counter for the experimenter.

One of the vanes of the egg beater is removed by cutting the vane support at the upper part. The remaining vane is bent to a "V" shape.

Then the vernier dial is secured to the beater support and coupled to the shaft with a suitable coupling. A coil can now be slipped on the V-shaped vane and the winding can be started by turning the crank. The beater should be secured in a vise or clamped to the bench. The vernier dial serves as a counter.

WILLIAM TOTH.

AN ELECTRONIC AND P.A. AMPLIFIER

(*Continued from page* 608)

duties of a conventional amplifier, this twin channel unit can actually be used for reproducing sound in true auditory perspective either in two, three, or four dimensions. (See RADIO-CRAFT issues for January, 1935, page 407 and February, 1935, page 481 for fundamentals of fourth dimensional sound systems.) Naturally, for the recreation of sound in four dimensions, two of these units will be required so as to provide the four clear channels necessitated by such a system.

Another interesting application of the two-channel amplifier, is the simultaneous amplification of both television and sound signals, a condition which ordinarily requires two separate receivers. Any ingenious experimenter can build a two-channel radio frequency amplifier to couple to this unit so that television images and accompanying sound are received together under high-fidelity conditions.

Additional interesting radio applications are discussed in the latter portion of this article. Because of its wide variety of electronic applications this amplifier is admirably suited for academic instruction in all schools and colleges. Practically every natural phenomena and scientific law can be measured, studied, and recorded with this amplifier and suitable accessory equipment. Of course, the amplifier can be used for *every* public address application that can possibly arise (within limits of its power output, maximum of 40 watts.)

A number of unusual features incorporated into this amplifier include:

1. *Combination high and low frequency cut-off control* (T) which is capable of introducing desirable frequency discrimination at either the upper or lower portions of the audio frequency spectrum, so that compound sounds may be simultaneously studied (or viewed on an oscilloscope) while these sounds are passed through both channels and subjected to predetermined frequency attenuation. For public address applications, this control may be used to cut off extraneously induced 60-cycle hum without seriously affecting the reproduction of speech. When undesirable acoustic feedback takes place at some resonant frequency, the control can be adjusted to suppress this particular frequency and so permit a velocity microphone to be operated in close proximity to its associated loudspeaker.

2. *Transformer-coupled phase inverter* which provides for a push-pull interstage coupling transformer to be connected between the second 6A6 (combined voltage amplifier and phase inverter) and the pure class A push-pull fixed bias output stage.

3. *Universal power operation.* To make this amplifier suitable for field use (where 110 volt A.C. power lines are not available) it has been designed for optional operation from a 6-volt storage battery.

4. *Two-program amplifier.* By virtue of its two distinct and clear channels it is possible to use the amplifier system for the amplification of two different phenomena or programs. It is particularly adapted for centralized radio program distribution wherein two separated programs are individually amplified and distributed to appropriate outlets within the various rooms of a hotel, hospital, school, etc., for ultimate program selection by auditors. One of the channels may also be used for some predetermined program distribution while the "spare" channel is used for special announcements, emergency instructions, etc. The two clear channels are of particular value in the study of feeble transient phenomena in relation to some other conditions which must be simultaneously amplified but separately photographed, recorded or otherwise observed. By interposing two suitable relays, in the plate circuits of the input sections (marked xx, in both channels) these relays may be made to operate any device either when some synchronized phenomena take place (connect relay contacts in series) or entirely independent of each other (connect operating contacts of relays in parallel).

ELECTRICAL CIRCUIT

A brief study of the input circuit will disclose the following interesting circuit details:

1. Low-level high impedance input devices as crystal microphones, or pickups, photo-cells, etc., are connected to the high impedance tap BP1 connected to switch SW1. By snapping SW2 to the 4-stage position, the full gain of the amplifier is made available. Ribbon (velocity), condenser or dynamic microphones are coupled into the first 6A6 tube through transformer T1 which may be coupled to either 200 or 500 ohm lines. Under these operating conditions, the "L" pad control (VC1) attenuates all low-level input signals, but does so only after these signals have been pre-amplified in one section of the 6A6 pre-amplifier.

2. High-level input devices or dynamic or magnetic phono. pickups, radio tuners, etc., are coupled into the *second stage* of the amplifier through transformer T3, or high impedance tap (BP2) by virtue of the selection switch SW3. Under these circuit conditions, the "L" pad (VC2) acts as the attenuator control for these high-level input signals while VC1 continues to modify the volume intensity of the low-level inputs, so that "mixing" and "fading" facilities are made available between these two input signal sources.

A 200 ohm double-button carbon microphone may also be coupled into the second stage of the amplifier through transformer T2 by setting switch SW2 to the 3-stage position. With this arrangement, the "L" pad VC1 (independently) controls the output level of carbon microphone.

The push-pull output stage of each channel utilizes a fixed bias class A circuit capable of delivering 15 watts with 2 per cent total harmonic distortion, and 20 watts with 5 per cent harmonic content. The total power output of both channels is 30 to 40 watts depending upon the permissible harmonic content. Under ordinary conditions, a 5 per cent harmonic content is permissible and unnoticeable.

It will be noted that the power supply circuit is composed of two separate voltage supplies utilizing two 5Z3 rectifiers. One of these circuits furnishes plate voltages for all tubes and optional dynamic speaker field supply, photocell "B" voltage, etc., while the other 523 supplies a constant bias of 62 volts to the grids of all 2A3's. It is of utmost importance to utilize two rectifiers made by the same manufacturer so that they both heat up at the same time, and avoid the detrimental condition of applying plate voltage before the bias voltage is established.

ELECTRONIC AND PUBLIC ADDRESS APPLICATIONS

We could fill volumes simply by listing all of the practical applications for which this amplifier is suited. To conserve space, we will merely mention a few of its most popular applications. It should be borne in mind, however, that for some uses, special auxiliary equipment such as sensitive relays, cathode ray oscilloscopes, photo-cells, etc., are necessary.

In the field of sound alone, the amplifier is particularly suited for call system and inter-office communication, listening in to two rooms at the same time, detecting leaks in water and oil mains, comparing and adjusting timepieces against a standard clock, study and comparison of echoes, operating automatic "announcers," "demonstrators," "salesmen," inspecting and detecting surface irregularities, talking signs and clocks, aeronautical and mobile advertising, superstethoscopes for listening to faint heart sounds.

With the aid of a photoelectric cell many light-controlled functions can be performed by suitable devices connected to a relay inserted in the plate circuit of the first 6A6 tube. A few of the more popular uses include sound-on-film recording and pickup, illumination control, automatic door openers, automatic elevator stops, smoke detectors, color matchers, automatic counters, and a host of other inspecting, and protective applications.

With a cathode ray oscilloscope connected to the output circuit the minutest transient voltages and currents may be studied or photographed.

In the public address field this amplifier is particularly suitable for all types of installations, rentals, and applications which heretofore required separate amplifiers: for storage battery operation or 110 volt A.C. operation; for high-fidelity reproduction; for medium and high power output; for indoor, outdoor, mobile, aeronautical, marine, and portable work; for ribbon, crystal, dynamic, condenser, inductor and carbon microphones; for high and medium gain; for radio tuners photo-cells, and phono. pickups.

The author will be pleased to answer any questions relative to the construction or application of this amplifier. RADIO-CRAFT.

THE MEANING OF "ELECTRON"

(*Continued from page* 592)

and pass to other electrodes called anodes.

The four methods of getting electrons out of metals, which are commonly useful at this time are:

(1) the electrical field;
(2) thermal agitation;
(3) electron bombardment;
(4) photoelectric emission.

(1) The first method (Fig. 1A) consists of putting on the surface of the metal an intense electric field, in the right direction to pull out the electrons.

(2) The next method (Fig. 1B) is that of heating the metal sufficiently, thus raising the thermal agitation velocity to such an extent that a few of the electrons have sufficient velocity to break through the surface tension.

(3) The third method (Fig. 1C) "splashes" out some of the electrons near the surface; by bombarding the surface of a metal with high-speed electrons, it is possible to knock out of the surface several electrons for every collision. This phenomenon goes by the name of "secondary emission."

(4) The fourth method (Fig. 1D) utilizes the energy of a light beam to pull electrons through the surface of the metal; certain of the metals yield electrons copiously when intensely illuminated by light of proper frequency. This action is called "photoelectric emission."

The use of a third electrode called the grid enables the flow of electrons to be controlled by varying the potential between it and the anode or cathode. One of the very important features of the grid is its ability to provide amplification. If the tube is evacuated certain performance is obtained. If the tube is filled by certain gases a somewhat different performance is secured. Additional electrodes are sometimes put into tubes by which the performance is still further modified.

In the passage of electrons through a gas collisions occur between the electrons and gas molecules and by virtue of their momenta electrons on the molecules may be knocked loose and thus exhibit a positive charge, or slow moving electrons may attach themselves to a gas molecule causing it to become negatively charged. In an electric field, ions and electrons are attracted and accelerated toward the electrode of opposite polarity to their charge. Gas ions as well as electrons may produce ionization by collision. With sufficiently intense fields, depending especially on the temperature, pressure, and type of gas, the ionization becomes so intense that the gas breaks down into a conducting state. Such a condition exists in arcs, sparks, neon sign tubes, and grid-glow tubes.

As the gas pressure is reduced, the gas is first more easily ionized, but finally as very low pressures are reached the gas molecules are so far a part that collisions are rare. No vacuum tube has been completely evacuated, but when the electrons can travel on the average a great distance compared to the dimensions of the electrodes it is classed as high vacuum.

CONDUCTORS AND INSULATORS

In certain of the elements, notably the metals, it appears that the atom does not hold all its electrons in rigid control; one of the outer electrons seems to be free to leave the atom and move around in the outer molecular space at will. If there is an electric potential gradient in the material, these free electrons will, of course, move against it (their charge being negative), and this progressive motion of these free electrons constitutes an ordintry conduction current; the material is styled a *conductor*.

If a conductor is positively charged, some electrons have been removed from it; and if it is negatively charged, some extra electrons have been supplied to it.

In other substances it seems that the internal molecular forces bind all the electrons firmly in place, making it impossible for an electron to leave its molecule and move along through the material. If a voltage gradient is impressed upon such material there can be no progressive motion of electrons and hence no conduction current. Such materials are called *insulators*.

There is no sharp demarcation between conductors and insulators. There are some materials having thousands of times as much resistance as copper, the most widely used material for carrying current, yet these high-resistance materials are styled *conductors*.

Also it must be remembered that the finest insulators (as e.g., glass) become fairly good conductors when sufficiently heated. The increased violence of atomic collisions which accompanies high temperature makes it easier for the normally tightly-bound electrons of the insulator to break loose from the atom and become free. They can act the same as the normally free electrons of ordinary conductors.

No experiment has yet been performed which shows how many free electrons there are in a metal; there are indirect proofs that there may be one free electron for every 10 or 20 atoms; others indicate that there may be nearly as many free electrons as there are atoms.

The atoms of a metal are reasonably well fixed in space with respect to the rest of the atoms of which the material is composed. This is, of course, in contradistinction to the atoms of a gas, each of which is free to bounce where chance takes it. The free electrons of a metal, however, seem to act like a gas; they are free to move about in the material, wherever collision, or other action, may urge them. Thus the metal is an aggregate of atoms, each of which is reasonably well fixed in position with respect to the others, and in between these atoms is an electron gas, the individual particles of which are free to migrate throughout the substance of the metal.

Electrons in a magnetic field are acted on only when in motion, and in a direction perpendicular to the magnetic field. This action is made use of in some specialized vacuum tubes.

The space charge in the region of the cathode is caused by the field which the electrons themselves produce and which interacts with the field due to the electrodes. This space charge retards the flow of electrons from the cathode in all tubes, but is neutralized by positive ions in grid-glow tubes.

(Credit is given to *Westinghouse Electric and Manufacturing Co., Inc.—The Literary Digest—John Wiley and Sons, Inc.*—and *RCA Manufacturing Co., Inc.*, for the information contained in this article.—Ed.)

*The American Standards Assoc. definitions of electrons, protons and ions are: An *electron* is the natural, elementary quantity of negative electricity; a *proton* is the natural, elementary quantity of positive electricity. An *ion* is an electrified portion of matter of subatomic, atomic, or molecular dimensions.

A LOW COST A.C.-D.C. VACUUM TUBE VOLTMETER

(*Continued from page 603*)

paper condenser. Resistor R was a 100,000-ohm and R_1 a 600-ohm, ¼-W. rheostat. This completes the equipment, all of which is either in the possession of or is readily accessible to any radio experimenter. Using the above circuit constants a range of 0—30 volts (effective) will be obtained.

While the set-up is operative on either 110 volts A.C. or D.C., calibration of the instrument on A.C. is rendered invalid on D.C. as evident by the following considerations:

With a sinusoidal voltage wave impressed upon the power input terminals, the resultant plate current pulses will be as indicated in Fig. 2A. Assuming these to be half sine waves, their average value will be $I_{AVE_{A.C.}} = \frac{I_m}{\pi}$ where $I_m = F(\sqrt{2}Eeff)$. With D.C. impressed, $Eeff = E_{D.C.}$ and $I_{ave._{D.C.}} = F(E_{D.C.})$. From these relations it follows at once that $\frac{I_{AVE\ D.C.}}{I_{AVE\ A.C.}} = \frac{\sqrt{2}}{\pi}$. Therefore, the voltage range of the instrument is approximately $\frac{\pi}{\sqrt{2}}$ times as great on an A.C. as it is on a D.C. power supply.

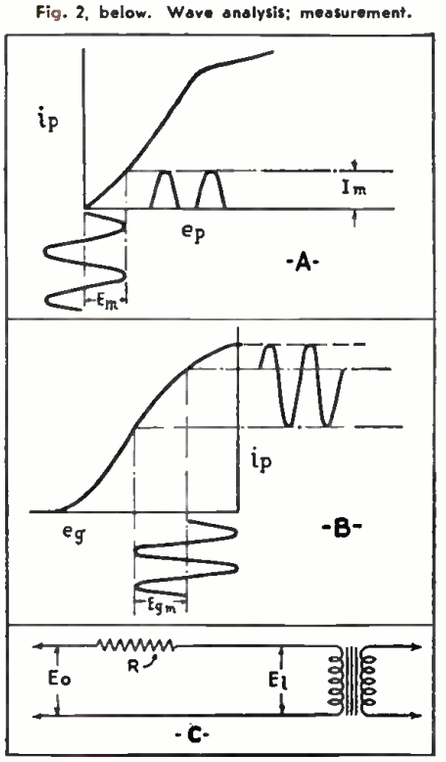
In setting the instrument up for calibration and for use, R_1 is adjusted for full scale deflection of (M.A.) This places the operating point of the tube in the region of plate voltage saturation, resulting in a decrease of plate current with the application of a grid E.M.F. instead of the inverse, as found in the usual type of V.T. voltmeter. This is made evident by inspection of Fig. 2B.

The advantages of selecting this operating point in preference to the customary one—taken near the region of plate-current cut-off—are:

1. Elimination of a plate current neutralizing device yet retaining the full sensitivity and utilizing the entire range of the plate milliammeter.
2. Simplicity of adjustment to the operating position.
3. Variational plate conductance very high just below region of saturation resulting in high-power sensitivity for this adjustment.

Above, inside view of V.T. meter.

Fig. 2, below. Wave analysis; measurement.



CALIBRATING THE INSTRUMENT

The V.T. voltmeter may be conveniently calibrated by comparison with a standard A.C. voltmeter, using 60-cycle current for the grid excitation. In order to avoid reverse reading of the plate milliammeter in this connection, however, the phase of the grid-exciting E.M.F. should be opposite to that of the power-supply source. This may be done by connecting these leads in the manner which results in a decrease of plate current instead of an increase upon their application to the voltmeter.

The versatility and uses of the V.T. voltmeter are so well-known and are so numerous that no attempt shall be made to delve into this subject in any great detail. However, one example shall be given which may be considered as typical of the uses of such an instrument. This shall pertain to the determination of the constants of an A.F. transformer under no-load conditions by a means which, in the writer's estimation, is not generally well known to the average experimenter.

DETERMINATION OF PRIMARY AND SECONDARY INDUCTANCES, Lp AND Ls:

This measurement consists of impressing an E.M.F. E_0, across either the transformer primary or secondary, in series with a resistor R as indicated in Fig 2C. R is selected so that it has a resistance value much greater than the winding under measurement. The voltage appearing across the transformer coil (E_1) and the voltage impressed (E_0), are now measured with the V.T. voltmeter. The inductance value of the transformer section is then given by—

$$(1)\quad L\ (\text{henries}) = \frac{R}{2\pi f\sqrt{\left(\frac{E_0}{E_1}\right)^2 - 1}}$$

when $R >> r1\ (\text{coil})$

DETERMINATION OF COUPLING COEFFICIENT (k):

For this measurement the same set-up is used as in the above, only in this case the primary inductance is determined by applying formula (1), first with the secondary open and secondly with the secondary short-circuited. Denoting the former value by Loc and the latter by Lsc, (k) can be determined by substitution of these into the formula—

$$(2)\quad k = \sqrt{1 - \frac{L_{sc}}{L_{oc}}}$$

From this information the leakage reactances are readily determined by the following: Primary leakage reactance $= L_p\ (1\text{-}k)$; secondary leakage reactance $= L_s\ (1\text{-}k)$.

The above example is typical of the uses to which a V.T. voltmeter may be applied. If a development of the formulas is desired, the writer shall be pleased to furnish such information upon request.

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BACK NUMBERS OF RADIO-CRAFT

Back issues of RADIO-CRAFT prior to December, 1932, are available at 50c per copy; except the following issues: 7/'29; 1, 2, 3, 4, 6, 7, 9 and 11/'30; 5, 8 and 9/'31; and 7 '33, which are out of print. Succeeding issues are still available at the regular price of 25c per copy.

NEW TUBES VS. OLD

(*Continued from page* 610)

tubes have been improved upon. First and foremost are the mechanical details. We can readily recall tubes of not so long ago that had to be carefully packed for shipment. It is a far cry from those tubes to those of today shipped in set sockets, instantly ready for use. The rapid rise of the auto radio set has also been responsible for sturdier tubes, particularly in the matter of eliminating looseness which, while perhaps unnoticed in the home receiver, would certainly show up big in the jiggled auto radio.

The most obvious refinement is the dome-shaped bulb generally introduced in 1931. Providing a rigid means of support at top of tube mount, by means of a snug-fitting mica washer or spacer, it has brought remarkable rigidity to tubes, sadly in need of this additional bracing. Crooked mounts are now a rarity. But it has also brought in its wake a multiplicity of mechanical problems.

In the first place, the dome section is not perfectly round. Tube designers therefore have made use of saw-toothed spacers, sometimes round, sometimes cruciform, sometimes something else. Large and small teeth have been used, as well as combinations. Yet loose fits have developed due to imperfect contact at the very beginning or the breaking of the thin mica teeth. Buyers, growing more and more critical of rugged radio tubes, hold a tube to their ear, strike it violently with open palm, and listen intently for the slightest rattle upon which to base a rejection.

Tube engineers have worked hard on dome-bulb rattles. Some time ago the mica pad was introduced—tiny mica members mounted perpendicular to the plane of and attached to the usual top spacer, or mounted on the metal cage, in either case bending and pressing against dome sides in a snug manner. Practically all refined tubes now have the dome pads or an even more recent refinement in the form of resilient spring clips. The latter are simply springy bits of wire mounted on mica spacer or metal cage and pressing against the dome sides. Wire clips insure a positive and lasting snug fit.

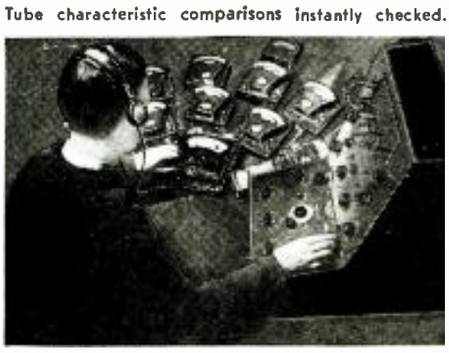
MICROPHONIC EFFECTS

Mechanical looseness is closely affiliated with microphonic troubles. What with powerful dynamic speakers mounted close to high-gain tubes, the slightest displacement of tube elements is apt to serve as a most effective microphone, causing marked distortion in rendition. Our British friends some two years ago decided that much of the microphonism was caused by vibrating filaments in certain types. They therefore introduced additional anchor hooks whereby to apply tension on hair-pin filaments between usual top hook and bottom terminals. In some American tubes the same idea is now to be found. Ceramic-coated or insulated tension hooks, welded to the grid, pull the legs of the hair-pin filament outwardly, thus applying tension necessary to eliminate undue vibration and microphonism. The idea sounds simple, but engineers have tried heavy-hook tension and light-hook tension, heavy and light filament coatings, ribbon filaments and circular filaments, in evolving the proper structure.

NEW TESTING METHODS

Vibration has been fought in many directions. Tube construction today is much heavier than a while ago. Support rods are of greater diameter. Present mechanical design is more suggestive of good structural engineering. Materials are more carefully selected. To cap the climax, tubes are sometimes employed deliberately as microphones and subjected to the full blast of a loudspeaker running the full gamut of audio frequencies. Thus any tendency towards microphonism or rattles in the tube is soon detected for any given audio frequency. The loudspeaker is fed by a beat-frequency audio oscillator and power amplifier. The tested tube is connected with an output amplifier and output meter for precise quantitative measurements. Plate or grids in the tube, together with cathode, serve virtually as a condenser microphone.

Tube characteristic comparisons instantly checked.



Tubes are also "taken for a ride." A device which is really an adaptation of the well-known beauty massage vibrator, receives a tube to be tested for looseness or weaknesses. The motor drive may be speeded up to any vibration frequency. Held in a conventional socket, the tube may be tested from time to time and any looseness or weakness immediately detected. Or the tube may have a suitable potential impressed between different elements, and connected with amplifier and loudspeaker, to detect imperfect contacts or faulty insulation. Much the same scheme is sometimes employed to detect lint or foreign matter present in a tube because of careless production. With high potential applied to elements, the jiggled lint is attracted to those elements. Its presence becomes known as it lights to incandescence with the passage of 20 or 30 milliamperes.

ELECTRICAL ADVANCES

Electrically, too, important refinements are being scored. Such activities center largely about the emitter, whether filament or heater cathode. In the former type, no end of improvement has taken place during the past few years. From tungsten to thoriated tungsten and then to oxide-coated filaments, chemist, metallurgist and engineer have worked together for better characteristics. In oxide-coated filaments, important improvements have been made by way of new alloys permitting heavier conductors for greater rigidity and minimum microphonism, as well as better emitters providing copious emission at minimum operating temperature. Troublesome types, such as the 22 battery-operated screen-grid amplifier and the 99 detector-amplifier, have been redesigned with new oxide-coated filaments in place of original, tricky, thoriated-tungsten filament, and made practical.

Meanwhile, corresponding advances have been made in heater cathodes. The short life and uncertainty of the early 27 type are history. Almost no end of materials and constructions have been tried in mounting the heater filament inside the cathode sleeve. The intense heat disposed of most materials originally tried. The unequal rate of expansion and contraction between ceramic and tungsten wire resulted in undue wear and tear. Chemical reactions accounted for many breakdowns. The partial conduction of some insulating materials caused leakage and corresponding noise between filament and cathode sleeve. Hum troubles were experienced.

Today the heater cathode is a perfected thing in the better brands of tubes. Here again, there is considerable divergence of opinion. Several manufacturers employ as many different methods of attaining the perfected heater cathode. Some still use a ceramic insulator to support the heater filament and isolate it from the surrounding metallic cathode sleeve. Others coat the heater filament with a suitable ceramic. There are hair-pin filaments, straight filaments, M-shaped filaments, reverse spiral filaments and even folded-ribbon filaments. The sum total is reliable performance and long life for most cathode-type or indirect-heater tubes.

Heating time, once held up as the main desideratum, is no longer a talking point for engineers to shoot at. A study of the heating time of a number of representative types and brands indicates no particular attempt to run a race on this score. Take the 36 type, for example. One manufacturer scores 9.88 seconds, another 20.40, and another 8.00. Type 58 shows up at 17.70 and 21.10 seconds. The 24 type scores 15.50 and 16.50 for two different brands. The 2A7 type scores 17.35 and 19.75. We don't seem to have those split-second performances which made advertising copy a few years back when 45 seconds to over one minute was by no means unusual, and 7 seconds was something to shout about.

THE CHEMIST HAS HIS SAY

The chemistry of tubes has become a prime consideration. Leading tube manufacturers now have impressive chemical laboratories and staffs for the purpose of testing, selecting and passing upon different ingredients that enter into tubes. These chemists get down to the smallest details, for production failures are often difficult to fathom, because of their minute causes. In one tube plant, for instance, chemists have worked out a means of coating mica spacers with a lacquer which evaporates during bombardment just prior to the sealing-off operation. The lacquer protects the mica proper from perspiration and oils that might be deposited by fingers of girl operators. Prior to this innovation, finished tubes might test noisy, because of leakage due to moisture or oil deposits on mica spacers.

PENNY-SPLITTING ECONOMIES

While tube manufacturers have made tremendous gains in tube refinements, they have at the same time met a steadily declining price level. Compare the $1.50 list price of say the O1A type in 1928 with its present 60 cents; the $4.25 for the 80 as against 70 cents today; the $4.00 for the 27 as against 70 cents today. Here you have pretty much the story of most tube prices. Improving quality while reducing costs has meant production economies of all sorts. Tube costs today get down to fractions of a penny. Short-cuts and daring innovations are the order of the day.

For instance: a leading tube manufacturer studied his costs on hydrogen gas bought in steel tanks and coming from quite a distance. His chemists suggested buying liquid ammonia instead, because there would be more hydrogen available in ammonia tanks for given freight charges. Of course, an elaborate device called a "dissociator," was necessary—a machine for breaking down the ammonia compound so as to release the desired hydrogen. The elaborate equipment is installed today to feed the hydrogen furnaces, and the manufacturer is saving still another fraction of a penny on each tube. But fractions of pennies mount into real money when multiplied by tens of thousands of tubes each working day.

Or in the matter of tube bases. Most manufacturers buy them complete, with prongs molded in place. One manufacturer in his penny-splitting adventures found that a saving could be effected by using plain bakelite bases and then riveting the prongs in place by means of ingenious automatic machines.

Savings are particularly evident in the parts end of tube production. While smaller tube manufacturers buy most of their components, leaders are fabricating their own almost entirely. Some mighty ingenious machines knock out complete parts, such as plates and grids, at minimum labor cost.

In the final analysis, however, good tubes get down to matters of sound engineering and chemistry, rigid inspection of materials and components, conscientious production with good labor and best obtainable automatic machinery, and thorough testing of finished product. No matter how carefully tubes may be designed and produced, it is unavoidable that some will not be good. Uncompromising tests on finished products are essential to good tubes. And here enters the conscience of the manufacturer, for tube rejects mean shrinkage in production output and rising costs. A high pile of broken glass behind a large tube plant is generally the hallmark of a good product, for only the quality producer dares scrap a liberal proportion of his output, particularly on newer types, in order to attain rigid characteristics.

There is definite salvage value in that junk pile, but not in the material sense. Outside of bakelite bases, there is nothing of tangible value. But far beyond tangible recovery are the engineering lessons that go to reduce future shrinkage. In leading plants tube shrinkage is critically studied. Remarkable devices have been developed for studying tube failures and drawing conclusions for future designs and production practices. Also in routine testing equipment. Some manufacturers have developed their own equipment. Small neon lamps which flicker on and off, in addition to usual meters, now serve to detect tube flaws which might get by unnoticed with test equipment of only a year or two ago.

And the account of refinement and improvement might go on and on. But the editor now calls a halt to this dissertation because of space limitations. Suffice it to state, in conclusion, that whatever progress has been made of late in radio sets, corresponding progress is to be found in many radio tubes fresh from the factories, as distinguished from bargain-price tubes that are as shy as a spinster when the conversation turns to birthdays.

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HOME ELECTRONICS

(*Continued from page* 595)

the sun close your window for you. When it becomes light, a cell supplies the relay mechanism, and if you like to wake with the sun, it will ring your alarm for you at the same time. Likewise, when you retire at night, why risk a draft while opening your window? Just wave your hand from the bed, and presto, the window opens. You can even go so far as to vary the amount of opening by several waves of your hand. The sky is the limit!

Getting back to automobiles, did you ever get a ticket because you forgot to turn on your parking lights? Dr. Caldwell prevents this tragedy by the simple expedient shown in Fig. G. When daylight gives way to dusk, the little PE. cell obligingly lights the lights. If you leave your car out all night, the same cell turns them off at daylight.

A PE. cell, placed at a crossroad approach, will operate traffic warnings to prevent crossing accidents, Fig. H. The car's headlights operate a PE. controlled timing device which keeps the warning light on red until the approaching car has had time to pass the crossing.

We could go on and on until you could finally be automatically matching the colors of socks and ties, controlling coffee and toast by their color, letting the cat in and out automatically, and dozens of other stunts. But these suggestions should serve to show that electronics in the home is the answer to many prayers.

Fig. G.—PE. cell turns on parking light.
Fig. H.—PE. cell prevents crossing accidents.
(© Wide World)

A MODERN PICTURE OF TELEVISION

(*Continued from page* 589)

portant patent holders. There are, of course, other companies in Germany outside of this agreement, but the fact that the German government helped this company by placing huge orders with it, and further that the government erected the first 10 kw. ultra-short-wave television transmitter in the world, and adopted the 180 line transmission system, has given the television technique in Germany the uniformity which is necessary to obtain real progress in television. No wonder that Germany is today the country with the greatest progress in television technique. While other countries discuss the question: "Shall we have television in the near future?"—the Berlin television station has been working on a regular schedule for months.

Despite the fact that the satisfaction in television reception is determined among other things by the number of lines into which the picture has been cut during transmission, no agreement could be settled until now about the number of lines to be used uniformly by all television stations in the United States. On the other hand, much work has been done during the last few years to find the right number of lines necessary for a satisfying television transmission, and we now know exactly how many lines are necessary to reproduce an acceptable television image. The results of the various experiments made in this country by E. W. Engstrom (RCA) and in Germany by R. Thun (German Post Office) are given in Table I.

TABLE I

No. of Lines	Classification by E. W. Engstrom	Classification by R. Thun
60	entirely inadequate	8.8 per cent
120	hardly passable	51.0 per cent
180	minimum acceptable	84.0 per cent*
240	satisfactory	97.0 per cent
360	excellent	99.5 per cent
480	equivalent of practical condition	100 per cent

(*Quality of home movies.)

This table shows that 240 lines are satisfactory according to Engstrom and promises an image natural to 97 per cent according to Thun. But it seems to be advisable to choose the 180-line television transmission, not only because it may be sufficient to have only a picture quality comparable to the image of a home movie, but also because the transmission and amplifier technique of today is not sufficiently well developed to start at once with more than 180 lines.

SOUND QUALITY VS. TELEVISION IMAGE

We know that the broadcast reproduction with an average radio receiver in use today (frequency range from 150 to 4,500 cycles), is natural only to about 65 per cent. Tests made by well-known experts have shown that the performance of a modern high-fidelity receiver (50 to 7,500 cycle – the latest in radio improvements) can be marked as natural only to 90 per cent. If we have been satisfied for 14 years with sound fidelity of 65 per cent, an image fidelity of 84 per cent should be acceptable.

There are, of course, a great many people who will not be satisfied with the decision to use a 180-line image. It might, therefore, be worth while to indicate what a transmission of 180 lines involves in respect to amplifiers and transmitters. It had been said often that a 180-line image is equal to 40 000 picture elements. The experiments of movie technique show that a change of 24 pictures per second is necessary to obtain a "motion" not fatiguing to the eye. This means that we obtain by a 180-line transmission, a picture frequency of about 500,000 cycles (500 kc.). The rules of transmitter technique indicate that for the reproduction of a high-class sound or television reproduction a transmitter is necessary which radiates two sidebands. Therefore, we need for television a communication band of about 1,000,000 cycles (1,000 kc.) a band 100 times as broad as used by broadcasting transmitters. With this fact in mind, it seems advisable to work a few years with a television system natural only to 84 per cent, because a 240-line television picture (natural to 97 per cent), necessitates a frequency band of 2,000,000 cycles (2,000 kc.).

(This most interesting discussion will be concluded in a forthcoming issue.—Editor)

NEW "1-TUBE" ALL-WAVE BATTERY SET

(*Continued from page* 609)

the regeneration control. A double-pole switch is used. One turns off the filament current, the other disconnects the "B" battery, thus removing all battery drain when the set is not used.

COIL WINDING DATA

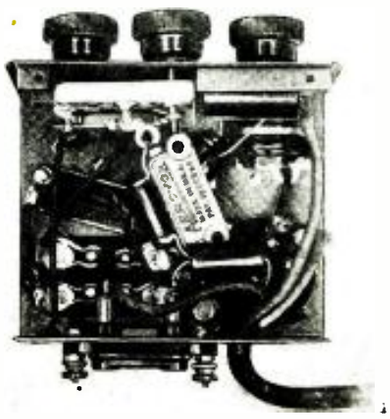
The coils are wound on small 4-prong forms, 1⅜ in. diameter and 1⅛ in. long. Coils A, B, and C are wound with No. 25 D.S.C. wire, and coil D with No. 30 D.S.C. wire. The bottom winding is put on first and connected to the two heavy prongs, and then the top winding to the two thin prongs. Turns: A—2¾-7¾; B—6¾-7¾; C—17¾-8¾; D—38¾-11¼.

Accessories needed are a type 19 tube, a pair of sensitive phones, and an antenna. The antenna may be an ordinary single wire antenna, high and clear of near-by buildings, trees, etc., about 35 to 75 feet long. It should be well insulated so that there will be no possibility of the antenna wire or lead-in grounding at any point. Batteries needed are but two dry cells and two 45 volt "B" batteries.

LIST OF PARTS

One 6-prong socket, 19;
One 4-prong socket;
One 50,000 ohm potentiometer, with D.P.S.T. switch;
One Harrison dial drive;
One Harrison dial scale;
One variable condenser, 140 mmf.;
Two 200 mmf. condensers;
One 5 megohm resistor;
One .01 mf. condenser;
One 10,000 ohm resistor;
One .1 mf. condenser;
One 1 megohm resistor;
Three knobs;
One 100 mmf. antenna coupling condenser;
One speaker jack;
One extruded washer;
Two knurled nuts.

Underside (above) and rear (below) views of the 1-tube all-wave battery set.



NEW NATIONAL WIREPHOTO SERVICE

(*Continued from page* 591)

ing plane from South America, a picture of yesterday's flood damage in Panama. The control station knows of other pictures which will be coming along as the day's events unfold, but meanwhile it schedules the order of sending for those awaiting transmission. New York, it decides, will send the European picture; Detroit, St. Louis and Miami will follow in order with theirs.

Before New York begins to send a picture it transmits for a few seconds, onto the line and into each receiving station, an amount of power corresponding to the lightest and darkest parts of the picture. Each point adjusts its power to the receiving equipment at the proper value for those two limits, knowing that the receiving machine, when adjusted to receive the two extremes of light and darkness in the print, will handle normally all the intervening shades.

All this has taken less than ten minutes, or has been accomplished in two or three minutes if an important picture was ready to send. Then the signal from the bay of the sending station —three interruptions of power—tells every point to press the button on its receiving equipment, operating the relays which prepare the circuits to start. A few seconds later a smaller button is pressed on the sending machine, starting in the same instant every receiving machine along the line.

A cylinder on the receiving machine at every station, 17 in. long and 12 ins. in circumference, has been loaded with a negative upon which can be received a picture of any dimensions up to 11 x 17 in. (the size of half a newspaper page). The negative is fastened around the cylinder and enclosed in a light-proof container.

This negative is then exposed to light from a lamp focused through an aperture .01-in. wide, which opens little or much according to the strength of the current caused by the picture on the sending machine. Where the portion of the incoming picture is very black the aperture which admits light to the negative is nearly closed; where very white, the aperture is almost open.

At the end of the picture the receiving machine automatically cuts off. The cylinder is lifted off and taken to a darkroom a step away, where the light-proof container is unlatched and the negative removed and developed. If the picture transmitted was of maximum size, reception took 17 minutes.

Development of the negative takes 5 more.

As soon as New York has sent its picture, Detroit becomes the sending station to transmit its fire photo. As soon as the operators in the other 23 cities have lifted the cylinders with the exposed negatives off their receiving machines, they put on another loaded cylinder.

But perhaps before Detroit begins to send, Cleveland comes in on the talking circuit and schedules two strike pictures of prime news value, taken a few minutes before. If the editor in charge at the control station decides that these are of greater news importance than the pictures awaiting transmission at Detroit, St. Louis and Miami, he may tell Cleveland to send its photos at once, and direct the other stations to follow it.

Thus through the day and night the schedules constantly change. Fresh pictures are available as the world wags, and the control station constantly rearranges the order of sending in accordance with the breaking of the news, putting this photo ahead, holding that back, bringing to the entire country the day's news in pictures in order of interest.

As the news day reaches its peak this becomes a more exacting task, but while the pressure increases the machines are rolling steadily, in perfect synchronism, delivering the pictures while the chattering automatic printers close at hand deliver the news.

On important and continuing stories there come every few hours fresher and later pictures, keeping abreast of the news, so that pictures which were news in the forenoon may have been superseded at midafternoon by subsequent shots showing developments which occurred in the meantime.

For 16 hours a day, on normal days, the wirephoto machines will function, delivering in that time enough pictures—60 odd at a minimum—to enable newspaper editors to choose those which most appeal to their readers.

If big news is breaking, and important picture news is on tap outside the regular hours of operation, the wirephoto service can be kept functioning, or set into motion at a moment's notice, to meet any emergency. For like any loyal reporter it knows no hours and asks no let-up when a big story is running.

THE TECHNICAL ASPECTS

Those whose hobby is electricity will delight in studying the advanced science of telephotography represented in the wirephoto service.

A positive print wrapped around the sending machine cylinder is scanned in strips .01-in. wide by means of a light beam focused first on a light valve aperture similar in all respects to the light valves used in sound picture work. The light valve chops the beam at a frequency of 2,400 cycles, passing a pulsating beam which is turned through 90 degrees to focus sharply on the surface of the picture. The light beam travels horizontally at an inch a minute. The cylinder, rotating at 100 revolutions a minute, is approximately 12 in. in diameter, thus giving a scanning area speed of more than 11 sq. in. a minute. Since the light reflected from the picture surface is proportional to the tone density of the surface, the pulsating beam is thereby modulated with the tone values of the picture before reflection to a photo-cell of the gas-filled cesium-oxide-on-silver type.

The optical system is made up of a condenser lens to focus the beam on the light valve aperture and an objective for focusing the pulsating beam onto the picture surface. Turning through 90 degrees is accomplished with a small stainless steel mirror, and parabolic surfaces also of stainless steel gather reflected light from the picture for passage to the photo-cell.

The light valve itself is an aperture .01-in. square with two parallel duralumin ribbons, .006-in. wide and .0005-in. thick, partially covering it and connected at one end to form a loop. A magnetic field at right angles to the plane of the ribbons, furnished by two permanent magnets, and a 2,400-cycle current through the ribbons furnishes the shutter action. As the ribbons vibrate on their inward swing the aperture is closed, and on their outward swing the aperture is opened.

Due to the small quantity of light that strikes the photo-cell cathode, its output is extremely low, and a 3-tube dry-cell amplifier having a gain of 77 db. is used to step up the power to a usable quantity for use on the network. Proper filters eliminate possible extraneous frequencies, and equalizers to eliminate frequency distortion are inserted following the high-gain amplifier.

A single-tube amplifier, having variable attenuators, furnishes the regulation necessary just before passing the power to the line.

The normal maximum line power is one milliwatt. That value represents maximum reflected light to the photo-cell, or the maximum highlight of the positive print. The minimum output is adjusted to 14 db. below maximum, the proper value being attained by inserting an adjustable mirror in the path of the light beam before it strikes the picture surface and cutting into the beam just a sufficient amount to send directly to the photo-cell the minimum light required to get the 14-db. contrast between the maximum and minimum representing respectively the lightest and darkest tones in the picture.

On the network, the overall gain is kept constant by automatic regulators which remain inoperative during the transmission of a picture. They do their work during the intervals between transmissions, compensating for progressive atmospheric and other conditions that must be contended with on a 10,000-mile network of wire.

THE RECEIVER

At the receiving stations the incoming power is regulated by a variable output amplifier similar to that in the sending circuit, after which it is sent through a full-wave rectifier and filters which eliminate the 2,400-cycle carrier, leaving the fluctuating direct current representing the modulation or the actual tone variation of the picture. This varying direct current is used to operate a duralumin ribbon shutter on the light valve of the receiving machine to vary the exposure of a negative, enclosed in a light-proof container on which the picture is received.

The principle of operation of the receiving light valve is similar to that of the sending light valve except that only one ribbon is used. It is caused to move by the fluctuating direct current representing the tone variations in the picture, and not by a constant frequency. This ribbon is tuned to the rather high natural frequency of 1,200 cycles, and suitably damped so that all movement of it is forced vibration caused by the incoming picture signal. In this ribbon circuit is a tuned equalizer which prevents unwanted or transient vibrations.

By varying the side motion of the receiving light valve ribbon, the opening through which the light reaches the film is varied proportionately, thus obtaining film exposure in exact proportion to the original tone values of the print on the sending machine. This light beam is adjustable in width, so that the exposure lines may be made to merge and be practically invisible on the finished print.

SCANNING AND POWER SUPPLY

The scanning of the negative is exactly at the same rate as the scanning of the print by the sending machine, the cylinders rotating at the same speed and the beam moving horizontally at the same rate.

Constant rotational speed for all motors within extremely small limits is obtained in a rather unusual manner. A controlled oscillating circuit, maintained by a tuning fork kept at constant temperature, furnishes 300-cycle power. Part of the power in this circuit is used in connection with an overloaded tube and filters, to supply the 2,400-cycle carrier for the sending light valve. Part of the power is fed to the grids of a 2-tube phase detector. Mounted on the same shaft as the cylinder driving motor is a 300-cycle inductor generator which feeds the plates of the phase detector. The tubes act as a full-wave rectifier to control the output of other tubes which furnish current for the driving motors, which are separately excited, 300-cycle synchronous units.

The output of the tubes furnishing power to the motors is dependent upon the phase relationship of the 300 cycles from fork and inductor generator. By suitable circuits the speed of the driving motors is thus kept at 100 revolutions per minute within one part in 300,000. The fork is sealed in a container, the temperature of which is kept constant by a tube-controlled thermostat.

A constant power source is obtained from small generators suitably filtered with electrolytic condensers and storage batteries.

●

HOW TO MAKE A GRID-GLOW TUBE CONTROL UNIT

(*Continued from page* 597)

voltage on the grid will flash the tube at the same frequency, and if these flashes are synchronized with rapidly turning machinery, the latter will appear to be stationary or nearly so, and its action may be analyzed.

If a condenser discharge through the tube be controlled by a feed-back to the grid, the plate current will pulsate at a regular frequency. These pulsations will induce A.C. in the secondary of a transformer whose primary is connected in the plate circuit. This forms the simplest type of single tube "inverter" or device for changing D.C. to A.C.

Other applications of the grid-controlled rectifier are appearing almost daily,—spot welding control, time delay relays, cable testing, voltage regulation, theater and highway lighting, and many others. With this control unit you can test these ideas for yourself, and develop new ones of your own.

LIST OF PARTS

One General Transformer filament transformer giving 2.5 volts, 7 amp. and 5 volts, 1 amp. (If Thyratron FG-17 is used filament requirements are 2.5 volts, 5 amp.);

One bell ringing transformer with 6-8 volt secondary;

One Aerovox 0.5-mf. 400 volt condenser (paper type), C1;

One 1RC high resistance carbon rheostat, R1;

One IRC 100,000 ohm 2 watt, carbon resistor, R2;

One 40-watt, or smaller, 110-volt lamp (Note: use of carbon filament lamp will reduce current surges in the plate circuit), R3;

One D.P.D.T. jack switch, with neutral position, SW1;

One S.P.S.T. toggle switch, SW2;

One Radio City AC voltmeter, 0-3 volts (optional), V;

Four binding posts;

One grid-glow tube socket;

One porcelain lamp receptacle.

●

A 10 TO 600 METER 3-TUBE A.C.-D.C. KIT SET

(*Continued from page* 609)

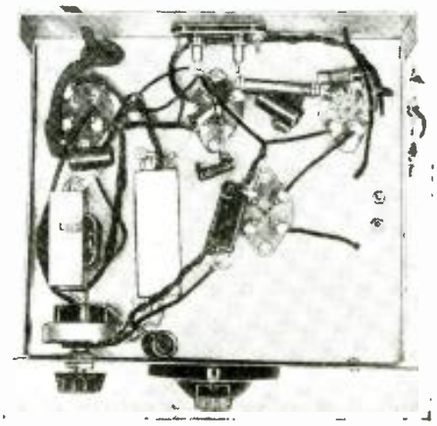
amplifier stage. Resistance coupling is again employed to the second stage which uses the type 76 tube. A type 1V tube functions as a half-wave rectifier, and the filaments of all tubes are connected in series in the usual A.C.-D.C. arrangement. The result is a screen-grid regenerative detector, two stage audio frequency amplifier, rectifier and complete built-in power supply. No external power pack or batteries are necessary.

Unit C1 is an antenna series condenser having a capacity range of about 6-70 mmf. Gridleak-condenser detection is used, values of 5 meg. and 100 mmf. respectively, being satisfactory. The large value of gridleak results in a high level of sensitivity. Feedback occurs between the coils L1 and L2 both of which are wound upon the same form. Regeneration is controlled by means of the potentiometer R2 which varies the screen-grid voltage of the 6F7 tube.

The plate resistance of the RF pentode section of the 6F7 is quite high, hence it is necessary to use a large value of plate resistor in order to take full advantage of the high gain possibilities of this type of tube. A value in the neighborhood of 12-megohms is satisfactory.

This receiver has given unusually good results both on the short-wave and broadcast bands. Foreign stations come in with excellent headphone volume. The volume on many of the near-by broadcast stations is ample for a good magnetic loudspeaker.

Under-chassis view of 10-600 meter receiver.



THE LATEST RADIO EQUIPMENT

(*Continued from page 602*)

NEW "DRY-CELL BATTERIES" (683)

(Burgess Battery Co.)

RECOGNIZING the desirability of producing batteries in which the electrical capacity is confined to small space and reduced weight, the engineers of a well-known battery manufacturer have developed a new type of 1½-volt *battery*, known to the "trade" as the Little Six.

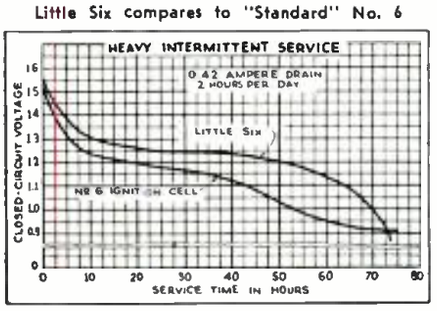
This battery is a combination of dry units of the size known as "F" cells, carefully manufactured and selected for maximum uniformity. Four of these cells are used—they are connected in parallel.

The rated voltage of the battery is, consequently, only 1.5 volts! The rated capacity is 40 watt hours—i.e., under typical conditions of discharge, for which the battery is designed, the Little Six will deliver 40 ampere hours of service at an average potential of one volt. It is, therefore, the electrical equivalent of the standard No. 6 cell, though *it is 30 per cent smaller and 40 per cent lighter than the latter!*

The new *batteries* may be used wherever No. 6 *cells* are called for and, because they are smaller, lighter, leakproof and because they maintain a higher average working voltage as shown by the typical discharge curve illustrated on the graph on this page. Figure 1, they will, without doubt, find extensive use in portable radio receivers, broadcasting equipment, telephone and telegraph lines, inter-office communication systems, railroad speeders, electric clocks, alarm devices and the myriad of other applications calling for dry cells.

It is interesting to consider that it is technically correct to call this new battery a "battery," as it is not a single "cell" like the No. 6, but actually comprises four individual cells in one small, neat container.

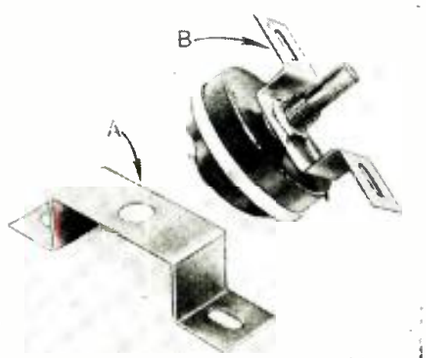
Little Six compares to "Standard" No. 6



MERCURY

Above, New Mercury Six Switch, No. 684

Below, adjustable Resistor Mounting, No. 685



As a companion to the Little Six, a 6-volt battery—being, in effect, four of the above batteries in series—has been introduced, also. This unit is provided with a metal container like previous 6-volt ignition batteries.

MERCURY SWITCHES FOR AUTOMATIC CONTROL (684)

FOR many forms of automatic control, switches of the mercury tilting type are unexcelled. This line of switches (including as standard, items rated from 200 W. to 4,000 W.) offers wide choice of types. Inert gases sealed within the tubes, stifle the arc instantly. There is entire absence of oxidation and corrosion. The switches operate silently and require no attention after original installation.

ADJUSTABLE MOUNTING BRACKETS (685)

TWO useful brackets for mounting potentiometers, volume controls and other small parts, are available. They have two features of especial merit. The mounting holes and foot-holes are slotted, to compensate for panel-hole variations. The metal of which they are made, while stiff, can be bent to compensate for different depth measurements of shafts. It would seem that a collection of these items ought to be real handy for every Service Man and experimenter.

CHUCKKER CONTEST AWARD

Freed's Radio Co., Philadelphia, Pa., recently concluded a contest among service men. Of the many answers received from all parts of the country, Paul G. Freed decided that the answer from Mr. J. N. Cole, Rutherford, Tennessee, deserved the prize. The idea, of course, was to sell more "Chuckkers," and nobody can object to that ambition. The Chuckker (RADIO-CRAFT, August, 1934, page 103) is a first-rate tool for service men. The prize was a Weston Tube Checker.

HOW TO MAKE A "1-TUBE" BATTERY-TYPE SUPERHETERODYNE

(*Continued from page* 606)

or the primary of an A.F. transformer (for matching into a stage or two of A.F. amplification).

The 6F7 is, as the code number signifies, a 6 V. tube. It may be operated from a 6 V. battery, as shown in the photographic illustration, or the filament ("heater") circuit may be powered from a 110 V. A.C. source by means of a step-down transformer. In the latter case, instead of using batteries for the "B" supply, a "B" eliminator could be used. However, the small "B" requirements of this set are best met with a battery supply, we believe.

Oh yes, by the way! The method used to secure first-detector regeneration without appreciably affecting the tuning, or causing sufficient radiation to affect a sensitive receiver a short distance away, is worth mentioning. Perhaps the circuit has appeared elsewhere, but we credit Scott-Taggert with the "screen-grid regeneration" used in this set; it is this connection (see RADIO-CRAFT, February, 1935, International Radio Review department, page 469), in essence, with which Johnny S.-T. climaxes, in his new "S.T.600" receiver, 20 years of radio designing! This form of regeneration results in much more stable feedback than can be obtained with plate-circuit regeneration.

The second-detector regeneration takes place at a fixed frequency (the I.F.), and consequently is quite stable.

Coil T is made by winding about 55 turns of No. 36 enameled wire on a form 11/16-in. in dia. Slip the wire off the form, cover with a single layer of adhesive or friction tape, and prepare to drop the coil inside, and about halfway down the length of L1. With headphones temporarily placed in the pentode-plate circuit, place T on top of L1 and note whether regeneration can be obtained at some point in the tuning range; if the characteristic hiss is not obtained, "flop" (turnover) coil T. Having secured regeneration, with R1 set for maximum regeneration, gently push T down toward its final position (horizontal with the baseboard) in the center of L1.

LIST OF PARTS

One RCA, Ken-Rad or Sylvania type 6F7 multi-purpose tube;

One Gen-Win 456 kc. 1-tube superhet. coil kit;

One Hammarlund, 2-gang variable condenser, with trimmers, C1-C2-C;

Two Hammarlund padding condensers, 140 mmf. (each), C3; (A single unit of twice this capacity may be used.);

One Cornell-Dubilier fixed condenser, 500 mmf., C6;

One Bud fixed condenser, 0.1-mf., C7;

Two Radio Trading Co. fixed condensers (with grid-leak mountings), 250 mmf., C8, C9;

One Aerovox fixed condenser, 100 mmf., C10;

One Aerovox fixed condenser, .001-mf., C11;

One Tobe Deutschmann fixed condenser, 2 mf. (paper), C12;

One CRL or Electrad volume-control potentiometer, 50,000 ohms, R1;

One CRL or Electrad volume-control potentiometer, 0.1-meg., R2;

Two Radio Trading Co. plunger-type grid-leaks, 0-20 megs., R3, R4;

One Hammarlund R.F. choke, R.F.C.;

Eight fahnestock clips (GROUND is not shown in the photo; ground connects to "B—");

One 6-volt "A" supply;

Two small 45-volt "B" batteries (at least one battery tapped at 22½ V.);

Three knobs (for C1-C2-C, R1 and R2);

One pair headphones, Blan Radio Man, Inc.

One wooden baseboard, 16x11½x¾-in.

OPERATING NOTES

(*From page* 604)

So I made the change as shown in the diagram, Fig. 3, A and B. A 10,000 ohm potentiometer was substituted for the old volume control; a fixed screen-grid voltage was put on the screen by substituting a wire-wound resistor for the old volume control; a bleeder was hooked to one end of the volume control and the aerial to the other. When new 35's were placed in the R.F. sockets, the thing worked perfectly.

JIM KIRK

THE LISTENING POST

(*Continued from page 599*)

sideration of a DX receiver, by all means find out if it is practical to install headphones in the particular model you have under consideration.

(6) *Is the main tuning dial so calibrated that you can depend upon finding a station at, or close to its stated frequency?* This is a most essential feature and it is indeed surprising to note how many receivers run off as much as 1000 kc., or even more at some place on the dial. See that the receiver you buy is at least reasonably accurate throughout the scale.

(7) *Does the receiver provide for the use of the doublet, or double-doublet type of antenna?* These two types of antennas have been found, as a result of numerous tests, to be most nearly adapted for all-wave reception. The superior results that will be obtained from a good antenna cannot be overestimated.

(8) *Does the receiver have a smooth, and well-graduated tone-control?* A tone control should be incorporated that will give you a deep mellow tone when turned to the base pitch position, a natural realistic tone when turned to about middle position, and a high grade of voice intelligibility when turned to high pitch position.

Although the receiver you finally select may not have all of these features, at least the main ones should be incorporated, so that you may be assured of not only full value for your money, but that you may have a receiver that will be suitable for DX work, and at the same time one which will also still be practical for ordinary home program enjoyment.

WHAT TO LISTEN FOR DURING MARCH-APRIL

Broadcast Band

March is the best time of the year, as a rule, to log and enjoy reception from stations in the Southern Hemisphere, especially those from Australia, and New Zealand. We prophesy that this March will bring the greatest period of successful reception yet from the stations "down and under." This will be partly due to the more powerful stations now in operation in these countries, and to a certain extent due to the ever-increasing perfection of receiving sets. More knowledge is now available also on just how, and when, to tune in these stations.

Reception of European stations will practically be over until next fall, except in Maine, Nova Scotia, and Newfoundland where the season sometimes lasts for a full month longer.

South American stations will be good over the whole continent of North America during March, and should provide mighty good hunting. Some of the larger South American stations are in fact so well heard now that they at times completely blot out U.S. stations on the same channel. This is partially due to the increase to super-power of a number of our Argentine friends.

Reception of Japanese and Chinese stations will continue good on the Pacific coast throughout March.

April will mark the decline of all broadcast band signals, although I have known April to yield a number of excellent DX-ing nights. Spring rains, however, with the attendant spring static will be upon us, and this is a signal for most DX-ers to close the broadcast band log for the season, and turn their attention to the higher frequencies (short waves) which will be getting better, and better as "Old Sol" climbs higher and higher in the sky.

SPECIAL BROADCAST FROM XGOD, CHINA

In an unusual and interesting dispatch from radio station XGOD of Hangchow, China, Mr. E. Pan, chief engineer of the station writes that XGOD will arrange some special programs for North American radio listeners on March 15 and March 16, from 4:30 to 6:30 a.m. C.S.T. on each day. In his own inimitable language Mr. Pan states: "And expect very much to hear from you as soon as the programs have been transmitted." Reports should be addressed to radio station XGOD, Telephone Administration, Chekiang Provincial Government, Hangchow, China. XGOD broadcasts on a frequency of

960 kc., with a power of 1000 watts. XGOD has been reported by a number of listeners on the Pacific coast recently.

MYSTERY SOLVED

For some weeks listeners on the Pacific coast have been mystified by a new and apparently powerful broadcasting station on about 560 kc. This station has now been definitely established as the new government super-power 100 kw. broadcast station located at Hsingking, Manchuokuo.

LIST OF BROADCASTING STATIONS OPERATED IN BUENOS AIRES

Call	Name of Station	Wavelength	KC.	KW.
LS10	Radio America	508.5	590	2.87
LS3	Radio Mayo	476.2	630	5.07
LS4	Radio Portena	447.8	670	5.09
LS1	Radio Municipal	422.5	710	5.
LR10	Radio Cultura	379.7	790	11.05
LR5	Radio Excelsior	361.4	830	30.
LR6	Radio La Nacion	341.8	870	39.
LR2	Radio Argentina	329.7	910	9.62
LR3	Radio Belgrano	315.8	950	13.9
LR4	Radio Splendid	303.	990	15.96
LR9	Radio Fenix	291.3	1030	3.88
LR1	Radio El Mundo (New Station)	280	1070	
LS5	Radio Rivadavia	270.3	1110	5.06
LR8	Radio Paris	260.9	1150	3.54
LS2	Radio Prieto	252.1	1190	30.
LS8	Radio Stentor	243.9	1230	15.46
LS9	Radio La Voz del Aire	236.2	1270	3.
LS6	Radio del Pueblo	222.2	1350	4.

NOTE: I take especial pleasure in presenting this list through the courtesy of Mr. Alberto Dougall, owner of Radio Excelsior, Station LR5, Buenos Aires. It is an absolutely accurate and authentic list of Buenos Aires broadcasting stations corrected to the date of writing. This is the first list to give the increased power of LR6, the station which is causing such interference with WENR in the evenings.—Ed.

●

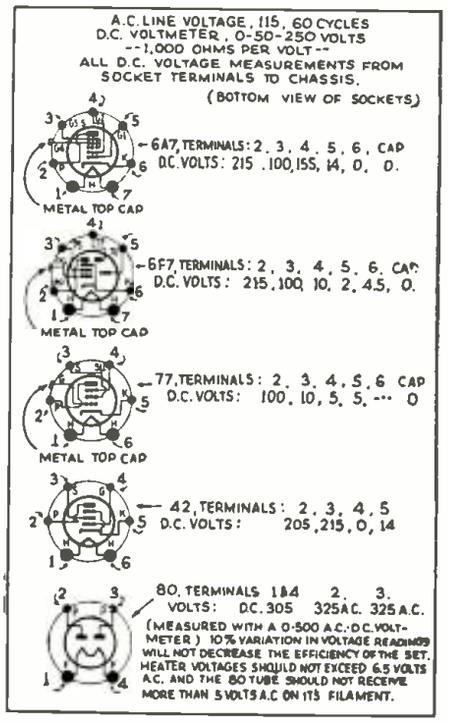
BUILD THIS 5-TUBE ALL-STAR "JUNIOR"

(*Continued from page* 598)

where it comes through the chassis will prevent wear on the wire at this point.

You are now ready for FIG. 3. A systematic method to complete this portion of the wiring is to install all of the condensers (except C1, which mounts last), and then the resistors.

Tube voltages and connections for All-Star, Jr.



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●

AN ELECTRONIC "PARTY" TREASURE HUNT

(Continued from page 587)

shows the closet effect. Immediately before the door opens the room is dark, except for the roaming flashlights. Then the photo-flash lamp blinds every one and the treasure is exposed. Much depends upon the effect you create, so fix it up well! Details of the figure are shown in Fig. 3. Here again you can use your originality. Flashlight bulbs, painted red, project from the eyes.

The door latch shouldn't prove difficult. Follow the kink in Fig. 5. The solenoid to operate the plunger is made as follows: Get a ¼-in. carriage bolt and cut it to 4 ins. in length. Slot one end for ½-in. and drill a ⅛-in. hole through the slot. Cut the latch in the shape shown in Fig. 5 and secure the bolt to it loosely with a cotter pin.

The coil is wound on a ⅜-in. form, 4 ins. long. Use round wooden or fibre end pieces 1⅝ ins. in diameter. Wind on 600 turns (in layers) of No. 20 enamelled wire. The door hook is the kind used to hold up curtain rods.

A skeleton or skull painted on a piece of white cloth, mounted on a wooden frame outside a window and illuminated by two or more 3 V. lamps gives a startling effect when seen from a dark room.

THE CONTROL ROOM

You will want to share in the fun, so the room selected for the party must have a window opening into another room, or better yet, a glass door. The room next to the party room is where you make your headquarters. Of course it must be completely dark, with curtains on your side (and locked!). Set up your table with the relay, switches, amplifier, and batteries in a convenient position. A hole in the curtain or peeping through the drapes affords means of seeing what is going on. If you want to add an additional control you can use a cheap microphone to the family radio receiver's audio system and broadcast ghost effects into the party room. It adds one more thrill!

RUNNING THE WIRING

The main point to remember in wiring up the job is to conceal every wire and device as completely as possible. Under no circumstances must it look like an electrical laboratory! (See Fig. 1.) Use fine wire for the photo-cell wiring, (No. 30 is large enough) and run it behind mouldings, under carpets—any way to keep it out of sight.

The switches may be manipulated in any combination you desire. Of course switch No. 3 can be used at any time to operate the devices selected by Switch No. 2, without using the photo-cells. This makes a highly flexible arrangement with a large number of combinations. Practice until you know just how every part works—and you are ready for the party!

THE KNOWN FREQUENCY SPECTRUMS

(*Continued from page 607*)

are discussed. One Angstrom unit is equal to .0000000001 or 10^{-10} meter. In Angstrom units the wavelength of violet light would be 3,300 units. The wavelength of yellow light which is in the center of the visible spectrum is 5,900 Angstorm units or about 1/100 the diameter of the average human hair.

THE INVISIBLE SPECTRUM

If we proceed to wavelengths shorter than 3,300 Angstrom units we advance into the invisible ultra-violet region and if we proceed in the opposite direction we advance into the invisible infra-red region. Included in the latter region are the heat rays such as those radiated by the sun, or other hot bodies. *The radiations of light and heat are similar.* (Conclusive evidence of this similarity is furnished by the fact that heat radiations obey the same laws of reflection, refraction, polarization, and interference as light radiations.) *The* apparent *difference merely arises in the different manner in which they affect our senses.*

INFRA-RED RAYS

When a solid object, such as a horseshoe, is heated, it glows at first with a dull red heat, then as it gets hotter it becomes bright orange, and then yellow. The act of heating it up causes it to emit radiations, and the hotter it becomes, the shorter are the emitted waves. We may say that, as an object gets hotter, its radiation moves along the spectrum in the direction of shorter and shorter waves. We do not begin to see the object by its own light until its radiation has passed into the visible part of the spectrum, but long before this stage is reached, it is giving out radiation in the infra-red part of the spectrum. Our skins, but not our eyes, are sensitive to this radiation. If we hold our hand near a hot horseshoe, we shall feel its radiation long before it can be seen. Ordinary photographic plates are not affected either by infra-red or by red light. For this reason red light can be used in a photographic dark room without damaging the sensitized plates.

Although the human eye cannot detect waves outside of the visible spectrum, the presence of ultra-violet and infra-red radiations can be easily detected by means of photographic plates. Ordinary photographic plates are sensitive to ultra-violet radiations but not to infra-red. Photographic plates with special emulsions are sensitive to infra-red radiations. If an ordinary electric flatiron is stood on its end and heated in a dark room by means of the electric current passing through the iron, no form of radiation from the flat surface of the iron is visible to the eye. But if a camera equipped with a special photographic plate is focused on the flat-iron and exposed to the infra-red radiations, *a negative of the flatiron is obtained.* (A soldering iron produces a similar effect.)

ULTRA-VIOLET RAYS AND OTHER "SUPER-VISUAL" FREQUENCIES

If one color of light is half the wavelength of another, the light having the shorter wavelength is said to be an octave higher in pitch. Violet light is just half the wavelength of red light so it is said that violet light is an octave higher in pitch. *The human eye can see all that lies within only one octave.*

However, scientists have found means of studying as many as 64 octaves. About 10 octaves above the octave of visible light, the X-rays are found. Light substances are more transparent to these than dense substances, so that when an object containing both light and dense substances is subjected to these X-rays the denser substances cast deeper shadows than the lighter ones. Because of this property a surgeon can use these rays to photograph bones through flesh.

Above these radiations come the gamma rays which are emitted by radium, and finally, 32 octaves above the octave of visible light, come

certain of the constituents of cosmic rays, possessing such an extraordinary penetrating power that they can pass through many feet of lead and have been detected 800 feet below the surface of Lake Constance (Switzerland).

"SUB-VISUAL" FREQUENCIES AND RADIO WAVES

Proceeding from the infra-red radiations in the other direction, we advance to the ultra-short radio waves of a fraction of a centimeter (one centimeter = 0.3937 in.) wavelength. Still proceeding we enter the region of the so-called "short waves," then the broadcasting waves, and then the long waves used for government and transoceanic communication. The ultra-short waves can be directed, reflected, and polarized like light waves. The long waves follow the curvature of the earth's surface while the short waves radiate skyward and are reflected back to earth by an ionized gas layer far above the earth (about 70 miles), known as the Kennelly-Heaviside Layer. For convenience the ether spectrum has been enlarged, Fig. 2, to show the positions of the various services in the radio portion of the spectrum.

Returning to the audible spectrum, shown as Fig. 1B, the ear is capable of hearing sounds ranging from about 16 to approximately 20,000 frequencies or vibrations per second. Some of us only hear up to 12,000 vibrations per second. Thus the middle C string of a piano vibrates 256 times per second but in addition to this "fundamental" or "note" also vibrates at higher frequencies or overtones which give the sound the distinguishing characteristic—the "timbre"—associated with a piano. The piano includes a little over 7 octaves, the lowest note having about 26 vibrations or cycles per second and the highest note 4,096 cycles. Each note contains the fundamental and many harmonic overtones. Harmonics at least as high as the 8th, that is 8 times the fundamental frequency, play an important part in determining the tone of a piano. The seventh harmonic, which produces a rough and discordant tone, is carefully eliminated by hammers, covered with felt and placed at strategic places along the wire, which strike the wire and prevent it from vibrating at the unwanted frequency. (It is the harmonics that produce the characteristic tone of the piano and differentiate it from a harp or violin.)

The difference in human voices also is due to a difference in the range of fundamental *notes*, and the *tone* as determined by the number and proportionate strength of the overtones produced. The average male voice has a fundamental of 128 cycles per second and the average female voice 256 cycles per second; (the overtones, however, extend to nearly the end of the audio spectrum).

Not so many years ago, large gaps existed in the frequency spectrum but *the advancement of science has now made the spectrum continuous.* Nevertheless, there is still an opportunity to advance beyond the mystifying cosmic rays.

●

TECHNICIANS' DATA SERVICE

(*Continued from page* 616)

70. DATA SHEET ON BUILDING AN ANALYZER ADAPTER. Compiled by the Capitol Radio Research Laboratories to show Service Men how any analyzer may be brought up to date; or how to build a complete, modern analyzer out of spare parts and the use of only a multimeter.

72. HALLICRAFTERS' SKYRIDER SHORT-WAVE RECEIVERS. Descriptions of the Skyrider tuned R. F. and Super Skyrider superheterodyne short-wave receivers designed and built by Hallicrafters, Inc. Features: range of 13 to 200 meters (with broadcast or 10-meter band optional), automatic wave-change switch, continuous band-spread, built-in monitor, speaker and power supply (or batteries), high-fidelity audio, and other refinements.

73. HETRO HOME AND AUTO-RADIO RECEIVERS AND ACCESSORIES. A folder containing descriptions, illustrations, list and net prices of the Hetro Electrical Industries, line of console, phono-radio and table-model home radio receivers, auto-radio sets, phonograph automatic record changers and motors, antenna systems and D.C. converters.

ELECTRONIC TUBE ARTICLES IN RADIO-CRAFT, FEBRUARY, 1933, TO MARCH, 1935

(*Continued from page* 612)

Article	*Issue*	*Page*
A Valuable Resistor-Condenser Chart ("Reciprocal chart" which simplifies calculations)	Sept. 1933	164
And Now—The "Shoe-Button" Tube (A practical tube only ½-in high)	Oct. 1933	205
How to Make the Beginner's Pianatron (Complete how-to-make-it instructions for workable instrument)	Jan. 1934	404
Making A Diode Multimeter (Practical vacuum-tube volt-milliammeter)	Jan. 1934	412
How the Sounds of Birds are Recorded on Film and Disc	Feb. 1934	462
An Introduction to Radio Dynamics (Interesting to all experimenters)	Feb. 1934	472
A Neon-Type Electro-Musical "Trombone" (Another Unique Musical Instrument)	Mar. 1934	525
Facts About Dynatron Operation (Part I of an informative series)	Mar. 1934	535
How to Make an Inexpensive "Talkies" Sound Head	Mar. 1934	538
Facts About Dynatron Operation (Part II, conclusion)	Apr. 1934	598
Save Your Old Tube Tester (Complete data for modernizing the old one)	Apr. 1934	602
The "Polytone" (An entirely different electronic musical instrument)	May 1934	657
"Telephotophone" (More about "light beam" transmission)	May 1934	663
Soundhead Optical Systems (Their adjustment and care)	May 1934	664
Applications of the 25Z5 Voltage Doubling Tube	May 1934	666
RADIO CRAFT Table of Bias Resistor Values (A handy chart for all Service Men)	May 1934	670
Radio Device Guides the Blind (Another photoelectric cell use)	July 1934	12
The Radio Pen (Facsimile reproducer for home or office)	July 1934	13
A Radio-Controlled Boat (Actual construction of model boat)	July 1934	18
A "Syntronic" Organ (New photocell instrument with amazing possibilities)	Aug. 1934	77
The PE. Cell (Explanations of characteristics and adaptations)	Aug. 1934	86
Radio Telemechanics (An editorial by Mr. Hugo Gernsback)	Sept. 1934	133
Talk and Hear Over a Light Beam (Still another PE. cell application)	Sept. 1934	140
How to Make a "Grid-Dip" Oscillator (To complete Service Man's test equipment)	Sept. 1934	154
The Marimbalite—A Musical Instrument Utilizing Photo-cells (A light-controlled novelty for stage work)	Oct. 1934	204
Uses of a Neon-Tube Condenser Analyzer (Tube indication of leakages and shorts)	Oct. 1934	214
How to Use the New Tubes (Smoothing out the wrinkles in tube selection)	Oct. 1934	217
A Compact Tube Tester (Complete in every detail)	Oct. 1934	220
Midget Tube and Set Tester (Complete facilities for all tubes and point-to-point testing)	Oct. 1934	223
A Service Man's All-Wave Oscillator (Generates fundamentals from 100 to 21,000 kc.)	Nov. 1934	282
Latest in Television (A new idea completely portrayed)	Dec. 1934	330
3 New Tubes (Acorn (ultra-short-wave); improved 80; 6A6)	Dec. 1934	343
A Real "How-to-Build" Service Man's All-Wave Oscillator (Build your own 110 V. A.C.-D.C. job)	Jan. 1935	416
The Radio Set of 1950 (Mr. Gernsback in a startling forecast)	Feb. 1935	458
WLW's "Electric Eye" Lighting Protector (Most unique photocell application)	Feb. 1935	471
Modern Theory of Electronics—Part I	March 1935	524
Replacement Status of the New Tubes	March 1935	525
How to Read Diagrams	March 1935	526

V.T. VOLTMETERS IN RADIO-CRAFT

Article	*Issue*	*Page*
Vacuum-Tube Multi-meter (versatile instrument, measuring voltage, current, resistance, inductance and amplification)	July 1930	13
Vacuum Tube Voltmeter for Testing	Jan. 1931	393
A Gooseneck-Type V.T. Voltmeter	Feb. 1932	466
A Dynatron V.T. Voltmeter (uses 1-24 tube)	Apr. 1932	614
Using the V.T. Voltmeter	May 1932	676
A Survey of the Vacuum-Tube Voltmeter Field	Mar. 1933	544
Building an A.C. Operated V.T. Voltmeter	July 1933	30
Making a Diode Multi-meter	Jan. 1934	412

RADIO-CRAFT'S INFORMATION BUREAU

(*Continued from page* 612)

tuning condenser of the oscillator and the potentiometer, which determines the horizontal deflection of the pattern, is kept continuously in rotation by a small motor. The rate of rotation is adjusted so that the trace repeats itself eight or ten times a second, thus providing a continuous indication of the resonance curve of the high-frequency amplifier.

"Frequency comparisons are a particularly useful application of cathode-ray tubes. In comparing two frequencies by the zero-beat method, listening to them with a pair of phones, the observer may be handicapped by two difficulties.

"(1) The two oscillators, unless well isolated, may have a tendency to lock into step over a fairly wide frequency range if working into a common detector.

"(2) Beats lower than about 20 cycles per second cannot be heard. Two equal frequencies impressed respectively on the vertical and horizontal plates will result in a stationary elliptical pattern. The mutual conductance between these pairs of plates is practically nil, thus the locking-in tendency is very slight. Any motion of the pattern at all is immediately apparent so that the comparison at zero frequency difference is readily accomplished."

Text in quotation marks, courtesy The General Radio Experimenter.

REPLACEMENT STATUS OF THE NEW TUBES

(*Continued from page* 605)

cause of the 59's heater cathode. However, the 59 as a triode cannot handle as much power as the 45. The 46 triode also has less output than the 45 and, not having a heater cathode, does not make a good replacement.

47 by 2A5 or 59 Socket Differences: 47 has 5-pin base; 2A5 has 6; 59 has 7. These new tubes give more power output and, since they have heater cathodes, less hum. The 59, of course, must be connected as a pentode.

SUBSTITUTIONS AMONG THE 6.3 VOLT TYPES

Voltage Amplifiers

77 by 6C6; 39/44 or 78 by 6D6 Socket Differences: 77 and 6C6 have same socket; 39/44 has 5-pin base; 78 has 6; 6D6 has 6-pin base. These substitutions are much like the 24A-by-57 and 35-by-58 replacements in the 2.5-volt class, and the circuit changes which may be necessary are again rather extensive. If any increase in amplification is obtained, it will probably be necessary to shield the tube individually and to improve the R.F. filter system in order to suppress feedback. For the same reasons as mentioned in the previous case, it may be necessary to change the volume control, A.V.C. system, grid bias, tuning alignment, and I.F. transformer coupling.

37 by 76 Socket Differences: None. The factors involved in this change are practically the same as those mentioned in connection with the 27-by-56 replacement. In addition, the difference in grid-plate capacity means a change in neutralization when substituting in R.F. stages.

Power Amplifiers

38 or 41 by 42 Socket Differences: 38 has 5-pin base; 41 has 6; 42 has 6. In both these substitutions an output transformer with a lower turns ratio should be used. The 42 of course is to be connected as a pentode.

The substitution of new tubes for early types of battery tubes, and also for other and *miscellaneous* types (12V., 25V., 30V., etc.) will next be discussed.

FUNDAMENTAL FACTS ABOUT CATHODE-RAY TUBES

(*Continued from page* 594)

consisted of two tuning forks, a beam of light and a screen, as shown in Fig. 1.

The two forks are so placed that one vibrates in a vertical plane and the other in a horizontal plane. The beam of light received on one mirror, attached to a fork, is reflected to the other mirror, on the other fork, and then reflected once more to a point on the screen. When the first fork vibrates alone, the point on the screen is lengthened out to a vertical line. The second fork lengths the point to a horizontal line. When both forks vibrate the point describes a curve.

In essentially the same manner Lissajous figures are obtained with the cathode-ray tube, although the electron beam replaces the light source and is deflected by electrostatic and electromagnetic fields instead of the actual mechanical motion as in the case of the tuning forks.

The relation of sine-wave voltages (in an oscilloscope circuit these voltages would be applied to each set of deflecting plates of the cathode-ray tube) is shown in Fig. 2. The various phase relations are illustrated, as well as the results obtained with multiples of frequency. (It would be a good plan to memorize these figures.)

A convenient method when observing such cyclic phenomena employs a *sweep circuit* which can be adjusted easily in frequency.

The applications of the cathode-ray tube are numerous, and only a partial list is given in Table I.

(This data, and the accompanying illustrations, are published by courtesy of BROADCAST NEWS, a house organ of RCA Mfg. Co., Inc., Victor Div.—Editor)

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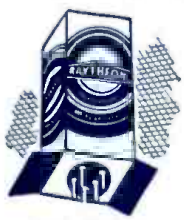

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