

B



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A Directory of Manufactured Radio Receivers
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The Eyes of a Future Air Liner

35 CENTS

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Garden City, New York

FEB 1928

Cunningham RADIO TUBES

CX326  C327



*Answer
AC
requirements
in modern
Electric*



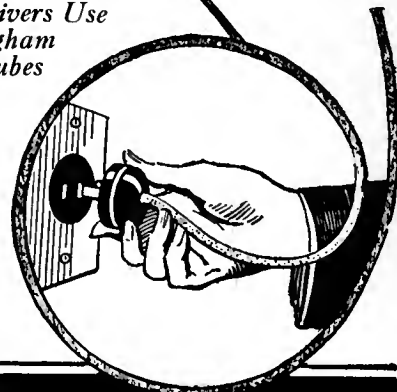
Radio Reception

THE popular demand for the latest and most improved A C power receivers calls for the latest development in A C tube construction.

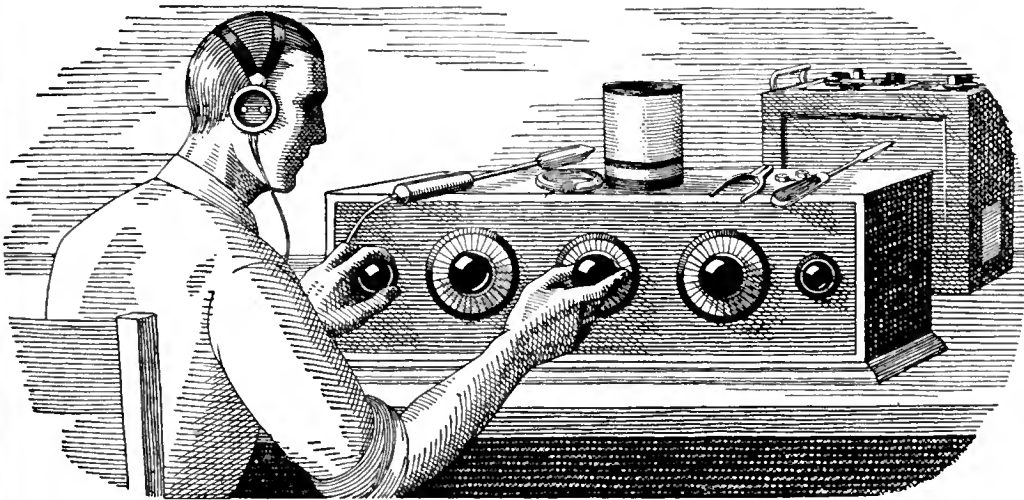
Cunningham A C tubes CX-326 and C-327 are outstanding in their performance and will bring your A C power receiver up to its highest efficiency.

See that these two tubes are doing their duty along with other Cunningham tubes in your A C Receiver.

*With A C Power
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A C Tubes*



E. T. CUNNINGHAM, Inc.
NEW YORK CHICAGO SAN FRANCISCO



If all the Radio sets I've "fooled" with in my time were piled on top of each other, they'd reach about halfway to Mars. The trouble with me was that I thought I knew so much about Radio that I really didn't know the first thing. I thought Radio was a plaything—that was all I could see in it for me.

I Thought Radio Was a Plaything

But Now My Eyes Are Opened, And I'm Making Over \$100 a Week!

\$50 a week! Man alive, just one year ago a salary that big would have been the height of my ambition.

Twelve months ago I was scrimping along on starvation wages, just barely making both ends meet. It was the same old story—a little job, a salary just as small as the job—while I myself had been dragging along in the rut so long I couldn't see over the sides.

If you'd told me a year ago that in twelve months' time I would be making \$100 and more every week in the Radio business—whew! I know I'd have thought you were crazy. But that's the sort of money I'm pulling down right now—and in the future I expect even more. Why only today—

But I'm getting ahead of my story. I was hard up a year ago because I was kidding myself, that's all—not because I had to be. I could have been holding then the same sort of job I'm holding now, if I'd only been wise to myself. If you've fooled around with Radio, but never thought of it as a serious business, maybe you're in just the same boat I was. If so, you'll want to read how my eyes were opened for me.

When broadcasting first became the rage, several years ago, I first began my dabbling with the new art of Radio. I was "nuts" about the subject, like many thousands of other fellows all over the country. And no wonder! There's a fascination—something that grabs hold of a fellow—about twirling a little knob and suddenly listening to a voice speaking a thousand miles away! Twirling it a little more and listening to the mysterious dots and dashes of steamers far at sea. Even today I get a thrill from this strange force. In those days, many times I stayed up almost the whole night trying for DX. Many times I missed supper because I couldn't be dragged away from the latest circuit I was trying out.

I never seemed to get very far with it, though. I used to read the Radio magazines and occasionally a Radio book, but I never understood the subject very clearly, and lots of things I didn't see through at all.

So, up to a year ago, I was just a dabbler—I thought Radio was a plaything. I never realized what an enormous, fast growing industry Radio had come to be—employing thousands and thousands of trained men. I usually stayed home in the evenings after

work, because I didn't make enough money to go out very much. And generally during the evening I'd tinker a little with Radio—a set of my own or some friend's. I even made a little spare change this way, which helped a lot, but I didn't know enough to go very far with such work.

And as for the idea that a splendid Radio job might be mine, if I made a little effort to prepare for it—such an idea never entered my mind. When a friend suggested it to me one year ago, I laughed at him.

"You're kidding me," I said.

"I'm not," he replied. "Take a look at this ad."

He pointed to a page ad in a magazine, an advertisement I'd seen many times but just passed up without thinking, never dreaming it applied to me. This time I read the ad carefully. It told of many big opportunities for trained men to succeed in the great new Radio field. With the advertisement was a coupon offering a big free book full of information. I sent the coupon in, and in a few days received a handsome 64-page book, printed in two colors, telling all about the opportunities in the Radio field and how a man can prepare quickly and easily at home to take advantage of these opportunities. Well, it was a revelation to me. I read the book carefully, and when I finished it I made my decision.

What's happened in the twelve months since that day, as I've already told you, seems almost like a dream to me now. For ten of those twelve months, I've had a Radio business of my own. At first, of course, I started it as a little proposition on the side, under the guidance of the National Radio Institute, the outfit that gave me my Radio training. It wasn't long before I was getting so much to do in the Radio line that I quit my measly little clerical job, and devoted my full time to my Radio business.

Since that time I've gone right on up, always under the watchful guidance of my friends at the National Radio Institute. They would have given me just as much help, too, if I had wanted to follow some other line of Radio besides building my own retail business—such as broadcasting, manufacturing, experimenting, sea operating, or any one of the score of lines they prepare you for.

And to think that until that day I sent for their eye-opening book, I'd been wailing "I never had a chance!"

Now I'm making, as I told you before, over \$100 a week. And I know the future holds even more, for Radio is one of the most progressive, fastest-growing businesses in the world today. And it's work that I like—work a man can get interested in.

Here's a real tip. You may not be as bad off as I was. But think it over—are you satisfied? Are you making enough money, at work that you like? Would you sign a contract to stay where you are now for the next ten years—making the same money? If not, you'd better be doing something about it instead of drifting.

This new Radio game is a live-wire field of golden rewards. The work, in any of the 20 different lines of Radio, is fascinating, absorbing, well paid. The National Radio Institute—oldest and largest Radio home-study school in the world—will train you inexpensively in your own home to know Radio from A to Z and to increase your earnings in the Radio field.

Take another tip—No matter what your plans are, no matter how much or how little you know about Radio—clip the coupon below and look their free book over. It is filled with interesting facts, figures, and photos, and the information it will give you is worth a few minutes of anybody's time. You will place yourself under no obligation—the book is free, and is gladly sent to anyone who wants to know about Radio. Just address J. E. Smith, President, National Radio Institute, Dept 20, Washington, D. C.

**J. E. SMITH, President,
National Radio Institute,
Dept. 20, Washington, D. C.**

Dear Mr. Smith:

Please send me your 64-page free book, printed in two colors, giving all information about the opportunities in Radio and how I can learn quickly and easily at home to take advantage of them. I understand this request places me under no obligation, and that no salesman will call on me.

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 Occupation.....

RADIO BROADCAST

FEBRUARY, 1928

WILLIS KINGSLEY WING, Editor
KEITH HENNEY
Director of the Laboratory

EOGAR H. FELIX
Contributing Editor

Vol. XII, No. 4

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AMONG OTHER THINGS. . .

WASHINGTON is distinctly the center of radio interest these days. One important conference which means much to radio all over the world is barely concluded with the closing of the International Radio Convention on November 25th when the Federal Radio Commission announces that public hearings will be held in Washington about the middle of January on the question of short-wave allocations. The thoughts of everyone have turned toward the short waves, and the Commission is very wise in holding hearings to enable some sort of ordered development to take place in these many vital channels now and in the years to come. Now in the short-wave channels are government, commercial, military, marine, naval, and amateur services. And, in addition, these channels contain some genuine experimental broadcasting stations and many more stations operating under experimental licenses which are broadcasting without any intelligent reason at all. The Commission is to be praised for its foresight in throwing this question open before it is too late.

THIS issue of RADIO BROADCAST contains articles of undoubted interest. "The Eyes of a Future Air Liner," for example, points out how radio can be applied to the present problems of air navigation. "Anonymous" cloaks the identity of an authority on radio and aviation—a man who is better qualified to write on these twin subjects than any one we know. There has been much almost hysterical writing about the wonderful possibilities of the screened-grid tube, recently announced, and precious little genuine information about actual experiment with the possibilities of this very interesting tube. The Laboratory Staff, in the article on page 282, presents actual facts about what this tube can do, highly important to every experimenter whose interests lie in this direction. . . . For the first time, too, as far as we know, the facts about output devices are related. From the story by Keith Henney on page 294 you can learn exactly what the different types are, what they will do, and how best to use each type.

REGULAR broadcasting in the New York area of photographs sent by the Cooley Rayfoto system will be established before this issue is in the hands of readers and, accordingly, we publish a story by the inventor, Austin Cooley, presenting some additional technical information about the receiver which is now available in parts form to every interested constructor. Many readers write to request their names be forwarded to the manufacturers of the essential products. Any reader who has not yet done so should address a letter to the undersigned who will forward the request to the companies concerned. Picture broadcasting is here and we prophesy that in the not too distant future great numbers of experimenters will take this field for their own, completely fascinated by it.

WE SHALL soon publish the descriptions of a remarkably inexpensive receiver using the screened-grid tube, a new receiver design by Glenn Browning, a technical description with circuit diagrams and data on the Crosley "Bandbox" set, and an interesting kit for an A-socket power supply which will furnish enough A potential for ten quarter-ampere tubes.

—WILLIS KINGSLEY WING.

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DISTANCE *lends* ENCHANTMENT

When you buy or build a radio set make sure that it has Copper Shielding. Where long distance reception is desired Copper Shielding is essential. It is a refinement to your set that will enable you to hear the programs of distant stations much more clearly.

Copper Shielded sets give:

BETTER RECEPTION
FINER SELECTIVITY
IMPROVED TONE QUALITY

By virtue of its easy working qualities and its high conductivity Copper Shielding is a decided improvement to any set.

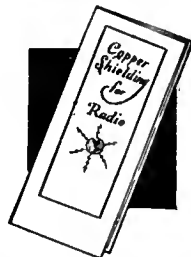
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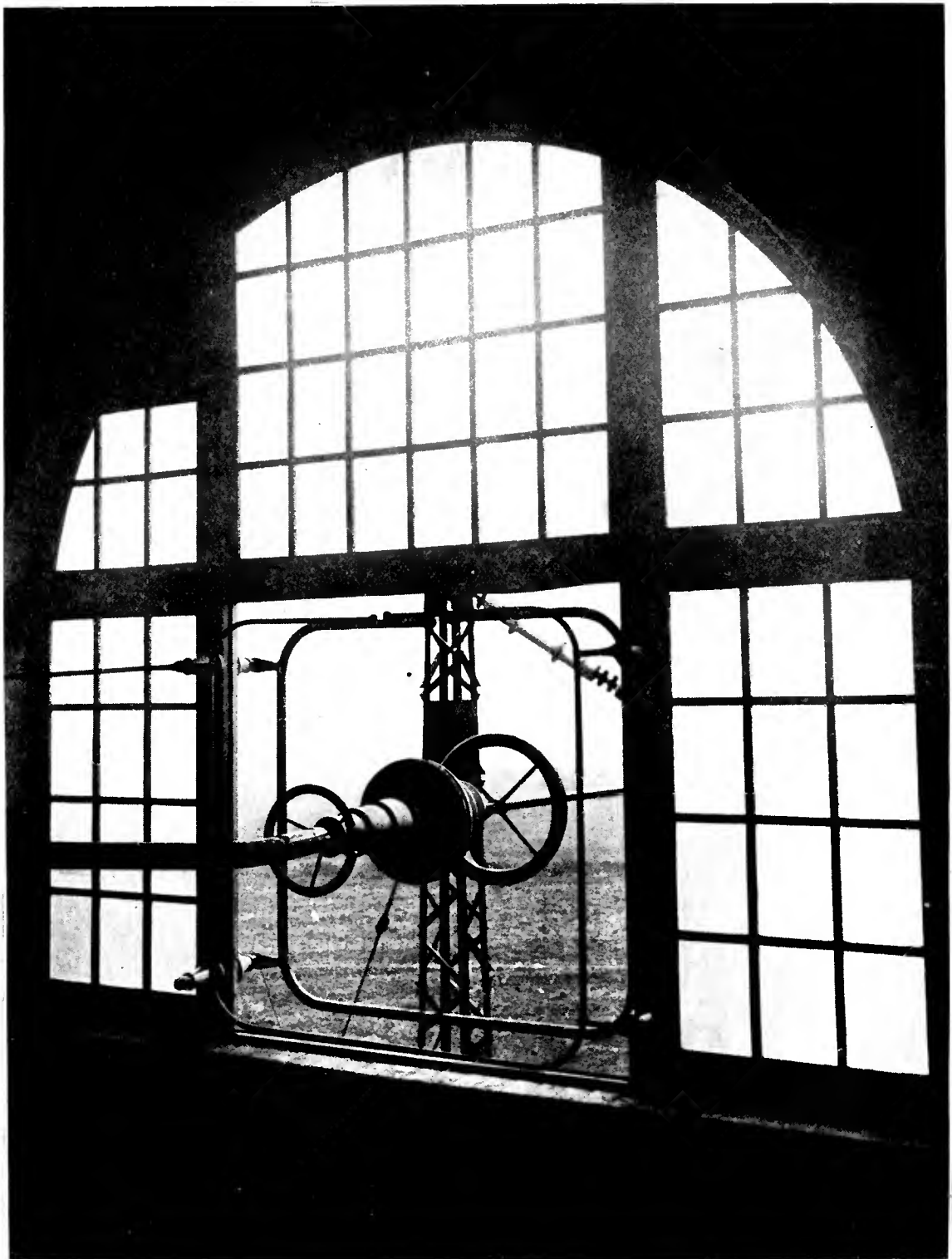
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25 Broadway, New York



*Write for your copy of this
book. There is no cost nor
obligation on your part.*





At the Rugby High-Power Station of the British Post Office

The antenna lead-in as seen from the interior of the transmitter house. This station is one of the transmitters built in England by the British Marconi Company for the British Post Office, for communication with the Dominions. The British transmitter for the transatlantic radio telephone circuit is located at Rugby and the high-power radio telegraph transmitter is used for direct communication with Australia



OUT OF TOUCH WITH THE WORLD

One need not be a meteorologist, versed in the significance of the clouds, to know what weather is ahead and below, after flying in the upper atmosphere for many hours. A simple application of modern scientific principles will supply the information to pilots out of sight of the terrain

The Eyes of the Future Air Liner

"Anonymous"

DURING one of the ill-fated attempts to fly to Hawaii this summer the short-wave signals from the radio transmitter aboard the plane were copied in New York. Entire messages were easily received and the progress of the flight followed by newspaper reporters at the receiving stations, although the power of the transmitter wasn't enough to thoroughly warm up a curling iron.

It was a dramatic occurrence. Soon after the pilot took his heavily-loaded, single-engine plane off the runway and headed it westward over an unmarked trail traveled by few, cheerful messages came flashing back telling of the progress of the flight. The confident jaunty messages continued for some time. Then suddenly came warning of disaster. "We're in a spin," was the startling and serious message. The pilot was evidently able to momentarily bring his ship out of the spin, and put it back on an even keel. But not for long for the next message announced that the plane was again in a tailspin. And that was all, the last that was ever heard from that plane. Undoubtedly, the plane, loaded to the limit, was unstable. It could not be held in level flight in a fog or clouds, and stalled, with the resultant crash to the water below. Radio told of the end.

Over 3000 miles away newspaper reporters listening to these messages were impressed with

the distance of transmission. In certain New York newspapers much was made over this feat of short-wave transmission. Reading these articles, one was ready to believe that something phenomenal in radio communication had taken place, and that the solution for problems of aircraft radio could be readily found in the use of short waves.

It is not believed that this is exactly so. Every radio amateur knows what can be done with low power on short waves. Bouncing his waves off a reflecting medium which scientists have named the Heaviside Layer, he is able to hop his signals all over the globe. He might well be something of a billiard player to properly angle his da-dit-dit-das so as to drop them on a friend's antenna perhaps on the other side of the world. But the amateur found that there were places, usually not so far away, where his waves could not be received, and other places close to him that reported considerable "fading." This much is known about short-wave transmission. But communication from plane to ground will be useless if not reliable over the entire route of flight. The "skip-effect" and the "fading" characteristic of waves much shorter than 80 meters makes their use in aircraft communication of little value. For what good will be the reception in San Francisco of a message sent by a plane flying from New York to Chicago

when the message is intended for someone in New York?

The "skip" distance, or immune zone, is known to vary with the wavelength, the time of day, the time of year, the kind of antenna, and the nature of structures surrounding the antenna. There is a great deal to be learned about short-wave transmission from an airplane before the adoption of a definite near-short wave can be decided upon. The low power required, the simplified apparatus, the light weight, small size, and cost of short-wave equipment tempts one to jump at the proposition of equipping commercial craft with these sets. But research work in this connection must be exceedingly thorough. This means that the period of research must be extended to include all conditions as to season, time of day, and kind of terrain flown over, if work with short waves is to result in anything conclusive.

Before such research is begun it would be well to make a survey of the needs of commercial aviation with regard to radio service. Let us consider this point very briefly. First of all it appears that radio can be put to at least two very good uses on regular express and passenger air lines. Some means of telling the pilot in flight what is happening to the weather along the route ahead of him as well as at his destination would seem to be very desirable. Equally

desirable would be a means for telling the pilot when he was off his course and to help him get on it again. These two are the most important requirements at the present time. Nothing need be invented to provide this assistance to aerial travel. It is but a question of application of things now known.

To see just how the two kinds of radio service mentioned might be utilized, let us use our imagination and picture an airway of the near future.

We may start where the most imagination is required and visit New York's great municipal airport. It is just dark and we have arrived in plenty of time for a glance around before we take the early evening express plane for Chicago. There are a number of planes on the "flying line." Busy mechanics are fussing around these while other mechanics and helpers push and wheel planes into and out of the huge squat hangars. Twinkling red, green, and white lights outline the boundary of the airdrome. The red lights indicate obstacles; the green lights show favorable approaches to the landing area, while the white lights show the general outline of the field. A flood light illuminates like day much of the landing area. Smaller lights flood the hangars and the concrete "aprons" between. A huge beacon flashes from a low tower on one of the hangars.

We approach the "flight office" and here we see a busy official marking up on a bulletin board news of the movement of "ships" on the various airways terminating at New York. Another official is marking the latest weather reports on a large weather map of the United States. Here we also see posted forecasts of the weather to be expected along the different airways. We read with no feeling of glee that on the route to Chicago we may expect rain, and low clouds through the mountain region, and somewhat higher clouds with

showers from Cleveland to Chicago. Anxiously we go to inquire if in view of the weather prospects the Chicago express will leave to-night. We are assured that it will, and are advised to go aboard soon, as the "take-off" will not be delayed.

Aboard the big three-engined air liner we soon find that most of the twenty seats in the cabin are already occupied. We have seats near the front fortunately, and can observe

through a doorway the controls and instruments in the pilot's cabin.

The engines have been warmed up and tested at full throttle and now are idling, the metal propellers turning over lazily, awaiting only the will of the pilot. He is getting into his seat and is talking to his mechanic in a seat at his side, when an official comes aboard to converse a moment with these members of the "crew." We are being "cleared" for Chicago. The official leaves, the doors are secured and we are off. The rumbling muffled roar settles down into a droning beat as the three engines are synchronized in speed.

Below, the twinkling lights of suburban towns glitter against the black of night. Soon, however, we leave the region of more thickly clustered lights and then we are able to pick up some of the rotating lights of marker beacons which show the way westward. They blaze a trail all the way to our destination which will be easy to follow if bad weather is not encountered.

Our attention having been directed so much below we failed to see the mechanic reel out his trailing wire antenna and tune the receiver located in front of him. Now we notice a small panel on the instrument board, just below a compass indicator. In this panel a small white light is blinking slowly—on-off, on-off, without a break. This is evidently a signal. After a time we notice other lights on this panel.

There are combinations of reds, greens, and whites, that come on for a few seconds, change, and then go out. More signals. The pilot and mechanic evidence interest but do not seem perturbed.

Looking out of the window at our side we see but a gray black nothingness faintly lighted by the illumination from the lighted cabin. We can see nothing below, and we realize that we are in clouds or fog. A large altimeter in the front wall

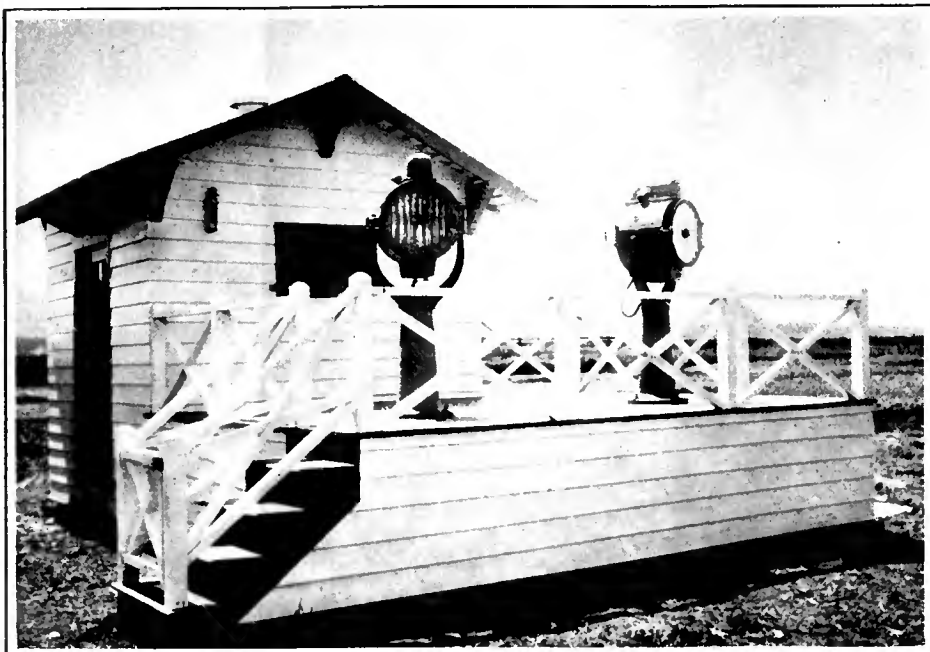


A SPERRY REVOLVING BEACON

This particular one was installed by the Department of Commerce



OFF FOR CHICAGO. THE NIGHT AIR MAIL LEAVES HADLEY FIELD, NEW JERSEY, BY THE AID



HIGH-INTENSITY LANDING FIELD FLOOD LIGHTS

One of these Sperry lights will illuminate a 50-acre field

of the cabin shows that we are 3200 feet above sea level. We are in the clouds. If they continue and we cannot fly beneath them and see the trail of lights on the ground, how are we to find our way? How will we know when it is safe to come down again?

We will watch the little panel with the steadily blinking white light and the peculiar combinations of colored lights that come only occasionally. As we watch, the white light blinks unsteadily and then changes to green and flashes regularly once more. We are off our course, to the right, we are told by a passenger just behind us. He has been over this route before and tells us that when the green light flashes we are to the right of the course. If it shows red, we are to the left. When it is white we are exactly on our course. The color combinations which we saw appear for only a short time on the panel were signals concerning the weather ahead. It was in

this way that the pilot knew that it was safe to climb up into the clouds, and so avoid the storm below, and yet steer clear of mountain peaks—reefs in this ocean of air.

For hours we fly through the night, yet there is no sensation of flying. That is because we are unable to see anything but the dense fog of the cloud bank through which we pass. Our feeling is that our comfortable, lighted cabin is floating in space. The vibration of the engines and the muffled drone of the exhaust nearly lulls us to sleep. We see the needle of the altimeter crawl slowly up. Five thousand feet, six thousand; perhaps the pilot seeks to climb above the cloud into the moonlight which should be above. But no, the altimeter now shows that we are descending a little. Evidently the cloud bank is very thick, and it is not worth while to go above it.

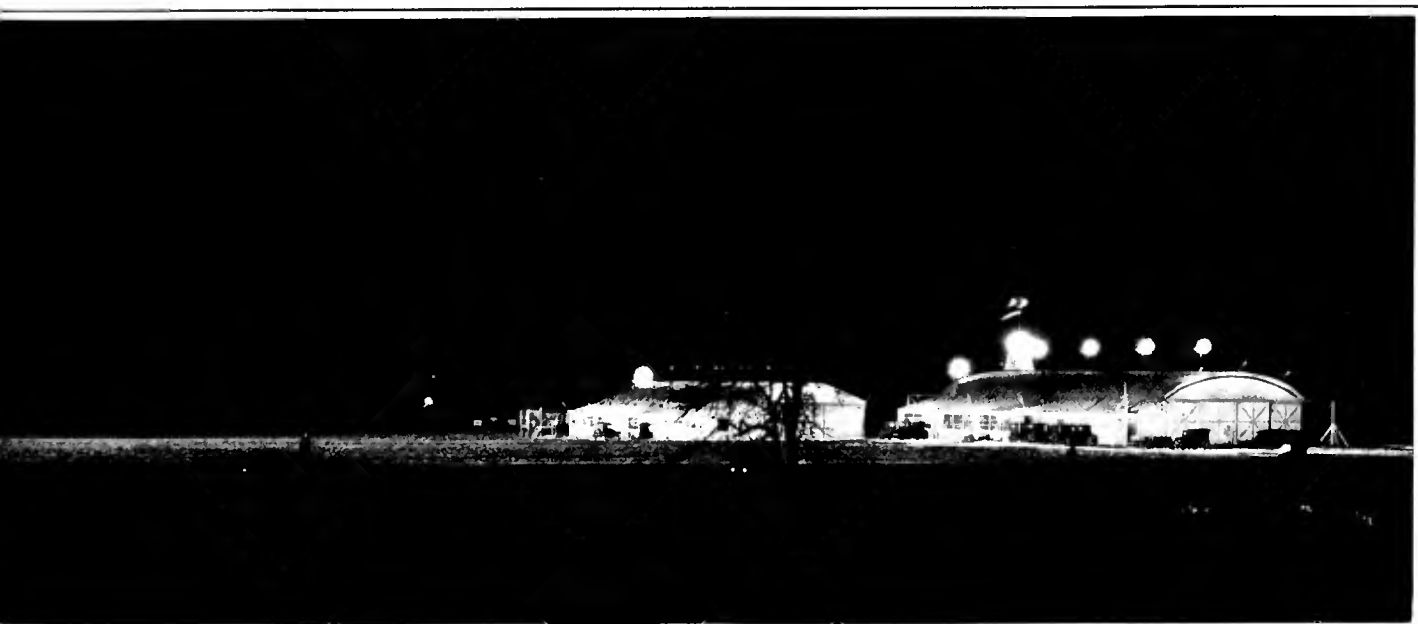
We should be nearing our destination, that is if these red and green and white lights have been

faithful to their trust. And the combinations of colored lights, which now again are gleaming in the dimness of the pilot's compartment. Have they been unerring too? We shall soon know. The engines have been throttled a little. The floor of our cabin slopes forward and the needle of the altimeter is dropping slowly. We are losing altitude, and soon should burst through the "ceiling" of cloud. Suddenly the gray black mass which has engulfed us for hours is swept away. Twinkling lights appear below showing towns and lighted highways. Off to our left we see the rotating beam of a marker beacon, and, some little way ahead, another. We are on our course. Ahead there is a great glow in the sky, and as we draw nearer we realize that it is the light from a large city reflected against the clouds.

Now we pick up a bright flashing red light. It marks the airport of this city. Soon we are circling over it, and can see the line of lighted hangars and a brightly lighted letter "T" on the ground. This is to indicate the direction of the surface wind. We glide smoothly down, circle once more, and come in to land. Leveling off we float along hugging the ground and then with a few gentle bumps and a short roll we come to rest. To taxi up to the line in front of the flight office, and disembark, requires but a moment. We are in Chicago.

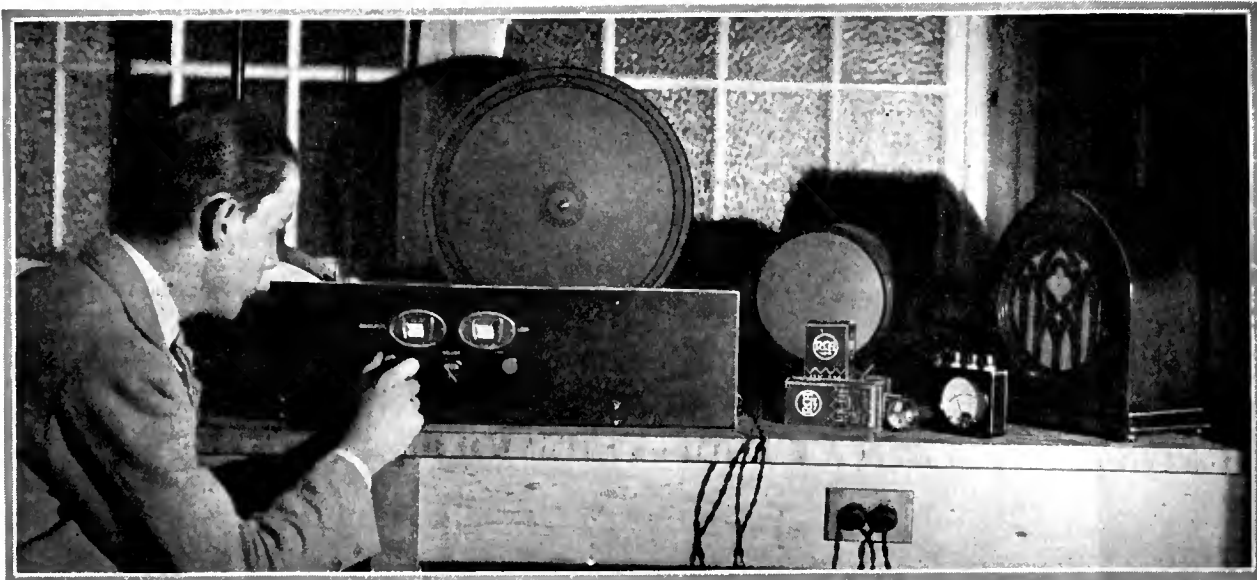
Radio has done its work. It told the pilot when he was off his course, and how to get on it again. It told him this and more, by very simple signals. Signals he could see. It told him of storms ahead, of cloud levels, and winds, and he was able to fly over disturbed areas and dangerous areas, and to come down safely at the proper time. No uncomfortable head-phones in a helmet were required, and it was not necessary that he know a telegraph code.

Some, perhaps many, may think the picture drawn is fantastic and only a dream. That remains to be seen. As for the ability to fly in the manner described, through clouds and fog, there are ships and pilots in plenty equal to the task. Let others apply things already known in the radio art, and the radio aids to aerial navigation which have been pictured will be a reality. Short waves may ultimately be the medium whereby this is accomplished, but considerable experiment will be necessary before the vagaries of these high frequencies will be fully understood.



WERFUL FLOOD LIGHTS. THE MAIL WILL BE DELIVERED IN CHICAGO TOMORROW MORNING

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RADIO BROADCAST Photograph

OBTAINING SOME DATA ON THE A. C. SUPER-HETERODYNE IN THE "RADIO BROADCAST" LABORATORY

Whenever receivers are described constructionally in RADIO BROADCAST, they are invariably tested out in the magazine's laboratory first. Frequently changes are recommended to the designers, and the technical staff does not give its O. K. unless the receiver comes up to expectations

A 45-Kc. A. C. Super-Heterodyne

By DORMAND S. HILL

IN A season during which a bewildering array of super-heterodyne receiver designs are offered to the radio fan and home builder, it is felt that, in presenting still another "super" to the readers of RADIO BROADCAST, it would be well to define, if possible, the relation of such a receiver to other designs, and to point out just why it was felt necessary that another entry should be made in an already too crowded field.

The forty-five kilocycle socket-powered super-heterodyne described here has as the greatest argument in its favor the fact that, though it is fully as sensitive and selective as the majority of eight, nine, and ten-tube sets of its class, its tuning controls are so simple that peak results are always at the command of even the novice operator, its tone quality is unusually good for super-heterodynes and, possibly most important, it derives all power from any sixty-cycle alternating-current home light socket.

The set is entirely self-contained, power unit and set being housed in a standard seven by twenty-four inch cabinet, twelve inches deep. The only external equipment required is a good loop and a modern loud speaker. Since there is not a single battery to run down, and as the power unit is entirely dry, the servicing problem becomes one of occasional tube replacements only. The new a. c. tubes, which make possible the socket powered super-heterodyne described here, give promise of greater average life than is experienced with five-volt battery-type tubes.

In view of the foregoing advantages—better performance, excellent tone, and complete self-contained light socket operation—it is felt that the appeal of this super-heterodyne set should be indeed great. There is another factor which tremendously enhances the value of the receiver—its low initial cost. The entire receiver and power unit, constructed of the finest quality parts throughout, will cost only about \$145.00, or, with a beautiful walnut cabinet, about \$22.00 more. Thus, for less than \$170.00 at list prices, the radio fan, or even the novice, can build for him-

self a full socket-powered super-heterodyne and obtain exceptional selectivity and sensitivity, while the 45-kc. super-heterodyne rivals one-dial sets in the simplicity of its tuning. Another factor in the home-built set is the beauty of finish of each individual part—a factor often neglected in all but the most expensive factory-built sets.

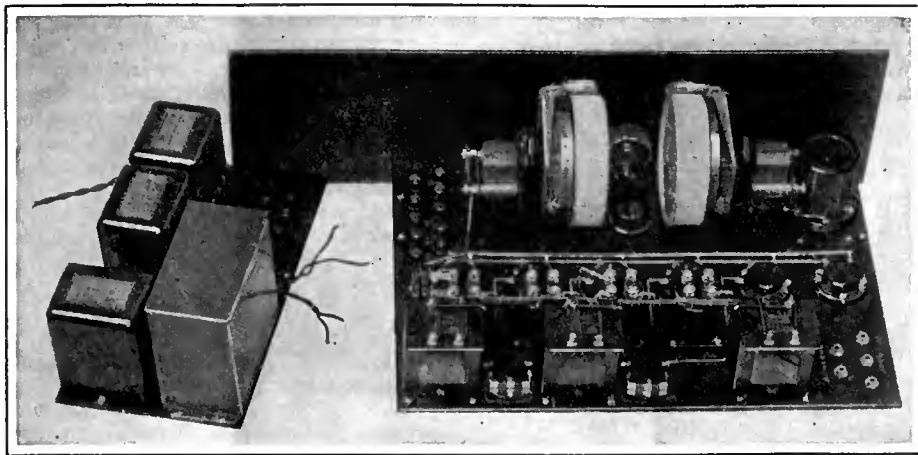
The forty-five kilocycle super-heterodyne employs eight tubes in a new a. c. tube circuit, carefully tried and tested. It possesses a great factor of "hum safety" due to the generous use of c-327 (ux-227) heater tubes instead of the greater hum-producing cx-326 (ux-226) type tubes. One c-327 type tube is used as a grid-tuned oscillator, one in a conventional Rice regenerative split loop first detector circuit, and three more follow in a forty-five kilocycle intermediate amplifier, which, in turn, works into a c-327 second detector. Then follows a two-stage low-frequency transformer-coupled amplifier employing a cx-326 (ux-226) first-stage tube, and either a cx-112 (ux-112) or cx-371 (ux-171) output tube with output transformer. The power supply consists of the conventional B device circuit using a cx-380 (ux-280) thermionic rectifier and a special filament heating transformer for all tubes. The power unit delivers 1.5, 2.5, and 5 volts a. c. and 200 to 220 volts pure d. c. to the receiver A, B, and C circuits.

A description of the individual circuit sections will help to provide a clear understanding of the unusual simplicity of the set, and the ease with which it may be built. On the front panel are three knobs. Two of these control the two illuminated tuning drums affecting the 0.00035-mfd. variable condensers, one of the two tuning the loop and the other tuning the oscillator, both with high reduction vernier drives and well-spaced 360-degree scales, numbered 0 to 200. In tuning, both dials tally approximately, stations being heard loudest at one point on the loop drum and at two points on the oscillator drum, although powerful local stations may be

heard at more than two points. The third knob, a volume control, provides adjustment from absolute zero to a full maximum. It is not critical as to setting, but if turned too far to the right, will cause the intermediate amplifier to block.

Looking down into the set from above, at the left front is the plug-in oscillator coil, L_1 ; behind it is the oscillator tube socket, and to the coil's right is the oscillator condenser, C_2 , and drum. At the left rear are the loop and loud speaker connection tip jacks; and at their right, along the rear of the Micarta chassis, is the audio amplifier. The latter consists, from left to right, of an output transformer T_3 , the output tube, a 3:1 ratio audio transformer, T_2 , the cx-326 (ux-226) first-stage tube, and then the first-stage 3:1 transformer, T_1 . The filament balancing resistors, R_1 and R_2 , on the audio tube sockets, are clearly visible. The frequency characteristic of the audio amplifier is practically flat from 100 cycles to over 5000 cycles, and then falls off for reasons to be given later. The voltage gain of the audio amplifier, with cx-326 (ux-226) and cx-112 (ux-112) tubes is about 400 overall.

Just in front of the output transformer, and behind the first detector tube socket (second from left), is the knob of the loop regeneration condenser, C_3 in Fig. 1. To the right are the four forty-five kilocycle intermediate transformers, L_2, L_3, L_4, L_5 , with the three amplifier and second detector (at right) tube sockets in front of them. At the center of the front panel is the loop tuning drum and condenser, C_1 . Between the two tuning drums is the 5000-ohm volume-control potentiometer R_3 , and on the sub-base also between the drums is a knob controlling the radio-frequency amplifier C bias by means of the potentiometer, R_4 . The first transformer, L_2 , of the intermediate amplifier is untuned; the next, L_3 , is a tuned stage (an XL 0.0005-mfd. Variodenser, C_4 , below the chassis, with adjusting screw projecting up, is used for tuning this filter). Then follows a second untuned transformer, L_4 , and, at the right, a second tuned transformer L_5 , feeding the de-



POWER UNIT AND RECEIVER PROPER

In the event that the power unit is to be mounted elsewhere than right beside the receiver, the front panel for the latter may be smaller

detector tube. This latter stage is tuned by means of a fixed condenser, C₉.

The power unit, consisting of a power transformer, T₄, a condenser block, C₁₂, filament transformer, T₅, and Clough selective filter choke, L₆, with tube socket, and binding posts (and resistor, R₁₀, below), is on a seven-by-twelve inch chassis at the right of the set chassis, the two being cross-connected by the use of Eby binding posts as shown. An under-chassis view shows the voltage dividing resistor, R₁₀, beneath the power unit chassis, and other obvious parts beneath the receiver chassis. The simplicity of wiring is evident.

SELECTIVITY

THE selectivity of the set is quite good, and allows of ten- to fifteen-kilocycle separation of powerful local and weak out-of-town stations. The frequency band passed is a good ten kilo-

cycles wide in normal operation, thus providing excellent tone quality with the audio channel used. This audio channel, due to its cut-off above 5000 cycles, materially aids the apparent selectivity of the radio-frequency circuits; in fact, the frequency characteristics of radio and audio circuits match very nicely.

An examination of the circuit indicates that all grid returns are brought back to the common B minus lead. First detector and oscillator are operated with approximately forty-five volts plate potential, and with zero grid potential; the grid-circuit returns and heater tube cathodes connect to the B minus lead. The three radio-frequency amplifiers derive an adjustable C bias from the 400-ohm potentiometer, R₄, which is connected between their cathodes and the B minus lead (a voltage is developed by virtue of the plate currents flowing through this resistor). The best bias is one-half to one volt, and, once set, varies automatically with changes in plate

voltage. The C bias resistor and the plate voltage potentiometer are bypassed with 1-mfd. condensers, C₆ and C₇, to prevent radio-frequency coupling. Plate voltage on the radio-frequency amplifier can be varied from zero to about ninety volts, using the 5000-ohm potentiometer (volume control knob), and generally about forty to forty-five volts gives greatest volume and sensitivity without amplifier oscillation. C bias for the detector is obtained from a 5000-ohm resistor, R₅, between the B minus lead and the detector cathode, shunted with a 0.0005-mfd. bypass condenser, C₅.

The C bias for the first audio stage is obtained across a 1500-ohm resistor, R₆, between the B minus lead and the center tap of a 64-ohm resistor, R₁, shunting the filament of the CX-326 (UX-226) audio tube. C bias for the second audio tube is similarly obtained by a 2000-ohm fixed resistor, R₇, between B minus lead and the center tap of a second 64-ohm balancing resistor, R₂, across the last audio tube's filament. This 2000-ohm resistor is bypassed with a 1-mfd. condenser, C₉, to improve low-frequency reproduction. For safety, a 64-ohm resistor, R₈, connected across the 2½-volt heater circuits of the CX-327 (UX-227) tubes, leads to plus 45 volts to prevent hum. The plate voltage of the first audio stage is about 90 volts; the C bias should be 5 to 6 volts—correct for CX-326 (UX-226) tubes. The last audio tube may be interchangeably a CX-112 (UX-112) or a CX-371 (UX-171) type tube, the former for greatest amplification, the latter for best quality on strong signals. With a CX-112 (UX-112) tube, C bias is about 20 volts and the plate voltage about 200—a safe value and one at which the performance of the 112 type tube is quite creditable. The C bias for a CX-371 (UX-171) tube would be about 38 volts, and the plate potential, about 170 volts—entirely satisfactory values, and slightly below the tube's rated maximum.

The construction of the set is quite simple, involving the use of the following parts. If the exact values specified are used, all adjustments for proper a.c. operation are automatic. Substitution may necessitate experiment:

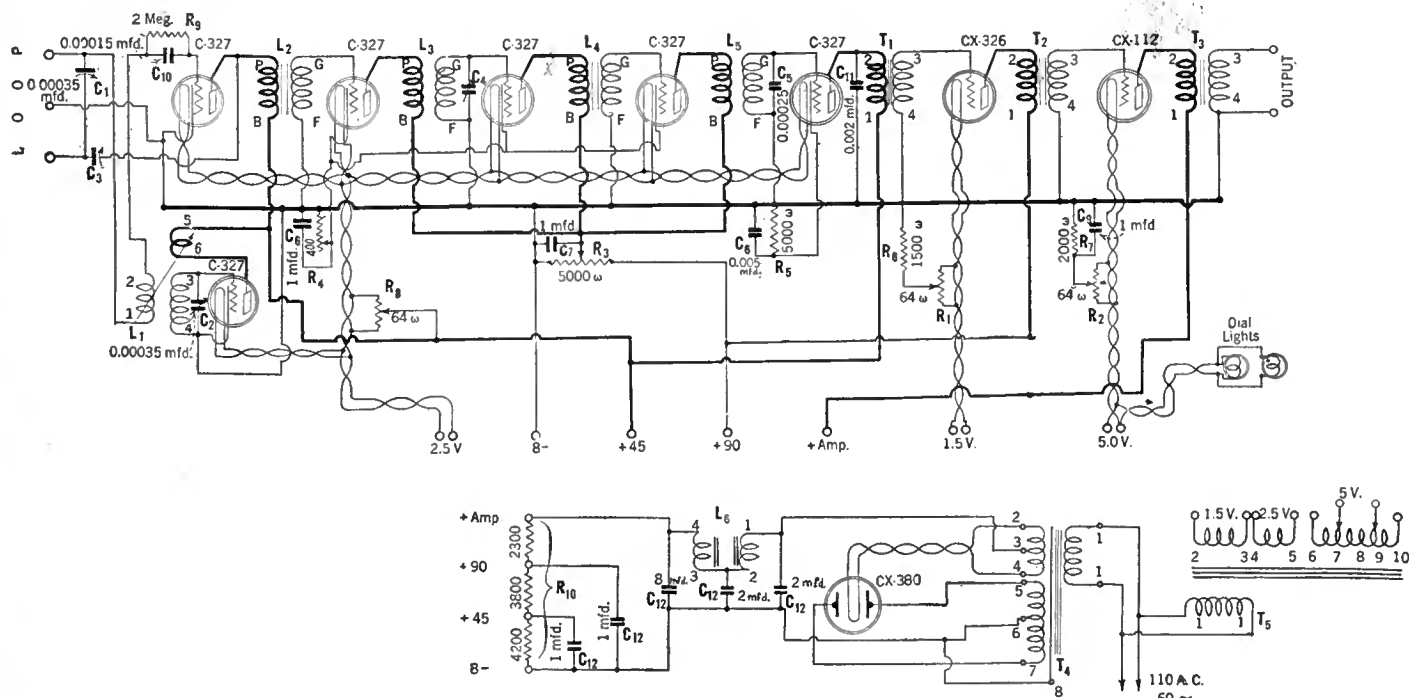


FIG. 1

The circuit diagram of the 45-kc. a.c. super-heterodyne

PARTS LIST

Two Remler 100 Universal Drum Dials	\$9.00
L ₂ , L ₄ Remler 600 Interstage Transformers	12.00
L ₃ , L ₅ Remler 610 Tuned Stage Transformers	10.00
C ₁ , C ₂ Remler 638 type 0.00035-Mfd. Condensers, Variable	10.00
T ₁ , T ₂ S-M 240 Audio Transformers	12.00
T ₃ S-M 241 Output Transformer	5.00
Six S-M 512 Five-prong Tube Sockets	4.50
Two S-M 511 Tube Sockets	1.00
One S-M 515 Coil Socket	1.00
L ₁ S-M 111A Coil	2.50
Two Pairs S-M 540 Mounting Brackets	1.40
C ₃ S-M 340 Midget Condenser	1.50
C ₁₀ Polymet 0.00015-Mfd. Condenser, with Clips	.45
C ₆ Polymet 0.00025-Mfd. Condenser	.35
C ₁₁ Polymet 0.002-Mfd. Condenser	.40
C ₈ Polymet 0.005-Mfd. Condenser	.60
R ₉ Polymet 2-Megohm Grid Leak	.25
C ₆ , C ₇ , C ₉ Polymet 1-Mfd. Bypass Condensers	3.00
R ₅ Frost F1500 Resistor	.50
R ₇ Frost F2000 Resistor	.50
R ₁ , R ₂ , R ₈ Frost FT64 Resistors	1.50
Five Frost 253 Tip Jacks	.75
R ₃ Frost 5000-Ohm De Luxe Potentiometer	2.25
R ₆ Polymet 5000-Ohm Resistor	1.00
R ₄ Frost 400-Ohm De Luxe Potentiometer	1.25
C ₄ XL Model G "Variodenser"	1.50
Sixteen Eby Binding Posts: (8-plain, 2 B-, 2 B+Det., 2 B+Amp., 2 B+Int.)	2.40

Westinghouse Micarta Walnut Panel	8.00
7 x 24 x $\frac{3}{8}$ inches	
1 Westinghouse Micarta Sub Panel	9.00
12 x 17 x $\frac{3}{8}$ inches	
TOTAL	\$103 60

POWER SUPPLY PARTS LIST

T ₄ S-M 329 Power Transformer	9.00
L ₆ S-M 331 "Unichoke"	8.00
T ₈ S-M 325 Filament Transformer	8.00
S-M 511 Tube Socket	.50
Pair S-M 540 Mounting Brackets	.70
C ₁₂ Polymet 14-Mfd. Condenser Block	9.50
R ₁₀ Ward-Leonard 659 Resistor	2.50
Westinghouse Micarta Power Unit	
Base, 12 x 7 x $\frac{3}{8}$ Inches	4.00
8 Eby binding posts: (4Plain, 1 B-, 1 B + Det., 1 B + Amp., 1 B + Int.)	1.20
TOTAL	\$43 40

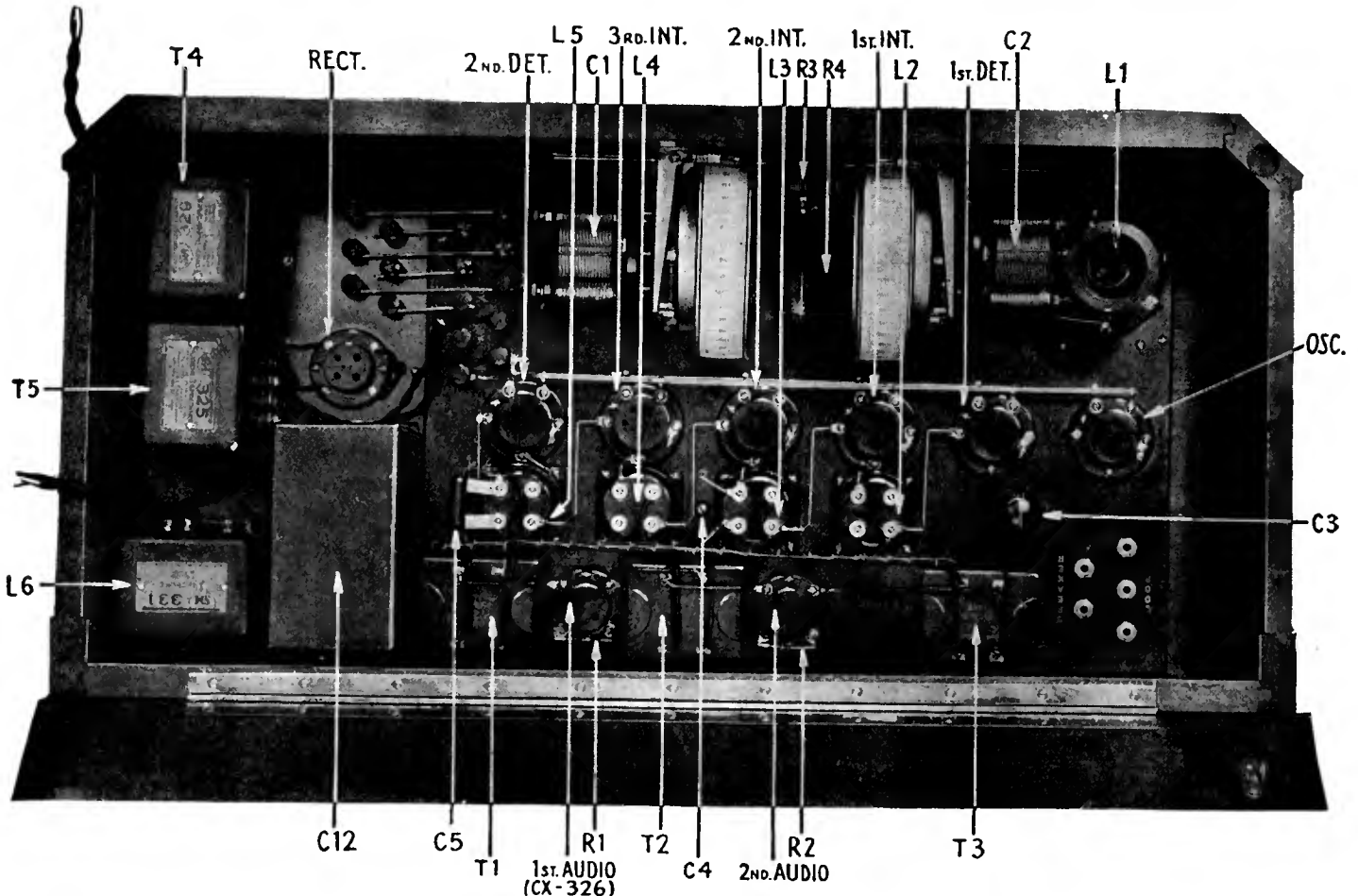
Panels can either be drilled, following the apparatus layout of the photographs, or procured drilled and engraved from any Micarta dealer. The apparatus should be mounted on them after careful study of the photographs, and in the positions shown. One point to observe is that all cathode leads from the c-327 (UY-227) tubes should be brought out below the chassis by one of the socket mounting screws, as this is good practice to follow wherever practicable.

In wiring the set and power unit, all 1.5-, 2.5-, and 5-volt a.c. leads should be twisted to localize their fields. All grid and plate leads should be of busbar, in spaghetti where necessary, as should the leads to the tuning condensers, while all other low-potential wiring should preferably be of

Kellogg switchboard wire. The leads from the 2.5-volt binding posts of the receiver to F posts of the five-prong tube sockets are each composed of two No. 14 tinned wires in parallel, for high current-carrying capacity. All metal parts of the set and power unit, such as transformer frames or shells and condenser bank case should ground to B minus. The drum dial frames, carrying the dial lights, are taken care of through the lamp wiring to the 5-volt a.c. circuit, which grounds through the F2000 C bias resistor, R₇.

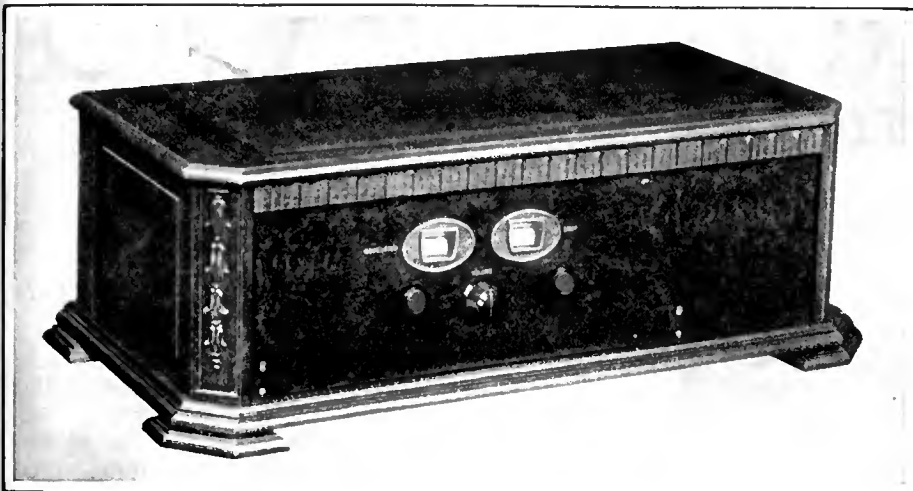
TEST AND OPERATION

AFTER finishing the set and power unit, it would be well to check voltages with a high-resistance voltmeter (1000 ohms per volt). The power unit not connected to the receiver should show about 70 to 80 volts on the 45-volt tap; 120 to 130 on the 90-volt tap; and 220 or more on the high tap. Next, the power unit should be connected to the receiver, no tubes being inserted in the set, and voltages again checked (for short circuits). All voltages should have fallen somewhat. The audio tubes should now be inserted in the set and the loud speaker connected. A strong hum evidences proper operation of the audio channel if B and C voltages (as given previously) check out *approximately*. If posts Nos. 1 and 2 of the first audio transformer are short-circuited, the hum will fall to the actual operating value; it should be so low as not to interfere with reception at average speaking volume. If the hum is stronger, ground the B minus post to a water pipe. If the hum is still too high (and it may be under unusual line or set assembly conditions), the solution is to move the power unit away from the set. If all CX-327 (UX-227)



LOOKING DOWN INTO THE CABINET OF THE A.C. SUPER-HETERODYNE

The various parts are lettered so that they may be easily identified by cross reference to Fig. 1, on the previous page



THE COMPLETE RECEIVER AND POWER UNIT

It is here shown in an attractive looking cabinet, a product of D. H. Fritts and Company, Chicago, Illinois

particular station. Therefore, set the rotor on a weak 300- or 325-meter (1000-or 920-kc.) station to produce greatest volume with good selectivity on either upper or lower oscillator dial setting, then use whichever point (upper or lower) is loudest, in tuning all other stations. On a weak signal, adjust the XL Variodenser for strongest signals and sharpest tuning of the oscillator dial.

TRUBLE-SHOOTING

REMEMBER, if the set does not give as good results for sensitivity and selectivity or tone as any other average eight- or nine-tube "super," or seven- or eight-tube t.r.f. set, under identical and simultaneous operating conditions, it simply is not put together or operated in accordance with the foregoing paragraphs. Therefore, look for your trouble in your own work.

The set should not squeal in operation; if it does, incorrect operation is the cause—look to midget condenser and volume control settings more carefully.

Lack of sensitivity and selectivity should cause careful readjustment of the XL condenser and midget condenser, and a comparison against some other set of known performance.

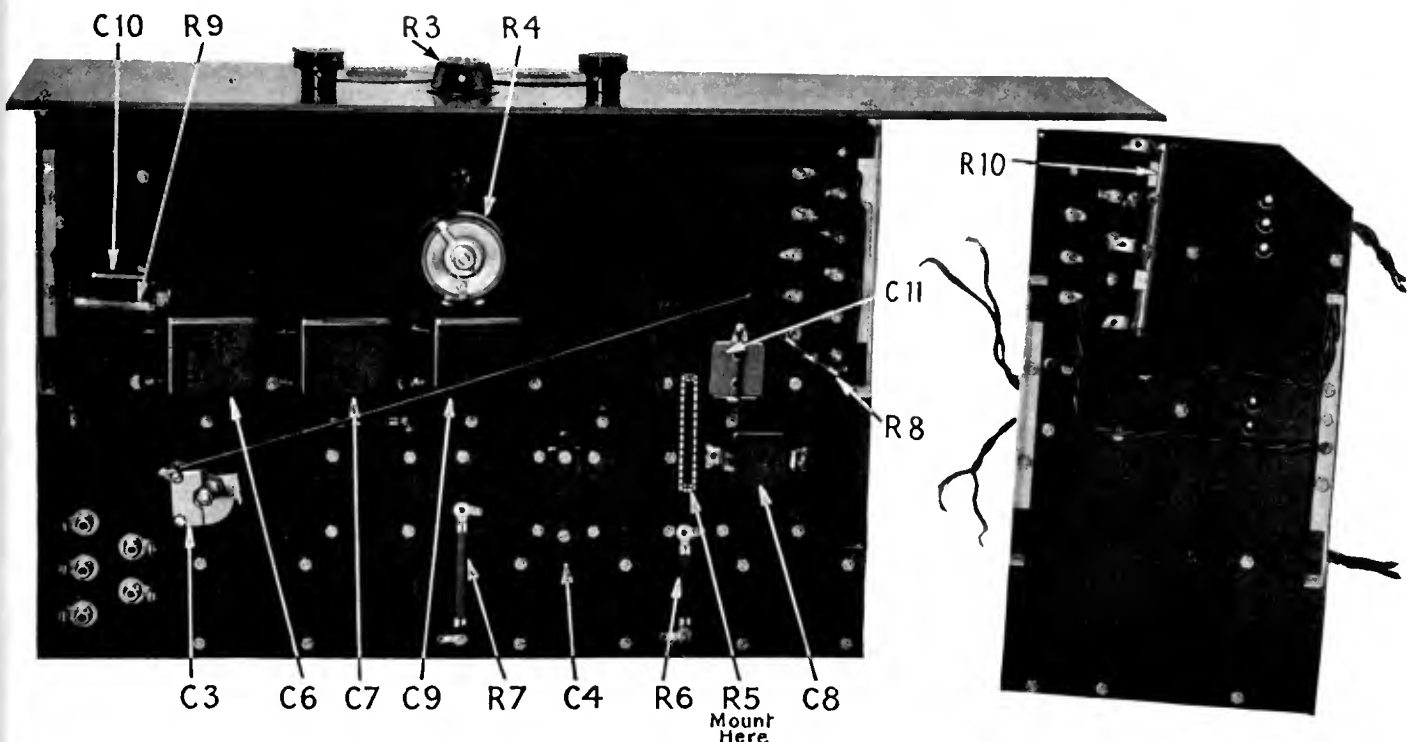
Hum should be checked as outlined for the a. f. amplifier. If it tests out correctly, and there is hum coming through the r. f. circuits, the trouble is an open grid-circuit and most probably due to poor or incorrect wiring. If loud hum is in the audio amplifier (with first a. f. transformer primary posts, Nos. 1 and 2, shorted) look for defective wiring, open balancing resistor, or poor tubes. Move the power unit several feet away from the set when making this test.

In proper operation the receiver should give good super-heterodyne performance, say, average 500- to 2000-mile loud speaker range, on all good stations, hum so low as not to be noticeable through station announcements at average speech volume, and absolutely dependable operation in the hands of a novice, with practically no servicing problem—and all at an operating cost of less than ten cents an hour.

heater tubes are inserted, the hum pitch will vary as the tubes warm up and, after a minute, will decrease to the average operating value observed with posts Nos. 1 and 2 of the first a. f. transformer shorted (this very low hum is always experienced with cx-326 [ux-226] or other "raw a. c." tubes.)

To operate the set, set the midget condenser all out, connect a Bodine L350 or equivalent good loop to the loop posts, and tune-in stations with the two drums. Set the C bias potentiometer to include $\frac{1}{2}$ to $\frac{1}{4}$ of its total resistance in circuit which will give $\frac{1}{2}$ to 1 volt negative bias on the r. f. amplifiers. A good starting point would be KDKA, tuned in at about 53 on the loop, and 46 or 58 on the oscillator, or WDAF, at 120 on the loop and 103 or 130 on the oscillator. If the volume knob is set as far as it will go to the left, no signal will get through; advancing the knob

right up to the oscillation point (sometimes called "spill-over," "plunk," or "squeal" point) will increase volume. If the volume knob is turned to the right of this point, only squeals will be heard. Remember, no squeals should be heard on the set, other than station heterodyne squeals of substantially unvarying pitch. On a short-wave station, the midget condenser should be turned in slightly to increase sensitivity; if turned in too far, only squeals will be heard—bear this in mind. Once set, leave it alone, but in the first case, be sure to set it on a 210- or 220-meter (1430 or 1360 kc.) station. The oscillator coil rotor should generally be set at about a 45-degree position. There are four of these points in the full 360-degree arc of rotation. Remember that full 180-degree rotation from any of these points will cause either upper or lower oscillator dial setting to give strongest signals on any



UNDERNEATH THE SUB-PANEL

Here again the parts have been lettered for easy reference. The grid bias resistance for the detector tube was being experimented with at the time this picture was taken, and, therefore, its correct location has been indicated by means of dotted lines

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The Commission Improves Broadcasting Conditions

THIS month we chronicle what should be an improvement of a most pleasing nature in the broadcasting situation, the clearing of 25 of the 36 channels between 600 and 1000 kc., accomplished by the Federal Radio Commission's General Order No. 18. Perhaps, by the time these lines are published, the entire 36 channels will be cleared. "Clearing" means that in most cases many stations operating on one channel have been placed elsewhere and coast-to-coast duplication of stations now obtains which "clears" the channel for all practical purposes.

But we thirst for even greater improvement. Having tasted the gratification which comes of the Commission's firm and commendable action, we hope for more. Every move in the direction of clearing channels means larger audiences and, in consequence, still better broadcasting.

With amazing strides in program development and with a Federal Radio Commission working for the best interests of broadcasting, we hope that, sooner or later, ideal reception conditions will be attained. Indeed, the order clearing channels from 600 to 1000 kilocycles, truly a drastic move, promises to bring good reception not only to urban districts but to rural as well, where radio is becoming the most important and essential form of home entertainment and education.

So many listeners who write us are unfair in laying the blame for heterodyne whistles upon the incompetence of the Federal Radio Commission. The Commission is not incompetent; it is impotent. No five men under the sun could solve the present broadcasting tangle without having undisputed power to eliminate stations from the broadcasting band.

In spite of any congressional declarations that the ether may be regulated in the public interest and that none have vested rights to use it, it is quite generally assumed that broadcasting stations have established

what amounts to vested rights in the ether. Having invested capital and legally conducted a public service, station owners contend that they cannot be deprived of the opportunity of continuing that service without compensation. Be that as it may—we contend that stations, which had to wait for broadcasting licenses until the regulatory powers of the Department of Commerce were nullified by unfavorable court decision, have no right on the air. If property confiscation is necessary to secure good broadcasting, let us find a way to confiscate worthless broadcasting stations.

The elimination of two or three hundred of the smaller stations, accomplished by a board with confiscatory powers, need not cost more than two or three million dollars, really a small sum when the social and economic importance of broadcasting and the magnitude of the industry serving it are considered.

We make a serious suggestion for a tax on commercial broadcasting. We realize that our numerous friends among broadcasting station owners will regard us, for a moment at least, as an enemy, seeking to add another to their already numerous burdens. A tax on commercial broadcasting would, at first, certainly penalize the good stations in favor of the bad. But a two per cent. tax, spent solely upon compensating the owners of confiscated stations, could bring radical improvements in broadcasting, such that audiences would

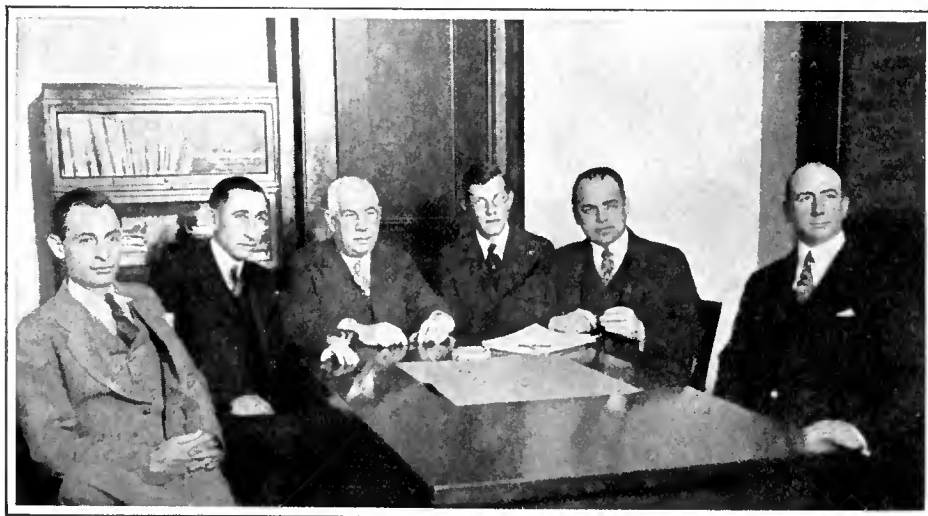
be enormously increased, with inevitably augmented revenues to broadcasting stations and improved program standards.

Furthermore, the amount of tax paid by stations would serve as an indisputable guide to their value. Educational and religious stations, now operating at considerable losses, could charge the organizations sponsoring them, on an hourly basis, an amount sufficient to cover their deficits and thus, having established revenue, suffer no penalty for their non-commercial status. A definite principle of compensation for station condemnation could be established, based upon a year's commercial revenue, plus the physical value of its equipment. Three years of taxation of commercial broadcasting and an honestly administered and efficient condemnation board would leave a strong broadcasting structure, consisting only of the most popular and successful stations, with the weak sisters bought out at minimum cost, and clear channels for the remaining. The stations to continue would be selected not only upon the basis of economic value but upon a definite and scientifically organized plan, taking into account power, service area, and geographical location.

The ultimate effect of such a policy would certainly double, triple, and four-fold the value of commercial broadcasting to program sponsors. Interference-free reception and increased coverage would inevitably result in program improvement. The clear reception of a program on every

channel would three-fold the usefulness of the receiver and increase program choice, serving as another incentive to add to the listening audience. The radio industry would, therefore, prosper by the sale of more receiving sets. On every hand, for the listener, station owner, and manufacturer, there would be greater prosperity and greater service.

We are indeed aware that, at first sight, to burden a harassed broadcasting industry, suffering from interference and insufficient



THE FEDERAL RADIO COMMISSION

© Henry Miller

This view was taken a few days before the death of the Chairman, Admiral Bullard, who is third from the left. Harold A. Lafount, the new Commissioner appointed to succeed John F. Dillon, deceased, is shown at the extreme right. Until a Chairman is chosen, Eugene O. Sykes is acting as Vice-Chairman. From left to right: Sam Pickard, E. O. Sykes, W. H. G. Bullard, Carl H. Butman, secretary, O. H. Caldwell, H. A. Lafount

revenue, is not likely to be popular among the commercial broadcasters. Too often, when taxation is suggested as a remedy, the cure is worse than the disease.

The Commission, by its recent allocations, has clearly demonstrated that fewer stations per channel means improved reception. But it has made its progress by virtually destroying almost two thirds of the broadcasting frequencies in order to make one third capable of performing maximum service. Is it efficient utilization of valuable ether channels to impair two thirds of those available so that one third may be of maximum service?

The only sensible ideal is to make every channel useful to the utmost of its capacity. Any channel, which serves as a graveyard for ten, twenty, or thirty stations, represents the confiscation of a substantial investment on the part of receiving set owners. If we value the receiving sets in service at \$450,000,000—and this is a conservative estimate—broadcast listeners have spent some \$5,000,000 a channel. Confiscating two thirds of the broadcast band, by allotting it to chaos, represents a loss of \$300,000,000 to listeners.

Is the listener not entitled to free and complete use of his apparatus, considering that his collective investment is much larger than that of the broadcasting stations? Broadcasters who wail about destroyed investments are themselves guilty of destruction a thousandfold greater than that which they suffer.

If confiscation of property is necessary to establish good broadcasting, let us give the Federal Radio Commission full power to condemn broadcasting stations and the funds with which to purchase them. We do not hesitate to condemn private property in order to build improved highways, a process which has made the automobile business one of America's greatest and most serviceable industries. Now let us condemn private property in order to have good highways of the ether. It will make radio a truly great industry, serving every American family and home.

Who Buys This Year's Radio Sets?

THE replacement market will be radio's most profitable sales field this year. The listener who has had experience and contact with radio is readier to appreciate the advantages of socket power operation and the greatly improved tonal quality attained by this year's better receiving sets. The radio trade quite generally overlooks the replacement market, although receivers of two, three, four and five years ago are still widely used. The automobile industry is now subsisting very largely upon replacements which reach a dollar total far in excess of new owner purchases.

To the radio industry, this is a new problem and the approach to the replacement market requires fundamental changes in sales and advertising methods. The industry should seize upon its opportunity en-

thusiastically because three fourths of the selling resistance has already been eliminated by the set owner's previous experience. He is ready to understand and appreciate the significance of modern improvements, with but a simple explanation, laid before him where he is accustomed to absorb his radio knowledge.

The replacement market has the fortunate advantage that those most enthusiastic about radio are efficiently reached through specialized mediums which appeal to the more ardent and, consequently, more responsive radio follower. The publications in the radio field have a combined circulation of nearly one million and, therefore, reach the best one fifth or one sixth of the entire replacement market. Those who purchase radio consumer magazines are naturally more interested in radio than those who do not. They have followed radio for several years at least, and are the most likely to possess obsolete sets. This invaluable group is reached at a lower cost than an equal number of prospects among general magazine circulations. Popular magazines, serving every class of society instead of singling out especially fruitful groups, reach an insignificantly small proportion of already interested buyers and persons sold on radio by actual experience. A general magazine is fortunate if one out of twenty of its readers have the slightest interest in its radio advertising; every reader of a radio magazine is a prospect for a 1928 radio.

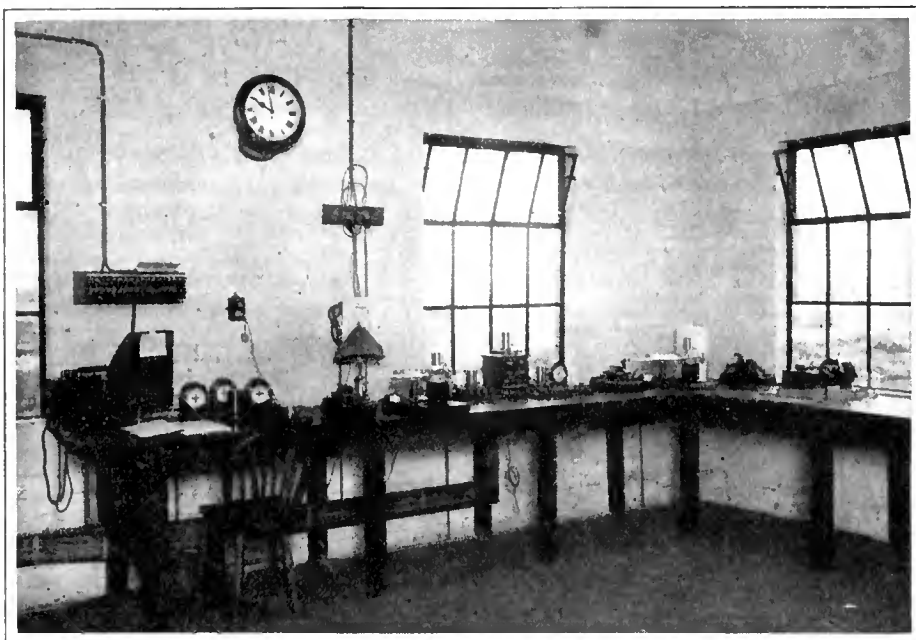
Since the general spirit of the better radio magazines is no longer predominantly technical, but covers all phases of the radio science, art, personality, broadcasting, as viewed behind the microphone and

heard before the speaker, progress in manufactured receivers, telephotography and television, and numerous other fields of wide appeal, circulations have changed in character so that they include not only the home constructor and radio engineer, but the dealer and jobber, the wealthy and ardent listener, and the most liberal purchasers of radio equipment. The new situation offers a great opportunity to the manufacturer to sell his wares at minimum cost.

A prophet is without honor in his own country and the radio manufacturer is quite inclined to regard the radio enthusiast as a sort of demented crank who has no influence upon the purchase of radio sets. However, he readily admits, when pinned down, that it was this very element which built up his industry and that, instead of being cranks, they are pioneers and leaders. Of course, there are a few manufacturers who cannot profitably address themselves to this discriminating and well-informed group, because they do not make a product fit to offer to an expert radio enthusiast. But, in general, the products of the radio industry have reached a standard which makes them highly acceptable to the man with some technical knowledge and appealing to him is an asset which means the sale of not only one but usually a good many radio receiving sets.

Rural Radio Listeners Served by Re-allocations

IN A statement issued by the Commission shortly after its clearing of the 600-to 1000-kc. channels, it points out that millions of listeners in remote communities, presumably a good two thirds



A BRITISH MARCONI SHORT-WAVE RECEIVING STATION

This receiving unit, located at Skegness, England, was built by the Marconi company for the British Post Office and is used as the British end of the India and Australia service. The view above shows a corner of the land line connections and high speed recording instruments. On the left are key and sounder for communication with the transmitting station and Radio Central in London; next are two sets of high-speed recorders with tape pullers and a Wheatstone transmitter for sending to the London Central office

of the radio audience, who have little or no choice of local programs, are especially benefited by the new allocations. It is this group which leans most heavily upon radio's utilitarian and entertainment service. The Commission states that, although the DX listener is served by these re-allocations, its principal purpose is to make radio more acceptable to the rural listener.

There is some criticism due to the fact that the thirty or more stations which now have clear channels are affiliated with one or the other of the networks. Therefore, a rural listener, going down the dials on a clear night, would find only three programs available to him, although he may tune-in twenty of the stations. Ultimately, this situation may be alleviated by the assignment of all chain stations to a single channel. This is not feasible at this time because of the great cost entailed in synchronizing stations, a complete and extra wire network being necessary to accomplish this, and, furthermore, because the affiliated stations do not receive their programs exclusively from the chain source. The better stations throughout the country have affiliated themselves with chain organizations and it is therefore inevitable that they should receive favored consideration in the matter of being assigned clear channels. Consequently, the Commission's action is unavoidable and it cannot rightly be accused of favoritism.

Sooner or later, however, it will be necessary to synchronize stations so that the same channel will be used by all stations radiating a program. This will give an added advantage to the rural listener because he will derive signal energy, not only from the nearest of the chain stations to which he tunes, but the combined signal energy from all the stations which energize his set. The Blue Network, for example, combined on a single channel by synchron-

ous broadcasting, would deliver an adequate local service signal almost anywhere in the eastern part of the United States.

It has been suggested that a single synchronizing signal be broadcast from which all stations are to derive the carrier signal. Such a synchronizing signal would have to be of a frequency low enough that its harmonics would include every broadcasting channel. Thus a 10,000-cycle synchronizing signal, radiated by modulating a high-frequency carrier, would be received at every broadcasting station in the country. Those assigned to a 500-kc. frequency, for example, would, by means of a harmonic producer, pick off the fiftieth harmonic of the 10,000-cycle synchronizing signal. This would be sufficient to serve as the carrier for the station. The 51st harmonic would provide the 510-kc. signal and so on throughout the broadcasting band.

Although this process appears to be a simple solution of the frequency stability problem, it is, unfortunately, full of technical pitfalls, sufficient to prevent its immediate general utilization.

We are unable to build harmonic producers of sufficient reliability to obtain the selected harmonic with unflinching certainty. Much investigation is necessary before reliable harmonic producers to cover the entire broadcast band would be available so that they could be employed by the usual broadcasting station technical staff. The harmonic producer is still a laboratory product, requiring the highest kind of engineering talent to secure satisfactory results.

Technical aids will certainly come to the help of the broadcasting situation, but they cannot be relied upon to give prompt and substantial relief, in our present knowledge of the radio art. The mills of the gods and the laboratories of scientists

grind slowly, but, fortunately, they never cease grinding.

Frequency Allocation Outstanding Achievement of International Conference

IT REQUIRES a careful study of the allocations adopted by the International Radio Telegraphic Conference to appraise the labors of that body briefly and it is premature to report on more than its outstanding and obvious achievement, the establishment of a complete schedule of international wavelength allocations. In examining this schedule, it must be borne in mind that nations may permit any kind of emission to any radio station under their jurisdiction at any frequency, under the sole condition that such emission does not interfere with any other country. To stations, which, by their nature, are known to be capable of causing material international interference, the contracting parties agree to assign frequencies in accordance with the schedule which appears below.

The assignments made to amateurs represent a curtailment of their present wide range of channels, although they have not lost completely the right to any of their accustomed bands. Those bands, designated as "amateur" without restriction or division, are exclusive amateur bands and therefore available for international communication. As to the broadcasting bands, the American standard has been adopted, although a few channels in the 150-kc. region have been made available for European broadcasting. A number of small but well distributed short-wave bands for international links are also provided, which take into account the possibilities of both daylight and night transoceanic rebroadcasting. The Conference, evidently, listened appreciatively to the advice of experts in selecting these short-wave bands.

How Radio Channels Are Internationally Assigned

10 to 100 kilocycles (30,000 to 3000 meters)—Point to point service.
 100 to 110 kilocycles (3000 to 2725 meters)—Point to point and mobile service.
 110 to 125 kilocycles (2725 to 2400 meters)—Mobile.
 125 to 150 kilocycles (2400 to 2000 meters)—Mobile, maritime service, general public correspondence only.
 150 to 160 kilocycles (2000 to 1875 meters)—(a) Broadcasting, (b) point to point, (c) mobile. Subject to agreement as follows: All regions where broadcasting stations now exist working below 300 kilocycles (above 1000 meters)—Broadcasting; other regions, (b) point to point, (c) mobile. Regional agreements will respect the rights of one another in this band.
 194 to 285 kilocycles (1550 to 1050 meters)—(a) Mobile, (b) point to point, (c) broadcasting. Subject to regional agreement as follows: Europe (a) Mobile (aircraft only), (b) point to point (air services only), (c) point to point (NGP) from 250 to 285 kilocycles (1200 to 1050 meters); (a) broadcasting from 194 and 224 kilocycles, (1550 to 1340 meters); other regions; (a) Mobile, except commercial ships, (b) point to point (aircraft only), (c) point to point (NGP).
 285 to 315 kilocycles (1050 to 950 meters)—Special (radio beacons).
 315 to 350 kilocycles (950 to 850 meters)—Mobile (aircraft service only). See Note 1.
 350 to 360 kilocycles (850 to 830 meters)—Mobile (NGP).
 360 to 390 kilocycles (830 to 770 meters)—(a) Special (direction finding); (b) mobile, where it does not interfere with direction finding.
 390 to 460 kilocycles (770 to 650 meters)—Mobile.
 460 to 485 kilocycles (650 to 620 meters)—Mobile, except damped and radio telephone waves.
 485 to 515 kilocycles (620 to 580 meters)—Mobile (distress calling, &c). See Note 2.
 515 to 550 kilocycles (580 to 545 meters)—Mobile (not open to general public correspondence), except damped and radio telephone waves.

550 to 1300 kilocycles (545 to 230 meters)—Broadcasting. See Note 3.
 1300 to 1500 kilocycles (230 to 200 meters)—(a) Broadcasting, (b) mobile (on the frequency 1364 kilocycles only, wave length 200 meters).
 1500 to 1715 kilocycles (200 to 175 meters)—Mobile.
 1715 to 2000 kilocycles (175 to 150 meters)—Mobile, fixed and amateurs.
 2000 to 2250 kilocycles (150 to 133 meters)—Mobile and fixed.
 2250 to 2750 kilocycles (133 to 109 meters)—Mobile.
 2750 to 2850 kilocycles (109 to 105 meters)—Fixed stations.
 2850 to 3500 kilocycles (105 to 85 meters)—Mobile and fixed.
 3500 to 4000 kilocycles (85 to 75 meters)—Mobile, fixed and amateurs.
 4000 to 5500 kilocycles (75 to 54 meters)—Mobile and fixed.
 5500 to 5700 kilocycles (54 to 52 meters)—Mobile.
 5700 to 6000 kilocycles (52.7 to 50 meters)—Fixed.
 6000 to 6150 kilocycles (50 to 48.8 meters)—Broadcasting.
 6150 to 6675 kilocycles (48.8 to 45 meters)—Mobile.
 6675 to 7000 kilocycles (45 to 42.8 meters)—Fixed.
 7000 to 7300 kilocycles (42.8 to 41 meters)—Amateurs.
 7300 to 8200 kilocycles (41 to 36.6 meters)—Fixed.
 8200 to 8550 kilocycles (36.6 to 35.1 meters)—Mobile.
 8550 to 8900 kilocycles (35.1 to 33.7 meters)—Mobile and fixed.
 8900 to 9500 kilocycles (33.7 to 31.6 meters)—Fixed.
 9500 to 9600 kilocycles (31.6 to 31.2 meters)—Broadcasting.
 9600 to 11,000 kilocycles (31.2 to 27.3 meters)—Fixed.
 11,000 to 11,400 kilocycles (27.3 to 26.3 meters)—Mobile.
 11,400 to 11,700 kilocycles (26.3 to 25.6 meters)—Fixed.
 11,700 to 11,900 kilocycles (25.6 to 25.2 meters)—Broadcasting.
 11,900 to 12,300 kilocycles (25.2 to 24.4 meters)—Fixed.
 12,300 to 12,825 kilocycles (24.4 to 23.4 meters)—Mobile.

12,825 to 12,350 kilocycles (23.4 to 22.4 meters)—Mobile and fixed.
 12,350 to 14,000 kilocycles (22.4 to 21.4 meters)—Fixed.
 14,000 to 14,400 kilocycles (21.4 to 20.8 meters)—Amateur.
 14,400 to 15,100 kilocycles (20.8 to 19.85 meters)—Fixed.
 15,100 to 15,350 kilocycles (19.85 to 19.55 meters)—Broadcasting.
 15,350 to 16,400 kilocycles (19.55 to 18.3 meters)—Fixed.
 16,400 to 17,100 kilocycles (18.3 to 17.5 meters)—Mobile.
 17,100 to 17,750 kilocycles (17.5 to 16.9 meters)—Mobile and fixed.
 17,750 to 17,800 kilocycles (16.9 to 16.85 meters)—Broadcasting.
 17,800 to 21,450 kilocycles (16.85 to 14 meters)—Fixed.
 21,450 to 21,550 kilocycles (14 to 13.9 meters)—Broadcasting.
 21,550 to 22,300 kilocycles (13.9 to 13.45 meters)—Mobile.
 22,300 to 23,000 kilocycles (13.45 to 13.1 meters)—Mobile and fixed.
 23,000 to 28,000 kilocycles (13.1 to 10.7 meters)—Not reserved.
 28,000 to 30,000 kilocycles (10.7 to 10 meters)—Not reserved.
 30,000 to 56,000 kilocycles (10 to 5.35 meters)—Not reserved.
 56,000 to 60,000 kilocycles (5.35 to 5 meters)—Amateurs and experiments.
 60 kilocycles (5 to 0 meters)—Not reserved. Note 1—3331 kilocycles (900 meters) is the international aircraft calling and listening frequency.
 Note 2—500 kilocycles (600 meters) is the international calling and distress frequency. It may be used for other purposes when it will not interfere with calling.
 Note 3—Mobile services use the band 550 to 1300 kilocycles (545 to 230 meters) on the condition that they do not interfere with the services of any nation using this band exclusively for radio telephone broadcasting.
 Note—NGP means: Not for general public correspondence.

New Commissioner Appointed

ON NOVEMBER 14, President Coolidge announced the appointment of Harold A. Lafount of Utah as a member of the Federal Radio Commission to fill the vacancy created by the death of John F. Dillon. Mr. Lafount has used a radio receiving set and therefore approaches the problems of broadcast regulation with a confidence equal to that with which we would assume the command of a battle fleet after a visit to a navy yard. The new commissioner may prove to be the dark horse who brings an ultimate victory over confusion and we wish him every success. But certainly, it has been amply demonstrated that the Commission's problems are highly technical and that the Commissioners are handicapped in their work until they have, at great cost of time and effort, learned the intricacies of broadcasting.

Inside the Radio Industry

A CLASSIFICATION of questionnaires returned by 3546 dealers, made by the Electrical Equipment Division of the Department of Commerce, indicates that 26 per cent. are electrical supply dealers, 20 per cent. radio dealers, 13½ per cent. hardware dealers, 8½ per cent. dealers in musical instruments, and 6 per cent. automobile dealers, 5½ per cent. battery and ignition supplies, 4½ per cent. tires and tire repair shops, and smaller percentages to other classes. A total of 68 different varieties of retail outlets is represented in the classification. It is rather surprising to find the hardware retailer so prominently represented and the music dealer outlet so small in proportion to the whole.

Another comprehensive statistical survey, to be a quarterly investigation conducted by the Department of Commerce, is an enumeration of the stock of radio sets and their principal accessories in dealers' and jobbers' hands. The survey is national in scope and the first returns are based upon 7718 filled-in questionnaires. This number of dealers had 147,548 battery receiving sets on hand and 9548 socket powered sets; ordinary speakers, 153,091; amplifier-speaker units, 5018; B and C batteries, rated in 45 volt units, 525,441; storage A batteries, 77,148. This makes an average of twenty battery-operated receiving sets and a little over one socket power set per dealer, a healthy situation, considering that both dealers and jobbers are represented. Moving less than 150,000 battery-operated sets at this season is not an abnormal demand upon the public.

RADIO INDUSTRY STANDARDS

OUR persistent campaign for the adoption of a single set of standards for the radio industry has now come to an end because both trade organizations have, at last, agreed to work together in this one respect at least. This move, however, is only the first step in our program, which calls for complete unification of the two trade associations. The present step, respecting standards, brings this objective nearer.

The Radio Manufacturers' Association and the Radio Division of the N. E. M. A. have agreed to review all manufacturing standards pertaining to radio and will publish a single industry standard. In cases of dispute, the American

Engineering Standards Committee will serve as an arbitration board. The entire industry is to be congratulated upon this outcome of the persistent campaign which a few individuals have waged quietly and persistently for many months.

THE Radio Manufacturers' Association has appointed a Patent Interchange Committee, with A. J. Carter as its chairman, which is to work out a patent pooling plan. It has obtained the consulting services of Mr. C. C. Hanch, who worked out the patent cross license system for the automobile industry. We would suggest that this worthy effort be combined with that along similar lines being made by the Policies Division of N. E. M. A. Without unification of effort, both associations are wasting time and cannot hope to accomplish anything of permanent value.

THE Radio Corporation's quarterly statement for the September quarter announces a net profit of \$4,141,355, its largest net operating profit for any quarter. Its earnings per share were \$2.80 and, for the same quarter a year ago, \$1.53.

NEWS FROM ABROAD

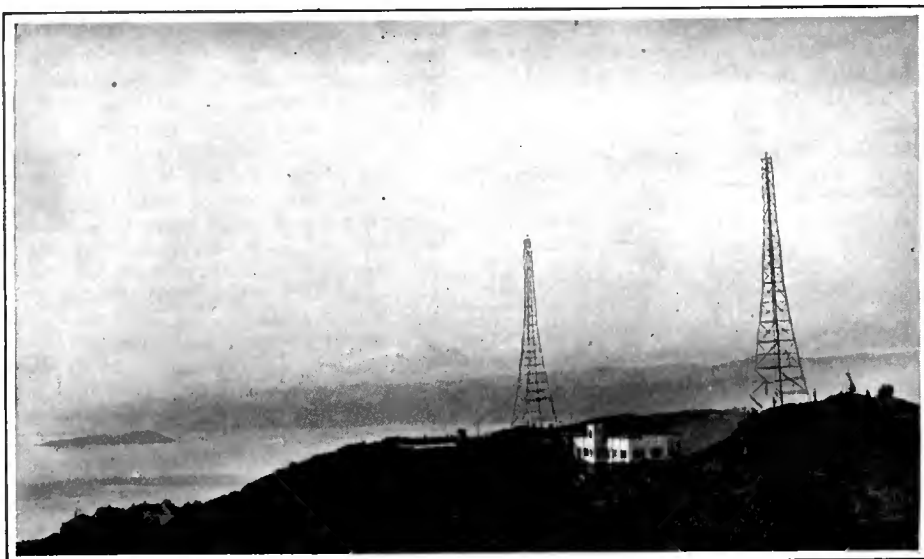
THE writer has had the privilege of talking to Mr. J. M. Bingham, the Chief Engineer of the New Zealand Broadcasting System, who is visiting the United States in order to learn the latest in broadcasting practice from American engineers. As a matter of fact, the entire broadcasting industry of the United States might profitably visit New Zealand in order to learn how to run radio broadcasting successfully. No country has more efficient regulation.

Broadcasting has been placed in the hands of a single company by authority of the New Zealand Parliament. This monopoly is supported by an annual tax upon broadcast listeners. The purchase of every receiving set and every part that goes into a receiving set, down to the last binding post, is recorded by dealers. Government agents have access to their books at all times. No listener can escape the vigilant eyes of government inspectors. The revenue thus gained is divided between the broadcasting stations and

the Government, but not in the unsatisfactory ratio which obtains in the British Isles. Eighty per cent. or more of the broadcast tax collected in New Zealand is actually spent in program talent or the erection and maintenance of broadcasting stations. No radio advertising or commercial goodwill broadcasting is allowed or necessary.

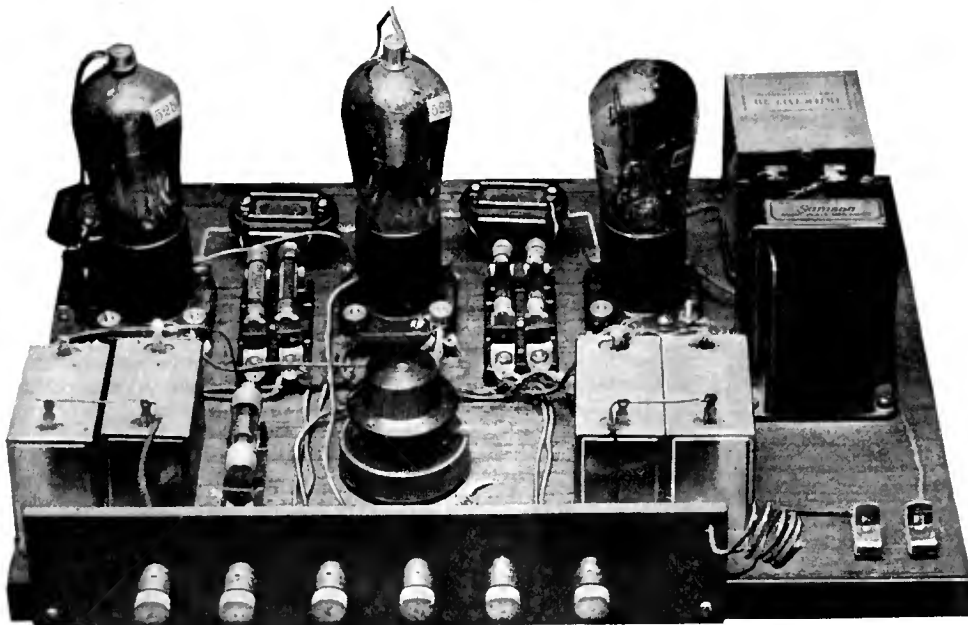
One would conclude that, under such an efficient system, with its magic wand to overcome any serious problems and vicissitudes, broadcasting would thrive and grow. Its growth has been steady but not startling. The number of licensees, in a population of one and a quarter million, is about twenty thousand. Four high power broadcasting stations cover the four-hundred-mile length of the country. There are some dead areas, but prospective changes in transmitter location will soon remedy these. Interconnecting wire circuits are being developed but, as yet, there is virtually no chain broadcasting. Naturally, with but four stations, there are no frequency allocation difficulties. There is no economic problem in meeting station maintenance cost. There is little or no evasion of listener tax. Altogether, it is the most efficient broadcasting system in the world.

A DEPARTMENT of Commerce statement advises that there are 685 broadcasters in the United States and its territories; the total in all nations, other than the United States, is 431. Of these, 106 are in Europe, 128 in North America, outside of the United States, 52 in South America, 18 in Asia, in Oceania 28, and in Africa 9. The four most powerful broadcasting stations in this country are WGY, 100,000 watts with 50,000 watts as its usual power; WEAJ, 50,000 watts; KDKA, 50,000 watts; and WJZ, 35,000 watts. In Russia, there are two 40,000 watt stations and one of 20,000 watts. The total number of broadcasting stations in numerical order are: Canada 59, Cuba 47, Russia 38, Sweden 30, Australia and Germany 24 each, Argentina 22, United Kingdom 20, France and Mexico 18, Spain 15, Brazil 12, Chile 9, Finland 7, England 6. There are four each in Belgium, Czechoslovakia, Uruguay, India, Netherlands, East Indies and New Zealand; three in Italy, Poland, China, Japan and South Africa, and smaller numbers in other countries.



STATION 2 YA AT WELLINGTON, NEW ZEALAND

The New Zealanders have elegant scenery on which to mount their radio stations if this can be taken as typical. 2 YA has 5000 watts power and is one of four stations serving the country



RADIO BROADCAST Photograph

USING 222 TYPE TUBES IN AN AUDIO AMPLIFIER

This is the conventional resistance-coupled amplifier using two screened-grid tubes and one 171 power tube. The little cap on top of the tube is the signal grid connection. The values of resistance, etc., are given on Fig. 5

THE SCREENED-GRID TUBE

By The Laboratory Staff

THE new screened-grid tube, the UX-222 or CX-322, is designed to appeal to the more experimentally inclined of the set constructing fraternity, and while it is comparatively simple to build receivers to utilize some of the advantage of these tubes, the great task comes after the last wire is in place.

Contemporaries of RADIO BROADCAST have devoted considerable space to this new tube and, perhaps, are so keenly alive to its potentialities that they have somewhat over-exaggerated its possibilities so far as the average non-technical set builder is concerned. The screened-grid tube has been in the RADIO BROADCAST Laboratory for several months now, and for a considerable longer period of years in the research laboratories of the R.C.A. and the General Electric Company. As a result of our experiments at Garden City, we must still say that this is an experimental tube, and that hard and fast rules for quickly throwing together coils and con-

tion constant of a tube is increased in this manner, however, the plate impedance also increases and, in fact, increases approximately as the square of the amplification constant, so that the plate impedance increases much more rapidly than the amplification constant. The table on this page will give some idea of how the plate impedance varies as the amplification factor is changed.

When a 201-A type tube is used in a radio-frequency amplifier circuit (see Fig. 1) in conjunction with an ordinary r.f. transformer, the amplification obtained will be a function of the number of turns in the primary coil and its coupling to the secondary coil. With either a very few or a great many primary turns the amplification will be low, but with some definite intermediate number of turns the amplification will become a maximum. Under such conditions the amplification using a 201-A tube will be about 10 at 500 meters (600 kc.) and about 15 at 200 meters (1500 kc.). In order to get even this amplification from a 201-A type tube, a carefully designed circuit is necessary, incorporating some method of neutralization to overcome the effect of the capacity between the grid and plate of the tube, which would otherwise cause the circuit to break into self oscillation.

Somewhat greater amplification can be obtained with an ordinary three-electrode tube if the electrodes are so constructed and arranged as to give the tube a higher amplification constant. Such a tube is called a "high-mu" tube and although such tubes have been used most frequently in resistance-coupled audio amplifiers, they may also be used in an r.f. amplifier. There are, however, several reasons why their use in the latter capacity is not advisable.

The amplification factor of a tube is entirely under the control of the tube engineers, and tubes can be built with little difficulty having constants anywhere from 0.5 to 500. When the amplifica-

tion constant of a tube is increased in this manner, however, the plate impedance also increases and, in fact, increases approximately as the square of the amplification constant, so that the plate impedance increases much more rapidly than the amplification constant. The table on this page will give some idea of how the plate impedance varies as the amplification factor is changed.

Now, in order to obtain considerable gain from a high-mu tube when it is used as a voltage multiplier in an r.f. stage, it is necessary to have a very high impedance load in the plate circuit, so that transformer coupling with a step-up ratio may not be practical. An ordinary high resistance might be used were it not for the fact that it would be shunted by the output and input capacities of those tubes preceding and following it. These capacities across the load resistance would limit the effective impedance of the load in the plate circuit to a low figure, so that the amplification will fall to a comparatively low value. An effective way in which to obtain high gain from a high-mu tube is through the use of a tuned-plate amplifier (see Fig. 2 and compare it with Fig. 1). In such a circuit the output and

TABLE 1

AMPLIFICATION FACTOR	PLATE IMPEDANCE
3	2000
8	12,000
15	25,000
30	150,000
35	250,000

densers with screened-grid tubes to connect them, are not yet possible.

Tubes available in the United States differ considerably from those used in England, and in our opinion suffer somewhat in comparison. This is not due to their electrical characteristics but, rather, due to the mechanical arrangement which, in English tubes, seems to have been worked out with more thought toward ease of use.

Readers interested in the tube may find Captain H. J. Round's book, *The Shielded Four-Electrode Valve*, very helpful. It is published by Bernard Jones Publications, Ltd., 58 Fetter

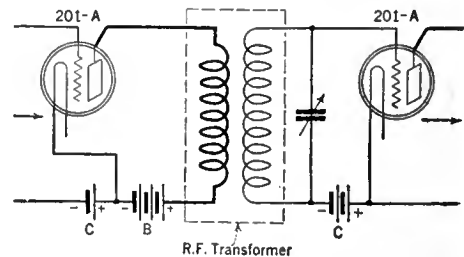


FIG. 1

A transformer is used to connect two tubes working as radio-frequency amplifiers. The number of turns on the primary for maximum amplification is controlled by the input and output impedance of the tubes used. For a given set of tubes and at a given frequency there is a number of turns which will give maximum amplification

input capacities of the tube are in parallel with the condenser which tunes the circuit and have no effect other than to decrease slightly the amount of capacity necessary in the variable condenser in order to tune to any given wavelength. At resonance the effective resistance as measured across the two ends of a tuned circuit is very high and the tuned plate type of amplifier is therefore capable of producing an effective high impedance in the plate circuit—a necessity if high gain is to be obtained, as stated before. The effective resistance at resonance of even a good coil-condenser combination, when it is connected into the plate circuit, is, however, probably not more than 100,000 to 200,000 ohms. When the effective resistance in the plate circuit of a tuned plate r.f. amplifier is equal to the plate impedance of the tube, the amplification obtained is one half the μ of the tube. Thus, a tuned circuit giving an effective resistance of 150,000 ohms, and used in conjunction with a tube having an amplification constant of 30 and a plate impedance of 150,000 ohms would produce an effective amplification of one half μ , or 15. It should be evident that the limiting factor preventing the attainment of much larger values of amplification, is the large increase in plate impedance that occurs when the amplification constant is increased. What we want, obviously, is a tube with a very high amplification factor and as low a plate impedance as possible. Such characteristics are not obtainable using an ordinary three-electrode tube because, as indicated previously, the plate impedance increases much more rapidly than the amplification constant. To obtain a high μ with a comparatively low plate impedance, it is necessary to introduce a fourth electrode into the tube. The effect of the fourth electrode was explained in articles on the four-electrode tube in the December, 1927, and January, 1928, issues of RADIO BROADCAST, and will not be repeated here except to point out that this fourth electrode does give a very large increase in the amplification constant without as large an increase in plate impedance as would be obtained with a three-electrode tube. Measurements in the Laboratory indicate that the amplification constant of the 222 tube is about 200, under certain conditions, and the plate impedance is about 800,000 ohms. If an ordinary three-electrode tube, such as a type 240 high- μ tube, were to be constructed to have a μ of 200, the plate impedance would be about five to seven million ohms! A high value of amplification constant with a comparatively low plate impedance is one of the major characteristics and advantages of the 222 screened-grid tube.

The amplification obtained from this tube is a function of the mutual conductance of the circuit and the impedance of the load in the plate circuit. Owing to the fact that the impedance of the tube is so high, higher than its load impedance, the mutual conductance of the circuit is practically equal to that of the tube. If the mutual conductance of the tube is assumed to be 350 micromhos the amplification with various load impedances can be obtained by multiplying the mutual conductance in mhos by the load impedance. The values have been calculated and appear in Table 2. For certain reasons, however, it is likely that we can't get more than about 200,000 ohms in a tuned circuit under operating conditions. If an effective resistance of 200,000 ohms is connected in the plate circuit of a 222 tube, then the amplification will be about 70 (see Table 2). Compare this with the amplification of 10 to 15 obtained with a 201-A type tube.

The 222 tube has another distinct advantage, also important in the construction of high-gain radio-frequency amplifiers. This second advantage is that the effective grid to plate capacity

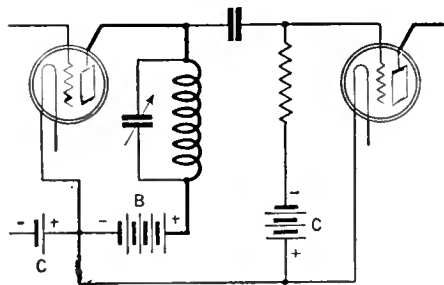


FIG. 2

If the plate impedance of the previous tube is very high the entire input coil of the following tube may be used to approach the maximum amplification possible. This is true when the screened-grid tube is used, for its plate impedance is very high indeed, of the order of one half to one megohm

of the tube is very small. It is this capacity which causes an ordinary tube to oscillate when it is used in an r.f. circuit. Theoretically, it is possible, therefore, to use this new tube in an r.f. amplifier without resorting to any scheme of neutralization to prevent the tube from oscillating.

Some experiments have been made in the Laboratory in an attempt to use these tubes in an r.f. amplifier designed for operation over the broadcast band. The circuit diagram is given here in Fig. 3. The experiments indicated more than anything else the difficulty of operating these tubes in a circuit designed to give the maximum amplification of which the tube is capable. The experiments also indicate that the tube can only be satisfactorily used in circuits containing very complete shielding and very complete filtering in the battery supply leads. This is to be expected, for such shielding and filtering is necessary in a good r.f. amplifier, using 201-A type tubes and, obviously, will be much more essential in an amplifier using these new tubes.

If the amplification of a circuit consisting of a UX-222 tube followed by a tuned circuit is measured, it be will found, with a good coil, to average about 30. The amount of gain obtained depends upon the efficiency of the coils used and increases as the coil is made better.

The first experiments were made with just one stage of r.f. amplification using the 222 tube followed by a detector, and even with very complete filtering and with both of the circuits shielded in aluminum cans the circuit would oscillate on practically all wavelengths. The coils used in the tuned circuits in this receiver were those made by Silver-Marshall, Incorporated, and it is probably true that, if poorer coils had been used, the circuit would have been found stable in operation. In fact, one ohm in series with the tuned circuit at 500 meters (600 kc.) and four ohms in series with the circuit at 200 meters (1500 kc.) was all that was necessary to make the circuit stable. This additional resistance necessary to prevent oscillation is not very great and many coils would have even higher resistances than that of the combined Silver-Marshall coils and resistances.

The same conditions of instability were, of course, also experienced when the receiver was changed over to use 222 tubes in two stages of r.f. amplification. Again, even with good filtering of the battery circuits, it was impossible to

TABLE 2
Effect of Coil Resistance

SERIES RESISTANCE OF COIL	EFFECTIVE RESISTANCE AT RESONANCE	FIGURE OF MERIT	AMPLIFICATION $G_m = 350$
50	50,000	31.5	17.5
25	100,000	63.0	35
17.5	150,000	126	42.5
12.5	200,000	252	70
6.2	300,000	504	105

Conditions: Coil inductance 250 microhenries
Frequency, 1000 kc.

control the circuit, and it persisted in oscillating over the entire broadcast band. The circuit could be stabilized by any of the "losser" methods. In this particular receiver it is found that a resistance of about 1000 ohms connected between the grid and tuned input circuit would prevent the tubes from oscillating. Also stabilization of the amplifier is possible by tapping the plate on to a portion of the output coil rather than connecting it to the top of the tuned circuit, but this method of connection also results in a decrease of amplification. The photograph on page 284 shows

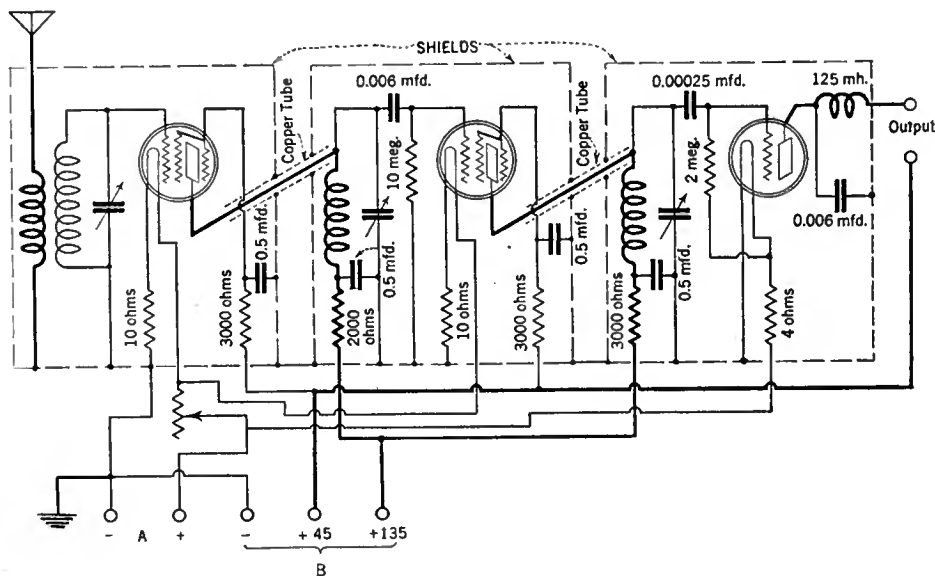


FIG. 3

Here is a two-stage screened-grid broadcast frequency amplifier hook-up. The stage shielding, and the filtering in each plate- and screen-voltage lead must be very good, and leads to the control or signal grid on top the tube must be short and often shielded. The leads connecting one stage to the next should be run in copper tubing which is grounded. Even then it may be found difficult to "hold down" the circuit

how the coil was tapped. Further experiments will be conducted in the Laboratory to indicate the comparative effect of these various methods of stabilizing the circuit where they are necessary, but the use of such methods of preventing oscillation probably decrease the amplification that can be obtained and it will be preferable to design the receiver in such a manner as to give stable operation without any stabilizing devices. It may seem peculiar to the reader that so much difficulty was experienced with oscillation in the r.f. amplifier when one of the major purposes of the tube was to give freedom from instability in r.f. circuits. It should be realized, however, that the tube gives a very high amplification and it is necessary to develop new design features in receivers before these tubes can be utilized to best advantage. When it is realized that very careful design is required to produce stable high-gain radio-frequency amplifiers using 201-A's it should be clear why even greater care is necessary when a 222 tube is used, and perhaps four times the amplification per stage is obtained. It is probable that high-gain amplifiers that are perfectly stable at high radio frequencies will be constructed, but as yet we have not been able to do it in the Laboratory. This should not be construed as a statement to the effect that the possible gain is not greater than that obtainable with 201-A type tubes, for it certainly is—considerably so, but what we wish to infer is that circuits designed to operate with the tube to its best advantage are not available.

There are other problems than those connected with gain and stability. That of securing selectivity is probably even greater than that of maintaining stability over a wide frequency band. Owing to the greater amplification of all signals, the apparent selectivity is poor. When one has a two-stage broadcast frequency amplifier using screened-grid tubes giving three times, to be conservative, the gain per stage of 201-A tubes, the problem of selectivity becomes serious. The solution may be to decrease the gain per stage or to use some type of filter circuit at the input of the receiver capable of increasing the selectivity.

USE IN AUDIO AMPLIFIERS

IN AUDIO-frequency amplifiers the difficulties are not so great, due to the fact that what grid-plate capacity exists in the tube (it is of the order of 0.025 mmfd.) cannot feed back such a

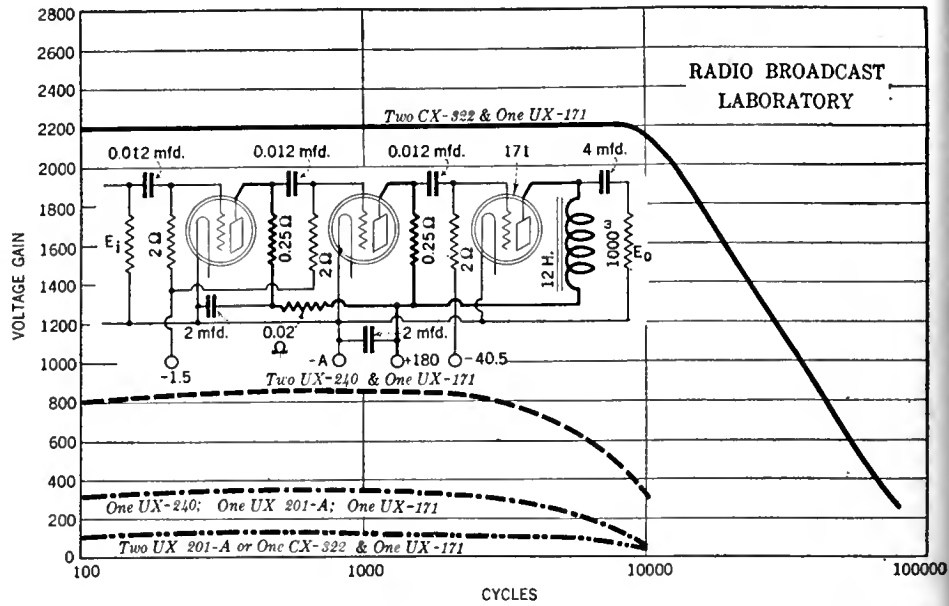


FIG. 4

When the total a.c. voltage appearing in the plate circuit of the last tube is divided by the input voltage to the first tube, this kind of curve results. In each case the final tube was a 171, and various combinations of high-mu tubes, screened grid tubes, and standard 201-A tubes were measured and the results plotted as shown

large voltage into the input as it can at higher frequencies.

The two uses of this tube have been pointed out in previous articles. It may be used as a screened-grid tube in which the grid-plate capacity has been almost eliminated, or as a tube in which the grids are reversed and one is used mainly to reduce the space charge of the tube so that we have a tube whose values of amplification factor and impedance are much greater than the best of our high-mu tubes, the plate-grid capacity still being appreciable.

Experiments in the Laboratory indicate that the space-charge application of the tube is a good talking point but not much good in practice. If one wants to use this new tube in a low-frequency amplifier, which is where the space-charge tube would be important, all that is necessary is to use the screened-grid tube with proper values of resistances, capacities, and voltages. A photograph on page 282 shows a conventional three-stage resistance amplifier used in the Laboratory

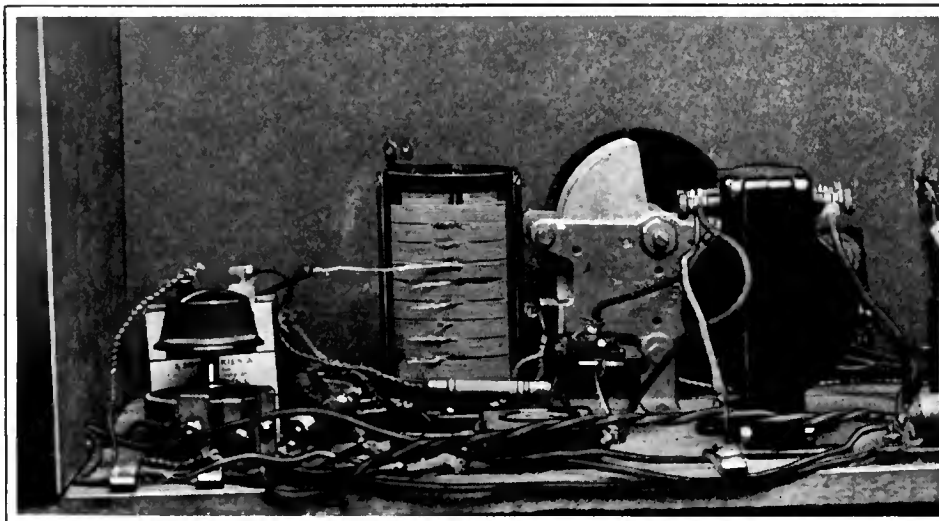
to obtain the data given in Fig. 4. Using screened-grid tubes with 180 volts to the 0.25-megohm resistors and 45 volts on the screen, a flat characteristic was obtained from 60 to 10,000 cycles. The total voltage appearing in the plate circuit, roughly three times that across the 1000-ohm resistance in its output, divided by the input voltage, gave a ratio of 2200, which is almost three times that obtainable when UX-240 high-mu tubes were used. Six volts were obtained across the output resistance when the input voltage was roughly five millivolts.

There is no catch in this amplifier, and for anyone who wants a voltage gain of 2200, and can use it, we recommend converting his old resistance amplifier into one using the new tubes.

While the curve in Fig. 4 shows that some amplification may be obtained at low radio frequencies with resistance coupling, much greater voltage step-up will be secured if tuned plate circuits are used, just as we use them at broadcast frequencies. Here the voltage gain possible is a function of but two factors, the mutual conductance of the circuit and the load impedance. The mutual conductance of the circuit is practically constant and equal to the static mutual conductance of the tube. Neither of these statements is true of ordinary tubes in ordinary circuits.

Multiplying the two factors together gives the maximum voltage gain to be expected, which is approached but not reached in practice. With a mutual conductance of 300 and a tuned circuit with an effective impedance of 250,000 ohms, a voltage step-up of 75 should be secured, and with air-core coils, amplification as high as 200 in the intermediate-frequency band has been recorded. When resistance coupling is used, the familiar drop in amplification at high frequencies is noted, due to the stray shunting capacities as well as the output and input capacities which tend to lower the effective impedance in the plate circuit.

In the amplifier of Fig. 4 a voltage gain of 2200 was indicated when 222 type tubes were used in the first and second stages. This is the total a.c. voltage in the plate circuit of the last tube divided by the input voltage. Figuring that the power tube, a 171, contributes a voltage amplification of 3, the two screened-grid tubes



RADIO BROADCAST Photograph

AN AUTO-TRANSFORMER MAY BE USED

In place of the conventional two-winding transformer between tubes, an auto-transformer may be used. This photograph shows how the proper place to tap the coil is determined in the Laboratory. The amplification at each tap is measured and the best number of primary turns found

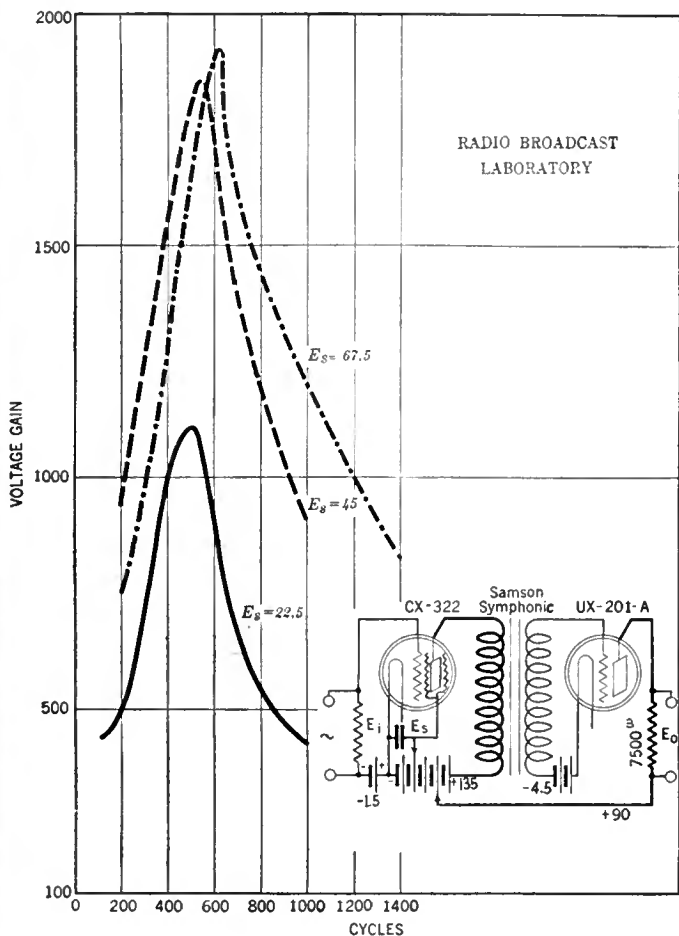


FIG. 5

There is often some advantage in a highly peaked amplifier. These curves were made with a Samson "Symphonic" transformer when used with a screened-grid tube

contribute about 27 each. In the Laboratory a single CX-322 (UX-222) fed into a UX-171 gave a voltage stepup of 120, corresponding to what may be expected from a three-stage resistance amplifier when two 201-A tubes with a 171 are used.

Off hand a voltage amplification of over 3000 with three tubes seems tremendous, but let us consider two transformer-coupled stages plus a final 171 amplifier. If the transformers have a 3:1 turn ratio, and the tubes have a μ of 8, the total voltage amplification from plate circuit of the last tube to input will be $(3 \times 8)^2 \times 3$, which gives 1730.

When transformers are used with the screened-grid tube, the effect of a low primary inductance transformer used with a low-impedance tube is obtained. In other words, a good transformer with a low-impedance tube gives a good characteristic; a high-ratio transformer (low primary inductance) with a high-impedance tube gives a peaked characteristic; a good transformer with a high-impedance tube also gives more amplification about the middle of the audio band than it does at the two ends. Curves of a Samson "Symphonic" transformer, which gives flat amplification with a 12,000-ohm tube, are shown in Fig. 5 and may indicate to code listeners how they can confine the amplification to a rather narrow band of audio frequencies. This transformer naturally resonates at a rather low frequency, and if the amateur or code listener desires his amplifier to peak at a higher frequency he should use a transformer with lower primary inductance, say a 5-1 transformer.

These curves show a discrimination of two to one in voltage amplification between 200 and 500 cycles, and a total amplification of nearly 2000 under certain conditions. In other words, across 7500 ohms in the output of a 201-A type tube, 8.85 volts were obtained with an input of 3.5 millivolts. This is vastly greater amplification than a amateurs use to-day, and probably far greater than they need. The average short-wave receiver with one stage of audio, and fair coupling to the antenna, goes down to the noise level, if the audio gain is about 30 to 50. The advantage of using more audio amplification lies in the fact that looser coupling to the antenna may be utilized, with consequent decreased radiation—with the usual type of receiver—and the fact that in good locations, where the noise is far down compared to weak signals, this amplifier will enable the listener to hear practically any radio-frequency disturbance in the ether, whether it is caused by signals or otherwise. The diagram of connections for this amplifier are given in Fig. 5. If

still greater discrimination in favor of a certain small band of audio frequencies is desired the screened-grid tube might be connected to the detector output by means of a low-inductance choke, say of two or three henries, as shown in Fig. 6. This will be practically a short-circuit on the low frequencies, and will lower the voltage gain at all frequencies,

but there will be plenty left. The average telephone receiver peaks very sharply between 700 and 1200 cycles and, combined with such a circuit as has been used in the Laboratory, should enable the listener to work through low-frequency static noises. There is some question among amateurs whether it is desirable to tune their audio amplifiers, since so many "hams" use low-frequency sources of plate supply for their power tubes, many using raw a.c. and others using self-rectifying circuits in which the

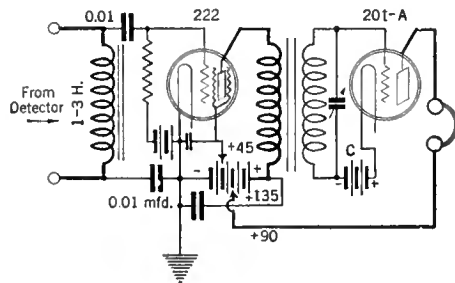
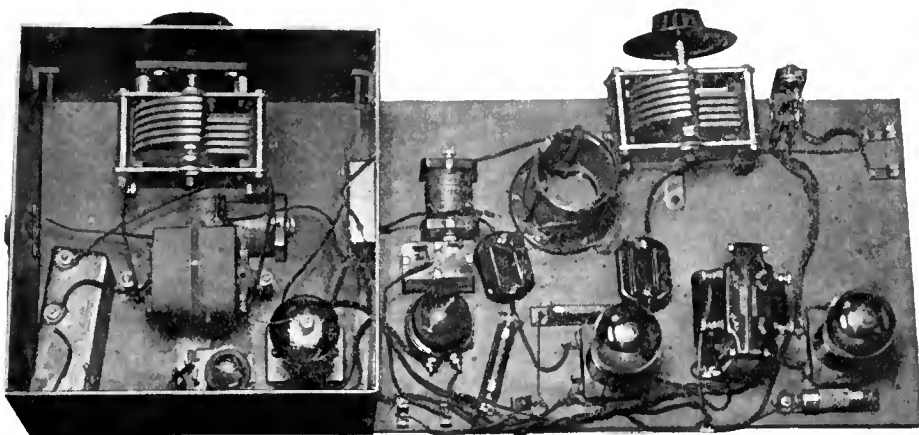


FIG. 6

If still greater discrimination against unwanted audio signals is desired, this manner of connecting the detector to the audio stage might be useful. The low-impedance choke in the input short circuits the low frequencies. The bypass condenser across the audio transformer secondary shunts out the higher audio tones and leaves only a narrow band around 1000 cycles

tone is rather low. It is probable that it is the higher audio tones which should be eliminated from a code amplifier by proper bypassing, for it is these tones due to tube noise and other sources that supply nothing to the amateur but, on the other hand, tax his nervous energy.

The screened-grid tubes which have been tested in the Laboratory are microphonic, and in the transformer-coupled system shown in Fig. 6, some trouble was encountered in keeping the amplifier from singing at the frequency where it amplifies greatest, which was near the mechanical resonant frequency of the elements of the tube. In the resistance amplifier less trouble was encountered, but it must be remembered that we are dealing with a large voltage amplification, which means that the likelihood of trouble from every source is increased.



RADIO BROADCAST Photograph

AN EXPERIMENTAL SET-UP

This is the Laboratory's "brass box" receiver—one r.f. stage using a screened-grid tube, with accessory apparatus, a detector, and a single stage of transformer-coupled audio amplification, are included. Arrangements are made for using a 201-A type tube in place of the 222 type so that the increase in amplification due to the new tube may be directly measured. The detector is calibrated and used as a vacuum-tube voltmeter while the audio stage enables the experimenter to monitor what is going on in the system

RADIO FOLK YOU SHOULD KNOW

WALTER VAN B. ROBERTS

Drawing by Franklyn F. Stratford

MR. ROBERTS is well known to readers of RADIO BROADCAST as a frequent contributor to the magazine, and as the author of the comprehensive and lucid "How Radio Receivers Work" (Doubleday, Page & Co.). He is the inventor of the Roberts receivers, combining cascade radio-frequency amplification and regeneration. Since 1924 he has been on the engineering staff of the Radio Corporation of America, as a receiver and patent specialist. Mr. Roberts was an instructor in Physics and Electrical Engineering at Princeton before assuming his present position.

With some exceptions, among which the Roberts receiver is noteworthy, new receiving circuits christened with the name of the inventor have been lacking both in originality and technical merit. The reason has generally been too much publicity urge and not enough engineering qualifications on the part of the begetter of the great idea. Mr. Roberts is utterly lacking in publicity itch, and very strong in engineering background. From Princeton he has the following degrees: B. S., A. M., E. E., and Ph. D., but he is so modest about them that few people know he has them. The same applies to his scholastic honors in mathematics and physics—membership in Phi Beta Kappa, a medal for electrical research, and several fellowships and scholarships. A characteristic touch is the footnote appended to the bibliography at the end of his excellent little book, "How Radio Receivers Work": "This Bibliography is recommended to radio experimenters who really desire to increase their technical knowledge." The book itself is a very good summary, even under the handicap of some degree of popularization, of technical knowledge in the radio receiver field, but this fact the author apparently declines to recognize.

In May, 1917, Mr. Roberts enlisted in the Signal Corps as a Master Signal Electrician, "a high-sounding title ranking along with some of the higher grades of sergeants, if I remember correctly," as he puts it. He soon returned to Princeton to organize and run the Department of Signalling and Wireless in the School of Military Aviation, an army ground school for aviators. The object of the course was to inculcate the several thousand men who took it with an elementary knowledge of radio theory and practice on the spark-set-and-crystal-detector level, and to teach them to receive and send Morse at low speed. The code students were taught to print each letter separately as received, and cautioned not to look at letters already recorded for fear that they would be influenced in copying what was to follow. "To this day," testifies Dr. Roberts, "I copy code by writing letters separately and get all 'balled up' if I try to see what the message is about before it is all finished." Evidently he found learning the code a very painful process at first, as it is for most people. A monograph could be written about the agon-

ized thoughts, amounting almost to hallucinations, the disturbances of breathing, the involuntary lapses of attention during which the code characters are heard while, in a sort of paralysis,

THERE are many and important figures in the radio world who are not especially well known to readers of this magazine. We have read in great detail of the lives and work of such men as Marconi, Alexanderson, DeForest, Sarnoff, Crosley, Armstrong—to choose names at random—but there are many others who are worthy of note and who are behind the scenes. RADIO BROADCAST will, from time to time, carry stories which will take the reader behind the scenes a bit. A short article in our January issue told something about Ralph H. Langley of the Crosley Company. This article, devoted to Walter Van B. Roberts, describes a man whose name is known all over the world because of his circuit, which was first described in this magazine for April, 1924. Mr. Roberts' activities are not especially well known to our readers and the accompanying article attempts to sketch some of his work.—THE EDITOR.

the mind refuses to decipher them, which afflict the learner, particularly when he is pushed ahead too fast. As far as the intellectual factors were involved, Dr. Roberts naturally had little difficulty, and one of his feats, which proved



WALTER VAN B. ROBERTS

useful in convincing the men that their memory of the code characters would improve with practice, was an ability to receive at ten words a minute any new code made up of four-element

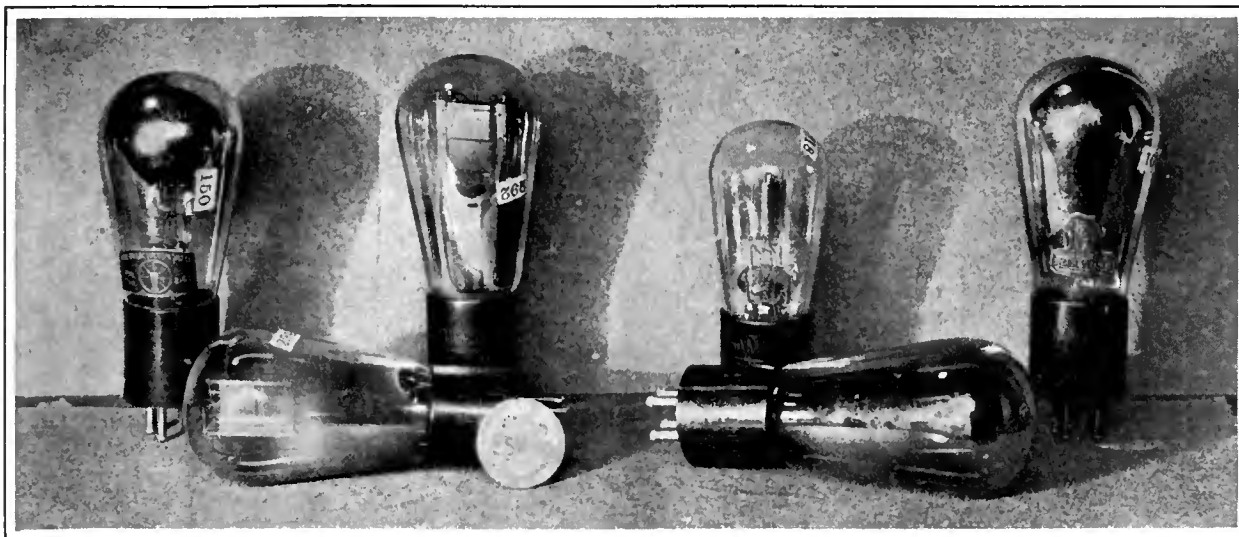
combinations of dots and dashes, after four minutes of study.

Early in 1918, Mr. Roberts obtained a commission as First Lieutenant in the Signal Corps, and soon after he was transferred to the 29th Engineers Sound-Ranging Service. In this branch of artillery practice microphones are placed at about half-mile intervals in convenient or possible places, depending on the terrain and the nature of the gun fire as well as on the technical requirements of the method. A pair of wires runs from each transmitter to a central station. When an enemy gun fires, the sound, traveling at only about 1200 feet per second, is received first by the microphone nearest to it, and, after an appreciable interval, by the next microphone, and so on. These times are automatically recorded at the central station, and the location of the gun follows after a few minutes of calculation. The big job is keeping the lines intact; Mr. Roberts states that half the personnel of a sound-ranging group is required for this purpose, over a hundred breaks in the lines during a night of heavy shelling being not uncommon. He thinks that a small radio transmitter associated with each microphone might be better than the wire links.

Mr. Roberts was a technical officer in the sound-ranging dugouts from June to October, 1918, when he was retired to hospital "with an excuse for getting a wound stripe," as he is pleased to phrase it. However, valuable technical officers were not sent back for bruised finger nails, and we may surmise that Mr. Roberts did not find his way to the rear alone, or under his own means of locomotion. He did go to the front alone, however, and by almost as painful a route. It seems that he sailed for France as a casual officer in charge of one hundred and twenty crates of sound-ranging equipment, including storage batteries, carboys of acid, wire, and special microphones responsive only to low-frequency sounds. His first job was to keep his one hundred and twenty crates together in the unloading process. He succeeded, presumably by exerting the forcefulness of a brigadier general, which is difficult without the silver star. With all the stuff in a freight car, Roberts added his baggage and a can of corned beef, and finally himself. He thus traveled in state to the freight yards outside of Paris, where he remained two days. He did not leave his freight car, because no one knew when it would pull out, and he wished urgently to be with it at that time. After a week in the freight car, he finally got close enough to the front to permit the equipment to be transferred to three trucks, which moved it into the trenches under cover of darkness.

Before the war Dr. Roberts had one other job—he worked on acoustic problems for the Western Electric Company, at \$12 per week. But he says that this sum was more than he was worth.

Mr. Roberts is married, has two children, and lives in Princeton, New Jersey.



RADIO BROADCAST Photograph

HERE ARE THE NECESSARY TUBES FOR THE UNIT DESCRIBED IN THIS ARTICLE
The metal disc is the size of a half dollar, and is shown to give some idea of the size of the tubes

An A. C. Push-Pull Amplifier and B Supply

By J. E. Coombes

THE introduction of a.c. tubes has greatly simplified the construction of complete receivers which derive all of their power directly from the electric light mains. For those of us who now have a tuner unit or a complete receiver with an out-of-date audio amplifier, the a.c. tube is a logical means whereby we can construct a completely a.c. operated audio amplifier that can be hitched on to the output of the detector tube or to which we can connect an electrical pick-up when we want to play phonograph records. And, incidentally, we can design our amplifier also to supply plate voltage to the detector and r.f. tubes of the radio receiver proper. Such a combination amplifier and B supply device is illustrated in this article.

The device illustrated herewith includes a two-stage transformer-coupled amplifier using a type

227 a.c. tube in the first stage, followed by two type 210 tubes in a push-pull arrangement. Plate potential for these tubes is obtained from two 216-B or 281 type tubes operating in a full-wave rectifier circuit. Filament current for the two 210's is obtained from a filament winding on the power transformer (T_1 in Fig. 1) and filament current for the 227 a.c. tube is obtained from a separate filament transformer, T_2 . The latter transformer also contains a winding which can be utilized to supply one or more r.f. tubes in the radio receiver proper, thereby making the entire set operate directly from the power mains. We are assuming that 226 type a.c. tubes will be used in the r.f. amplifier, and a 227 type tube for the detector. The latter will be supplied by the same transformer winding as the first audio stage. The B power part of the amplifier contains a

glow tube to maintain the output voltages constant independent of the load drawn by the radio receiver.

Some readers may merely want to construct the push-pull circuit and B supply rather than a complete two-stage amplifier. For this reason the circuit diagram has been divided into two parts by a dotted line, the push-pull amplifier and B supply being located to the left and the first stage of audio amplification to the right. Neglect the right-hand side of the diagram if only the push-pull amplifier and B supply are to be constructed, and connect the output of the receiver proper to the terminals marked X-Y, the new input posts. This latter unit (the push-pull amplifier) will operate without any appreciable hum although a slight amount of hum is noticeable during the silent periods in a pro-

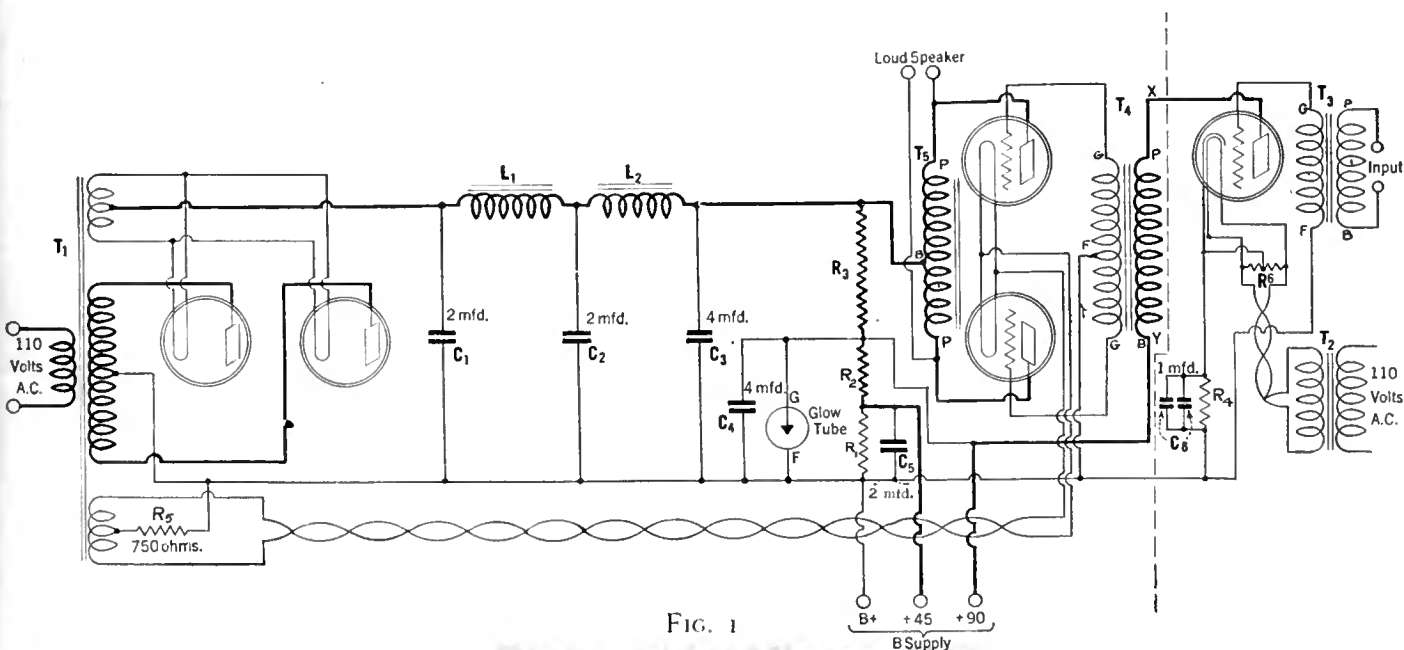


FIG. 1

gram when using the complete two-stage amplifier.

Naturally this amplifier can handle considerable volume. Volume, however, is not the main objective any more than an 80-mile-per-hour automobile is expected to travel at top speed through traffic. Like the automobile, however, this heavy-duty power amplifier has the liberal fund of reserve power essential to prevent overloading and thereby reproduce a radio program with the least possible distortion.

The power transformer, T₁, contains three separate windings. One winding provides 550 volts either side of the center tap to supply a full-wave rectifier system using two 216-B or 281 type tubes. The latter tube, because of its greater rating, will generally have somewhat longer life than a 216-B tube and will also give a slightly greater output voltage. In addition to the center-tapped high-voltage secondary, the transformer also contains two 7½-volt windings to supply filament current to the rectifiers and the 210 power amplifier tubes. The output of the rectifier is fed into a filter system containing two filter chokes, L₁ and L₂, and three condenser banks, C₁, C₂, C₃. The high-voltage output, (about 450 volts under load) of the filter is fed directly to the plates of the UX-210 (CX-310) tubes.

All of the resistances necessary in the construction are contained in the Ward-Leonard Vitrohm resistor kit, type No. 507-47. R₁ and R₂ in the diagram are two 5000-ohm resistances contained in the kit. R₃ is composed of a combination of resistors. By using different values of resistance at this point the amount of current drawn by the glow tube is varied. Generally, it will be satisfactory to have R₃ consist of the 3500-ohm and 1500-ohm resistances in series, to give a total resistance of 5000 ohms. However, when the tuner unit consists of only a couple of tubes, say a detector and one stage of r.f., this resistance may be increased by connecting the 3000-ohm resistance in series with the two mentioned above. This combination will give a total resistance of 8000 ohms and this additional resistance will decrease, somewhat, the current drain on the filter system and the maximum possible voltage is thereby delivered to the plate of the power tube.

The C bias for the 227 type tube is obtained from the voltage drop across the 1500-ohm resistance, R₄. This resistance is bypassed with a 2-mfd. condenser. C bias for the 210 tubes is obtained from the 750-ohm resistance, R₅, con-

nected to the center tap of the filament winding supplying these tubes. A bypass across this resistance is not necessary because there are no audio-frequency currents flowing through it.

The following table shows how the total output voltage of the rectifier-filter system varies with current drawn from it:

D. C. CURRENT, MA.	D. C. VOLTS
60	537.5
70	515.0
80	487.5
90	462.5
100	440.0
110	427.5
120	417.5

In normal operation the 210's take about 20 mA. each, the glow tube a maximum of 40 mA., the first audio stage requires a maximum of 5 mA., and if the detector and r.f. tubes take a total of 10 mA., then the total load on the B supply unit will be 95 mA. At these current drains the output is about 450 volts and subtracting about 30 or 35 volts which is lost in the C bias resistance, there is left an effective voltage of about 415 volts on the plates of the 210 tubes.

The complete amplifier, as the illustration shows, was constructed on a baseboard, measuring 9 x 24 inches, and most of the wiring can be done under the baseboard by drilling holes through the board directly beneath the terminals on the various units and threading the leads through. The filament leads to the 210's and 227 should be twisted. No special kinks are necessary in the construction and the circuit diagram and illustration in this article should supply all the necessary constructional hints.

To assemble the complete amplifier and B supply exactly as illustrated, the following parts are necessary:

- T₁—Thordarson Power Transformer, T-2098
- L₁, L₂—Thordarson Double Filter Choke, T-2099
- T₂—Thordarson Filament Transformer, T-2445
- T₃—Thordarson R-200 Audio Transformer
- T₄—Thordarson Push-Pull Input Transformer, T-2408
- T₅—Thordarson Push-Pull Output Choke, T-2420
- C₁, C₂—Acme Parvolt Filter Condensers, Series B, 2-Mfd.

- C₃—Acme Parvolt Filter Condenser, Series B, 4-Mfd.
- C₄—Acme Parvolt Filter Condenser, Series A, 4-Mfd.
- C₅—Two Acme 1-Mfd. Parvolt Filter Condensers, Series A
- C₆—Acme Parvolt Filter Condensers, Series A, 1-Mfd.
- R₁—5000 Ohms
- R₂—5000 Ohms
- R₃—5000 to 8000 Ohms (See Text)
- R₄—1500 Ohms
- R₅—750 Ohms
- R₆—General Radio Center Tapped Resistance Five Benjamin Sockets, 4-Prong, No. 9040
- One Benjamin Socket, 5-Prong, No. 9036
- Seven Eby Binding Posts

All these resistances are contained in the Ward Leonard Vitrohm Resistor Kit, No. 507-47

THE REQUISITE TUBES

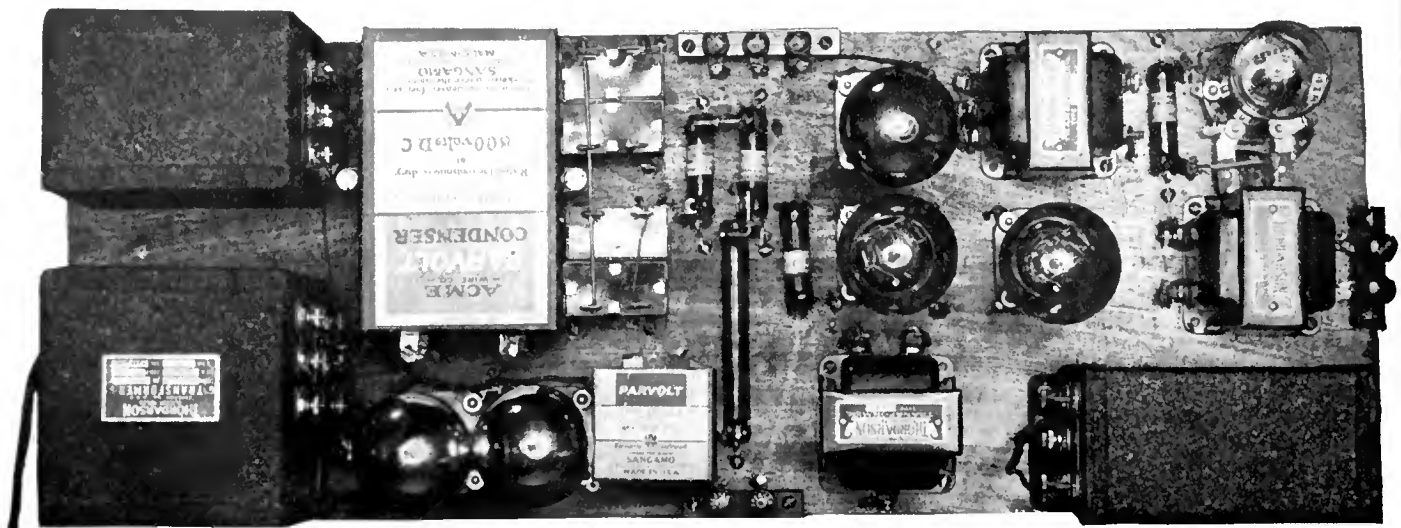
- Two UX-210 Power Tubes
- One UX-874 Glow Tube
- Two UX-216-B Rectifier Tubes
- One UX-227 A.C. Heater Type Tube

The power lead from T₁ can be plugged into an extra receptacle which is in the end of the filament transformer, leaving one lead to be plugged into the regular light socket. In operation, the resistances will get quite warm and the regulator tube should glow with a bluish or pinkish glow. The input terminal connecting to the P post of the input transformer should connect to the plate of the detector tube and the other input lead should connect to the B + 45-volt terminal on the B supply. If one side of the A battery is not grounded, it should be.

It will be noted that R.C.A. terminology has been resorted to throughout this article when referring to tube types. Tubes exactly similar to those bearing the R.C.A. stamp are supplied by Cunningham. The following table shows the parallel types:

R. C. A.	Cunningham
UX-226	CX-326
UX-227	CX-327
UX-210	CX-310
UX-216-B	CX-316-B
UX-281	CX-381
UX-874	CX-374

Many independent manufacturers are also supplying tubes the characteristics of which are similar to or approximate very closely those of the tubes specified in this article.



THE COMPLETE PUSH-PULL AMPLIFIER AND B SUPPLY

RADIO BROADCAST Photograph

New Recordings by Radio Favorites



FAMOUS SYMPHONY CONDUCTORS



THE insert at the top, shows Nikolai Sokoloff, conductor of the Cleveland Symphony, shown in the large oval. Many records have been made for Brunswick by the Cleveland orchestra. Henri Verbrugghen is shown in the left-hand insert of the lower group of three conductors, the center one being Willem Mengelberg, and the right-hand one Walter Damrosch. Verbrugghen is conductor of the Minneapolis Symphony, heard over wcco; Mengelberg now conducts the New York Philharmonic, heard over wor; Walter Damrosch, conducting a large group of New York Symphony men, is heard over wjz and chain each Saturday night. The Cleveland orchestra broadcasts through WEAR

iota of color is lost by the recording of this magnificent overture, which has been played in masterly fashion by the Cleveland Orchestra under the direction of Nikolai Sokoloff.

Nor are any of the delicate shadings lost in the exquisite *Dernier Sommeil de la Vierge* of Massenet, as played for Brunswick by the Minneapolis Symphony under the baton of Henri Verbrugghen. This lovely ecclesiastical music contrasts strangely with the robust *Coppelia Ballet* which appears on the reverse side of the record. This delightful composition by Delibes has as much swing to it as any present day dance number you can think of and a melody as simple as any jazz strain—and furthermore it is many times as soul-satisfying.

Two more classical dance numbers are Johann Strauss's *Artist's Life* and *Tales From the Vienna Woods* (Brunswick). The interpretation of these oft-heard waltzes by Willem Mengelberg, conducting the New York Philharmonic Orchestra, is to their usual rendition as a production of *Midsummer Night's Dream* by Max Reinhardt is to a high-school performance of the same comedy.

Perhaps the most famous musical selection in the world is the *Wedding March* from Lohengrin. Certain it is that a great many people, be they married or single, know it and love to hear it played. Certain it also is that most of them have never heard it more beautifully interpreted, if as beautifully, as it has been by the Cleveland Orchestra under the direction of Nikolai Sokoloff, for Brunswick. This makes the usual rendition, cloaked in romance and sentiment though it be,

seem stale by comparison. And the same may also be said about the *Prelude to Act 3 of Lohengrin*, which selection is on the opposite side of the *Wedding March* (Brunswick).

Another familiar number is the *Song of India* by Rimsky-Korsakow. We once thought that we never wanted to hear this again. That was because a neighbor of ours—oh, years ago—had just invested in a phonograph and a few records, very few! One of them was the *Song of India* popularly recorded. The thrill of having a phonograph was evidently great, for the machine was never silent. It was Spring and all windows were open. Need we say more? But we find that this record by the Cleveland Orchestra is something else again. We can hear it with as much delight as if it were entirely new to us. This same orchestra's version of Tschai-kowsky's *Sleeping Beauty* waltz is full of color and feeling and contrasts vividly with the usual performance of this favorite by hotel orchestras and bands, whose treatment of it is seldom more than an adequate reading of the notes (Brunswick).

On the next page we give a list of recent electrically recorded symphony records.

Recent Popular Records

HAVING on various occasions thrown stones in no uncertain fashion at popular music it behooves us to explain ourselves before we proceed to review some of the popular records. While we still contend that it wears us in bulk, we admit that we thoroughly enjoy it in small doses. A little of it over the radio is an excellent thing; and the same applies to the phonograph.

Recent Symphony Orchestra Recordings

A FEW records which have been recently issued deserve special attention, particularly because they are noteworthy achievements in recording. If you are not aware of the vast improvement that has been made in this art by the development of electrical recording, play a record of the old method and compare it with one of the new method. You will observe the extended tone range of the latter, in which you will hear high and low notes which were lost by the old system of recording. Of course that is taking for granted that your own reproducing apparatus is adequate. If you are still making use of one of the pioneer phonographs, or an antediluvian horn as your loud speaker, all records will sound equally bad. But with good equipment it won't require much imagination to believe that you are in the hall with the orchestra itself instead of in your own home listening to canned music.

One of the new records which would be particularly successful for this demonstration which we suggest is the "1812" *Overture* of Tschai-kowsky (Brunswick), in which the composer has plumbed the musical depths with the resounding tones of the tympani, then in the next breath climbed to ecstatic heights with the strings. The full orchestra is brought into play and not an

But the dose must be moderate and we want it palatable.

Though we can't seem to get away from the stumbling block of a limited number of current songs which we are forced to hear over and over again, the better orchestras do their best to vary the music as much as possible by the addition of frills in studied orchestration. Those who orchestrate well can make good music out of mediocre. Take for instance *Good News* and *Lucky in Love* as played for Brunswick by Ben Selvin and His Orchestra. Yes, those are the same selections which we frowned on so severely last month. But you would never know they were the same! That is what Selvin orchestration does for a piece. A little trimming here and there by a steel guitar—and the trick is done. The result: a simply grand dance record!

This orchestra is versatile, too. In *I Could Waltz On Forever* it makes the most of the strings, the sax, and the piano. Even that moss-grown favorite, *Cheerie-Beeie-Bee*, on the reverse, takes on new life under Selvin treatment (Brunswick).

Play-ground in the Sky from "Sidewalks of New York," being a particularly good number to start with, doesn't need much doctoring and it has very wisely been simply treated by this same orchestra. Incidentally, why haven't we heard this selection oftener? It is swell! *Wherever You Are* from the same show isn't as good but the most has been made of it (Columbia).

The fourth record by this outfit is *I Call You Sugar* and *Yes She Do* (Brunswick). Again trick orchestration. Selvin does this instrumental ornamentation extremely well, making it fit into the general scheme of things instead of letting it stand out like the ball on the Paramount Building, as a lesser light would be apt to do. The result is that the records are not ruined for dancing but are improved.

Our old favorite, Ernie Golden, is a past master at this art of orchestration. He rings the bell again with *All By My Ownsome* and *A Night In June*, in which he introduces a steam caliope effect which is grand! We suggest that he get it patented and use it as a musical trade mark (Brunswick).

Don Voorhees has made four recordings on three different discs for Columbia. These four are: *Rain*, *Baby's Blue*, *Highways Are Happy*

Ways, and *When the Morning Glories Wake Up In The Morning*. There is a sort of smooth placidity about this orchestra by which you can always identify it. It never gets excited, it is uniformly good and yet it never seems to climb quite to the topmost heights. However, it has personality and that is a lot in these days. We have named the records in the order in which we rate them, the first being by far the best. Listen to the saxophone.

On the opposite side of *Baby's Blue* is *The Calinda* by the Radiolites. It is a very good number with an irresistible swing. Not the least attractive feature of the record is the vocal chorus by Scrapy Lambert, of cough drop fame. (Columbia).

The Radiolites are responsible for another good dance record, *There's A Cradle in Caroline* and *Everybody Loves My Girl*. Neither selection is inspired but each moves along with a smooth rhythm (Columbia).

A record that stands out from the rest is *Charmaine* and *Did You Mean It?* by Abe Lyman's California Orchestra. Both numbers are played with a restraint not often displayed by a dance orchestra. Soft pedals and plaintively insinuating rhythms are a relief after robust, vigorous jazz (Brunswick).

If you have once heard Phil Ohman and Victor Arden stroke, jingle, bang, and otherwise urge on the ivories, you will look forward eagerly to hearing them again. We have and did, and were disappointed by their record for Brunswick, *There's Everything Nice About You and Mine*. Oh, yes, they are good numbers, well played, but there is too much of the orchestra and too little piano. You can always hear good orchestras but there is only one Ohman and Arden.

Two more disappointments were records by Ben Bernie and His Hotel Roosevelt Orchestra and by Vincent Lopez and His Casa Lopez Orchestra. By rights one can expect the best from these two bands. But they both play as if pay day were at least a month away. The records are *Miss Annabelle Lee* and *Swanee Shore* by the first outfit and *Someday You'll Say "O. K."* and *Just a Memory* by the second. Both are Brunswick.

Only moderately good are the rest: *A Night in June* and *Are You Happy* by the Ipana Troubadours (Columbia); *Feelin' No Pain* and *Ida*

Sweet as Apple Cider by Red Nichols and His Five Pennies (Brunswick); *Manhattan Mary and Broadway*, both numbers from "Manhattan Mary," by Cass Hagan and His Park Central Hotel Orchestra (Columbia); *Like the Wandering Minstrel* and *Molly Malone*, from "The Merry Malones," played by The Cavaliers (Columbia); and *No Wonder I'm Happy* and *Sing Me a Baby Song* by the George H. Green Trio (Columbia).

Taken all in all these dance records that we have reviewed form a good collection. Not one of them is really poor.

If you are a devotee of Roxy you will welcome three records played in the Roxy Theatre by Lew White, the organist, *Broken Hearted* and *Just Like a Butterfly*, *When Day is Done* and *Forgive Me*, *Underneath The Weeping Willow* and *At Sundown* (Brunswick all). It is all typical movie organ music. Many people object to that sort of thing but we like it when it is well done, as this is. Our preference is for *Underneath the Weeping Willow* and second choice is *Broken Hearted*. Neither of these has a vocal chorus and the rest have. Does a vocal chorus go with organ music?

The male counterpart of Vaughn De Leath seems to be Vernon Dalhart. He isn't as gushy, for which let us be truly thankful, but the idea is the same. He offers *My Mother's Old Red Shawl* and *Down On The Farm* on a Brunswick record.

Billy Jones and Ernie Hare, the Happiness Boys, again present us with a little vulgar singing of a nice sort. Well, you know they aren't exactly refined but they are good. This time they have recorded *You Can't Walk Back From An Aeroplane* and *Who's That Pretty Baby?* for Columbia.

Art Gillham, the Whispering Pianist, hands out the typical vaudeville sob stuff, piano and recitative, in *Just Before You Broke My Heart* (Columbia). On the other side is *I Love You But I Don't Know Why* which is moderate.

About the only thing to say about *Roam On My Little Gypsy Sweetheart* and *There's A Cradle in Caroline* as sung by the Goodrich Silvertown Quartet is that they have been in better shows than this (Columbia).

The same might be said of the Anglo-Persians who play *Call of the Desert* on a Brunswick record. But they redeem themselves by the selection on the reverse side, *Down South*. We end on a note of praise for the carpet riders.

New Electrical Symphony Orchestra Recordings

New York Philharmonic Orchestra	VICTORY BALL—Fantasy. Parts 1 and 2	(Schelling)	1127	Victor
	VICTORY BALL—Fantasy. Parts 3 and 4	(Schelling)	1128	Victor
	ARTIST'S LIFE	(Strauss)	50096	Brunswick
	TALES FROM THE VIENNA WOODS	(Strauss)		
	MARCHE SLAVE, Parts 1 and 2	(Tschaiakowsky)	50072	Brunswick
Chicago Symphony Orchestra	MIDSUMMER NIGHT'S DREAM—Scherzo	(Mendelssohn)	50074	Brunswick
	MIDSUMMER NIGHT'S DREAM—Nocturne	(Mendelssohn)		
	WINE, WOMAN AND SONG	(Strauss)	6647	Victor
	SOUTHERN ROSES	(Strauss)		
	CARNIVAL OVERTURE, Parts 1 and 2 (Op. 92)	(Dvorak)	6560	Victor
	IN SPRINGTIME—Overture, Parts 1 and 2, Op. 36	(Goldmark)	6576	Victor
	(1.) SERENADE (Volkman, Op. 63.) (2.) Flight of Bee	(Rimsky-Korsakow)	6579	Victor
	VALSE TRISTE	(Sibelius)		
	TO A WATER LILY	(MacDowell)	1152	Victor
	TO A WILD ROSE	(MacDowell)		
St. Louis Symphony Orchestra	COUNTRY DANCE, No. 1	(German)	9009	Victor
	PASTORAL DANCE, No. 2—Merrymaker's Dance, No. 3	(German)		
	FINGAL'S CAVE—OVERTURE, Parts 1 and 2	(Mendelssohn)	9013	Victor
Cleveland Symphony Orchestra	BLUE DANUBE WALTZ	(Strauss)	50952	Brunswick
	TALES FROM VIENNA WOODS	(Strauss)		
	DANSE MACABRE	(Saint-Saëns)	50089	Brunswick
	MERRY WIVES OF WINDSOR OVERTURE	(Nicolai)		
	FINLANDIA	(Sibelius)	50953	Brunswick
	SYMPHONY No. 2	(Brahms)		
	HUNGARIAN DANCE, No. 5, G MINOR	(Brahms)	15992	Brunswick
	VALSE TRISTE (Op. 44)	(Sibelius)		
	SLAVONIC DANCE No. 3	(Dvorak)	15991	Brunswick
	TRAUEREI	(Schumann)		
	1812 OVERTURE—PARTS 1 AND 2	(Tschaiakowsky)	50090	Brunswick
	LOHENGRIN: Prelude to Act 3	(Wagner)	15121	Brunswick
	LOHENGRIN: Wedding Music	(Wagner)		
	SLEEPING BEAUTY WALTZ	Tschaiakowsky	15120	Brunswick
	SONG OF INDIA	(Rimsky-Korsakow)		
Minneapolis Symphony Orchestra	COPPELIA BALLET—Prelude and Mazurka	(Delibes)	50087	Brunswick
	DERNIER SOMMEIL DE LA VIERGE	(Massenet)		
	DER FREISCHUTZ, OVERTURE, Parts 1 and 2	(Weber)	50088	Brunswick
	MELODRAMA FROM "PICCOLINO"	(Guiraud)	15117	Brunswick
	WAIATA POI	(Hill)		

“Our Readers Suggest—”

OUR Readers Suggest. . . is a regular feature of RADIO BROADCAST, made up of contributions from our readers dealing with their experiences in the use of manufactured radio apparatus. Little “kinks,” the result of experience, which give improved operation, will be described here. Regular space rates will be paid for contributions accepted, and these should be addressed to “The Complete Set Editor,” RADIO BROADCAST, Garden City, New York. A special award of \$10 will be paid each month for the best contribution published. The prize this month goes to Conrad Ederle, New York City for his suggestion entitled “Extending Loud Speaker Leads.”

—THE EDITOR.

Extending Loud Speaker Leads

IT IS often very desirable to place a loud speaker some distance from the set in conjunction with which it is operating. The long leads, however, are somewhat bulky, and are especially conspicuous when run along the wood molding.

It was recently the writer’s job to install a loud speaker diametrically across the living room from the receiver in such a manner as to merit the approval of several discriminating family critics. The method used to accomplish this task may be of general assistance.

In the first place one of the two long leads generally necessary was dispensed with. There are two available grounds in our living room, a radiator by the receiver, which is used for the set ground, and gas logs in a fireplace, on the mantel over which the loud speaker is mounted. A connection from the loud speaker to the logs was used as one wire, the other loud speaker terminal being connected to the receiver as shown by the dotted lines in Fig. 1. As a matter of experiment, the resistance of the ground circuit (*i. e.*, the matter between the set ground and the loud speaker ground) was determined, and its value found to be 28 ohms. This is not, indeed, very low, but, on the other hand, not high enough to occasion an appreciable loss in signal strength.

A No. 26 single white cotton-covered wire was used as the conductor from the loud speaker to the set. This wire was run inconspicuously along the cream colored molding. However, the last six feet, from the molding across the wall to the loud speaker cord, was necessarily exposed. The visibility of the exposed portion was reduced materially by running the single wire down a corner and gluing the wire in place rather than using tacks. A drop of LePage’s glue was placed at one foot intervals along the wire. This was allowed to become tacky before being pressed against the wall. Talcum powder was blown from the palm of the hand, while the glue was still moist, effectively hiding the brown color, and blending successfully with the buff tone of the walls.

CONRAD EDERLE,
New York City.

STAFF COMMENT

AS MR. EDERLE observes, it is often desirable to operate a loud speaker at some distance from the receiver. The desirability of this arrangement may be dictated by esthetic or technical considerations. Some receivers, notably those operating from loop antennas, function best in a definite section of a room.

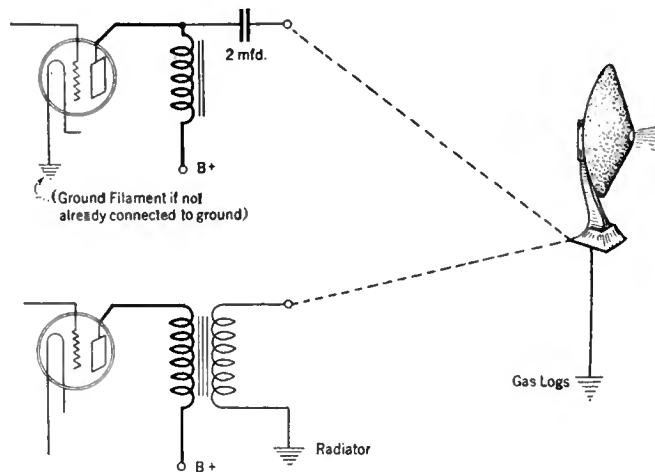


FIG. 1

Showing how a single lead to the set, plus a ground connection, can be used with either transformer or choke coil output device to operate a loud speaker at some distance from the receiver

The same holds true with loud speakers when careful consideration is given to acoustic effects.

Belden has produced a flat two-wire extension cord which may be laid under a rug, providing a very convenient form of inconspicuous wiring. While the Belden arrangement was designed ordinarily with the requirements of the 110-volt power line in mind, there is no reason why it should not be adapted to a loud speaker output circuit.

In using the ground return suggested by Mr. Ederle, it is quite essential that an output device be employed—either a choke coil arrangement or a transformer. Unless one of these is used, the high voltage to the plate of the output tube will, in many cases, be shorted over to ground. Both circuit arrangements are shown in Fig. 1.

The Cartridge Type Charger

MANY fans have the connections from the storage A battery to the charger arranged as shown in Fig. 2A, merely closing the 110 volts a. c. circuit whenever the battery needs charging. This scheme is entirely satisfactory when a bulb type charger is used, for the path between the plate and the filament of the tube becomes non-conducting when the filament heating current is cut off and, therefore, no discharge path through the charger is presented to the A battery current.

When the cartridge type charger which has recently appeared on the market is used, however, this scheme is no longer satisfactory. An investigation made to learn why a battery connected to the charger as shown in Fig. 2B seemed to lose its charge in a few days disclosed the reason. An ammeter introduced into the circuit to indicate the rate of charge showed a slight negative reading when the a. c. power was cut off. Further investigation disclosed a reverse current of approximately 180 milliamperes passing continuously when the transformer was disconnected from the power line.

A double-pole double-throw switch was included in the circuit as shown in Fig. 2C. The battery now retains its charge as long as it did before the type of charger was changed.

HERBERT J. HARRIES,
Pittsburgh, Pennsylvania

STAFF COMMENT

MEASUREMENTS in the Laboratory on the new type National full-wave charger, which employs two cartridge recti-

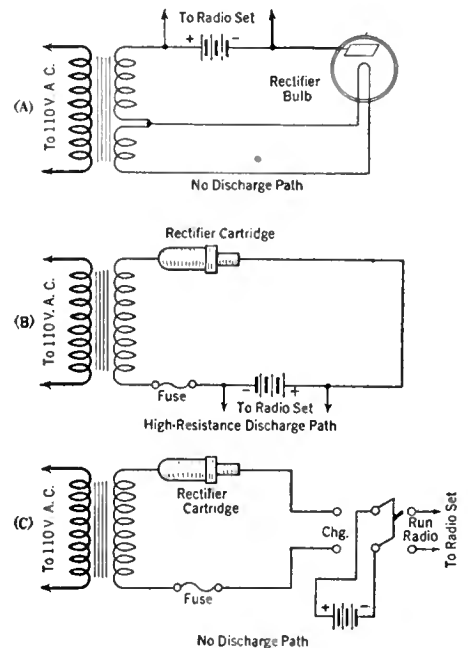


FIG. 2

Various methods of A battery charger connections. C shows a system of connections for a cartridge rectifier

fiers, indicate that practically no current will flow if the arrangement in Fig. 2B is employed, suggesting that the switching is unnecessary. We believe that the current Mr. Harries noted was due to a defective cartridge. In such a case the switching arrangement might very well be resorted to since a cartridge that is only slightly defective will still give many hours service. The switching arrangement shown in Fig. 2C may be slightly improved by using a three-blade switch, the extra contacts being used to control the 110-volt line to the charger. When the switch is in the right-hand or charge position, the charger will automatically be turned on.

The Glow Tube

THE use of the glow or regulator tube, such as the ux-874 (cx-374) or the Raytheon type R, effects a general improvement in socket power circuits. The stability of the r. f. circuit is sometimes improved, while the tendency to "motorboat," and oscillation in the audio-frequency amplifier is considerably reduced by its use. The glow tube is connected between the ninety-volt tap and the negative binding post on the power supply unit and is so designed that a practically constant potential is maintained across these posts regardless of the current load.

The regulator tube was specified or furnished

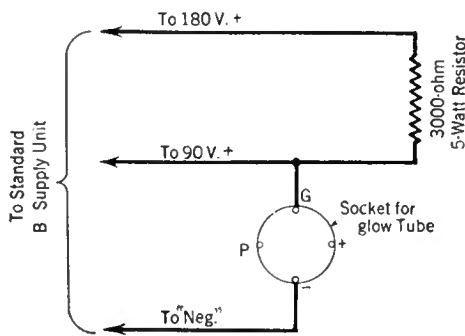


FIG. 3

How to add a glow tube to any B supply device. The addition of the glow tube will increase the stability and all-around efficiency of the circuit.

with very few B supply devices, homebuilt or ready made, previous to the present radio season. The benefits of the glow tube can be obtained with such power sources by connecting the tube externally. The addition of the tube is a matter of a few simple connections. Briefly, the glow tube is connected between the ninety-volt tap and negative, and an additional resistor, having a value of three thousand ohms, is wired between the high-voltage tap and the ninety-volt tap. The regulator tube plugs into a standard ux socket, the grid post on the socket being the anode terminal of the tube and the negative filament terminal the cathode. The anode should always be wired to the ninety-volt post. The diagram of connections is shown in Fig. 3.

HENRY LANDON,
Chicago, Illinois.

STAFF COMMENT

A REGULATOR tube should never be added to any socket power set until it is determined whether the device will supply an additional drain of 30 milliamperes without an excessive voltage drop.

Output Transformer Connections

WHEN connecting up an output transformer it may be noticed that the instrument is usable for either the straight transformer form of output or as a choke with condenser bypass type (Fig. 4). The idea, when I tried it out, proved to be quite successful and showed some possible advantages for the arrangement.

The tone quality, from the two jacks, was different. The transformer coupling was more mellow and softer and the impedance coupling more brilliant in tone with the particular in-

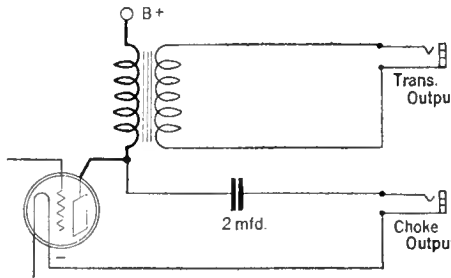


FIG. 4

An output arrangement making it possible to use the transformer as a choke if desired

struments that I used. General tone fidelity was good in both cases so one could select the arrangement most pleasing at the time, or match the reproduction from different loud speakers to some extent.

The double output suggested the simultaneous use of two reproducers and was tried using Sparton and Baldwin loud speakers. Both worked perfectly alone or together in either position and neither reproducer seemed in any case to reduce the volume obtained from the other one alone.

J. B. HOFFMAN
Kewanee, Illinois.

STAFF COMMENT

MR. HOFFMAN suggests a simple and practical method of connecting two loud speakers with different characteristics to secure a tonal combination more pleasing to the ear than the more usual series connections—always providing, of course, that the loud speakers used have impedances adapted to this particular arrangement. The choke connection will, in some cases, provide more pleasing reproduction than the transformer system. Mr. Hoffman's arrangement may be used in conjunction with the resistor controls suggested for tandem speaker operation in this department last month.

The volume from the individual loud speakers is necessarily reduced when two or more of them are used but the total volume from the receiver may be increased.

A Simple Vernier Condenser

WITH the present-day congestion of radio traffic, any device that may facilitate tuning is worthy of consideration. The writer found that the construction of a simple vernier condenser along the lines to be described improved reception on his tuned r. f. receiver. The vernier is connected across the main tuning condensers in the receiver, and is employed in securing that delicate adjustment so often essential to quality reception.

The mechanical details of the device are illustrated in the drawing, Fig. 5.

The base consists of a piece of spare panel material, 2½ inches long by 2 inches wide. The plates are cut from stiff copper sheets with a ¼-inch radius. The peak of the stator plate is cut away for the shaft of the rotor. The fixed plate is fastened to the base by small screws threaded to the panel, or with nuts.

A long brass screw (See Fig. 5) provides the shaft to the rotor, which is clamped between a nut and the screw head. A shim or several washers between the rotor plate and the panel, space the two plates of the condenser from ⅛ to ¼ of an inch, depending upon the amount of tuning desired.

The closer the plates are arranged together the greater will be the variation. A lock-nut and washer on the other side of the small panel holds the shaft at the desired tension. A hard rubber top of a binding post is used as a knob. In the author's receiver the vernier condenser is mounted on the main tuning panel, as shown in the sketch.

L. B. ROBBINS,
Harwich, Massachusetts

STAFF COMMENT

THERE are many uses for a small variable condenser of this type. Its possibilities as a short-wave vernier, as a compensating condenser across the main tuning capacities in a gang condenser, and as a neutralizing condenser in capacity stabilized circuits, are immediately suggested. With the exception of such instances where the vernier condenser is actually employed for tuning, in which case constant adjustment is necessary, it will be desirable to mount this capacity adjuster on the sub-panel of the receiver.

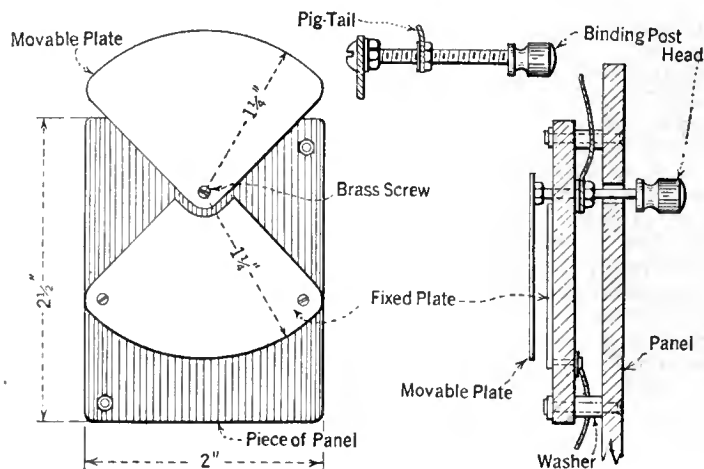
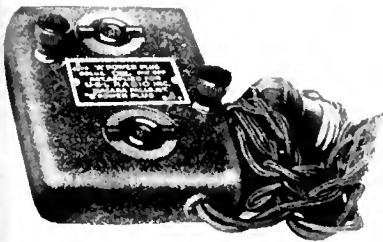


FIG. 5

Constructional details of a useful vernier condenser

SOME RELIABLE RADIO POWER-SUPPLY ACCESSORIES



AN AUTOMATIC CONTROL

The purpose of this switch is to automatically connect the a. c. power source to either the A battery charger or the B socket-power device, depending upon whether the set is switched off or on. It is a product of U-S-L Radio, Incorporated, Niagara Falls, New York. Price, \$3.75

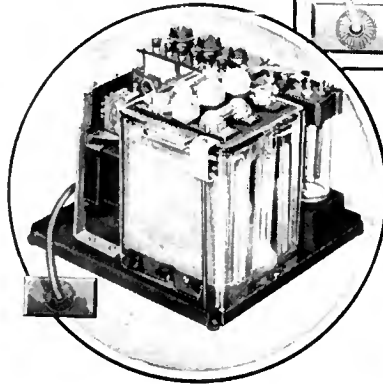
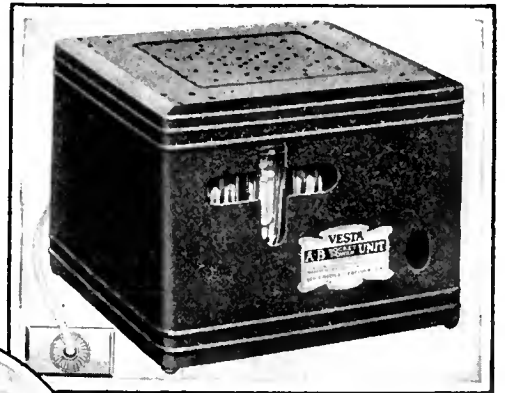


AN "ALL AMERICAN" B DEVICE

THERE are four B taps on this unit—15 volts, 67 volts, 90 volts, and power tap. In addition, the two knobs which may be seen on the front panel are for adjusting the 15-volt and 67-volt outputs to any desired amount for most satisfactory operation. There is also a "Hi-Lo" switch for increasing or decreasing the voltage output in accordance with the milliamperage drain. The price of this unit, in the 110 v., 50-60 cycle model, is \$31.50, less tube

A AND B POWER

THIS Vesta power unit combines a source of A current with one of B current. Features are: A Westinghouse rectifier is used; built-in hydrometer; side windows enable the state of charge and liquid level to be viewed; there is an automatic relay incorporated. The B supply is 180 volts at either 40 or 60 mils. Price, 40 mils, \$72.00; 60 mils, \$77.00. The lower picture shows the unit with case removed



TOWER OF BOSTON

IS responsible for this ruggedly constructed B device. The output is rated at 65 milliamperes, 180 volts. There are five positive B taps—detector, 67 volts, 90 volts, 135 volts, and 180 volts. An automatic power control switch is built in the unit. If a trickle charger is used, this latter control switch automatically switches it in or out of circuit. Price, \$32.50



A NEW A-SUPPLY DEVICE, BY GRIGSBY-GRUNOW-HINDS

IT IS here shown with the popular "Majestic" Super-B, in combination with which it is particularly adaptable. This new "Majestic" A unit is completely dry in construction, and uses no acids or liquids whatever. The manufacturers claim that there is absolutely no hum in operation. The maximum output of the "Majestic" A unit is 2½ amperes at 60 volts, and it lists at \$39.50. The Super-B unit, incidentally, lists at \$29.50 with tube. The complete "Majestic" A-B supply therefore sells for \$69.00



AN INEXPENSIVE B UNIT

BY Modern, of Toledo. The maximum voltage output at 25 mils. is 185 volts, and at 30 mils., 175 volts. The Modera B Compact lists at \$26.50 without Raytheon tube. The voltage at the power tube tap may be reduced by inserting a fixed resistor in the fuse clips provided within the case



RADIO BROADCAST Photograph

Why the Output Device?

By Keith Henney

Director of the Laboratory

IN SPITE of its apparent simplicity (it consists of a core of iron, windings of copper wire, and perhaps a paper condenser), an "output device" performs several useful purposes, aside from being the connecting link between one's loud speaker and a power amplifier. In the first place it keeps the d.c. plate current of the last amplifier tube from circulating through the windings of the loud speaker and, secondly, it may adjust matters when a loud speaker and a tube are used whose respective impedances do not "jibe."

From the standpoint of keeping d.c. from the loud speaker, the output device is only necessary when power tubes are used—when the plate current is greater than ten milliamperes. From the standpoint of fidelity the device is necessary when the loud speaker impedance differs considerably from that of the tube out of which it works. In the latter case, only one kind of output device, the output transformer, does any good, the choke-condenser type serving no useful purpose from the standpoint of fidelity unless the choke has taps on it, when it becomes an auto transformer, and not, strictly speaking, a choke.

What does it matter if the d. c. plate current of the last tube in one's amplifier goes through the loud speaker?

There are several effects. The power which the loud speaker winding must dissipate as heat may be found by multiplying the resistance of the winding by the current squared through it. If the loud speaker has a resistance of 1500 ohms and the final power tube is a 171 with a plate current of 20 milliamperes (0.02 amps.), the power lost is 0.6 watts, which may or may not be too great for the winding to dissipate in heat, depending upon whether the winding was made with this thought in view. If the winding will not satisfactorily dissipate this heat (such will eventually become evident by a burnt-out winding) the use of an output device, of suitable electrical dimensions, may be resorted to as a safety measure.

One fiftieth of an ampere (20 mils.) flowing through the loud speaker which has a resistance

of 1500 ohms represents a voltage drop, obtained by multiplying these two values together, of 30 volts, which must be subtracted from the terminal voltage of the plate supply source to calculate what voltage is actually on the plate of the final tube. If the B battery consists of four standard blocks we should have 180 volts and accordingly we place a C bias on the 171 type tube of 40.5, but since there are 30 volts drop in the loud speaker winding, the actual plate voltage is only 150, and 40.5 volts C bias is, therefore, too great. The use of an output device in which the voltage drop is lower than through the loud speaker is to be recommended in such a case.

When d.c. flows through the winding of the loud speaker, the armature, the little lever that moves in accordance with voice-frequency currents and imparts its message to the loud speaker diaphragm, is pulled from its neutral position with respect to the winding, and is much more liable to strike the pole pieces of the magnet under strong signals. In other words, the armature is working under a permanent bias which is neither necessary nor desirable; it forces the armature to work under a hardship that is easily removed by means of the output device.

Some types of output devices have the additional advantage that they remove d.c. plate voltages from the loud speaker tips with the result that these tips or any part of the loud speaker mechanism or the output jack or terminals may be touched while the "juice" is on without danger of shock. No output device, however, will protect one from being shocked

by the loud speaker voltages produced by strong signals. What one hears as kettle drums—or static—is the result of very strong sudden voltages across the loud speaker after they have been translated into sound by the loud speaker diaphragm.

Output devices, then, are used to:

- (1.) Keep d.c. from the loud speaker winding.
- (2.) Prevent serious loss in plate voltage.
- (3.) Prevent heating of the loud speaker winding due to power loss there.
- (4.) Prevent placing a mechanical bias on the loud speaker armature.
- (5.) Adjust serious impedance differences and, therefore, improve fidelity.

AND SOME OUTPUT DEVICES:

- (6.) Keep the loud speaker terminals at low d.c. potentials preventing shock or burn.

As mentioned previously, there are two types of output devices, or loud speaker filters, as they are sometimes called. There is the true transformer, with two windings, of copper wire insulated from each other and wound on an iron core which is insulated from the windings; and there is the choke and condenser combination. The transformer, by its very nature, keeps the d.c. from the loud speaker and d.c. voltages from the terminals. It has the added advantage that, by proper design, differences in impedance which may exist between the loud speaker and the power tube may be adjusted.

The choke-condenser combination consists of a high-inductance copper coil of many turns on an iron core—and the condenser. If the choke is tapped, impedance differences may be adjusted, but for purposes of discussion, it then becomes a transformer, although the two windings are not insulated from each other but possess a certain part of the copper wire in common. This combination of a coil and a condenser may be connected into the power tube circuit in two ways, one of which is better than the other. The transformer may be connected in only one way, which corresponds to the poorer of the condenser-choke connections.

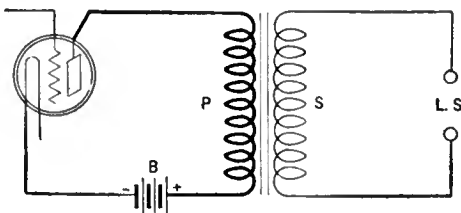


FIG. 1

The output transformer is illustrated in Fig. 1. The d.c. resistance of the primary should be low so that little plate voltage is lost; the a.c. impedances of both windings should be high so that most of the a.c. voltage developed by incoming signals will appear across the loud speaker winding and not be lost on the tube's impedance. The d.c. voltage lost is again the product of the current and the resistance, so that every time one milliampere flows through 100 ohms, a tenth of a volt is prevented from reaching the plate. If the tube requires 20 milliamperes and the resistance is 500 ohms (a typical case) we have lost 10 volts.

The transformer has one disadvantage in that all of the voice-frequency currents must return to the filament of the last tube through the common impedance of the plate supply apparatus, as shown in Fig. 1. Unless this impedance is small, either inherently or unless it be reduced by proper bypassing, the amplifier is liable to "sing," or to cause poor reproduction from otherwise good apparatus, due to audio-frequency regeneration.

Two condenser-choke combinations are illustrated in Fig. 2. The resistance of the choke must be small, for the same reason that it must be small in any case—to prevent plate-voltage loss; the inductance must be high at rather large values of d.c. current, and the condenser must

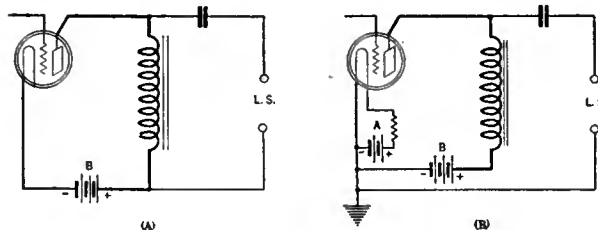


FIG. 2

shows the result, 32 per cent. of the current which should flow through the loud speaker being lost. The condenser which is in series with the loud speaker must take its share of the voice currents which are circulating in this circuit, and for that reason its impedance, compared to that of the loud speaker, must be small.

METHODS OF CONNECTION

IF THE condenser-choke arrangement is connected as in B Fig. 2, all of the a.c. currents in the plate circuit of the last tube return to the filament directly. This connection has the added advantage that neither of the loud speaker terminals are at high d.c. potential with respect to ground. One side connects directly to A minus, which is at ground potential, while the other connects to the condenser and is insulated from the high potential. If the condenser breaks down

used without impedance adjustment with a 4000-ohm, or even higher impedance, loud speaker. But if two 5000-ohm tubes are used in a push-pull circuit so that the resultant impedance is doubled to 10,000 ohms, and one considers a loud speaker whose impedance at 100 cycles is 1000 ohms, trouble will occur.

Here we need a transformer. If the primary and secondary individual impedances are high compared with the impedances of the tube and loud speaker, and provided a good core with good coupling is used, there will be little voltage loss, and practically the entire a.c. voltage on the plate of the last tube will be transferred to the loud speaker, the magnitude depending upon the turn ratio of the transformer, of course.

The trouble mentioned above will not be loss of power due to improper impedance matching so much as distortion due to another cause. All tubes have a plate current plate voltage characteristic that is somewhat curved. This curve produces additional frequencies when incoming signals produce large values of a.c. plate current. If, however, a large impedance is placed in the plate circuit, changes in grid voltage, due to large signals, produce a smaller proportionate change in a.c. plate current, and the characteristic is straightened out. Mathematics shows that when the impedance of the load is twice that of

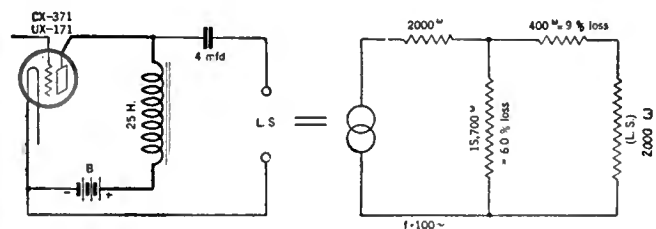


FIG. 3

be large. The equivalent circuit is shown in Fig. 3. Here is a source of voltage, a series impedance representing the plate resistance of the tube, a shunt impedance representing the choke, and a series impedance representing the condenser, and another impedance representing the loud speaker. The shunt impedance is a bypass for the audio frequencies and naturally must be large compared to the remainder of the circuit, i.e., the series impedance of the loud speaker and the condenser.

Let us take a definite example. We shall consider a 171 type tube with an internal impedance of 2000 ohms, a shunt choke of 25 henries, a condenser of 4 mfd., and a 2000-ohm loud speaker. This latter figure represents the impedance of the loud speaker at some audio frequency, say 100 cycles, and has little to do with its d.c. resistance. At this frequency the choke has an impedance of 15,700 ohms, representing a loss of 6.0 per cent., and the condenser has an impedance of 400 ohms representing a loss of 9.0 per cent., with the result that all but 15 per cent. of the voice-frequency currents flow through the loud speaker, compared to the case in which neither condenser or choke were used when there is no loss. The 15 per cent. loss will be hardly detectable to the human ear. The impedances of the condenser and choke are most important at low frequencies.

Let us consider another case, this time choosing a loud speaker which has an impedance of 1000 ohms at 100 cycles, a tube with an output impedance of 5000 ohms, a choke of 10 henries, and a 1.0-mfd. condenser series impedance. Fig. 4

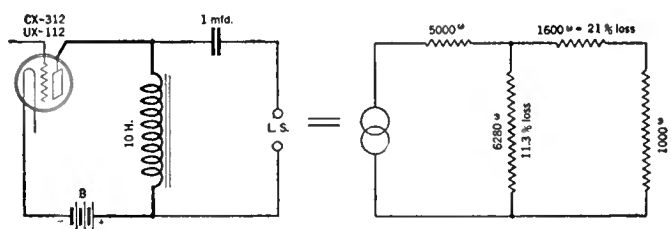


FIG. 4

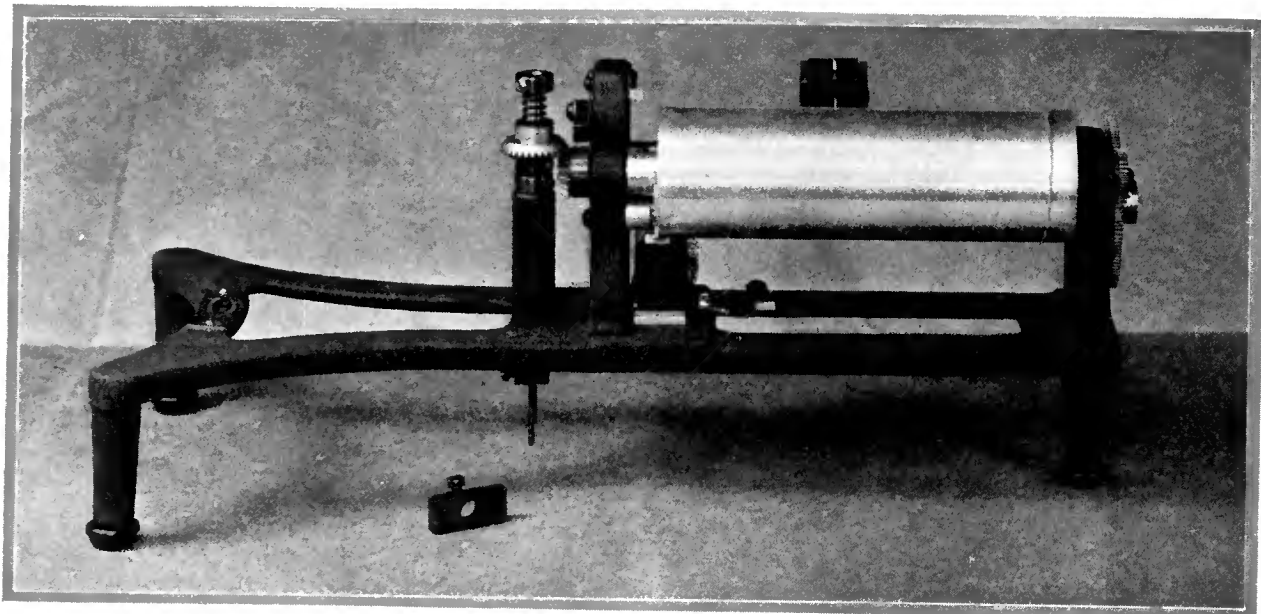
the B-battery voltage will be put across the loud speaker, therefore a good condenser must be used—one capable of withstanding not only the voltage of the plate supply without puncturing but the added voltages produced across it by the audio frequencies, which, however, will be small if its capacity is large. In A of Fig. 2 one of the loud speaker terminals is "hot" since it is connected to the positive side of the plate supply, which is high above ground potential. In this case nothing happens if the condenser breaks down except that the plate current will divide between the loud speaker and the choke, most of it still going through the latter because of its lower d.c. resistance. The voltages across the condenser in this case are lower than in B of Fig. 2 since there is no steady voltage due to the plate supply but only the audio-frequency voltages, and these will be small owing to the low impedance of the condenser.

The absolute values of the inductance and the capacity may be varied within certain limits depending upon the tubes and the loud speaker used. With a 2000-ohm tube and a 4000-ohm loud speaker, 20 henries is plenty and a capacity of 4.0 mfd. is correct.

Since the effect on audio frequencies of both the choke and the condenser may be neglected, if proper values of each are used, the loud speaker looks directly into the plate circuit of the power tube, and as far as a.c. currents go, might just as well be connected there. This is perfectly proper provided the impedances of the tube and loud speaker do not differ too widely. For example, a 2000-ohm or a 5000-ohm tube may be

the tube, the greatest amount of undistorted power will be secured from the tube. At low frequencies the impedance of most loud speakers is very low, so that the tube's characteristic is curved, and loud low-frequency signals produce a rattle or rumble that is objectionable. For this reason, the loud speaker should not match the tube in impedance, but should have a greater impedance, and if this is not possible, a transformer must be used which makes the loud speaker look like a higher impedance to the tube. This may be done by using a step-up transformer, looking from the loud speaker to the tube, so that the impedance of the former is stepped-up or increased as far as the latter is concerned.

Such is the story of loud speaker filters, or output devices. With power tubes in the plate circuit, when there are over ten milliamperes flowing, they are useful in protecting the loud speaker; when low-impedance speakers are used with high-impedance tube circuits, they are desirable. Unless the plate current is such that the loud-speaker armature is sadly biased and rattling against the pole pieces of the magnets, it is doubtful if the average listener can tell the actual difference in fidelity whether the device is used or not. If a condenser-choke combination is used the loud speaker should be connected to the negative filament lead or the center tap of an a.c. operated power tube. Connected thus, the owner of the loud speaker will be protected from d.c. shocks, although he can get a severe jolt by holding to the speaker terminals when a kettle drum operator gives his instrument a good "whack."



THE RAYFOTO RECORDER

RADIO BROADCAST Photograph

This photograph illustrates a final model of the recorder. The pictures are recorded on a piece of photographic paper wrapped around the drum. This unit is designed to fit over the turntable of any standard phonograph

Operating Your Rayfoto Picture Receiver

By Austin G. Cooley

THERE are several details concerning the Rayfoto printer and Rayfoto recorder which were not discussed in the article in the December RADIO BROADCAST; a knowledge of these is not necessary in order to construct the printer although necessary to obtain most satisfactory results. In this article we will use several terms that have not been used in preceding articles but which will serve to differentiate between the various units of the Rayfoto apparatus. A description of these terms, with a brief explanation of the function of the various parts which they define, will be found in the table of definitions on this page.

Readers of this series of articles will recall the description given in the November article of the Rayfoto relay and its function. This relay is operated by the plate-current increase produced in the amplifier tube of the printer by the synchronizing signal. There is a natural tendency, however, for the relay contacts to vibrate for a very short time after they first close. This causes irregular operation of the trip magnet which the relay controls, and the irregular operation in turn produces uneven synchronizing which causes jagged effects in the received picture.

To prevent this irregular action of the relay it was necessary to arrange the circuit so that when the relay contacts closed they would lock tightly together. The most important part of this locking circuit is a resistance, R_2 in the circuit diagram published on page 297.

When the relay, R_1 , closes, due to the synchronizing impulse, it causes current to flow through the trip magnet coil and hence through resistance R_2 to minus B. The current through R_2 produces a voltage drop across the resistance of such polarity as to decrease the negative bias on the grid of the amplifier tube. This causes

the plate current to increase a comparatively large amount, and this plate current, flowing through the coils of the relay, R_1 , makes it lock fast and prevents the contacts from vibrating. As soon as the armature on the trip magnet releases the drum, the contacts on the trip magnet close and thereby short-circuit the relay so that it is out of the circuit while the drum is making a revolution.

The locking resistance should be adjusted so that the plate current of the amplifier tube, as read at jack J_2 , is about 15 milliamperes when the relay and trip magnet contacts are closed.

There is always a certain amount of sparking at the contacts but this causes no harm unless the spark is sufficiently intense to cause an arc after the contacts have opened. This is remedied

by increasing the gap between contacts when they are open.

The contacts should be kept clean although there is nothing to be gained by excessive filing and cleaning. Cleaning the contacts about once a month with a piece of cloth is all that is necessary.

Reliable operation of the synchronizing system is impossible if there are excessive set noises. Such noises can often be traced to noisy batteries or poor connections. Make no attempt to receive Rayfoto pictures until such noises are cleared out. This does not imply that perfect receptive conditions are necessary for picture reception but considerable extraneous noise is not conducive to success.

The photographic paper that has been found most satisfactory is Azo No. 2 semi-matt or semi-gloss, singleweight, size 5 x 7 inches. The room in which the pictures are received must be somewhat darkened and a test can be made to determine if the room is dark enough by placing a piece of paper on the drum, allowing it to remain there about five minutes, and then developing it. If, in the developer solution, it turns gray or black in about 30 seconds there is too much light in the room, and the room will have to be darkened in some way. Of course, in the evening, no difficulties will be experienced and it will generally be found safe to operate the Rayfoto receiver without any shading at a distance of about ten feet or more from a forty-watt electric light.

In wrapping the piece of photographic paper around the drum for this test be sure that the emulsion side is on the outside. The side of the paper with the emulsion on can be determined by biting a piece of the paper with your front teeth. That side of the paper with the

Table of Definitions

Printer: A two-tube unit consisting of a one-stage audio-frequency amplifier and an oscillator. The Rayfoto signals from the radio receiver are amplified in the audio amplifier the output of which is impressed on the Rayfoto modulation transformer which, in turn, modulates the oscillator. The output of the oscillator produces the corona discharge which prints the picture.

Recorder: The mechanical unit for attachment to a phonograph turntable, and consisting of a drum on which a piece of photographic paper is wrapped, a clutch system, and a trip magnet for use in obtaining synchronism.

Relay: This relay is operated by the synchronizing impulse and when the contacts on the relay close, the trip magnet operates and releases the drum on the Rayfoto recorder.

Lap: The interval between the time that the drum on the Rayfoto recorder completes a revolution and the time that the synchronizing impulse is received. The recorder lap was explained fully in the November, 1927, RADIO BROADCAST.

Static Slip: The operation of the Rayfoto relay by a static impulse instead of by the regular synchronizing impulse.

emulsion will take the impression of the teeth or will stick to the teeth.

After experience has been gained in the operation of the system, No. 4 Azo paper can be used and it will be found that this paper can stand more light without being affected. When No. 4 paper is used a greater discharge of corona is necessary than with No. 2. If the signal strength is low so that not much corona is available, it will be best to use No. 1 paper, which is more sensitive.

In making preliminary tests it is a good idea to let the printer operate on broadcast signals and, after a run has been made, to develop the paper for about thirty seconds and determine if the corona discharge from the strong signals is sufficient to print out black.

Be sure to wrap the paper around the drum in the right direction, which is opposite to the direction of rotation of the drum. If the paper is wrapped in the wrong direction the corona needle will catch under the edge of the paper and pull it up.

The speed of the drum at the transmitter has been standardized at 100 revolutions per minute and, therefore, the speed of the drum on the Rayfoto recorder should be near 106 revolutions per minute in order to obtain the correct lap. Adjust the speed of the drum to this value by letting the drum revolve for a minute with the trip magnet armature down, counting the number of revolutions.

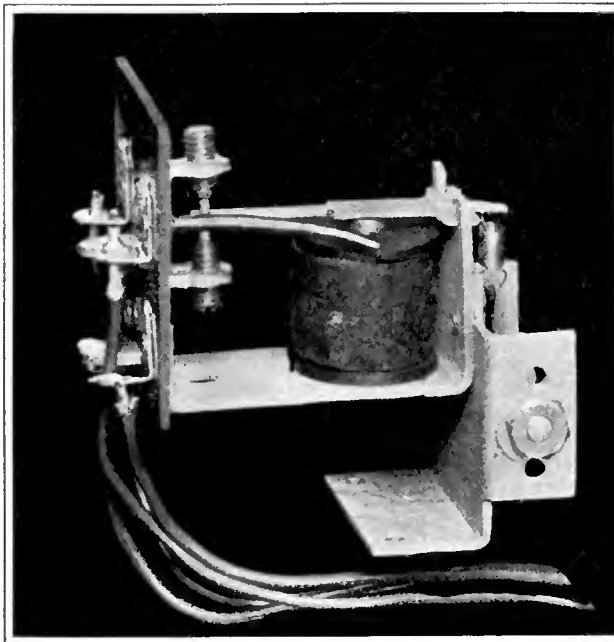
If the Rayfoto recorder unit is examined it will be found that the arm which carries the corona needle will slide along the machined shaft located at the rear of the device. If the arm does not move along the shaft very easily, it should be oiled. At no time should the shaft be touched with emery paper or sandpaper. The shaft may be cleaned if necessary by mixing a little Gold Dust powder with some lubricating oil and wiping off the shaft.

To adjust the Rayfoto receiver to operate through static, it is necessary to first adjust the relay and corona discharge. Tune exactly to the station transmitting the pictures. Reduce the signal in the printer by the gain control to a point where the relay just ceases to operate on the synchronizing impulse. Determine whether there is sufficient corona by examining the discharge from the needle point. There should be quite a noticeable discharge. A piece of Azo paper should, of course, be on the drum when any test of corona discharge is being made and if there is not sufficient corona for making a fairly black mark from the strong signals, increase the spring tension on the relay, then boost up the gain until the relay just starts to operate. Check again to see if the corona discharge is sufficient. If not, repeat until a fair discharge is obtained. When working through static, it may be necessary to work with a discharge much lower than normal. Consequently, the print will be weaker, unless a more sensitive paper, such as Azo No. 1 is substituted for that generally used, to make up for the reduced corona.

In making the above adjustment, the drum may be held in such a position that the stop-shoe does not strike the push rod by revolving the drum half a turn. The discharge made by the synchronizing signal may then be observed.

If it is difficult to obtain sufficient control of the relay by the spring adjustment, the gap between the armature and pole tip may be increased by adjusting the contacts.

After these adjustments have been made, tune the radio receiver to a frequency about fifteen kc. above or below the frequency of the picture transmitting station. If the relay operates more than once a second from the static noises, the experimenter might as well turn in



RADIO BROADCAST Photograph

THE RAYFOTO RELAY

A close-up of the relay. It is this relay, actuated by the synchronizing signal, that causes the drum of the recorder to be released, every revolution, at exactly the correct moment

and give up the idea of picture reception for the rest of that night. If the relay does not operate from static noises, the gain should be increased to a point where it just commences to operate; then reduce the gain a small amount. Thus you find the critical point of maximum permissible gain without static tripping the synchronizing relay. After this has been done, tune back to the picture signal and check to see that the gain has not been increased too much.

The next thing to do is to adjust the speed of the recorder. The speed should be such that the recorder lap is as small as is consistent with regular operation of the trip magnet.

the primary of the audio transformer in the printer should be reversed to determine which arrangement gives most satisfactory operation.

If there is a large recorder lap, that is, if the receiving drum has sufficient lead to arrive at the end of the revolution considerably ahead of the converter drum, the relay will be connected in the circuit for a longer period than necessary. Should some static of strong intensity be received during the lap, the drum will be released ahead of the synchronizing impulse. Such jumps, due to static operation of the relay, are known as *static slips*.

The possibility of these static slips decreases

CHECKING PERFORMANCE OF THE EQUIPMENT

THE November RADIO BROADCAST gives some of the essential information on the subject of blurring and detail. It may be well to mention here one or two things the experimenter may check if he experiences trouble. In many cases, the following simple checks will solve the difficulty.

First, be certain of the connections to the modulation transformer, making sure that the proper terminals are used, because this has an important bearing on the operation of the entire system. The primary terminals are No. 1 and No. 2. No. 1 should go to the plate of the input amplifier tube and No. 2 to the meter jack and then to the battery supply. No. 3 of the secondary should be connected to the plate of the oscillator through the r. f. choke and No. 4 goes to the meter jack and then to the booster voltage supply.

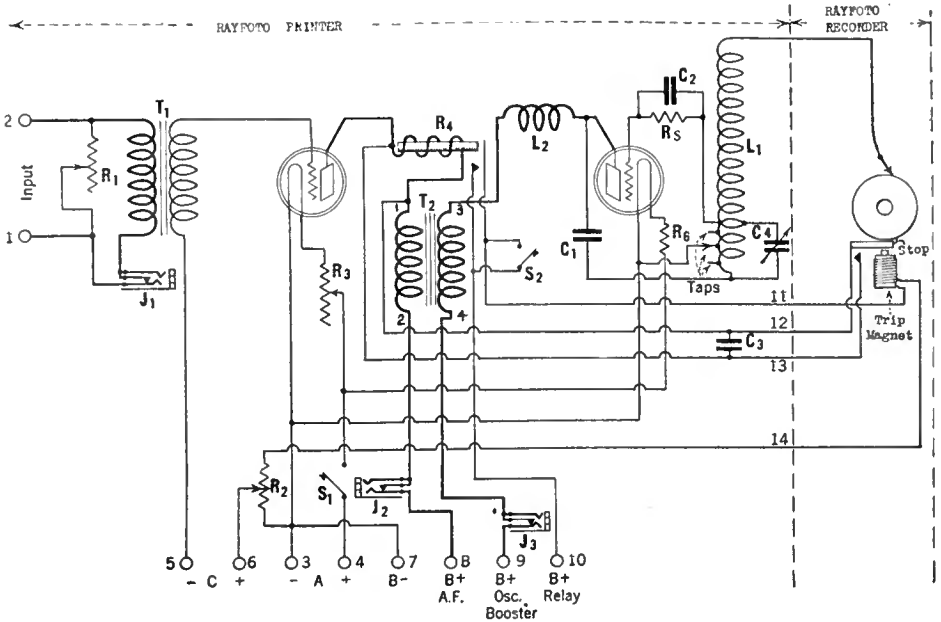


FIG. 1

The circuit diagram of the Rayfoto printer unit. The connections between this unit and the Rayfoto recorder are indicated. Constructional information on the printer was given in the December issue of RADIO BROADCAST. The Recorder unit cannot be home constructed but may be purchased as a complete unit

as the lap is reduced. Careful adjustment of phonograph motor speed is suggested to maintain a minimum lap. If, however, the speed is matched too closely, there is no lap. The trip magnet then operates as the stop shoe strikes the push rod. Such operation is very unstable and produces very jagged pictures.

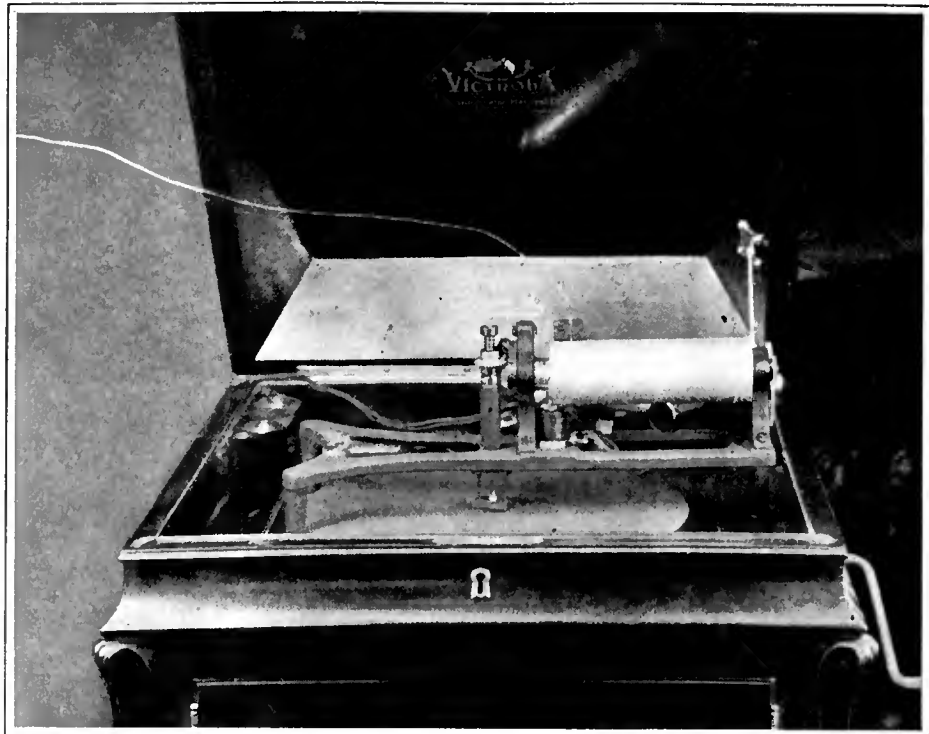
If the recorder speed is reduced so that it is slightly slower than that of the convertor, the recorder drum will not reach the end of the revolution in time to receive the synchronizing impulse. The relay will then operate on the impulse of the next revolution, or, if there are strong picture signals, during the revolution, and the result will be no picture at all or one that is very badly distorted.

After a little experience, the experimenter will be able to tell from the sound of the recorder whether the lap is correct. Sometimes streaks occur in the Rayfoto pictures because the oscillator tube ceases to function for a moment. Such a streak appears in the Rayfoto picture printed on page 216 of the January RADIO BROADCAST. This frequently occurs when the oscillator is tuned to give the maximum amount of corona. To avoid these streaks, detune slightly with the variable condenser across the oscillator coil. A higher resistance in the grid circuit also tends to reduce the possibilities of streaks.

Streaks are also caused by poor connections and by detuning of the radio receiver by hand or body capacity. For this reason, it is desirable to have a well-shielded receiver.

At present, pictures with fairly strong contrast are being transmitted so that good Rayfoto prints may be made with the average haphazard adjustment of the printer. Some may find that they are getting a little too much corona on the minimum signals and that the intermediate shades are produced as blacks. Correction for the minimum signal can be best accomplished by reducing the booster voltage. The difference between the intermediate shades and blacks can easily be increased by reducing the gain and then allowing a little more time for development of the picture. When reducing the gain, it may be necessary to reduce the spring tension on the relay.

From the foregoing it should be obvious that some skill is required to secure the best possible results. Poor pictures are a matter of poor ad-



RADIO BROADCAST Photograph

THE RECORDER IN PLACE

The photograph illustrates how the Rayfoto recorder is mounted over the turntable of a phonograph

justment of motor speed, amplifier gain, stop-start mechanism. Good pictures are a credit to the experimenter who receives them. In picture reception, the amateur has one advantage over the fan who contents himself with mere audio reception. He obtains permanent and irrefutable evidence of his success—a catalogue of his progress throughout the development of what will some day be a widely practised science and art—the reception of high-grade pictures in the home.

PARTS FOR A RAYFOTO PICTURE RECEIVER

CERTAIN parts for use in a Rayfoto receiver have been especially designed for the purpose and therefore possess the essential char-

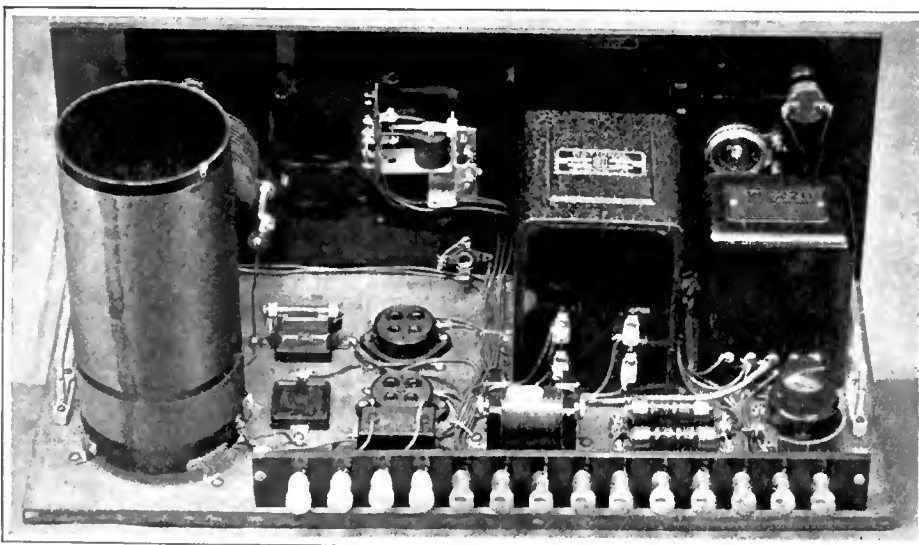
acteristics for good results. They have been designed to take care of the present requirements of the system and will also be satisfactory for use as the system may be gradually developed. These special parts, made under the Rayfoto trade mark, are listed below:

- L₁—Rayfoto Corona Coil
- T₁—Rayfoto Amplifying Transformer
- T₂—Rayfoto Modulation Transformer
- R₄—Rayfoto Relay
- Rayfoto Printer Unit

The remainder of the parts necessary to construct a picture receiver are given below. Any standard parts conforming with the specifications given below may be satisfactorily used.

- R₁—Variable Resistance for Gain Control
- R₂—200-Ohm Variable Resistance Capable of Carrying 100 Mils.
- R₃—12-Ohm Filament Rheostat, 0.5-Ampere Capacity
- C₃—0.1-Mfd. Fixed Condenser
- R₅—0.01-Megohm Grid Leak and Mounting
- C₁, C₂—0.0005-Mfd. Fixed Condensers
- C₄—0.0005-Mfd. Variable Condenser
- L₂—Radio-Frequency Choke Coil
- S₁—Filament Switch
- S₂—Push Button Switch
- J₁, J₂, J₃—Double-Contact Short-Circuiting Jacks
- R₄—4-Ohm Filament Ballast Resistance
- Telephone Plug
- Milliammeter, 0-25 Milliampere Scale
- Two Sockets
- Fourteen Binding Posts
- Panel
- Panel Brackets

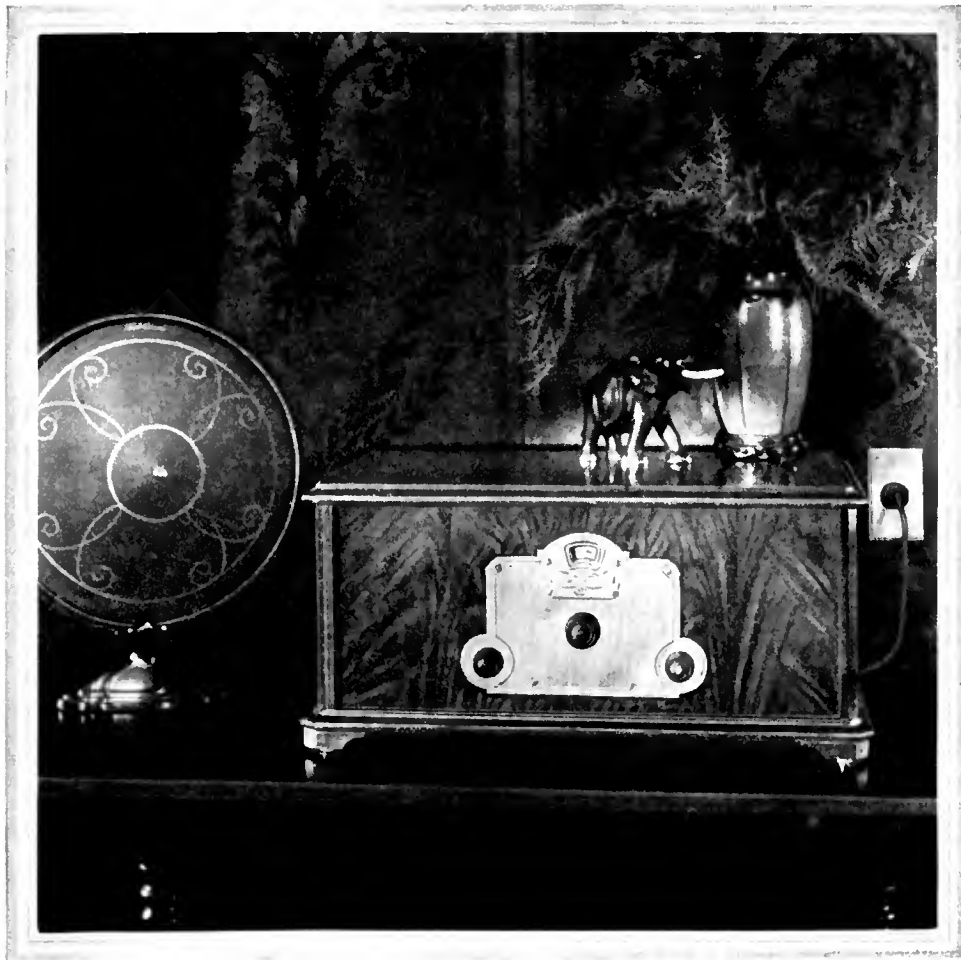
The designating letters preceding the parts given in the above list refer to the lettering on the circuit diagram given on page 297 of this article. Readers interested in constructing a Rayfoto picture receiver and desiring further information regarding the necessary parts may obtain this data by writing to RADIO BROADCAST magazine.



RADIO BROADCAST Photograph

THE RAYFOTO PRINTER UNIT

The parts for the unit, containing the amplifier and oscillator circuits, can be purchased and then wired together as indicated in the photograph. The circuit diagram is given in Fig. 1. At the left is the Rayfoto corona coil. The transformer at the extreme right is the Rayfoto amplifying transformer and at its left is the Rayfoto modulation transformer. The Rayfoto relay can be seen mounted on the panel



THE FREED-EISEMANN "NR-60" ELECTRIC RECEIVER

How the "NR-60" was Engineered

By John F. Rider

GENTLEMEN, we need a new electric receiver, designed for a.c. tubes and equipped with B supply. The receiver must be a single-control set to retail at \$150.

The above is the sum and substance of a message delivered to the engineering department of the Freed Eisemann Corporation and is the reason for the birth of the "NR-60 receiver."

The electrical development of this receiver will prove of intense interest to the radio fraternity at large, because it covers a subject very much in the public eye at present.

One can readily see that the problem placed before the engineering department of this organization differs greatly from that usually confronting the average research staff. The request was not for a d.c. receiver, but one designed for use with tubes utilizing raw a.c. upon the filaments and also a B supply unit. Hence we have four requirements. First is the receiver circuit itself, which constitutes a problem replete with many obstacles, particularly so in this day of competition. Secondly, the use of a.c. tubes means the provision in the design of the receiver for the elimination of the 60-cycle hum in the filament supply. Thirdly, the design of the power transformer which will supply all the filament voltages and the a.c. for the plate voltage, later to be rectified by the rectifying tube, is a problem not to be scoffed at. Fourth, is the coordination of all

the parts to produce a satisfactory all-electric receiver. The latter is more easily said than done, as can be attested by many fans.

Let us follow in the order mentioned above and watch the progress of the electrical development. Six tubes are to be used in the receiver. The receiver is to be operated with an outdoor antenna. A certain amount of selectivity is therefore necessary. Considering the status of broadcasting at the present, and the possibility of increased power at the transmitters, provision for satisfactory selectivity must be incorporated in the event that more stations go on the air, station wavelengths are reallocated, or transmitter power is increased. This necessitates that at least three tuned stages be used. Furthermore, the manufacturer specifies a certain antenna length, which, however, is not always obtainable. To assure satisfactory sensitivity in the event that a short antenna is used, three stages of tuned radio-frequency amplification are decided upon. Such decision, however, can be made only after the gain or amplification per stage has been determined mathematically and checked empirically.

In order to permit this determination, a large number of different types of tuned radio-frequency transformers must be first designed on paper and then constructed for experimental purposes. This experimental work is of para-

mount importance during the development of a radio receiver. The variance in types of the different experimental tuned radio-frequency transformers is found in the type of wire used, the diameters of the winding form, the spacing of the individual turns, the placement of the primary with respect to the secondary, the ratio of inductance to capacity on different wavelengths, the length of the winding form, and many other intricate details. Comparison in a mathematical manner is not sufficient, because phenomena encountered in practice can not be included in the calculations. Hence both mathematical and experimental determinations are necessary.

The actual experimental work of measuring the gain per stage for various radio-frequency amplifying systems is a tedious, detailed procedure. The tuned radio-frequency transformer to be measured is coupled to a tube. A known radio-frequency voltage is fed into the input circuit of this tube. The output of the tuned radio-frequency transformer is then measured at various broadcast wavelengths by means of a vacuum-tube voltmeter. A comparison of the output voltage values of the various radio-frequency transformers is a direct indication of their merit.

After a large number of tests of various forms of inductances, and with the realization that a

special system of neutralization was available in addition to the fact that individual shielding was permissible, the staff decided to utilize what is considered to be the most efficient form of inductance, the single-layer solenoid with spaced winding. With this decision the design of the three tuned stages was complete, but what about the antenna system? Should this be untuned, and of the conventional system? The consensus of opinion was to deviate from the conventional and to utilize a tuned antenna circuit. The sensitivity of the complete system would be greater, the receiver output would be greater and, in addition, the frequency response characteristic of the complete r.f. system would be better. Last but not least, the tuned antenna system could be designed so that single-control would be satisfactory, regardless of the length of the antenna employed.

This started another series of investigations, and after a period of time, the variometer tuned type of input was selected. This arrangement possessed several salient features. First, it permits unicontrol. Second it provides greater gain or amplification as the wavelength is increased. This property is inherent in inductively tuned circuits and is diametrically opposite to the phenomena in capacitively tuned circuits. This is due to the increase of impedance of inductively tuned circuits with increase in wavelength. The action of the variometer-tuned antenna-input circuit by increasing the gain on the upper wavelengths of the normal broadcast spectrum would tend to compensate the falling characteristic of the other stages. This type of tuned antenna input circuit affords a much greater signal voltage to the grid filament circuit of the first r.f. tube. As a matter of fact the difference between such a tuned system, Fig. 1A, and the conventional untuned antenna, Fig. 1B, is of the order of 3 to 1 in favor of the former arrangement (system A).

By the use of a small series capacity, connected between the antenna and the grid input terminal of the first tube, the variance in antenna capacity when different lengths of antenna are used, is practically nullified, and the tuned system is to all intents and purposes, isolated. This means that the setting of the variometer dial will remain constant regardless of the length or type of antenna used.

Stability of the radio-frequency system was the next point of interest. Being in possession of a Hazeltine license, neutralization of this form for the radio-frequency stages was an immediate decision. Having designed the inductances and knowing the operating characteristics, the conventional Hazeltine system was selected. This system utilizes a voltage transfer of reversed phase from one grid circuit to the preceding grid circuit. The value of the feed-back voltage is governed by the design of the secondary of the tuned radio-frequency transformer and is the voltage across a certain portion of this

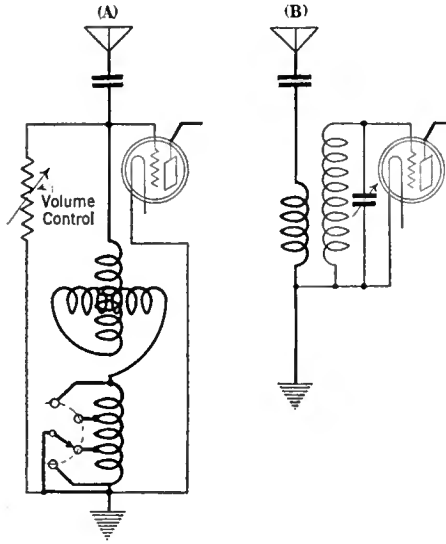


FIG. 1

winding. The voltage is obtained by tapping the secondary winding at a predetermined point.

With respect to shielding, the decision to shield individual stages by enclosing the tube, coil, and condenser in a can, was immediate. The choice, however, of the shielding material, required some consideration. Electrical conductivity and economy are the two important factors. After considering these two points the selection was aluminum.

The experimental work carried out upon the tuned radio-frequency transformers influenced the selection of the type of winding. Now arose the problem of producing "matched" inductances. Accuracy is very important in all single-control units. To overcome slight discrepancies, such as would be occasioned by one or two turns more or less on the coils, each tuned radio-frequency transformer is equipped with a copper vane located at one end of the main inductance. Manipulation of these vanes permits accurate variation of the inductance of the windings, thus facilitating "matching" of the condenser-inductance combinations, and the tuned circuits.

Summarizing the radio-frequency amplifying system we have the following: A tuned antenna input, complete individual shielding, three stages of tuned radio-frequency amplification, complete neutralization, and single tuning control. The maximum capacity values of each tuning condenser is 0.00032 mfd. The shape of the tuning condenser plates affords a modified straight frequency-line variation.

DETECTOR AND AUDIO SYSTEMS

Now for the detector and audio systems. Utmost sensitivity is desired, hence the grid leak-condenser system of detection is employed.

As to the audio system, the choice must be

made consistent with three factors, economy, results, and knowledge. Only two tubes are available for audio amplification. The best way of obtaining sufficient volume is by means of transformer coupling, and since extensive research work has been carried on to design and produce an excellent audio-frequency transformer, the decision to use transformer coupling was natural. That the research work along this line was of high calibre is shown by reference to Fig. 2. This curve shows the operating characteristic of the audio transformer. It is a 3 to 1 coupling unit, without a pronounced peak on the higher audio frequencies, a characteristic seldom found with the average audio-frequency transformer. The elimination of a sharp peak at some frequency between 3000 and 10,000 cycles is due to scientific coil design and minimization of leakage reactance.

The next problem was the selection of a means of coupling the output tube to the loud speaker. Some coupling medium is necessary because of the heavy output plate current occasioned by the necessity of using a power tube in the output stage. Passing the heavy plate current through the loud speaker windings would injure them, in addition to the possibility of reducing the magnetic strength of the magnets in the event that the polarity of the loud speaker is reversed with respect to the polarity of the plate battery. The design of a coupling unit was imperative. A transformer of very good design was developed, and its frequency operating characteristic when used with a 171 type tube is shown in the accompanying curve, Fig. 3, at the bottom of this page.

Now arose the problem of volume control. Much work was done along this line; as a matter of fact, this work could not be avoided, since the method of controlling receiver signal output with a d.c. receiver is not wholly satisfactory when applied to a.c. receivers. After an extended period the system shown in the wiring diagram on page 301 was selected as being most effective. This is a variable high resistance shunting the tuned input circuit

This arrangement provides a means of adjusting the receiver output by controlling the signal voltage passing into the first radio-frequency amplifier. This arrangement proved satisfactory because it does not display an effect upon the sideband characteristics of the radio-frequency amplifier, nor does it manifest any variation in the degree of neutralization. Yet the control of volume is perfect.

THE TUBES USED

Under the existing circumstances, the tubes selected were the RCA 226 and 227, with a 171 in the output, or the equivalent Cunningham 326 and 327 with a 371 in the output. The operating characteristics of these tubes are practically identical to that of the regular d.c. filament tubes, hence the design of the associ-

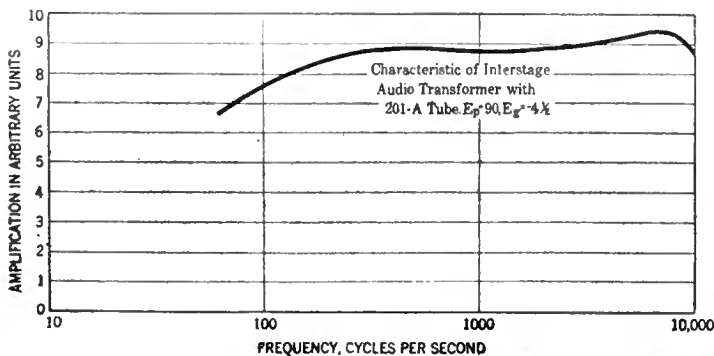


FIG. 2

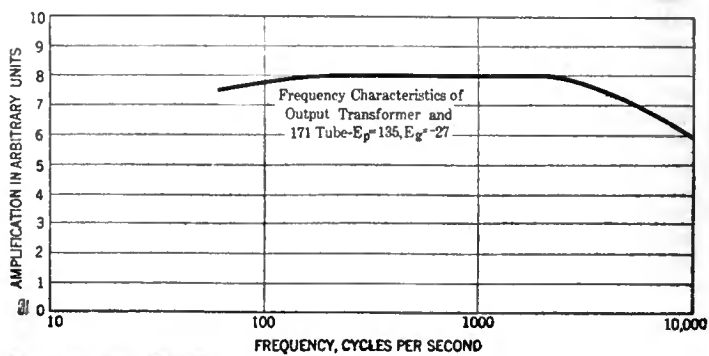
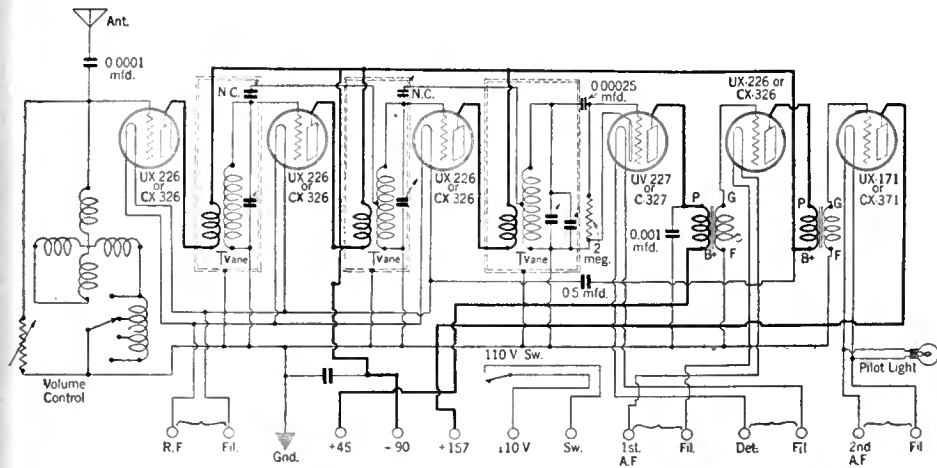


FIG. 3



CIRCUIT DIAGRAM OF THE "NR-60"

half-wave rectifier would permit 65 mils., a full-wave rectifier would permit 130 mils. at the same voltage. Hence, by using the full-wave rectifier, sufficient current is provided at high voltages.

To eliminate any possible hum due to induction from the power device to the receiver, the complete unit is housed in a shield. The condensers used in the B device are, in turn, housed in an individual can within the main can. Both cans are grounded to the common ground terminal and the main can is at ground potential.

One side of the main line is connected to ground through a 0.1-mfd. condenser, thus bypassing to ground any radio-frequency energy in the power line.

The design of a receiver is not limited solely to the choice and pattern of the individual components of the receiver. Complete test of the combined parts may show that they are not satisfactory when used together.

The method of testing the radio-frequency transformers applies to the method of testing the gain or amplifying power of the complete radio-frequency amplifier.

The audio-frequency transformers are also tested with vacuum-tube voltmeters. Each transformer is tested on three frequencies and a definite output must be obtained before the transformer is passed.

A vacuum-tube voltmeter is employed when balancing out the hum in the receiver and by means of the meter reading the value of the existing ripple is ascertained.

After the receiver is assembled ready for the first complete test, it is placed into a test rack. The source of energy supply for this test comes from a crystal-controlled master oscillator circuit tuned to a fixed frequency of 600 kilocycles. This type of oscillator also supplies testing frequencies which are multiples of the fixed frequency. These multiple frequencies are the harmonics generated by the crystal-controlled tube. The tuned circuits in the receiver are adjusted to 600 kilocycles and are brought to resonance by means of the copper vanes associated with the inductances. Then the receiver is tuned to the second harmonic of 600 kilocycles, which is 1200 kilocycles, approximately 250 meters. It is then adjusted to perfect resonance by means of balancing condensers on the shortest wavelength within the broadcast band.

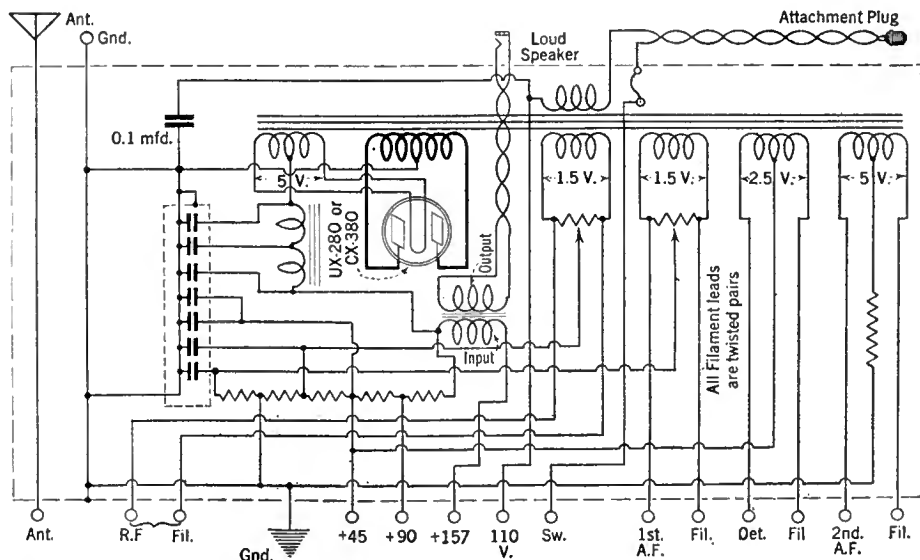
ated apparatus did not require special precautions. The 226 type of tube was selected for the three stages of radio-frequency amplification and for the first audio stage. The 227 heater type of tube was selected for the non-regenerative detector and the 171 was used as the output tube. A precaution required in the receiver was that twisted cables be used and that they be isolated so that transfer of the 60-cycle hum was minimized. That the arrangement was effective is demonstrated by the satisfactory operation of the receiver, despite the fact that the audio-frequency transformers have satisfactory response on 60 cycles. Were the filament wiring in a position to cause hum due to induction, this hum would be heard with regularity in the loud speaker.

The use of a.c. tubes necessitates a mid-tap for each amplifying system. Experience proved that a variable potentiometer shunting each tube filament circuit was a better means of obtaining an accurate electrical balance than the use of a mid-tapped transformer winding. The use of such a mid-tap requires a separate grid bias for each amplifying system. This grid bias is obtained from the B supply.

The design of the B supply unit and the A supply unit was an interesting problem. Let us consider the power unit as a whole. The power pack supplies all the voltages required for filaments, grids, and plates. It is complete in itself encompassing the B device, the A supply, and the output transformer. A study of the wiring diagram of the power supply on this page shows an arrangement which can be followed to excellent advantage by many manufacturers of power transformers and by others interested in a.c. tubes of the type mentioned herein. The 226 tubes are rated at 1.5 volts and 1.05 amperes and the 227 is rated at 2.5 volts and 1.75 amperes. The voltage is low and the current is high. If a large number of these tubes are fed through one cable and from one source of supply, that is, from one winding, the total amount of current will reach a fairly high value and any small resistance in the circuit will cause an appreciable voltage drop. To minimize this effect each system of amplification is equipped with a separate filament winding, supplying energy to the tubes in that system. This arrangement also eliminates the necessity of inserting various values of resistances to supply the correct voltages, were one single winding used. For example, the maximum filament winding voltage is 5 volts, for the 171 tube. The 227 requires 2.5 volts and the 226 requires 1.5 volts. All of these voltages could

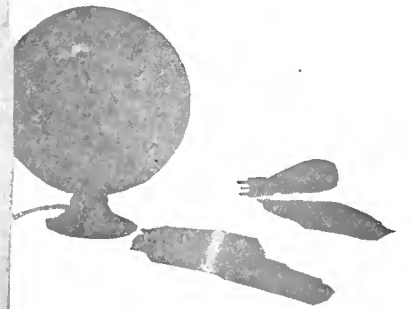
be supplied from one 5-volt winding of proper capacity. But the insertion of the necessary resistances for reducing the 5 volts to the correct value for the other tubes would increase the cost of manufacture and would be less efficient. The method used was found much more efficient and, therefore, adopted. An accurate mid-tap is made possible for the radio-frequency and the first audio-frequency tubes by the use of a potentiometer. Furthermore, each filament circuit consists of a pair of twisted cables. The 227 detector tube receives a plate voltage of 45 volts from the B unit. By employing filament windings which provide the required filament voltages, all filament controls are eliminated.

The design of the B device was cause for considerable thought. Should it be a half-wave rectifier or a full-wave rectifier? Each possessed certain advantages. The half-wave rectifier is simpler, but the full-wave rectifier affords certain technical and practical advantages. In the first place the frequency of the charging voltage applied to the condensers of the filter system is 120 cycles with a full-wave rectifier and as such the action of the condenser is better; the reactance of the condensers is lower. The filtering action improves as the frequency of the hum to be eliminated increases. In addition, the current capacity of the unit is doubled. Where a



THE POWER SUPPLY OF THE "NR-60"

RADIO
RECEIVERS
REPRESENTING
A WIDE PRICE
RANGE



SPLITDORF'S "BUCKINGHAM"
Designed to blend in with the surroundings of a home decorated in the English style, the period of this cabinet work dates back some four hundred years. The "Buckingham" is a six-tube receiver employing three r.f. stages, tuning being accomplished by an attractive rose shaped knob which may be seen in the center of the receiver. A complete A. B. C power unit is housed within the cabinet. Behind the cane center panel in the upper part of the chest is the "Maestro Cone Tone" reproducer. The list price of the "Buckingham" is \$800.00 complete.

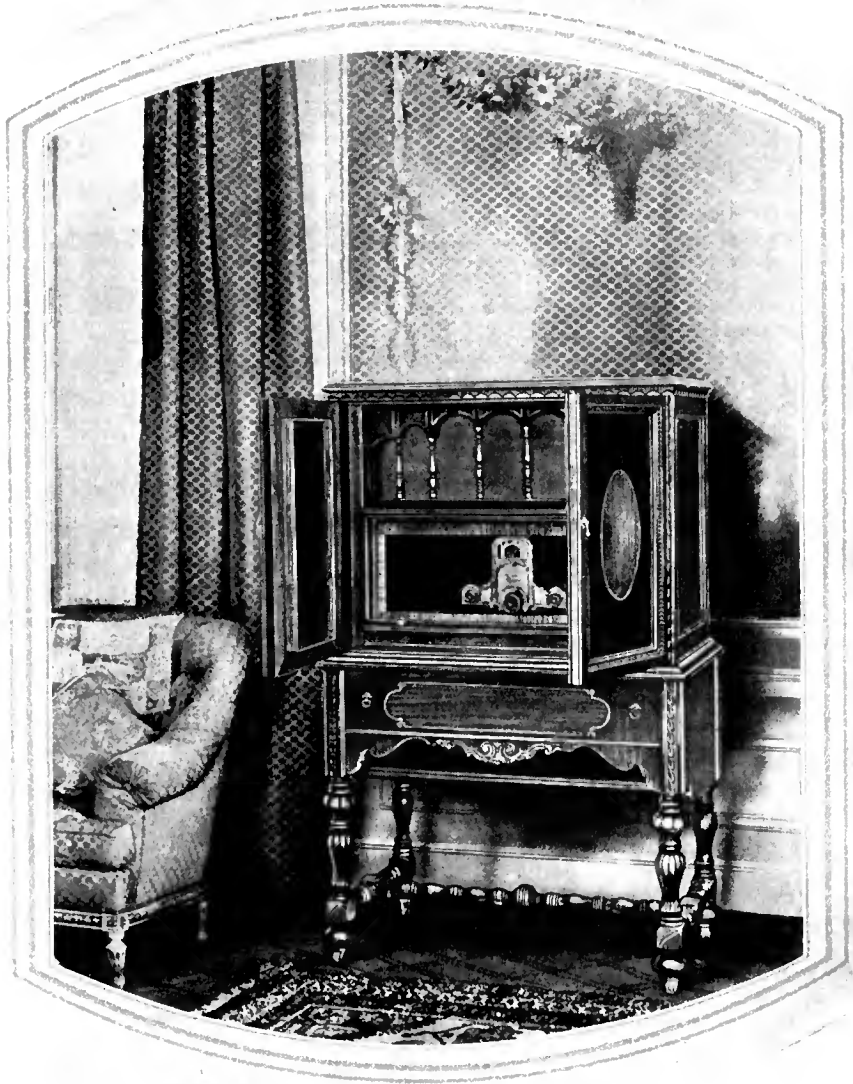


THE FERGUSON "HOMER"
Compactness is expressed in this new receiver by J. B. Ferguson. Housed within an exceptionally attractive little cabinet is this seven-tube receiver, employing four r.f. stages, two only of which are tuned, and two audio stages. A single illuminated dial accomplishes the tuning, and there is also a volume-control handle on the panel. Control of volume is obtained by means of variable plate coupling. The audio channel makes use of General Radio transformers. The "Homer" lists at \$95.00 as illustrated. Chassis only, \$30.00



Digitized by Microsoft®

THE advent of the more expensive, more luxurious, receiver, is not to be heralded as something new, although developments along this line have been very marked of late. Ever since its swaddling clothes days radio has been represented in a surprisingly wide range of prices. That a certain manufacturer charges ten times as much for one receiver as for another using the same circuit and number of tubes, need not deter the man of modest means from investing in the least expensive model. Frequently the chassis in both models is identical, the extra cost being due to refinements of cabinet work, the inclusion of a complete power-supply unit and also, perhaps, a built-in loud speaker



A LOOP RECEIVER

This is the "Ortho-sonic" F40 receiver, by Federal of Buffalo. The circuit makes use of seven tubes in a carefully balanced and shielded circuit. The loud speaker, which is built in and concealed by a silk screen and hand-carved grille, is said to be capable of beautiful tone. The loop may be seen mounted upon the inside panel of the left-hand door. There is ample space for installing the necessary power equipment. The cabinet is of walnut with vermilion inlay and hand carving. Price, without tubes or accessories, \$450.00



THE "CRUSADER"

By King, also of Buffalo. Many interesting features distinguish this receiver. Special attention, for example, has been paid to its design that the use of a B-supply device will not complicate matters. There are two r.f. stages and three audio stages, the latter employing a combination of transformer and double-impedance coupling. The three variable tuning condensers are adjusted by means of a single knob, but there is an auxiliary knob for the first stage so that exact resonance may be obtained. The "Crusader" is completely shielded. The cabinet will fit in with either mahogany or walnut home furnishings particularly well. Price, without accessories, \$115.00



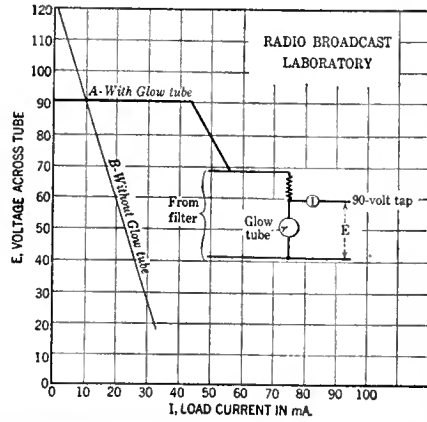
The Type 874 Glow Tube

HOW IT FUNCTIONS

THE type 874 tube is a special voltage regulator designed for use in B power units to maintain the voltages, supplied by the unit, constant. An ordinary B power unit operated without a glow tube has a comparatively poor regulation, *i.e.*, the voltage changes considerably with changes in the amount of current being drawn from the unit. It would obviously be of decided advantage if this voltage could be made to remain practically constant at all loads. The power unit could then be used with any receiver irrespective of the amount of current being drawn by it (within reason) with the knowledge that the actual voltages designated on the binding posts of the B device were being supplied. How the glow tube functions to maintain the voltage constant may be understood by reference to the curve A. This curve is plotted by measuring the voltage across the glow tube with various load currents and it should be noted that the voltage across the tube is practically 90 at all loads up to more than 40 mA. In ordinary operation, when there is no current being drawn from the 90-volt tap, the glow tube current is about 45 milliamperes. Then, if current is drawn for a receiver from the 90-volt tap, which would ordinarily cause the voltage to go down, the current through the glow tube automatically decreases, providing for the current required by the set. The voltage thereby is maintained at exactly 90.

Curve B illustrates the curve of output voltage

that might be obtained from a B power unit not using a glow tube. At no load the voltage is 123, while at a load of 10 mA, the voltage drops to 90. If, however, the receiver requires 20 milliamperes, the actual voltage available would be only 60 volts.



A "NUT-SHELL" EXPLANATION OF GLOW TUBE OPERATION

The functions of a well-known type of regulator tube were fully described on Laboratory Sheet No. 129, which is reprinted above. The principles underlying the performance of the Raytheon R tube, illustrated below, are somewhat different to those of the 874 type tube

Constant B Device Output

By G. F. Lampkin

THE most obvious problem in the construction of a B device is that of filtering—of reducing the hum to a negligible value. In some power units, especially those made during the last few years, so much attention was paid to this problem that another problem, not so apparent, but fully as important, was somewhat neglected. This latter problem is one of voltage regulation—the changing of the B device output voltage when the output current is varied. A cut and dried definition states that voltage regulation of an electrical device is the rise in voltage when full load is thrown off the device, expressed as a percentage of the full-load voltage. The regulation of ordinary electrical apparatus is seldom greater than ten per cent. The regulation of some B power units runs above 100 per cent.

If a 90-volt set of B batteries be connected to a receiver, it may be known with reasonable certainty that the voltage applied to the receiver is 90, whether there are one or six tubes being supplied. If a B device is connected to a receiver and the device has poor regulation, the voltage



GLOW TUBE CONSTRUCTION

The use of a glow tube in B power units is becoming increasingly popular. The Raytheon one here shown is very efficient. It was described at length in the October, 1927, RADIO BROADCAST

may be 150 when supplying one tube but less than half that figure when supplying six. If the experimenter has available a high-resistance voltmeter suitable for the measurement of the output voltages of a B power unit, the voltages may be checked while the power unit is connected to the receiver to make certain that the voltages supplied to the set are correct. Some power units are equipped with variable resistance units so that the correct voltage may be obtained

by the proper adjustment of them. Without a high-resistance voltmeter it is difficult to adjust accurately the voltages of a B supply unit, containing variable resistances to control the voltage. However, if the variable resistances are loosened so that the resistance is as high as possible and are then gradually tightened until the receiver operates satisfactorily, it is possible to adjust the voltages with fair accuracy. There is a danger of shortening the lives of the tubes in the receiver if the resistances are tightened beyond that point which gives satisfactory reception.

Under some circumstances the variation of the d.c. voltage with the load current introduces another disadvantage in that it tends to cause audio distortion. When the loud speaker is connected as indicated in Fig. 1, the plate current delivered by the power unit supplying the entire receiver may have a swing of ten milliamperes when a loud low note is being amplified. A receiver that would give such a signal might draw a total load of about thirty milliamperes and the plate current swing will, therefore, form an ap-

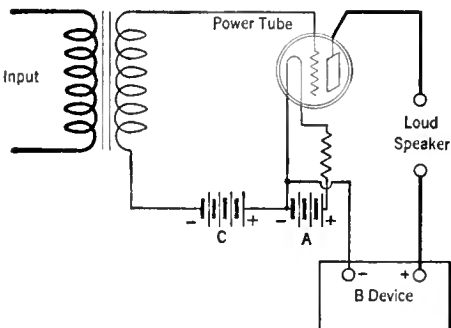


FIG. 1

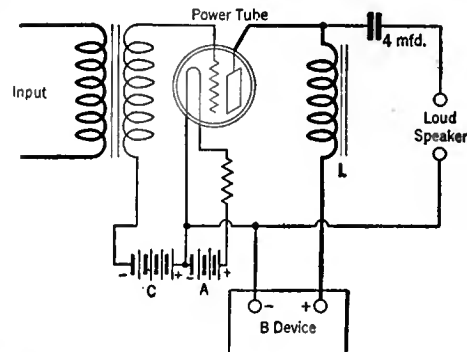


FIG. 2

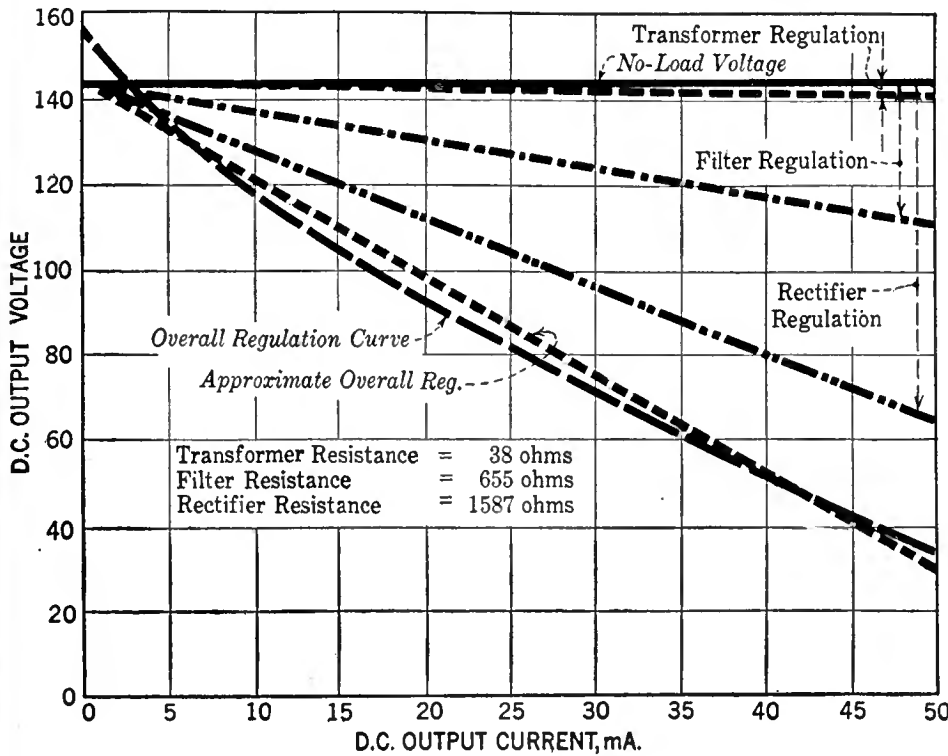


FIG. 3

preciable part of the total load so that the B device voltage will also vary. When the plate current increases, due to the signal, the B device voltage drops and tends to nullify the change; similarly, when the plate current decreases the voltage goes up and again tends to nullify the change. The regulation of the device would thus tend to cut off both the positive and negative peaks of the signal. The filter condenser at the output of the B device can take care of the plate current swings to some extent by charging and discharging on the negative and positive swings respectively. The effect of the condenser in this function is dependent on the frequency, however, and at low frequencies it does not exercise control to any great extent over the output voltage.

When the loud speaker is connected as in Fig. 2, distortion due to a variable load on the power unit is prevented because all the a.c. currents must flow around through the loud speaker and back to the filament and hence do not go through the power supply. As a result, the current drawn through the choke L from the power supply is practically constant and the load on the power

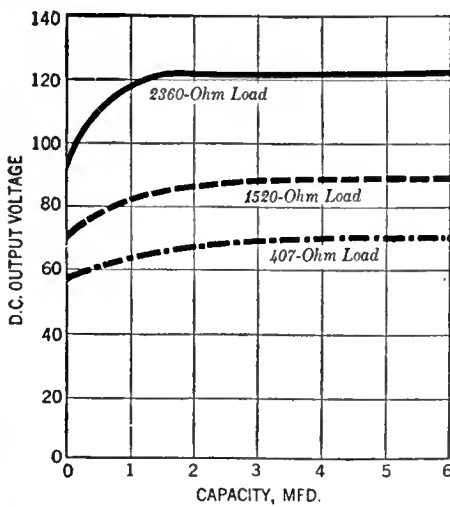


FIG. 4

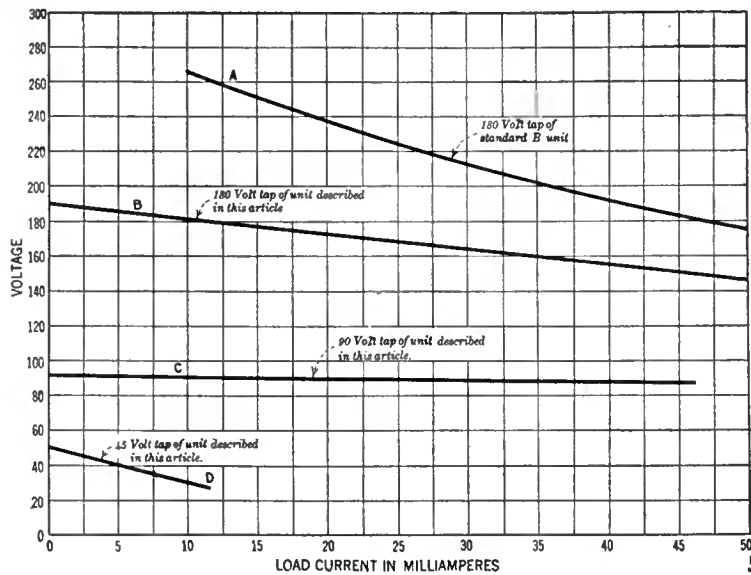


FIG. 5

unit does not vary appreciably with the signal.

The regulation of a B device is caused by the internal impedances of the three units that make up the device—the transformer, the rectifier, and the filter. As the current drawn from the device increases, the internal voltage drops also increase and the result is that the output voltage becomes less. A graph of the output voltage of a typical B device for different values of current is shown in Fig. 3. Such a graph is called a regulation curve. It is nearly a straight line and for purposes of simplification it may be replaced by one such as the lowest straight line of the group. The vertical distance between this line and the upper horizontal line, which represents the no-load voltage, is the internal voltage drop for any given current value. The drop at 50 milliamperes load is $144 - 30$, or 114 volts. Dividing voltage by current, $\frac{114}{0.05}$, gives the value of total internal resistance as 2280 ohms. This resistance is partly hypothetical, for it represents the overall value

from a.c. input to d.c. output. It might be called the "equivalent" internal resistance.

That part of the regulation which is due to the transformer is comparatively negligible. The secondary voltage of the transformer dropped from 116 to 114.5 when the output current was changed from 0 to 50 milliamperes; this corresponds to a regulation of 1.3 per cent., and an equivalent internal resistance of 38 ohms. The regulation due to the filter is dependent chiefly on the resistance of the filter chokes, and on the capacity of the first filter condenser, i.e., the one immediately after the rectifier. The curves of Fig. 4 show what effect the size of the first condenser has on the output voltage. At light loads, high-resistance, the voltage goes up sharply, then flattens out, as the capacity is increased. For any load, the voltage curve is flat at a value of 4 microfarads. This is a more or less standard value, so the contribution of the first condenser to the filter regulation may be neglected, and only the resistance of the chokes considered. This resistance can be measured with d.c., and was in this case 655 ohms. The equivalent resistance of the rectifier, is, by subtraction, $2280 - (655 + 38) = 1587$ ohms. Thus, for this particular B device, the rectifier constituted the major cause of regulation. The individual curves of transformer, rectifier, and filter regulation shown give a good idea as to how the voltage drops are distributed. The total of the distances from the no-load-voltage line to these three curves gives the approximate overall regulation curve.

The problem of producing power units with good regulation is important. As a result several methods are at present in vogue whereby power units can be constructed with comparatively good regulation. The use of a glow tube in the output circuit of a power unit will cause the regulation of the unit to be excellent over the entire range of useful load. A group of curves taken on a power unit utilizing a glow tube are given in Fig. 5. Also it has been found that by

decreasing the total resistance across the output of the power unit the regulation can be improved. When the total resistance R, Fig. 6, is reduced, the currents circulating through it, which represent a loss, are increased, but if the power unit has available sufficient capacity, this loss of current is advisable because it improves the regulation of the entire unit.

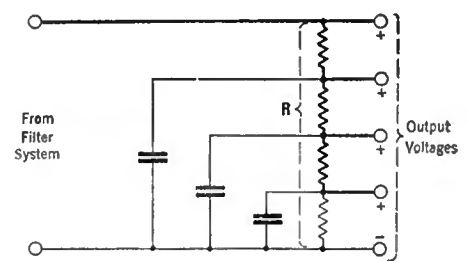


FIG. 6

The Listeners' Point of View

A FANTASY ON SPONSORED PROGRAMS

By JOHN WALLACE

THIS is station kwok broadcasting on a wavelength of four yards and six inches by authority of the Federal Boxing Commission. Station kwok is loaned and saturated by the McSwif Stomach Pump Company and the Quebec Liquor Commission, Chicago Branch, and is situated on top of the Division Street gas holder, holder of high-grade gas. Every Wednesday evening at this time a program of detrimental music is brought to you by buggy from New York through the courtesy of Hamstein, Hoffstein, Snickelby, and Snootch, manufacturers of taxi cabs, doll cabs, bottle caps, and cogs, kwok, Where Everybody's Sappy. Please stand by for the Eastern pronouncer.

This is woop, New York, broadcasting by special license of the city pound with a frequency that is positively dismaying. Every Monday evening at this time our facilities are engaged by the Hoffstein, Hammerstein, Snigelby and Scrooch Company, manufacturers of high grade taxi caps, doll cats, bottle cogs and coops, presenting the "Hof-hac-snack-co Hour" through woop together with 43 other stations, four precincts, three wards, and the juice of one lime. Stand by please while your local station idem-nifies itself.

This is kwok, Chica-

This is woop New Yo- (just to give the boys in the switch yard a chance to do their stuff.)

This is kwok

'Taint, it's woop

'Tis

'Taint

'Tis (O dear, this could go on forever, but at this point both stations join hands in a circle and the girls choose partners.)

You're on your back in the studios of woop the key station of the Duodecimal System. I will now tip the microphone over on Mr. Gregory Swallow advertising manager for the Hatstein, Hemstein, Hockelby and Pooch Company who will renounce the program. Mr. Swallow.

Good evening folks. Well once again the "Hic-haec-hoc-co Hour" is with you and I know how happy you are to hear from us and I

just know you are going to enjoy our program. I also know the color of your eyes—yes I do, take those handies down!—and how high up is, and the date of the second coming, and oh lots of other things. Seven days is an awfully long time to wait, isn't it, my ducks? Why of the 17,586,864,203 letters we received during the week 117 were from listeners who died because they couldn't wait. Ha, ha, they must have had jobs in a cafeteria! Ha, ha. Well, I will have my little joke. Well I know you are anxious to hear the program so I will not delay you any longer except to divulge to you that this hour of entertainment is donated to you gratis as a Christmas present, free, through the munificence of Messers—shhh! Come over closer—HINKLESTEIN, HOCKELSTEIN, SNOOPELBY and SNATCH. Don't tell! This high grade firm was founded in 1898 and has been engaged for forty years in the manufacture of high grade taxi backs, doll craps, bottled cats, and bogs. Our taxi backs are equipped within and without with equilibrated non-actinic colloidal stradilators and sometimes with metaspheroid double-trussed oscillators—a reassuring thing to know, my doves, in case of eggs. Hinc-hoc-sno-co Brand Bottled Cats may be obtained at any grocery store, your money back if the color frays. Our bogs are shipped direct to you from the boggerly, untouched by human hand.

Were you Mr. Listener, and you Mrs. Listener too, ever caught in the rain without a taxi cab? You got soaked didn't you? And if you'd of hired a cab you'd of got soaked too, wouldn't you? You should own your own. So I will now present to you the Old Soak who with his White Mule will spirit you away this evening to the Never-never Lands, there to hear lovely strains of music of foreign crimes, rendered for you by the Lard-Werks orchestra. Here take it you bum!

Hello folksch, thisich me. An afore we gawan wisha program thorchestra sgonna play for you our musical trade mark the Funeral March so that whenever you heah it, wherevah you may be, you may remembah the lovely, "Hing-hang-snig-co Hours" and recall that one of our bogs in your back yard means immediate death for your neighbors' chickens.

Orchestra plays Chopin's Funeral March

... and as the last strains softly strain o'er the distant strains we vault lightly from the saddle of good old Black Beauty while the carriage boy informs us that we bring to you tonight a pogrom of Hebrew heirs collected for you by our research department in the picturesque pathways of Palestine and Palisades Park. And now if you will extinguish your lights, turn off that damned radio, relax, returning to the squatting position at the count of five, we will enter the tonneau of the Brox Bros. Travelling Crane and —wisst!— We find ourselves on a sunny slope in Spain whilst from the half open door of a little tepee in the very shadow of Popocatapetl we hear the gentle warble of the Swiss Marine Band crooning plaintively to its young that lovely lullaby "On the Road to Mandalay-hay."

Orchestra plays the Prelude in C Sharp Minor.

Boom! Boom! Boom! Three crashing chords on the piccolos followed by some thin tweedling sounds, four policemen and a cat.

This is woop—We Own Our Pants—broadcasting the Himpstein, Hinchbein, Snogerty and Snike program. Stand by please for your local anaesthetic.

This is kwok broadcasting on a wa— (woop's switchman wins this chukker by seventeen words, receiving in award two kewpie dolls and a ham.)

This is woop my dears, Old Soak speaking. Our sturdy steed seems to have gone back to pasture and rubbing our eyes we find ourselves on a Kansas farm! Well I swan! And so now the boys are going to play for you a new derangement of that lovely piece by Saahnt Saahns called "The Swan." This is the first time to our knowledge that a female child under the age of fourteen has ever been choked to death over the radio and is presented to you by special arrangement with the composer. Saahnt Saahns was born in Moravia in 1792. He was the son of a sea cook and a bridge keeper's daughter. His great grandfather on the maternal side invented the poodle by interbreeding dachshunds and cotton batting so it is not surprising that the age of three found the gifted young Saahnt conducting his own works in the Ruhr district. There were no bond houses in that day so he decided to become a musician. He never got around to this, however, and in 1632 his unclad body was found in the Thames. Morticians discovered three measures of rye in his stomach and nineteen measures of music tattooed on the elevation nearest London Bridge. Thus was this immoral melody given to the world, which will now be played for you by Gilles de Rais on the flute. Mr. de Rais is the greatest living flautist. He was the first man to flaut across the English Channel. For your interest, his flute is a genuine Strad and is valued at \$17.98 an inch except in leap year one cent more. Mr. de Rais will be accompanied by Miss Elva Orkney on the night boat. The Swan. . .



LESTER PALMER

Chief announcer and program director of station wow, at Omaha



BOB HALL OF KOIL

Mr. Hall is chief announcer, studio director, baritone soloist, "Uncle Josh" and director "Little White Church on the Hill" at this middle western station

Orchestra plays Tschaiakowsky's Nutcracker Suite.

... and as this lovely Air for the G String concludes we discover that our old faithful White Mule has stumbled over the last bar and must be shot. (Three sobs followed by a cannon shot and screams of protest from the loud speaker). But hopping blithely on the bullet we find ourselves suddenly conveyed to Alsatia. "I'll Say She Does" will be the next number by the dance orchestra.

Orchestra plays Tschaiakowsky's Nutcracker Suite.

And now folks, before this "Squawk-squack-co Hour" comes to a close we want to tell you about the elegant booklet we have prepared just for you. It is printed on décolleté vellum in an edition strictly limited to four million copies, each one signed in six places by the authors, Hipstein, Hopstein, Spiggoty and Speck, manufacturers of waxey tacks, boot jacks, model gats and fogs. It contains not only a copy of the Constitution, multiplication tables up to ten, a list of contributors to the Yale alumni fund of 1876, the population of the principal cities of Denmark and the Lives of the Saints, but also such valuable information as "Eighty-nine Appetizing Ways to Serve Coddled Bats," "How to Re-cog Your Baby," and "How To Make Attractive Lamp Shades, Bird Baths, and Pen Wipers Out of Old Taxi Backs." Write us and tell us how much you enjoyed our program and how it has brought cheer into your life—or leave out all that but anyway give us your name and address and the addresses of twenty of your friends who you think would also be interested in high-grade blueing. And now we conclude our program with the "Squawk-squack-co March."

Orchestra plays Tschaiakowsky's Nutcracker Suite

This is WOOP. The program you have just heard was handed to you on a silver platter as the joint offering of Santa Claus, the Celestial Powers, and Hamstein, Hoffstein, Snickelby and Snootch, manufacturers of . . . hey, Joe, what the hell do those buzzards make anyhow?

The Possibilities of the Radio "Talk"

WE WERE pretty nearly won back to radio "talks" the other night after having at one time sworn off them for life. We happened to tune-in wjz at 6 p.m. Central Time on a Tuesday and heard a Mr. Frank Dole holding forth on the Airedale. Mr. Dole's weekly dog talk, it seems, has been a regular wjz feature for many years. He is known as an expert on dog life and is kennel editor of the *New York Herald-Tribune*.

However, we didn't know all this when we accidentally stumbled across his program and it had to survive or be tuned-out on its own merits. Our speaker was violating all the rules in the little hand book on elocution. He was dropping the "g's" on words ending in "ing" and mispronouncing some others. His speech could certainly not be described as fluent and was decidedly lacking in that first requisite of elocution—polish. Furthermore, he occasionally got tangled up in his words and would have to start a sentence over again. Some times, even, he paused—an infamous procedure in radio delivery, wasting the station's good time like that! And along toward the end of his dissertation he waxed sentimental—an oratorical device we

heartily abhor. But that's not all: to cap the climax he terminated his talk with some personal messages to friends of his in the old home town in Maine!

Certainly a sufficiently lengthy catalogue of faults to damn any speaker—in the face of which we stoutly maintain that the talk was one of the best we have ever heard on the radio.

Mr. Dole succeeded in that oft talked of, but seldom demonstrated, stunt, to wit: putting across personality. He spoke exactly as he would have if you had cornered him on the street and asked him to tell you something about Airedales. Each one of the "faults" enumerated above contributed to this impression of informality and the net effect was convincing—he sounded as if he *did* know something about Airedales. Your average radio speaker, given the same material, would have made it sound as if he had just looked up the subject in the *Encyclopedia Britannica*.

Which last remark sums up the general run of radio talks. Almost invariably they give the impression of having been dug out of some book for the occasion. The listener's reaction to such a



FRANK DOLE

Kennel Editor of the *New York Herald-Tribune* who is regularly heard through wjz speaking on dogs, a subject which he handles remarkably well

delivery is invariably this—"why not look it up in a book myself? it's easier to read than to listen to," click!, and the would-be talker is switched off. The speaker has to add something to the words if they're to mean any more than the same stuff printed. Mr. Dole's addition to his mere subject matter was his indubitable love for dogs, which stuck out all through his dissertation. His was no speech performed for the sole purpose of filling out a fifteen minute radio program. He likes dogs, likes to talk about them and wants other people to like them. His interest in his subject was contagious and we suspect that he may even number non-dog owners in his audience.

Given other speakers with similar qualities of delivery and we don't know but that we would alter our opinions concerning the merits of the radio talk. If we could be assured that enough untutored speakers could be obtained, who would talk naturally and not dress their material up for the microphone, we would suggest an admirable series of radio talks—let some metropolitan station schedule a series of weekly ten minute talks, promising a new speaker, an authority on his subject, each week. Then as speakers get head waiters, bakers, subway guards,

mounted policemen, customs inspectors, window demonstrators, flag pole painters, information clerks, pan handlers, bell hops, ribbon clerks, bootleggers—or any others of the numerous people whose work gives them a unique slant on humanity, and with whom the average man doesn't ordinarily have an opportunity to be clubby. Let them tell the inside dope on their business in their own words.

Of course it would first be necessary for the director of that program to interview the prospective speakers to ascertain whether or no their garrulities would be interesting. He could question them in the course of an hour's interview about entertaining and intimate sidelights on their trade. During the course of the conversation he could keep a topical record of the interesting things that came up. Then the speaker could be furnished with this brief list of reminders, perhaps only five or ten sentences long, and told to go ahead and talk until his ten minutes were up.

The series would succeed or fail according to its convincingness. Absolutely no editing, other than by the method suggested above, could be indulged in, and the speaker would have to be encouraged to talk in his every day language. Any faking of material, or permission of exaggerations for the purpose of putting "punch" in the talk, would defeat its own end. The listeners—a suspicious lot—would immediately decide that the "confessions" were faked in their entirety and delivered by some actor-announcer.

But if the thing were honestly done it would be honestly convincing. Suppose a window washer, inexperienced at formulating his ideas, got "microphone fright" before his speech was two minutes under way, and the program had to be filled out with piano music—the catastrophe would only serve to build up the prestige of the whole series.

INTERESTING news from France, translated by ourself at the cost of much labor and consulting of dictionaries, for your delectation:

Acting upon the Radio Broadcasting decree issued on December 31, 1926, the constitution of a new organization, the "Radio-Diffusion Française," is being prepared by the qualified representatives of literary and artistic groups, of radio manufacturers and dealers, of the press, and of various associations interested in the development of radio.

The "Radio-Diffusion Française" proposes to act upon the suggestions and orders of the statute established by the government by bringing about broadcasts of such quality and interest as will be worthy of French thought, technique, and art.

Under the auspices of the "Radio-Diffusion Française," a complete broadcast of the performance of "La Traviata" at the National Opera House was transmitted by station Radio-Paris, with full power, on January 26, 1927. The opera was offered to the listeners by the "Grands Magasins du Printemps." (The which, as you know, is a department store in Paris).

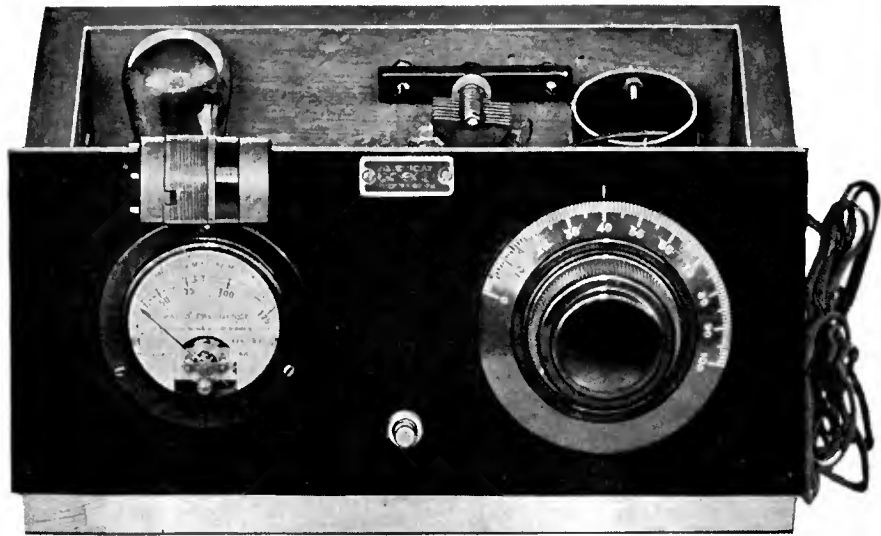
A NEW day time schedule has been inaugurated by wjr. It is called the Musical Matinee program and lasts from 12:45 to 2 o'clock every day except Sunday. Dance music is alternated with concert music, and occasionally a soloist is added. Dance music is by Charles Fitzgerald and his Rhythm Kings, and light concert numbers by Jean Goldkette's Petite Symphony Orchestra.

MATCHING R. F. COILS

By

F. J. FOX and R. F. SHEA

Engineering Dept., American Bosch Magneto Corporation



THE CRYSTAL-CONTROLLED MASTER OSCILLATOR

See Fig. 2 for the circuit diagram

THE trend toward simplicity of operation as manifest in the design of radio receivers during the last few years has rendered necessary a rapid development in the technique of production testing. During the time when single-control receivers were unknown, there was less necessity for precision test methods. It was desirable that the coils and tuning condensers be identical in order that the dials might read alike, but considerable tolerance could be allowed without affecting the efficiency of the receiver. It is quite evident that this cannot be permitted with modern receivers, where as many as five or six tuned circuits are coupled together and controlled from one central drive. In this case any appreciable departure from uniformity will reduce the efficiency of the receiver and, consequently, it becomes very necessary to develop and maintain elaborate inspection equipment in order to insure absolute uniformity of all the component parts of the tuned circuits. In this article it is our purpose to analyze the various means of testing and matching radio-frequency inductances.

Most of the methods of testing inductances at radio frequencies involve some variation of the well-known resonant circuit, wherein the coil to be tested is used in combination with a calibrated condenser as a wave trap. This wave trap may be attached to some sort of detector circuit or else it may be incorporated in an oscillator circuit. If the former is used, an oscillator must be used to supply power, so, as a rule, it is more economical to make the tuned circuit part of the oscillator circuit.

The type of apparatus to be designed for this purpose is determined by several considerations. If the test set-up is to be used for matching coils,

its frequency must be fixed and the tuning of the wave trap condenser must not change the power or the frequency of the oscillator. The apparatus must be designed for all possible accuracy consistent with quantity production, and, above all, it must be reliable and fool-proof. The accuracy required depends on whether the coils are to be sorted and then matched, or whether they are to be passed or rejected. If a small receiver using not more than three coils is being built, it is advisable to match coils. If, however, a large set is being manufactured, it is too expensive an operation to match five or six coils. In this case

it will tune the coil to 1000 kc. Across the condenser is a vernier, C_3 , of approximately 30 mmfd. capacity, and this vernier will indicate the amount that the test coil deviates from standard. The variable condenser, C_2 , is so adjusted that the galvanometer will give a maximum reading when the vernier is set at 15 mmfd. or, let us say, a dial reading of 50, the standard coil being connected at X. If, now, a coil to be tested is placed across X it will usually necessitate a readjustment of the vernier in order to obtain a maximum galvanometer deflection. The amount of this deviation is an indication of the deviation of the coil's inductance from standard. Coils which give vernier readings between 40 and 60 on the dial may be passed since the deviation is, roughly, only plus or minus 1 per cent. By passing all coils coming within the limits and rejecting any which fall outside we can hold coils to as great a degree of uniformity as desired. Or if the coils are to be matched, they are labeled with the reading of the vernier and sorted, all coils bearing the same number being identical.

MATCHING THE TESTING DEVICE

WHILE the above system is extremely useful when small quantities of coils are being tested, it has several disadvantages when applied to quantity production. Chief among these is the difficulty of exactly duplicating two such testing devices. If coil matching is desired, we cannot match coils tested on one set-up with those tested on another set-up.

To overcome this disadvantage, a coil-testing method has been worked out with which it is possible to duplicate measuring set-ups and in this way handle a large volume with a minimum of expense and a maximum of efficiency.

This improved system employs a constant-frequency master oscillator and a number of auxiliary oscillators. The last-mentioned oscillators incorporate the test circuits. The master oscillator maintains the test frequency of 1000 kc. and all the other oscillators are adjusted to this frequency by means of a detector loosely coupled to each oscillator.

Fig. 2 shows a wiring diagram of the master oscillator using a quartz crystal for frequency control. The crystal is connected between the grid and filament of a vacuum tube and is shunted by a grid leak. The plate circuit is tuned by means of a coil and condenser in parallel, and the circuit will oscillate when the natural period

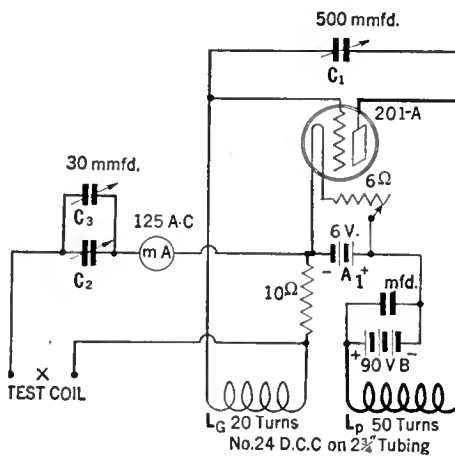


FIG. 1

A setup developed for matching coils

it will be found more advisable to hold the coils within a certain percentage variation from a standard, this allowable variation being as much as can be tolerated without serious loss in receiver performance.

In Fig. 1 is shown a coil test set-up which was developed for the purpose of matching coils. This set-up utilizes a Hartley oscillator in connection with a wave trap circuit. L_g and L_p are the grid and plate coils respectively and C_1 is the main tuning condenser. The oscillator may be set at a frequency of about 1000 kc. A resistance of ten ohms is placed in series with the grid coil and the wave trap circuit is shunted across this resistance. The wave trap consists of a thermogalvanometer in series with the coil to be tested, and a variable condenser, C_2 , of such a size that

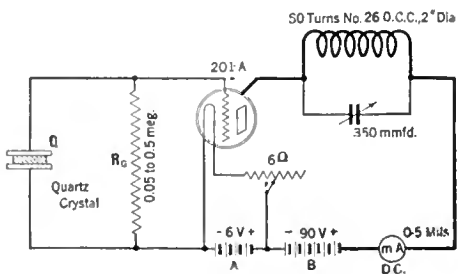


FIG. 2

The master oscillator circuit with quartz crystal control

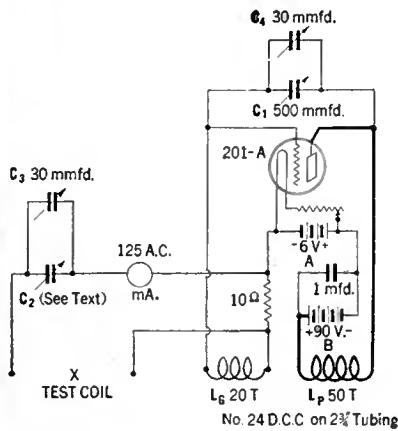


FIG. 3

The circuit of the auxiliary oscillator. A detector circuit is loosely coupled to it

of the crystal is found. A 5-milliamper d. c. meter is connected in the plate supply circuit and this serves to indicate the condition for maximum oscillation. When oscillation begins, the plate current decreases, and maximum oscillation corresponds to minimum plate current. It will be found best to operate with the tuning condenser set for a slightly lower capacity than that for best oscillation in order that oscillation will start when the switch is turned on. Crystals having an accuracy of $\frac{1}{100}$ of 1 per cent. may be obtained from the General Radio Company. Since only constant frequency is required, the crystals need not be ground accurately to any particular frequency, and hence may be obtained at a lower price.

The wiring diagram for the auxiliary oscillator is shown in Fig. 3. The oscillator is the same as that shown in Fig. 1 with the addition of a 30-mfd. vernier condenser, C_4 , across the main tuning condenser, C_1 , so that the latter may be set and locked and C_4 used to adjust this oscillator to the same frequency as that of the master. Loosely coupled to the auxiliary oscillator is a detector circuit consisting of a coil and condenser and a vacuum-tube detector. A pair of headphones is connected in the plate circuit. The auxiliary oscillator is tuned to the frequency of the master by the heterodyne or beat note method. In other words, the vernier is turned until the beat note heard in the headphones is lowered to "zero beat." The test circuit is placed across the ten-ohm resistance in the grid circuit in the same manner as shown in Fig. 1. This test circuit has the main condenser, C_2 , and the vernier condenser, C_3 , as before, the large main condenser being used to set the standard coil reading for maximum meter deflection when the vernier is set at mid-scale. The vernier condenser, C_3 , is the only piece of equipment that has to be matched in each oscillator set-up. To facilitate this, the condenser is made of heavy plates with extra large spacing, and each condenser is measured on a capacity bridge before being used. This is necessary in order that coils tested on one set-up can be used with coils giving the same reading on another set-up.

A saving of one test set-up may be accomplished by adding to the crystal oscillator a coil test circuit. This is done by inserting a resistance in the plate or tuned circuit and shunting the wave trap circuit across it, as shown in Fig. 4. It is seen that the crystal oscillator is unchanged except for the introduction of the measuring circuit. This test circuit is identical with those used in the previously described oscillators with the exception that it is in the plate circuit instead of the grid circuit of the oscillator.

TEST PROCEDURE

IN USING this arrangement the following procedure is employed. The crystal oscillator is set to a stable operating condition as described previously. A standard coil is now connected at X and the tuning condenser, C_2 , is adjusted until maximum current flows in the test circuit when the vernier condenser, C_3 , is set at mid-scale. Limits are set on either side of the vernier mid-scale by inserting coils which are known to be plus or minus the desired amount in inductance. There are a number of ways by which

a standard may be obtained. A number of coils may be made in experimental production, and these may be measured on an inductance bridge. One of these is used which is representative of the average. Another method is to run a large number of coils through the coil tester and pick

kilocycles. Thus, if the test coil has an inductance of 200 microhenrys and if the test frequency is 1000 kc., the capacity required is:

$$C_2 = \frac{1,000,000,000}{0.0395 \times 1,000,000 \times 200} = 127 \text{ Mmfd}$$

A 150 mmfd. condenser will, therefore, easily serve the purpose.

A photograph of the crystal-controlled oscillator described above accompanies this article. The test coil may be seen in the test position. The eyelets on each end of the coil serve as coil terminals and these are also used to make contact with the tips provided on the test setup. The adjusting condensers are placed inside in order to prevent the operators from tampering with them. The dial on the panel controls the vernier, C_3 . The limits are either marked on the dial or they may be posted near the operator.

A photograph of an auxiliary oscillator and detector combination is also shown, in this case the main adjusting condensers are inside the case. The vernier, C_4 , used for frequency setting, may be adjusted by means of a screw driver from the outside. The detector coil is on the right-hand side and is placed about eight inches from the oscillator coil so that the coup-

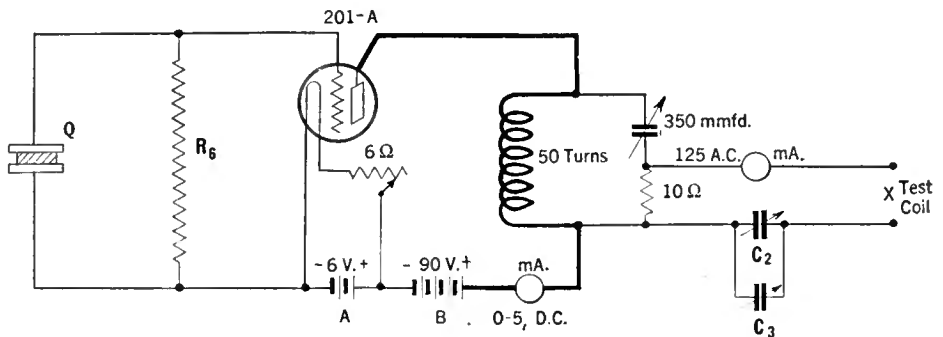


FIG. 4

A saving of one test setup is possible by combining the latter with the crystal oscillator

out a coil which is equal to the average. The choosing of limits is a difficult problem. It is possible to set up a radio-frequency amplifier and try coils which are plus or minus standard inductance and vary these limits until the radio-frequency gain is affected appreciably. These coils can then be placed in the tester and the maximum allowable limits determined. It is also possible to compute the limits which may be allowed and from this obtain the capacity variation which will tune these coils to resonance and thus obtain the allowable limits in terms of the vernier condenser capacity. Another and less accurate method is to choose limits from a study of the tests of a large number of coils. In this case the smallest limits possible, consistent with quantity production, may be selected.

All auxiliary oscillators are brought to the same frequency as that of the standard by the "beat frequency" method as described above. The oscillators are checked as frequently as possible, say every few hours.

The size of the tuning condenser (C_2 in the diagrams) necessary to bring the test coil to resonance will of course depend on the test frequency and the inductance of the coil to be tested. The proper value of C_2 can be easily computed from the following equation:

$$C_2 = \frac{1,000,000,000}{0.0395 f^2 L}$$

where C is in mmfd., L in microhenrys, and f in

ling is small. The dial on the panel is for the vernier, C_3 .

The system described in this article has been in operation in a well-known laboratory for some time and has given very excellent results.



THE AUXILIARY OSCILLATOR AND DETECTOR

The circuit diagram of this unit is shown in Fig. 3

**New Tubes
Mean Greater
Economy**

THE ARRIVAL on the open market of power tubes of the 112 and 171 types (the CX-312-A and CX-371-A, UX-112-A, and UX-171-A) which require but one-quarter ampere, half of the original filament current, is another step in the evolution of the vacuum tube. Now we hear rumors of new general purpose tubes of the 201-A type which will consume but one-eighth ampere, half the present tube's requirements, again reducing the power required by filaments to the low value of 5.25 watts for the average six-tube receiver. Years ago we used tubes which ate up our batteries to the tune of more than one ampere each—but in those days we did not have six-tube sets—and the new tubes, present and promised, mark one more step in a continual advance toward economy.

The 112-A type of tube, which is a quarter-ampere semi-power tube, has an amplification factor of 8 and an impedance of 5000 ohms, similar to the 210 power tube except that one cannot use plate voltages as high. This semi-power tube, in our opinion, is a tube which should be used more generally than is the 171 or 171-A tube. Two of them in parallel will deliver as much *undistorted* power as a 171 type on one-third the input a.c. voltage and with slightly less plate current drain from one's batteries. This business of requiring adequate volume with smaller input voltages is important to one who dwells over 100 miles from powerful stations. Here more voltage amplification is needed to bring signals to the volume level desired and, since the 171 type of tube with its low μ is essentially a local station power tube, that is, it requires large input signals, its advantage over the 112 type is not always apparent.

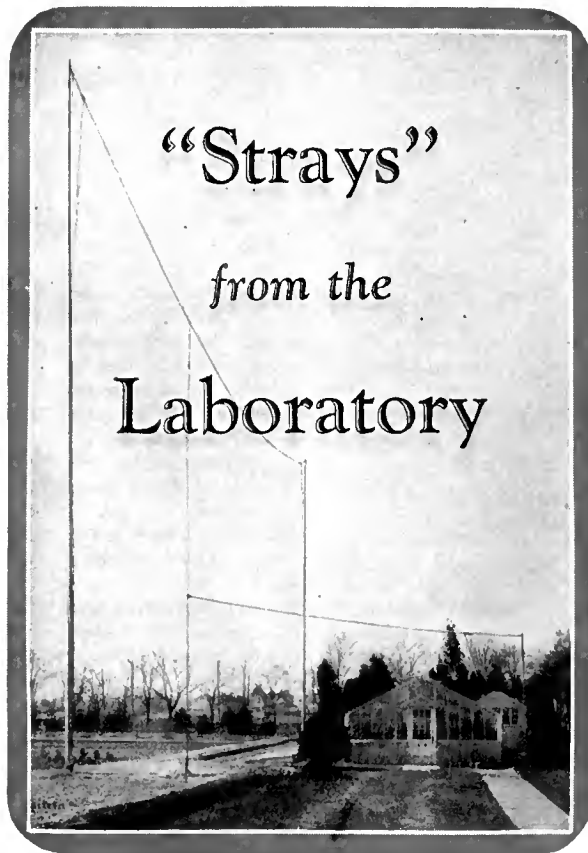
Two 112's in parallel, which is a better combination than push-pull when choke-coupled to the average low-impedance loud speaker, can be operated from B batteries economically. A single 171 tube with only 135 volts on the plate draws as much from the B batteries as two 112's in parallel with 157 volts on the plate and requires more than twice the input voltage to deliver less power output. In other words, weaker signals will deliver the volume required when 112 type tubes are employed.

The screened-grid tube is another step toward economy. Its filament operates from 3.3 volts and requires 0.132 amperes—the same filament as is used in the old and, we must say, rather poor, 120 type tubes—and delivers roughly three times the voltage amplification at high frequencies as the 210-A type of tube. Probably as many stages of amplification as we are accustomed to in r.f. circuits will be required with the screened grid tube to furnish sufficient selectivity, but the resultant input to the detector will be much greater than when our present general-purpose tubes are used.

**Don't Over-
work the
A Battery**

ONE OF THE most frequent complaints made to radio service men sounds like this: "My radio seems to be all right when I first turn it on, but then fades out. What is wrong?" This is invariably prefaced with the statement that all batteries are in good condition, i.e., that new B batteries are in use and that the A battery has been newly charged.

What is wrong? The answer in nearly every case is that the storage battery is run down, and



that if it is thoroughly charged trouble will disappear like dew in the morning. People using trickle chargers apparently fail to understand or appreciate the fallibility of all things mechanical or electrical. Over the week end, they work the radio for hours at a time giving it little chance to recharge from the trickle charger, until the little booster cannot hold up its end of the bargain longer. The battery is down and nearly out, the signals fade after a few minutes of the program, and the only thing left to do is to cart the battery to the nearest service station.

**Better Loud
Speakers
Are Here**

WE TAKE considerable pleasure in announcing that the loud speaker situation seems to be improving rapidly. For years we knew of no loud speaker that could be compared to the W.E. 540-AW, or the larger W.E. cones, either in sensitivity or in tonal range or in what we might call "intelligibility." This latter term is taken from telephone practice to mean the ability to distinguish the various instruments of an orchestra—when listening to it from a given loud speaker—or to recognize various consonants such as d, b, t, s, when spoken singly and without context, or to recognize the identity of an announcer. Many loud speakers convey sounds to us in a comparatively decent fashion, it seems, but when we try to distinguish the piano from a banjo, or to pick out the wood winds from the violins, we realize that something is wrong. All of the instruments seem "blended" together; we cannot distinguish one from another. We wonder how many loud speakers have been sold because the salesman, or the advertising told how carefully the loud speaker had been designed so that a proper "blending" had resulted?

We have listened to two cone speakers recently which will give the 540-AW a close race—the Fada 415-B and the B.B.L. Both of these are rather large cones, of about 24 inches diameter, and both are remarkably good. As a matter of fact they are so good that we have decided to

call upon all of the loud speaker manufacturers to send their instruments into the Laboratory, and to get to the bottom of the present loud speaker situation.

And speaking of loud speakers, it is our opinion that improving the loud speaker will spell trouble for the designers, manufacturers, and owners of a.c. sets. With a Balsa loud speaker which we operate with a Western Electric 540-AW unit out of a single 171 tube with about 160 volts on the plate, the average a.c. set is too noisy for pleasure although on other loud speakers the hum is inaudible. In other words, the a.c. tube either marks the limit of loud speaker development, or the newer and better loud speakers will force a.c. tubes to deliver signals unruffled by a.c. hum. We hope the latter, for the average loud speaker of to-day is less than five per cent. efficient, considering the entire audio band to be passed. Which prompts us to ask Mr. Burke, writing in the *General Radio Experimenter*, what he means when he states that most of the power delivered to a loud speaker by a power tube is transformed into sound waves and radiated. The average power radiated by man talking is about ten microwatts, and yet to get the same degree of loudness, we shove into the loud speaker 500 milliwatts of so-called undistorted power.

**New
Amateur
Regulations**

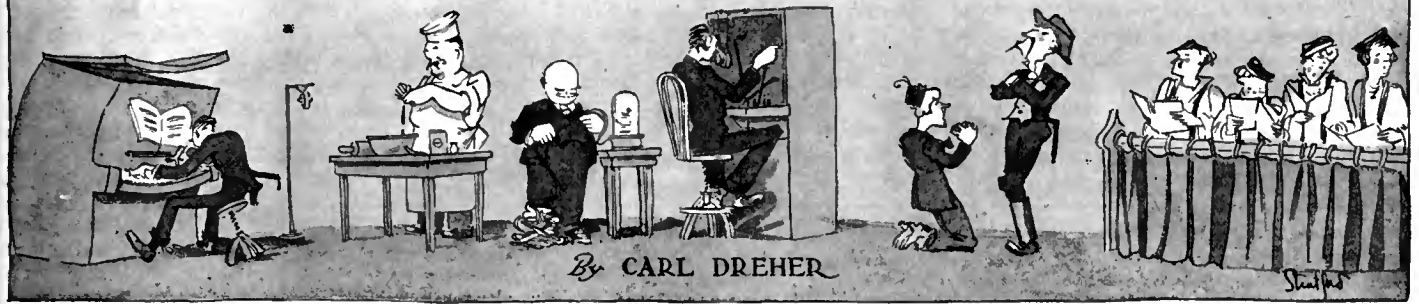
NEWSPAPERS credit the Radio Commission with following the advice of the A. R. R. L.

in removing from the so-called 80-meter band the many amateur 'phone stations now existing, and opening up the 20-meter band for radiophone communication. In addition, the amateurs have from 1580 to 2000 kc. (150 to 190 meters) and a nice fat band between 56,000 and 64,000 kc. for communication by 'phone. This sounds fine until one realizes that the lower-frequency band has always been open for amateur 'phones—except when they caused disturbance to broadcast listeners, when they could not be operated until late at night—and the higher frequencies are in the so-called 5-meter band which is probably no good for code and worse for voice. The 80-meter band disturbed no B.C.L.'s, and was high enough up the wavelength scale that fairly good quality of speech could be transmitted.

But let us hasten to admit that we have had radiophone apparatus working in the Laboratory on as low as 3 meters and that with 20 watts input we were able to hear the ticking of a watch held near the microphone as far away as one mile. We didn't experiment over greater distances.

The new international regulations, probably in effect by 1929, narrow the so-called 40-meter band, but leave the other bands about as before. In this 40-meter band all of the amateurs of the world who once could be found from 30 to 50 meters will be shoved, and instead of listening for South America and South Africa on 27.5 to 33 meters and England and France above our American band, we may find them mixed up with 8's and 9's which are so numerous in this country. We shall be thankful for one thing when these new regulations go into effect—they will automatically remove from the amateur bands the many high-power commercial stations, such as RW in France and several in Germany, which clutter up amateur communications that seem futile to commercial interests, and yet which paved the way into a band that will in ten years carry the bulk of the world's communication.

AS THE BROADCASTER SEES IT



Technical Radio Problems for Broadcasters and Others

QUESTION 1: What is usually wrong with a loud speaker of which it is said: "It sounds all right on music, but not as good on speech?" How may the characteristics of the monitoring loud speaker affect the output of a broadcasting station?

ANSWER: The fault in such a case is usually loss of the high frequencies, causing speech to sound muffled, and even unintelligible if the cut-off point is low enough. In reality the defect is equally present in musical reproduction, but most people are more sensitive to this particular defect in speech. A loud speaker which cuts off on the high end at about 3000 cycles will sound manifestly "tubby" on speech to almost any observer, but many listeners tolerate it readily for music, some even praising the result as "mel-
low."

The ideal condition for judging the quality of a broadcasting station would naturally be to have the apparatus, including the monitoring equipment, flat over the whole audio band, and to have the same condition hold for the receiving sets. The broadcast operators could then be assured that the listeners would hear everything just as it was heard at the station. Under existing conditions, with many types of receivers and loud speakers in use, the best course for the broadcasting station to follow is the same as if all the receivers were good. Its own monitoring equipment, including the loud speaker, should respond impartially over a band between, say, 100 and 5000 cycles. If the loud speaker at the station is "drummy," or "down" in high frequencies, the operators may tend to over-emphasize this portion of the band in microphone placing, equalization of lines, etc. If, on the contrary, the station loud speaker is "tinny," or relatively lacking in low notes, there may be a preponderance of bass in the station's output without the operators being aware of the fact. While such effects may benefit some listeners whose receiving apparatus requires acoustic correction, it will result in distorted reproduction in both the good receivers and those which have the opposite fault relative to the monitoring circuits at the transmitter. Thus the characteristics of the station loud speakers are often an important element in the fidelity of reproduction attained.

QUESTION 2: What amount of energy is required for effective loud speaker operation under the usual listening conditions?

ANSWER: A well designed cone loud speaker requires a telephonic level of plus 10 TU. This is roughly the maximum distortionless output of a tube of the 120 power type. Such a tube will de-

liver 110 milliwatts of undistorted output. On the basis of zero level equalling 10 milliwatts, and calculating from the formula for conversion from energy units into TU, which has been cited so often in this department that it need not be repeated, this corresponds to plus 10.4 TU. For broadcast transmitter monitoring it is preferable to use a tube affording more margin, say up to plus 15 TU (the 171 type or equivalent). On the other hand, if the loud speaker is improved in sensitivity 100 milliwatts of audio energy may be ample for its operation.

QUESTION 3: Why does a loud speaker sound "tinny" (lacking in bass tones) when the volume is decreased below the comfortable listening level?

ANSWER: The same effect occurs with natural sources of sound when the volume reaching the ear is decreased. The cause is found in the ear rather than in the source of sound. The ear is much more sensitive to relatively high-pitched sounds (say between 1000 and 4000 cycles) than to bass notes. For example, while the threshold of hearing in the favorable middle portion of the audio range, say at 1000 cycles, may be around minus 60 TU, at 100 cycles it may be no lower than minus 20 TU. When the volume is decreased the bass notes drop below the auditory threshold, so that the ear no longer responds to them, long before the treble disappears and all audition ceases. This phenomenon explains the effect observed. In some cases there may be contributing causes in the loud speaker mechanism.

Death Among the Broadcasters

TOO often we have had occasion, in this department, to discuss recent electrical fatalities among broadcast technicians and ways of avoiding such accidents in the future. It is admittedly impossible to render work with high-tension currents perfectly safe, and there will always remain an irreducible minimum of unavoidable mishaps. A transformer may break down without warning, admitting high voltage to a circuit where no one expects it, lightning surges may take place, psychological lapses sometimes upset the most carefully planned precautions. A fatal casualty in the last case occurred recently at the Daventry station of the British Broadcasting Company. The man killed was W. E. Miller, a Maintenance Engineer. The B. B. C. gives the following account in its announcement:

"Mr. Miller threw in a high-tension switch in

connection with the apparatus at 5 GB and a few minutes later was observed to lean over a guard rail apparently with the object of making an adjustment which should not have been undertaken with the switch on."

The death of Mr. Miller is stated to be the first in the five years of operation of the B. B. C.

The question in such a case is whether mechanical precautions can be elaborated to a point where a man will be protected against his own temporary unawareness of danger. In other words, must a sharp distinction be made between accidents due to circuit breakdowns and the like, and psychological failures resulting in death or serious injury? Knowledge of circuits appears in some cases to be no protection at all. As I have pointed out in previous articles on the subjects, some of the men, or rather boys, working on broadcast transmitters are altogether too young for dangerous jobs, but older men, it must be admitted, are sometimes no more fortunate. What, then, can be done to establish safety by machinery?

One device is to enclose all the high-voltage apparatus in a grounded cage with special doors. The doors may be opened by turning a wheel which cuts off the high tension inside the cage and grounds the plate circuits. The wheel cannot be turned back while the door is open. This comes close to being an absolute safeguard when only one man is involved. He cannot get into the dangerous portion of the station without cutting off the current. If another operator is involved, however, it may happen that one man is working on the apparatus while another, unaware of the fact, closes the door, locks it with the wheel, and burns up the operator inside the cage. A red tag system will obviate this, if it is faithfully followed—but where there is an "if," someone will get killed some day.

A similar device consists of circuit interrupters on doors in panels giving access to tubes from the front of the panel. When the door is opened, for replacement of a tube, or observation, the plate supply to that tube is cut off. But it is sometimes almost imperative to allow a man to observe the operation of the set, from a point behind the panel, while the circuits are energized. If that man starts to touch the equipment, he is on his way to the undertaker. Or, if he leans over a guard rail, as Mr. Miller did, he invites immediate death in the same way. Such a guard rail, it may be pointed out, has scarcely more than a symbolical value.

There are, in sum, two schools of design, working on opposite fundamental assumptions. One group contends that the best thing is to

leave the high-tension circuits open and accustom the operators to keeping away from them. If they realize fully, it is argued, that only their own care stands between them and death, they will be careful. The other group carries out the design on the assumption that human beings are irremediably fallible and must be safeguarded by forethought operating through mechanical devices. Probably one system fits some men best while others are safer under the opposite scheme. But unfortunately we do not select personnel on the basis of temperament in such details, nor do we possess adequate psychological data which would enable us to control accidents by such means.

It is in this general direction that I would suggest study and thought. Personally I am not convinced of the superiority of either of the design systems outlined above. There is no doubt that much can be done with mechanical safety devices. One has only to consider the low ratio of accidents in a well conducted vacuum-tube factory to realize that. With highly dangerous potentials distributed through such a plant, and most of the workers on the forty-cents-an-hour level, it is possible practically to eliminate accidents by careful safety engineering and attention to orderly procedure and cleanliness. Nevertheless, with highly-trained technical personnel the margin of safety may be as great at the end of a hooked stick, even with the live parts of the set accessible, if a special effort is made to control the psychological factors. At army aviation fields the pilots are frequently under the scrutiny of surgeons who are expected to detect anomalies of sight and hearing, chronic fatigue, and emotional disorders in time to prevent avoidable accidents. The engineer in charge of a broadcast transmitter should watch his men in somewhat the same way. Usually he is in a position to know when anyone on the staff is in some personal difficulty which might interfere

with his ability to keep out of danger. Psychiatrists can cite cases where men working in factories have injured themselves as a result of lack of normal coordination clearly traceable to domestic troubles and other emotional disturbances. In a broadcasting station the part of wisdom would be to detach a man in such a condition from transmitter duty and place him temporarily in the control room or wherever he would be safe.

But, aside from such acute cases, preventive measures of a psychological nature may also be applied at intervals. After the monthly resuscitation drill for members of the staff a discussion may be started on accidents which have occurred in the experience of the men, and how they might have been prevented. This will direct attention to the problem and may in a measure preclude the contemptuous familiarity with the apparatus into which technicians are apt to fall

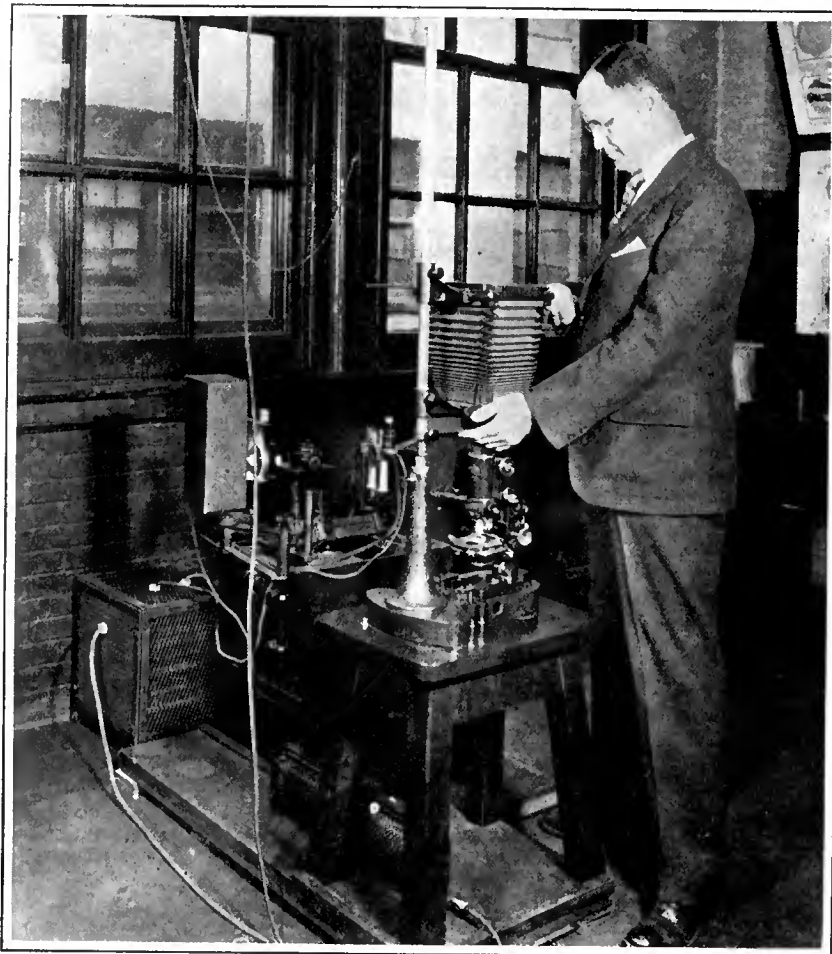
after nothing has happened for a period. There is no danger of making radio men morbidly conscious of such danger as exists. Their faults are in the opposite direction; they are not afraid enough. Yearly medical examinations, with special attention to the condition of the heart, are very desirable, in that a man with a sound heart who is caught on a high-tension circuit usually has a good chance for his life if he is released quickly, whereas a cardiac case is snuffed out in the first few seconds. To compel or allow men to work excessively long hours is plain criminality on the part of the employer.

mile-long antenna strung on four-hundred foot masts. The four-hundred footers were taken down and stored away. When, four years later I viewed the cement blocks still set in the earth I reflected with amusement that the engineer of the Marconi Company had been bad prophet, and, with the superficial confidence of a young man, I probably thought I could have done better had I stood in their shoes when the decision was to be made.

In 1923, ten years after that die was cast, I left the Riverhead transatlantic receiving station of the Radio Corporation of America, having served my time as a receiving engineer. The wave antenna at Riverhead, a type developed by Harold H. Beverage, stretched to the southwest over miles of Long Island sand, through forests of scrub pine, and oak, almost to the sea. I did its stretching on thirty-foot telephone poles. It was a good antenna, one which was kind to European signals and not at all kind to the static which came from the opposite direction. Many more such antennas have been built since that time on the same sort of poles. When I left Riverhead, had anyone told me that transoceanic receiving antennas would ever be built otherwise, I should have expressed polite doubts. Had my informant added that steel towers would rise in Riverhead almost as high as the Marconi masts at Belmar, before I returned to the town, I should have expressed doubts not nearly as polite. Had he stated finally that there would be five of them, with ninety-foot cross arms at the top, I should have taken him, I am afraid, for a harmless lunatic whose aberration led him to imagine towers instead of the more usual pink elephants or snakes.

Another four and one-half years flit past. The short-wave explorations of the ether (if you care to assume one) begin, and soon reach formidable portions.

A short-wave receiving system is developed in which vertical antenna wires hang from steel crossarms which, curiously, are supported by steel towers three hundred feet high, while at the other ends of the crossarms reflector wires sweep gracefully to the earth. The wave antennas are still at Riverhead, combined and phased for even greater efficiency, and even more inconspicuous, for five of the three-hundred foot towers have come to keep them company. The fact that none of us expected them did not keep them from coming. They obeyed a different sort of logic than that which ground out conclusions in our brains. They followed the innate logic of invisible oscillations propagated through space and the laws of the materials which men use in communicating over the distances separating one continent from another. And so, for the moment, they stand proudly over the scrub pine woods.



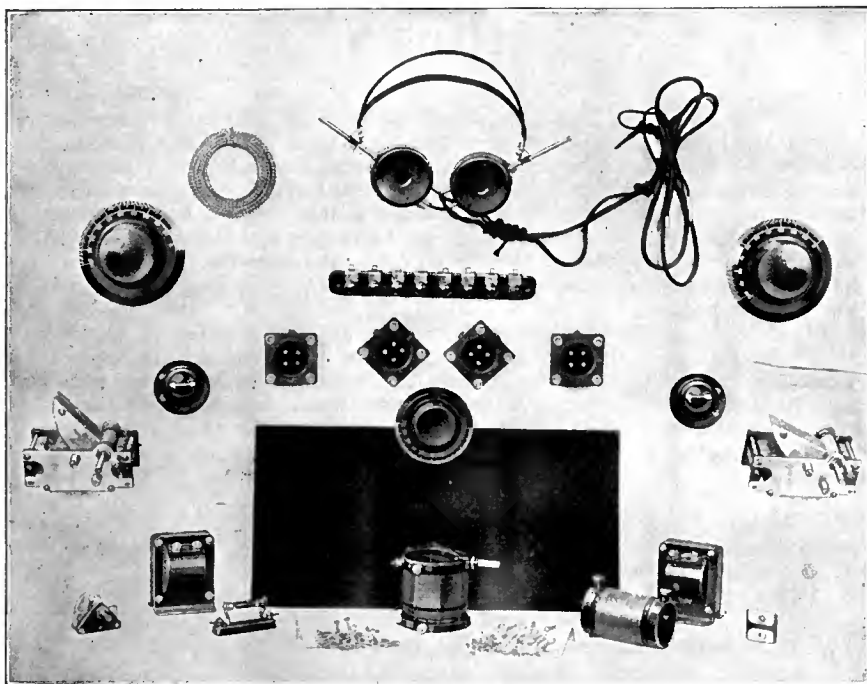
HOW ULTRA-VIOLET RAYS AID PHOTOGRAPHY

Ultra-violet photomicrographic apparatus in use at the Bell Telephone Laboratories, New York. The lenses of the apparatus are of quartz and the ultra-violet rays are furnished from an arc light using rods of cadmium or magnesium instead of carbons. A system of quartz prisms, in front of the lamp house, permits the operator to "tune-in" on one particular frequency of the invisible rays

Antennas from 1913 to 1927

BACK in 1913, when I was just getting out of preparatory school, the Marconi Company was engaged in erecting a series of transmitting and receiving stations for transoceanic communication. The receiving stations on the Atlantic seaboard were located at Chatham, Massachusetts, and Belmar, New Jersey. At each of these points the placid skyline of the countryside was broken by a string of four-hundred foot iron masts, mounted on cement emplacements, and guyed to anchorages in the surrounding fields. Much money went into those hollow masts—and never came out again. Within a year the development of the vacuum tube had reached a point where an amplifier, fed from an antenna of moderate height, would produce as readable a signal from over the ocean as the

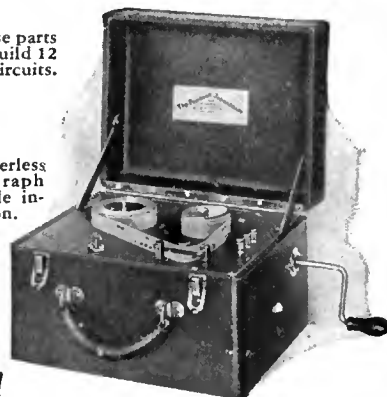
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Stranded Enameled Antenna

Best outdoor antenna you can buy. Seven strands of enameled copper wire. Presents maximum surface for reception, resists corrosion; this greatly improves the signal. Outside diameters equal to sizes 14 and 16. (We also offer solid and stranded bare, and stranded tinned antenna.)

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A cable of fine, tinned copper wires with non-inflammable Celatsite insulation. Ideal for sub-panel or point-to-point wiring. Strips easily, solders readily. Nine beautiful colors; sold only in 25 ft. coils, in cartons colored to match contents.

Acme Celatsite Wire

Tinned copper bus bar hook-up wire with non-inflammable Celatsite insulation, in 9 beautiful colors. Strips easily, solders readily, won't crack at bends. Sizes 14, 16, 18, 19; 30 inch lengths.

Spaghetti Tubing

Oil, moisture, acid proof; highly dielectric — used by leading engineers. Nine colors, for wire sizes 12 to 18; 30 inch lengths. (We also make tinned bus bar, round and square, in 2 and 2½ ft. lengths.)

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New Haven, Conn.

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MAKES BETTER RADIO

The Radio Broadcast LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all Sheets appearing up to that time was printed.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of Sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for \$1.00. Some readers have asked what provision is made to rectify possible errors in these Sheets. In the unfortunate event that any such errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 161

RADIO BROADCAST Laboratory Information Sheet

February, 1928

Comparing the 112, 171, and 210 Type Tubes

THEIR RESPECTIVE OUTPUTS

ON LABORATORY SHEET No. 162 are shown three curves that indicate an interesting relation between the three most common types of power tubes, i.e., the 112, 171, and 210 types. The curves indicate the relation between the power output of the tubes and the value of the signal voltage impressed on the grid. The plate impedance and amplification constants of the 112 and 210 type tubes are practically identical and, therefore, the curves for these two tubes coincide from zero up to that point corresponding to the maximum output power of the 112, which is approximately 195 milliwatts, or 0.195 watts.

If a vertical line is drawn at any point on the curve, for example, at A, the points at which this line crosses the various curves will indicate the power output obtained from the particular tube associated with the curve being examined. In this particular case, line A, drawn at the point corresponding to a signal voltage on the grid of 15 volts indicates that, with this value of signal voltage, the power output of a 210 tube with 425 volts on the plate is approximately 0.34 watts. The power output of a 171 at the same point is approximately 0.1 watts. The maximum grid voltage that can be impressed on a 112 without resultant output distortion is about 10.5 volts and, therefore, a 112 tube cannot be used if the signal input voltage is greater than this value. At B we have drawn

another line corresponding to a signal on the grid of 8 volts. Here we find that the power output of a 112 is approximately 0.1 watts and the power output of a 171 about 0.04 watts. It is therefore evident that at low values of input voltage a 112 tube is capable of putting more power into the loud speaker than is a 171. If the signal voltage, however, is in excess of 10½ volts, the 112 cannot be used and the choice then lies between the 210 and the 171. The curves indicate that the 210 will give much more power output than a 171 but it should be realized that much greater plate voltages are necessary on the 210 than on the 171. With 180 volts on the plate the 171 can deliver approximately 740 milliwatts of power, but 250 volts on the plate of the 210 will only permit this tube to handle signal voltages up to 18 volts and the maximum output power will be only 460 milliwatts. From these data the following conclusions can be arrived at:

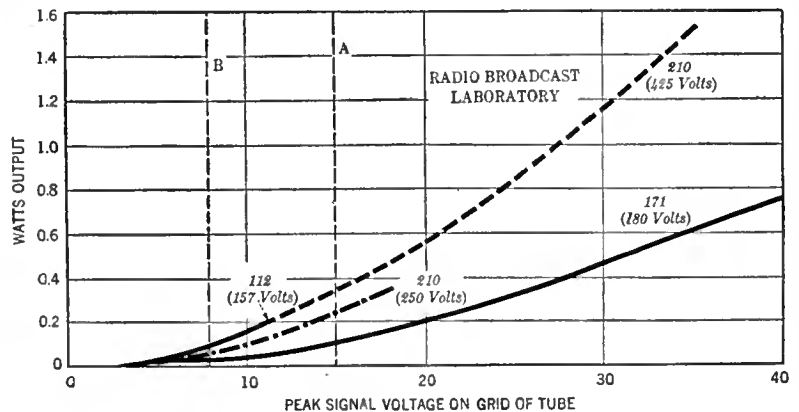
- (1.) For input signals on the grid of the power tube of 10 volts or less the 112 tube will deliver the most power to the loud speaker.
- (2.) When more power output is required and only moderate plate voltages are available (not in excess of 200 volts) a 171 is capable of giving greater output than can be obtained from a 210 under similar conditions of plate voltage.
- (3.) Where high plate voltages around 400 volts are available the 210 should be used and under the same input signal it will give approximately 2½ times as much power as can be obtained from a 171.

No. 162

RADIO BROADCAST Laboratory Information Sheet

February, 1928

112, 171, and 210 Tube Curves



These curves indicate how the power output of the 112, 171, and 210 type tubes varies with different values of signal voltage on the grid of the tube. The significance of these curves is explained in detail on Laboratory Sheet No. 161.

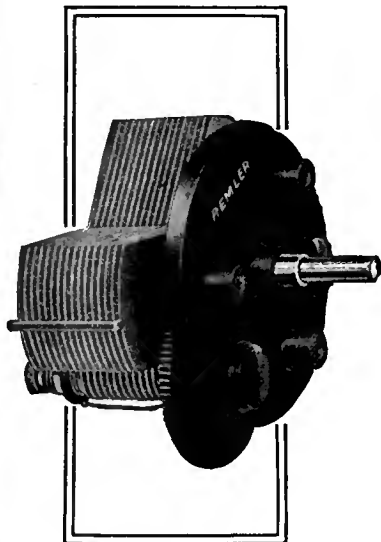
Not What We Say— But what they DO!

That's the Secret of

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Parts Popularity

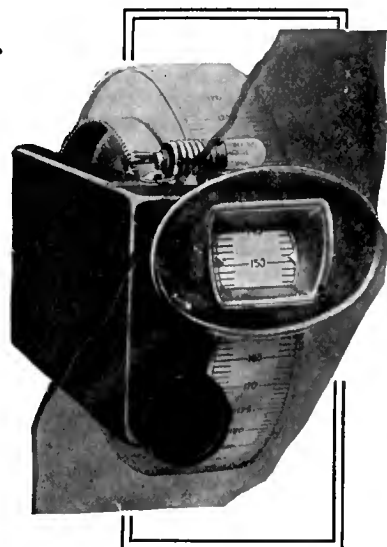
PERHAPS they are too Good. . . . It would be so easy to cheapen them here and there, to rush them out without the final certainty of maximum performance which is built into every Remler part.



**REMLER Twin-Rotor
CONDENSER**

Both sets of plates are entirely insulated from the dial shaft and both sets of plates rotate. Body capacity effects are entirely absent. Insulation is of genuine bakelite. Because of the high ratio of maximum to minimum capacity, the condenser will cover an unusually great wavelength range. S. L. Frequency and S. L. Wavelength Types. Capacities .00035; .0005 and .0001.

Price \$5.00



REMLER Drum DIAL

The Remler Drum Dial permits quiet velvet smooth, vernier control of any type of condenser. The drum is 15 inches in circumference and is divided into 200 divisions—two for each broadcast channel. Six-volt lamp and bracket are supplied for illumination. It will drive either a single or gang condenser and is adaptable to either right or left-hand drive.

Price \$4.50

But we know we are on the right track when we make every Remler part just as if it were a precision instrument. For 10 years, Remler parts have set the pace as quality radio products. No part has even been cheapened to meet a competitive price. Precision standards govern every operation from the purchase of raw material to final testing of each part. These standards are your guarantee of satisfaction.

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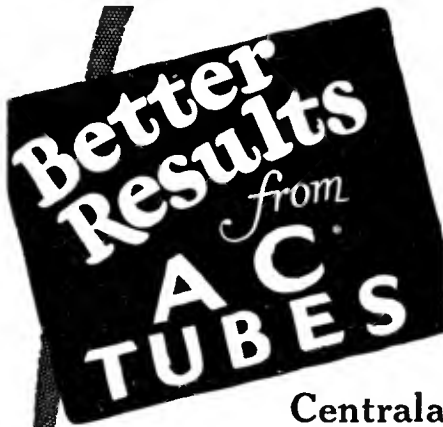
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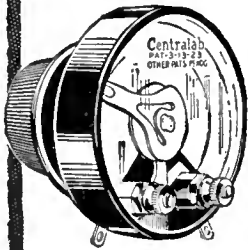
Eastern Warehouse: Elkhart, Indiana

NEW YORK



Centralab Radiohm RX 100

A new taper of resistance specifically to control volume of receivers using the new AC tubes. A variable resistance in R. F. plate circuit or R. F. filament circuit, customarily used in battery circuits, cannot be used with AC tubes without destroying the delicate balance of voltage for efficient operation.



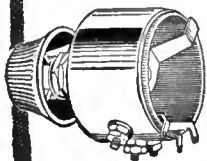
Centralab RX 100 Radiohm, with minimum capacity and smooth, noiseless action, inserted in the grid circuit of one of the R. F. stages, does not affect the filament or plate potentials, insuring balance and eliminating a source of AC hum.

In "super" circuits, the most satisfactory volume control is obtained by inserting the RX 100 in the grid of the intermediate frequency that is not sharply tuned.

Also a 50 ohm Centralab Power Rheostat inserted in the primary of the transformer will compensate for any line fluctuation—increasing life of tubes and holding entire circuit at the point of best operating efficiency.

Centralab Heavy-Duty Potentiometer

A new improved positive voltage control for B-climainers, insuring better tone. In any ordinary circuit this unit is burn-proof, warp-proof and constant in resistance. It is all wire-wound, and will carry entire output of any B power circuit. Resistance remains constant at any knob setting, so that panel or knob can be marked in volts. Resistances 2,000, 3,000, 5,000, 6,000, 8,000, 9,000, 10,000, 15,000, 25,000, 50,000; price \$2.00, at your dealer's or C. O. D. Write for folder.



Central Radio Laboratories

22 Keefe Avenue Milwaukee, Wis.



Other products of Centralab are Radiohms, Modulators, Potentiometers, Power Rheostats, and Heavy Duty Potentiometers—Folder 328 describes them all. Write for it.

No. 163

RADIO BROADCAST Laboratory Information Sheet

February, 1928

Testing Receivers

USING THE MODULATED OSCILLATOR

THE accurate determination of the characteristics of a radio receiver requires a careful laboratory test, but it is possible to construct comparatively simple apparatus of much practical value for the testing and repairing of receivers. The instrument that will enable us to make such tests is the modulated-oscillator. From a modulated oscillator we can obtain an audio-frequency tone which can be fed into the input of the audio amplifier in a radio receiver and the functioning of the audio amplifier thus checked, or by turning on both r.f. and a.f. oscillators we can obtain a modulated wave which can be used to test both the r.f. and a.f. circuits.

The circuit diagram of a modulated-oscillator will be found on Laboratory Sheet No. 164. The following paragraphs will explain how to use the instrument for testing receivers.

(1.) Audio Amplifiers

Place all the tubes in and connect all the batteries to the amplifier. Do not place the detector tube in its socket. Connect the plate terminal of the detector tube socket to audio output terminal Nn. 1 on the modulated oscillator. Connect both the B +

detector lead on this receiver and terminal No. 2 on the modulated oscillator to B — on the receiver. Turn on the receiver and audio circuit of the modulated oscillator and adjust potentiometer P to give an output of medium intensity from a loud speaker connected to the output of the audio amplifier. A defect in the amplifier is indicated if the output is low or distorted or both.

(2.) Radio-Frequency Amplifiers.

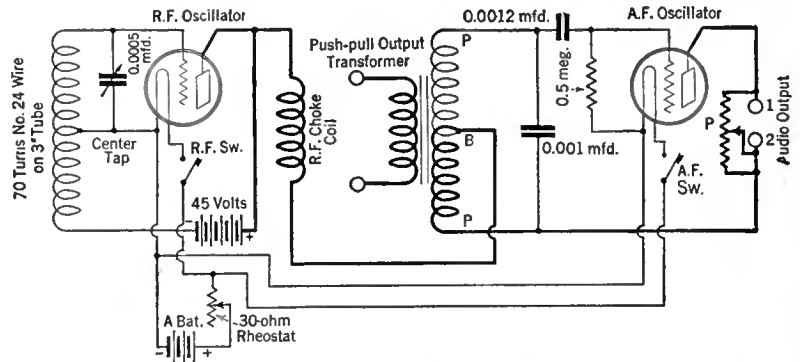
A test of the r.f. amplifier of a receiver is accomplished by first placing all the tubes in the receiver and connecting all the batteries, and then winding about two turns of insulated wire around the coil on the oscillator, connecting the other end of this wire to the antenna post on the receiver. The oscillator should be located about ten feet away from the receiver. If the a.f. and r.f. tubes in the modulated oscillator are turned on and the receiver's tuning circuits adjusted to resonance, an audio-frequency tone should be audible in the output. Since the a.f. amplifier in the receiver was tested previously, any defect in the operation of the receiver must be located in the r.f. amplifier or detector circuit.

No. 164

RADIO BROADCAST Laboratory Information Sheet

February, 1928

A Modulated-Oscillator



All the constants of the apparatus used in the instrument are given on the diagram. Some information on the use of this instrument will be found on Laboratory Sheet No. 163. The frequency of the audio-frequency oscillations can be varied by using various values of capacity across the push-pull transformer.

No. 165

RADIO BROADCAST Laboratory Information Sheet

February, 1928

Audio Amplification

GENERAL CONSIDERATIONS

AN AUDIO system can be considered satisfactory if it amplifies the signals impressed on its input sufficiently to operate adequately a loud speaker and does so without distorting the signals to an extent sufficient to become apparent in the output of the loud speaker. Such performance can only be realized when the amplifier has been correctly designed and is operated properly.

The overall frequency characteristic of an amplifier is frequently quite dissimilar to the characteristic of a single stage. This is especially true of transformer- or impedance-coupled amplifiers and is probably due, in most cases, to coupling in the plate supply. Regenerative effects are thereby introduced into the circuit, which may produce considerable changes in the frequency characteristic of the audio system. Such effects are also present, at times, in resistance-coupled amplifiers and, generally cause such an amplifier to "motor-boat."

The solution of such difficulties is either to design the amplifier so that with the regenerative effect present the system has a flat characteristic or to

design two units to have a flat characteristic and then arrange the circuit so carefully that regenerative effects will not be present. This necessitates feeding all the grid and plate circuits through resistances or choke coils and bypassing all the circuits with condensers.

Some recent audio transformers are designed to have a fairly sharp cut-off at about 5000 cycles to reduce the effect of various extraneous sounds, such as tube noise, high-frequency heterodyne whistles, etc., which are composed mostly of frequencies above 5000 cycles. Frequencies above this value add little to the quality of the speech or music and can therefore be eliminated without introducing noticeable distortion. It is doubtful whether the majority of broadcasting stations themselves transmit notes of more than 5000 cycles in frequency.

Also many amplifiers have a tendency to oscillate at very high audio frequencies and sometimes at supersonic frequencies. If the amplifier is designed, however, to give little or no amplification to frequencies much above 5000 cycles, this tendency of the amplifier to oscillate will be nullified.



More "Pep" With Sovereign A. C. Tubes

In addition to freedom from all bother with "A" Batteries or "A" Battery Eliminators—freedom from hum—noise—microphonics—Sovereign A-C Tubes will make your set seemingly 100% more powerful. The music will roll in full, rich, clear-toned.

Write for treatise on how to convert your set to A-C power. No obligation.

Sovereign Electric & Mfg. Co.
127 N. Sangamon St., Chicago, Ill.

Don't burn out your Loudspeaker!



make it more responsive to weak signals—IMPROVE TONE QUALITY—eliminate tube noises.

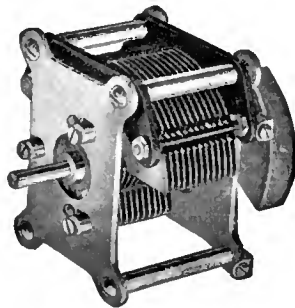
THE Sterling Power Output Transformer connected between the radio set and loudspeaker absolutely prevents the high voltages now delivered by "B" Power Units from ruining the speaker. This transformer is more than a protective device. It permits closer adjustment of speaker diaphragm, increasing its sensibility to weak signals. Prevents shock when using headphones. Eliminates tube noises and IMPROVES TONE QUALITY of the speaker. Attach in two minutes, leave permanently connected, Model R-360—\$5.00.

Sterling
POWER OUTPUT TRANSFORMER

THE STERLING MFG. COMPANY
2831 Prospect Avenue, Cleveland, Ohio

General Radio Quality Apparatus

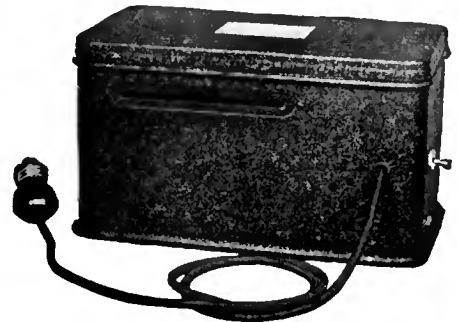
THE apparatus manufactured by the General Radio Company is the result of careful engineering design. Every Laboratory instrument and part is guaranteed, and in many cases they represent the result of years of development work and investigation in the General Radio laboratories. It has been the aim of this Company to contribute only quality instruments to the radio and electrical industry.



Type 334 Condenser

- Type 334-F 500 MMF Panel mounting without gear \$4.25
- Type 334-H 500 MMF Panel mounting with gear \$5.25
- Type 334-N 350 MMF Panel mounting without gear \$4.00
- Type 334-P 350 MMF Panel mounting with gear \$5.00
- Type 334-K 250 MMF Panel mounting without gear \$3.75
- Type 334-M 250 MMF Panel mounting with gear \$4.75

Low loss condenser design has received much attention and the General Radio Company was the first concern in this country to supply such condensers commercially. The Type 334 Variable Condensers illustrated are of the grounded rotor type and soldered plate construction.



Type 445 Plate Supply and Grid Bias Unit

The General Radio Type 445 Plate Supply has been designed to meet the demand for a thoroughly dependable light socket "B" Power unit. The current output is sufficiently high to permit its use where the current drain is unusually large. Through the use of a wire wound voltage divider, equipped with movable clamps, any combination of voltages from 0-180 may be obtained. An adjustable grid bias voltage from 0-50 is also available for use on the power tube of the amplifier.

The Type 445 Plate Supply is designed for use on 105 to 125 volt A.C. lines (50-60 cycles) and uses the UX 280 or CX 380 rectifier tube. This unit is licensed by the Radio Corporation of America for Radio amateur, experimental, and broadcast reception only, and under the terms of the R.C.A. license the unit may be sold only with tube.

Type 445 Plate Supply and grid bias unit \$55.00
UX-280 or CX-380 Rectifier tube . . . 5.00

Write for Bulletin No. 929 describing our complete line of Quality Apparatus

General Radio Co., Cambridge, Mass.



And NOW
... the

VOLUME CONTROL CLAROSTAT

A GENUINE Clarostat in miniature, designed for light duty applications in usual radio set. Just the thing for control of volume, tone, regeneration, stabilization, plate voltage, balancing and many other purposes wherein limited current is being handled.

It does not, however, replace the Standard (20 watt) and the power (40 watt) Clarostats for the heavy-duty requirements of radio power unit, line voltage control, and super-power amplifier.

The volume Control Clarostat has a resistance range of 0-500,000 ohms in several turns of knob, providing micrometric adjustment. Handsomely nickel plated with new style bakelite knob. One hole mounting. Screw binding posts. And a real Clarostat through and through—noiseless, holds the adjustment, trouble-proof and durable. Best of all, the price—\$1.50.

As with all Clarostats look for familiar green box and CLAROSTAT stamped on shell. Beware of inferior substitutes.

Ask your dealer to show you the complete Clarostat line. Or write us direct for descriptive literature and technical data.

American Mechanical Labs., inc.
Specialists in Variable Resistors
285 North 6th St. Brooklyn, N. Y.



No. 166

RADIO BROADCAST Laboratory Information Sheet

February, 1928

Acoustics

DAMPING AND REVERBERATION

THE quality of reproduction from any loud speaker depends to a considerable extent upon the room in which it is used and upon the room's furnishings. The reason why the room and its furnishings influence the output of the sound generator, whether it be a piano, phonograph, or a loud speaker, is not difficult to understand, and will be explained briefly here.

In an average room the sounds from a piano, for example, are somewhat damped by the hangings, carpets, furniture, etc., so that they decrease to inaudibility quite rapidly. When the furniture, rugs, etc., are removed and the piano is permitted to stand on the bare boards, the sounds from it will be prolonged and the music will become jumbled, especially when playing forte. This effect is due to the absence of the furniture, which normally acts as a damping agent, and also due to the fact that the piano is resting directly on the floor so that the latter acts to increase the effective area of the sound board. The sounds produced by the piano when it is in direct

contact with the floor will be somewhat louder than usual, indicating increased efficiency.

Under any given room conditions the rate at which a sound dies away is the same whether the sound at its beginning is loud or soft. However, the time taken for the sound to become inaudible depends upon the loudness of the original sound and, of course, the louder the sound, the longer it will take to decrease in volume to a point where it is inaudible. In a room containing furnishings that cause considerable damping, we may, therefore, play much louder than in an unfurnished room, without causing any excessive blurring.

A room can be too completely damped, when the playing will sound "dead." A certain amount of blurring or intermingling of succeeding chords is considered good, for it adds coloration to the music.

The importance of these matters in relation to the design of the studios in broadcasting stations is evident. The correct amount of damping must be obtained to prevent deadening the music (too much damping) or to obviate difficulties due to reverberation (too little damping).

No. 167

RADIO BROADCAST Laboratory Information Sheet

February, 1928

Resonant Circuits

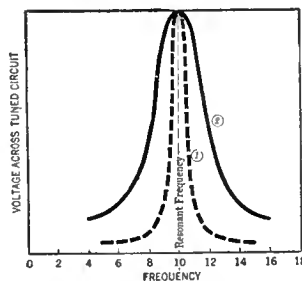
GAIN AND SELECTIVITY

THE current at resonance in a tuned circuit is equal to the voltage induced in the circuit divided by the total resistance of the circuit. The actual capacity of the condenser or the inductance of the coil used in the circuit do not enter into the calculation once the induced voltage and the resistance are known. The voltage across the coil in the circuit is equal to a constant times the current times the inductance of the coil and, the voltage is, therefore, larger the greater the inductance of the coil. Since a vacuum tube is a voltage rather than a current operated device, it might appear that best results, i.e., greatest amplification, would be obtained by making the coil very large. When we increase the inductance of a coil by adding to the number of turns, however, we also increase the resistance and the increase in resistance nullifies to some extent the advantage gained through the use of a larger coil.

The selectivity of a tuned stage in a receiver depends upon the series resistance of the circuit; with low-resistance circuits the selectivity is good while with high-resistance circuits the selectivity is poor. The curves on this Sheet indicate the effect of resistance in the tuned circuit. Curve 1 shows the characteristic of a very low-resistance tuned circuit and curve 2 a comparatively high-resistance circuit. Since practically all of the resistance in a tuned

circuit is in the coil, it follows that carefully constructed, fairly "low-loss" coils should be used in a radio-frequency circuit. A coil can be made so good as to cut "side-bands," however, and thereby distort the received signal head-band suppression results in the loss of the high audio frequencies in the modulated wave.

If the ratio of the inductive reactance of the coil (6.28 times the frequency times the inductance of the coil) to the radio-frequency resistance of the coil at the same frequency is made much more than 250, distortion of the "side-bands" results.



No. 168

RADIO BROADCAST Laboratory Information Sheet

February, 1928

The Ear

ITS CHARACTERISTICS

THE characteristics of the human ear have been determined and investigated by many different scientists, and some of these characteristics are given below:

(a.) There is a minimum sound intensity below which the ear cannot detect any sounds. A curve was published on Laboratory Sheet No. 109, indicating how this minimum audible intensity varied with frequency.

(b.) There is a maximum intensity of sound above which the auditory sensation is one of pain rather than sound. The intensity and its variation with frequency was also explained on Lab Sheet No. 109.

(c.) There is a lower limit of the pitch of a sound below which the ear will not respond. This lower limit is about 20 cycles.

(d.) There is an upper limit to the pitch of a sound above which the ear will not respond. The upper limit is about 20,000 cycles.

(e.) The ear can distinguish between about 300,000 separate sensations of sound.

(f.) The ear can respond to pressure changes between the pressure required to produce a minimum audible sound and a pressure 100 million times greater. These two pressures correspond to an energy ratio of 10,000 trillion.

(g.) The ear can distinguish between the loudness of various sounds. At low levels of sound intensity a change of about 25 per cent. is necessary to be distinguishable. At greater intensities a change of 10 per cent. in loudness is detectable by the ear.

(h.) The ear can distinguish between the pitch of various sounds. At medium frequencies a change in frequency of about 0.3 per cent. can be detected; at low frequencies a change of about 1 per cent. is necessary.

A knowledge of these characteristics is useful to the student interested in problems of sound reproduction.

SUPERIOR PARTS for Sets and B-Eliminators

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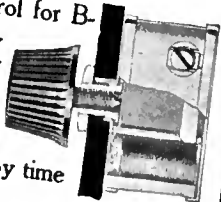


provides the ideal resistance for B-eliminators requiring fixed resistors of permanent resistance value. Not affected by age, temperature or humidity. Will not deteriorate in service.



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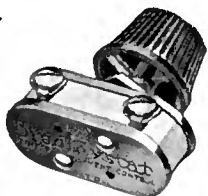
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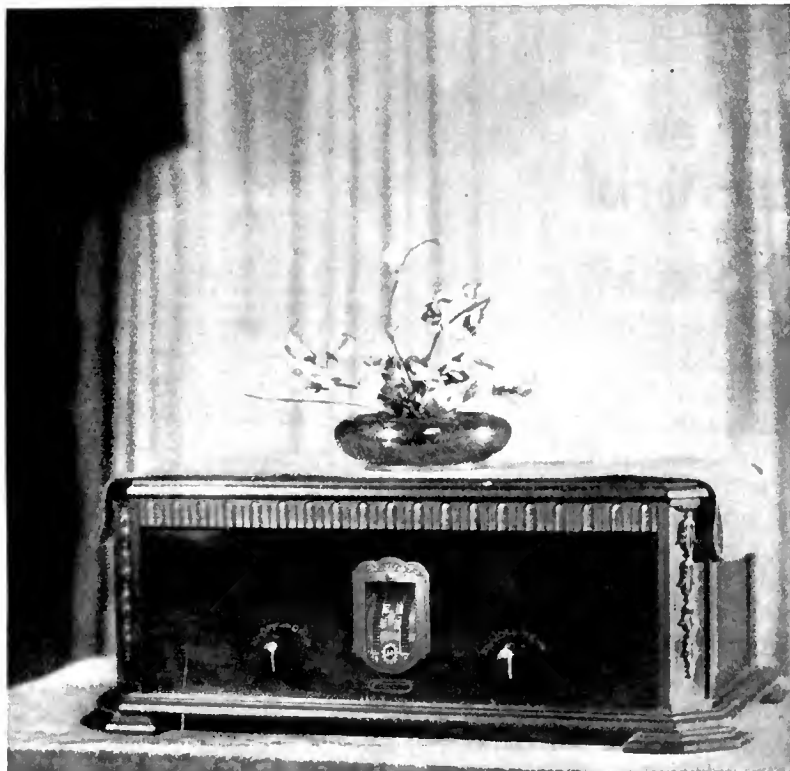


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READERS may obtain any of the booklets listed below by using the coupon printed on page 328. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.
2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.
3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.
5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.
7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.
9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.
10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.
11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS COMPANY.
12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.
15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.
- 15A. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.
16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.
17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION.
19. POWER SUPPLY—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. ACME APPARATUS COMPANY.
20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL-AMERICAN RADIO CORPORATION.
21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVE-METER—Constructional data and application. BURGESS BATTERY COMPANY.
46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.
47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.
48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.
49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.
50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.
51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1099 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.
52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.
56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.
57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.
59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.
62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MFG. COMPANY.
63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.
64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.
66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.
70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.
72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.
80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.
81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.
82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.
83. SOCKET POWER DEVICE—A list of parts, diagrams,

and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

100. A, B, AND C SOCKET-POWER SUPPLY—A booklet giving data on the construction and operation of a socket power supply using the new high-current rectifier tube. THE Q. R. S. MUSIC COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier, with operating curves. KODEL RADIO CORPORATION.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.

32. METERS FOR RADIO—A catalogue of meters used in radio, with connecting diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEO BATTERIES COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

77. TUBES—A booklet for the beginner who is interested in vacuum tubes. A non-technical consideration of the various elements in the tube as well as their position in the receiver. CLEARTRON VACUUM TUBE COMPANY.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

91. VACUUM TUBES—A booklet giving the characteristics and uses of various types of tubes. This booklet may be obtained in English, Spanish, or Portuguese. DEFORST RADIO COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a c. operated receivers, together with a diagram of the circuit used with the new 400-milliamperer rectifier tube. CARTER RADIO COMPANY.

97. HIGH-RESISTANCE VOLTMETERS—A folder giving information on how to use a high-resistance voltmeter, special consideration being given the voltage measurement of socket-power devices. WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY.

102. RADIO POWER BULLETINS—Circuit diagrams, theory constants, and trouble-shooting hints for units employing the BH or B rectifier tubes. RAYTHEON MANUFACTURING COMPANY.

(Continued on page 328)



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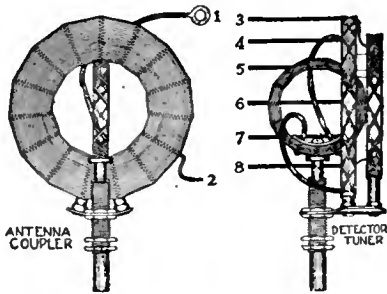
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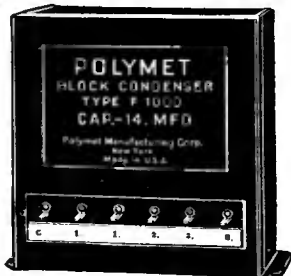
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