MODERN RADIO Annex

Part 1

The Reinartz $2.85 Oscilloscope

by

John L. Reinartz

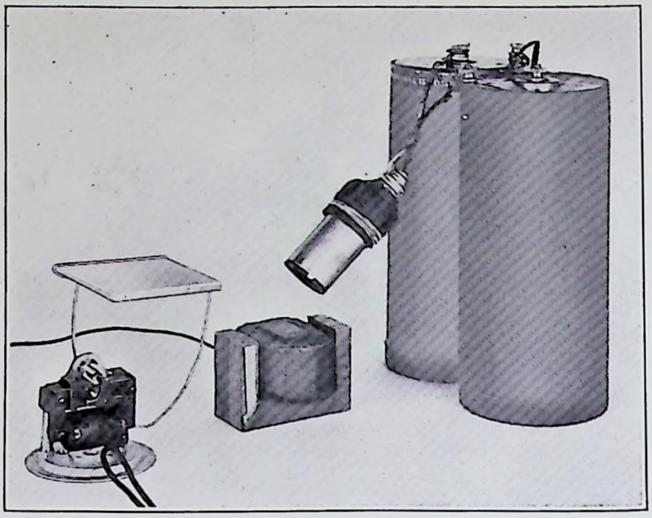
Part 2

How to Pass the new Amateur Radiophone Examinations

by

the staff of Modern Radio

25¢



At the right is the 2½ volt flashlamp in its housing, lamp and all being suspended by the connecting wires from the dry cells which drive it. A transformer will serve if used with care as explained in the story. Just below the lamphouse is the vibrator-system and its driving choke-field. To the left is the rotating mirror and screen system.

The lighter strip on the choke is the vibrator-strip, called V in the line following drawings.

An Oscilloscope for $2.85

By John L. Reinartz*

Most of us have wished for some way of taking snapshots of the many things in our radio receivers and transmitters which happen too fast for our ordinary voltmeters, ammeters, wattmeters, and the like. If we could only see a picture of the bothersome hum, or motor-boating, or key thump, we would have some idea of the way to cure it—and of course we could then take more pictures and make sure that it really WAS cured. Now oscillographs designed to do just such work can be bought—if you have from $300 to $3,000! Who has?

Fortunately we can in one evening make a device that will serve most of our purposes for just about 1% of these prices. Like all amateur devices it has some limitations, hence judgment (and the precautions mentioned later) must be used. Still, one can put up with a few shortcomings for 99% of $3,000—or even $300. And make no mistake—the simple device we are to describe will teach you an amazing lot of things about your equipment.

The Principal

All oscillographs and oscilloscopes must be FAST—because their only business is to make visible things that are so fast that they can't be followed by the needle of a meter. The reason that the ordinary meter cannot follow very fast changes is that the needle has some weight, also it must be moved across the scale by small bits of machinery which also have weight. A meter movement which has no weight would be very fast —so that is what we try to approach when making an oscilloscope—which means nothing at all but "things to see oscillations with". Instead of the usual aluminum meter needle we use a thin RAY OF LIGHT, which has exactly no weight at all. We move this weightless light needle by means of a tiny scrap of mirror (S in the diagram) and this mirror-scrap is almost weightless. From this simple beginning a useful oscilloscope can be built up as shown in the diagram and photograph.

The Practical Device

The small flashlamp in the casing throws a ¼" pencil of reasonably parallel light rays through the holes in the diaphragms D1 and D2. This beam impinges on the tiny mirror S, attached to the vibrating iron strip V. (The way V is made to vibrate will be shown later). For the moment we only need to observe that as V moves to and from the reader a small portion of the light—a mere line or thread of light, barely visible at all—is moved back and forth on the surface of the rotating mirrors M. These mirrors again reflect the light to the under side of the ground glass

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screen. Now if both V and M are stopped we will see a dot of light on the screen, the size and shape of this dot being determined solely by the size and shape of S.

If V is left stationary and the rotating mirror M is set to turning by starting the motor which drives it (more of that motor in a moment), the dot of light will be stretched out into a long line across the screen as shown in Fig. 2A. If the motor be stopped in such a position as to put the light-dot on the center of the screen and V then be set to vibrating we will have a transverse light-line on the screen as shown in Fig. 2B. If BOTH M and V are set going—that is, if the motor is running and the strip vibrating we will see some sort of a wavy line on the screen AND THE SHAPE OF THE WAVES WILL TELL US HOW V IS VIBRATING—and that's exactly where the whole value of this device comes in. For instance, if the mirror were turning at an even speed and the strip were being vibrated by steady a.c. of a good wave-form (any good power-and-light system supplies such current) we would see such

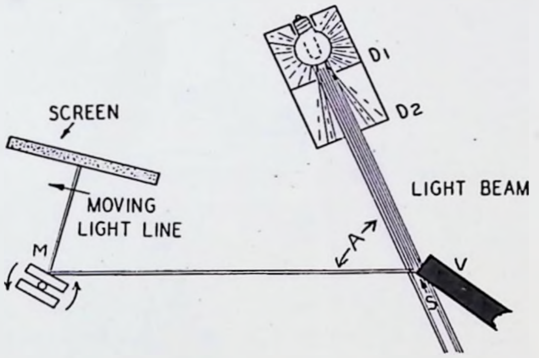


Fig. 1. The proper placement of the parts, which are somewhat wrongly placed in the picture to permit a clear photo. Increasing the distance between the motor and the vibrator will give a wider image on the screen, but also make the line fuzzy—work for a sharp, clean line.

a curve as is shown in Fig. 2C. The curve has the familiar sinusoidal wave shape—which is just what it should have, for that's the wave-form which we know the a.c. to have—but now we are SEEING it instead of reading about it in a book. If the curve is steady on the screen we know that not only is the strip V vibrating steadily, but the motor M is running IN TIME with the 60 cycle line, so that each time its rotating mirrors throw an image on the screen it lands just where the last one was. Such a steady picture is very convenient, and

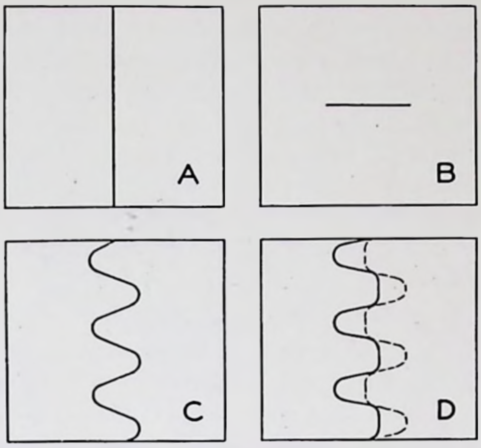


Fig. 2. A few oscillograms—hand drawings of the effects seen on the screen in 10 minutes of work. More will be shown next time.

since much of our radio work is done with 60 cycle current it is very convenient to have a motor which will turn in exact step with the 60 cycle line-current—and, of course, that's what we call a synchronous motor. If you have not guessed from the photograph where we get it, we will soon tell you.

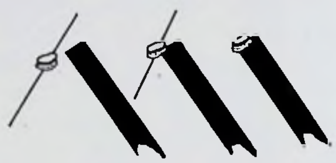
The Vibrator

To make a working device we must evidently find ways to turn M at an even speed (synchronous if possible), and to make V vibrate in accordance with the effect (current—voltage or whatnot) we are trying to see.

V moves by virtue of magnetic attraction, the frequency (and wave shape) of which depends on the current which is sent through the coil around the filter-choke core (see photo) to which V is attached and by which it is attracted as the current magnetizes the core. In the particular device photographed a Philco B-eliminator choke was used. The straight part ("I side") of the core was removed, leaving the E shaped section, which is 2¼" wide, 1½" high and 1" thick. The original coil was retained and gives satisfactory amplitude to the vibrator-strip when about 10 volts is applied to its terminals from the circuit to be looked into. The vibrator-strip V was cut from a slip of .007" silicon core steel. The .007" iron can be taken from an old i.f. transformer—or "Modern Radio" will send it gratis. A piece about ⅛" x 1½" is useful. It is NOT to be clamped to the core but is only glued by its lower end in the position shown in the photograph—or even stuck on with a drop of sealing wax and then bent slightly away from the core. The natural frequency of V is below 25 cycles and any mechanical resonances which might be expected at harmonic frequencies are considerably reduced by the "dead" material securing the strip in place.

The Small Mirror S

The mirror S will be the cause of most of your grief and when successfully attached will give you a measure of satisfaction—try it and see. We begin by finding a piece of discarded mirror and with a safety razor blade (Gillette or otherwise) scraping off some of the backing, while holding the mirror over



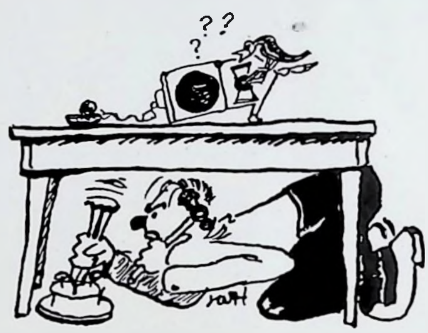
How to mount the small mirror S on the vibrator-strip V. At the left we see the stretched thread carrying the glue and mirror, S. In the second sketch S is being stuck on V. At the right —finished.

a sheet of clean paper. Among the scores of pieces which fall off you will find a few that will suit you—pieces 1/64" in diameter. The next job is to pick up such a tiny scrap of silver with its backing of paint, and secure it to the vibrator, for this is of course the mirror-scrap S. With the point of your knife carefully turn these pieces face downward, exposing the paint-backing. Now with a toothpick apply a tiny daub of LePages glue (advt.) to the middle of a 6 inch length of fine silk thread or No. 38 wire. Holding this thread stretched between your thumbs and forefingers—and holding your breath at the same time—cautiously approach the bit of silver and touch the gluey center of your thread or wire to its back. By that means only pick the bit of silver up. Continuing to keep the thread stretched, carry the bit of mirror to the strip V, turning the thread so that S is now right side up. Touch the glue-daub to V and then cautiously work the thread out by a sidewise sliding motion, finally patting the mirror into proper position with a toothpick. After several trials you will be successful in having S. stick to V. If you now use the vibrator the mirror S will instantly be thrown off and you will never see it again. Better go to supper and let the glue dry for half an hour!

J. F. Furey suggests that in handling the bits of mirror for the Reinartz oscilloscope vibrator, one gets into less trouble if the glue or cement is spread on the vibrator strip and the scrap of silver is picked up with a bit of wire or a "teaser" such as used in microscopy, first rubbing the pickup device through the hair, gold-beater fashion, to make it slightly oily. No advice on procedure for the baldhead.

The Motor

Now for the mirrors M. We buy an electric clock for as little as possible—the local record so far is 77 cents. When



"When the wife is away, quickly take this clock apart."

the wife is away, quickly take this clock apart and if your luck is good it will turn out to be one of the sort that either has a fairly slow motor, or else has a geared-down shaft where we can get at it. In either case we hope for at least ¼" of unobstructed shaft, either between the bearings or extending beyond them. To this shaft we glue two small strips of mirror, about 3/16" wide and as long as the clear part of the shaft permits. They are glued back to back as shown in the drawing. Care must be used to make them parallel, otherwise the picture will jump back and forth. Better do a little trying before the glue is entirely hardened, and shift the mirrors if necessary. Do not start the motor at this time or you will again lose mirrors. A movie can be attended while this glue is hardening.

The mirrors can be put on the motor shaft with cement and plastic wood mixed, and will stay put.

The Screen

The screen is simply a piece of ground glass as thin as possible so that little light will be wasted in its structure. It needs to be not more than 2" x 2". If you have no ground glass—make some from thin glass.

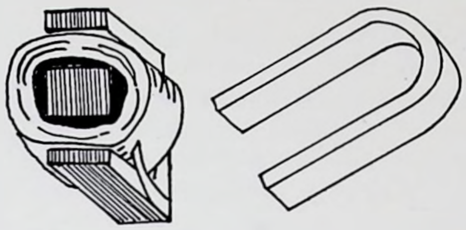
Setting Up

For clarity the parts have been shown somewhat out of position in the photograph. Actually the angle A should be much sharper and the parts should be located as shown in the drawing.

Operation

Setting up for the first time will require some juggling. Even in a dark room the little light-line which leaves S is invisible until it strikes something, therefore a bit of thin paper is used to trace its direction by putting the paper in the path of the light and following it. In this way M is located correctly and then turned until the light-spot is found on the screen. The screen-supports will probably require some readjusting—be patient. If everything appears to be in line we will begin by amusing ourselves by watching the antics of the little dot on the screen when we apply 60 cycle a.c. to the winding of the filter-choke. This will also give us a further opportunity to make such necessary alignment adjustments as are needed to provide us with the undistorted picture of Fig. 2C. Patience is the whole requirement—there's no magic about it. When you have finally caught the knack you will be astonished at the clearness and sharpness of the picture—and the perfect way in which it stands still, thanks to the synchronous motor.

Now with the nice sinusoid of Fig. 2C on the screen we bring an ordinary permanent magnet (from a telephone receiver, a magneto—or the dime store) near V and find that we are able to change the wave form of the image, depending on the magnet's nearness to V. The wave will then look somewhat as



Using a magnet to obtain the waveforms of Fig. 2D. This sketch also shows vibrator-strip V in proper position.

shown by the solid line in 2D, while if we turn the magnet over we get the opposite distortion as shown by the dotted line in 2D. If another winding is put on the filter-choke-core and d.c. is passed through that winding, exactly the same sort of picture will appear on the screen. The effect in both cases is clearly caused by a distortion of the magnetic waveform which drives V—whereby we have learned several things all at once. We now know that we CAN see wave forms with this simple contrivance, also that the vibrator V DOES follow changes in the wave form—and that we must be careful not to get stray magnetic fields from transformers, magnets and chokes too close to our oscilloscope or we will be seeing "things that ain't".

If you have followed this far, you have already spent several hours in an entertaining way—and made the whole family watch with you (Check—L. W. H. and R. S. K.) beside thinking of a dozen uses for the oscilloscope—and as many objections to it. How to use the oscilloscope most easily on your transmitter or receiver—and how to get around the objections, must be our next story. For this time it's enough to have saved $293.15!

Next month also we will show you some pictures of key-thumps, motorboating and bad filtering, and then show what happens when one starts to cure them.

Seeing Power Factor Action

By John L. Reinartz*

Now that we have the $2.85 oscilloscope all made†, and have tried out the stunts shown in the February issue, let's introduce another low-priced stunt which will be very useful when we start to make good the promise to let you "see" key thumps and motorboating.

Power factor measurements have always had the interest of the radio amateur, and have been much argued over in conventions and in print. While much of the worrying has been over r.f. circuits, the effects are the same at low frequencies. We will now take a look at the power factor business in a 60 cycle circuit, because it is slow enough to be in synchronism with our motor and will therefore show a steady picture which will mean something to us. If the motor and the circuit frequency did not agree we would have a jumble of moving light for our pains.

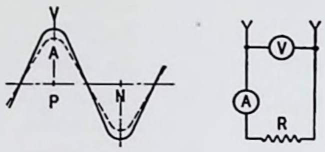


Fig. 1, in Phase Unity Power Factor.

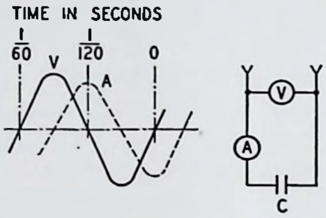


Fig. 2, Leading Zero Power Factor.

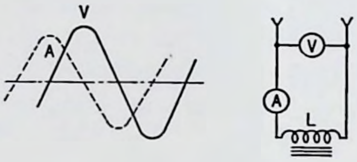


Fig. 3, Lagging Zero Power Factor.

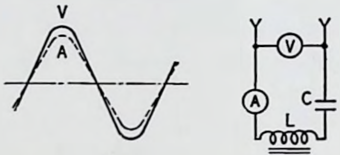


Fig. 4, Resonance Unity Power Factor.

We will now review just a little theory before starting to "look" at the effects which cause us to be interested in power factor. First of all let us recall that in 60 cycle circuits, exactly as in r.f. circuits we have resistance, capacity and inductance. If we had a circuit like Fig. 1, in which only the resistance needs be considered then the current (dashed line A) will be in time with the voltage (solid line), rising and falling with it. We ordinarily say in a. c. work, they are "in phase". The resistor gets hot, and if we measure the heat we find that the same power is being used up as if d. c. were being used at the same voltage and current. Keep this in mind, as we will come back to it.

In Fig. 2 there is no resistance, no inductance, and only the condenser to consider. Now a strange thing happens; a very short time after the circuit is closed the current is actually AHEAD of the voltage that causes it, as shown by the time marks and the position of the A curve in Fig. 2. A bit later we will let you SEE this happen, and also show that, although the current and voltage are the same as in Fig. 1, the circuit is using NO POWER AT ALL.

In Fig. 3 we have only inductance. Now the current "lags" BEHIND the voltage. If the inductance really was without resistance the current would lag as much as shown and AGAIN we would have zero power. Note that in both Figs. 2 and 3 the current is one-quarter cycle out of step (out of phase), but in opposite directions—and thus it seems reasonable to expect that we could neutralize the capacity effect of Fig. 2 by using the inductance effect of Fig. 3.

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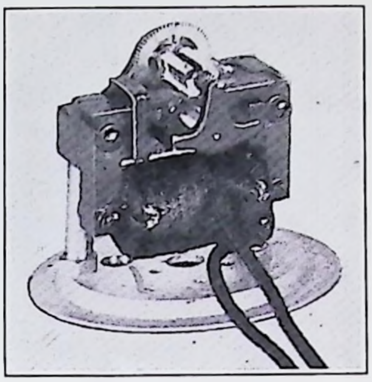
† Page 4, "Modern Radio" for February.

Later on you will SEE this happening. For 60 cycles this can be done with a combination of (for instance) 1 microfarad of capacity and 7.04 henrys of inductance, giving us the condition of Fig. 4. (If the capacity is made larger the inductance must be made smaller in the same proportion. These effects are hard to understand until we have seen them—but that's just what oscilloscopes are for—and we have all the elements necessary to provide us with instructive entertainment, not of course without



A synchronous clock-motor equipped with the necessary mirrors as was explained in the February issue.

doing some work in the form of building a small addition to the oscilloscope. This we will proceed to do at once.

Let us now assemble as in Fig. 5 a neon lamp, (N), two pieces of copper tubing (T1 and T2), another piece of ground glass (S) and the synchronous motor mounted on a panel by virtue of a velvet vernier dial (see Fig. 6) so it can be revolved while it is running and the amount of such change can be accurately noted. The panel is mounted vertically on a base and the whole can be enclosed in a box made of whatever you have available in the form of thin wood or celotex with the panel becoming one of the sides. The box must be made as light proof as possible as we want to see the effects by the reflection from the mirrors on the motor and may wish to do this during daylight. We place the neon lamp so that it faces toward the mirrors (M) somewhat as shown in Figs. 5 and 6, keeping the break between the two plates of the lamp vertical so that the mirrors may throw separate images on the screen S. Of course these images will appear only when a plate is glowing at the instant when the rotating mirror passes through the proper position to throw the image on the screen. To make the timing more exact and to give us a definite point to watch we now mount the two pieces of copper tubing T1 and T2 (we don't care where you got it), and the paper screen. The main idea is to place the paper screen so that light does not come from the lamp directly to the screen and then to locate the copper tubes so that the light from lamp-plate P1 passes through T1 and the light from P2 passes through T2. If we had only one side of the lamp lighted we would then see a single bright spot on the screen PROVIDED that side of the lamp was either lighted steadily or else was blinking at the right moment so the

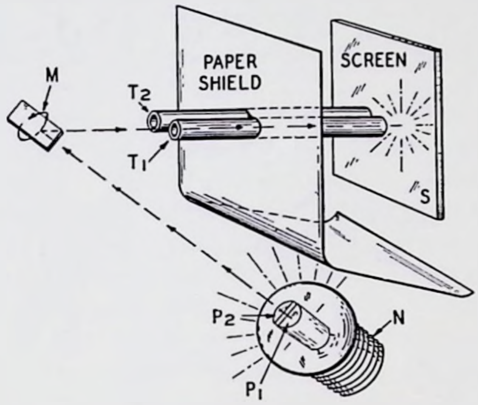


Fig. 5. The schematic arrangement of the parts. N is the neon lamp, whose plates P1 and P2 glow alternately when a.c. is connected to the lamp. M is the rotating mirror from which the light passes through the tubes T1 and T2, depending on which plate is glowing. A bright spot appears on the ground glass screen S at the end of the tube.

flash would be caught by the mirror at the moment when it could be reflected through the tube to the screen. If the lamp were blinking at the wrong time no light would get to the screen. We are going to make use of this fact to demonstrate by eye the effects that cause us to be interested in power factor—and we will also show that it can be measured even with so crude an instrument as we have assembled. We are now ready to see the results of our work.

We will begin by connecting 110 volts a.c. to both the motor and the neon lamp and amusing ourselves with the two light spots on the screen, aligning the copper tubes and turning the motor by means of the dial until we have the brightest spot from one plate, then writing down

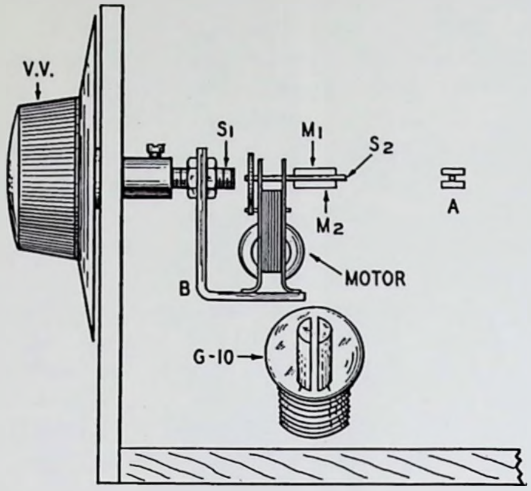


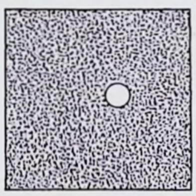
Fig. 6. Mounting of the synchronous motor to permit rotating the motor while it is running. The mirror-shaft S2 must align with the stub-shaft S1 which is held by the dial, and carries the bracket B. End view of shaft and mirrors at A.

the dial reading and turning the motor until the other spot appears and becomes brightest, then writing down a second dial reading. These two are evidently the positive and negative peaks P and N in Fig. 1. The distance between these peaks is ½ cycle, or 180 electrical degrees. IF the mirror shaft ran 3600 r.p.m. it would take an exact half-turn of the motor dial and motor and therefore 180 electrical degrees would also be 180 dial degrees. This will probably not be your combination; all sorts of figures will come out in different oscilloscopes because they may have 1 or 2 mirrors, different motor speeds, different dial markings or even a geared-down mirror shaft like that shown in the photograph. Don't be disturbed—just make sure what dial-change is equal to 180 electrical degrees on YOUR dial and go on from there.

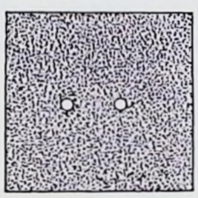
Anyway it is now time to so adjust the motor to the dial that you get a light beam through one of the tubes most brilliantly when the dial is set at zero as we will wish to start from scratch for all our subsequent experiments. We now take a one microfarad condenser of good make and connect it in series with the neon lamp. We find that the light spot on S has gone out and has appeared in the OTHER tube, we then turn the dial and find that we can make the spot show itself in tube number one again at almost exactly ½ of the dial-shift which we have previously discovered to be equal to 180 electrical degrees! The only possible explanation is that the TIME at which the plate blinks has been changed by 90 electrical degrees (almost)—which is to say ¼ cycle or 1/240 of a second. It has been moved FORWARD as is shown by the fact that we had to turn the motor AHEAD in the direction of rotation to catch up with the blink.

Now remove the condenser and instead connect an inductance in series with the lamp. Again the spot disappears and by trial we find that the motor must be turned BACKWARD to find it. This agrees with Fig. 3. Furthermore, if you used just 7 henrys and if the resistance of the condenser and the inductances by chance were alike in value

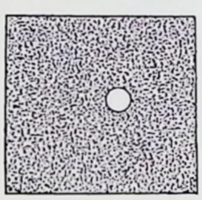
"—adjust the motor to get a light through one tube."



"—the light has appeared in the OTHER tube."

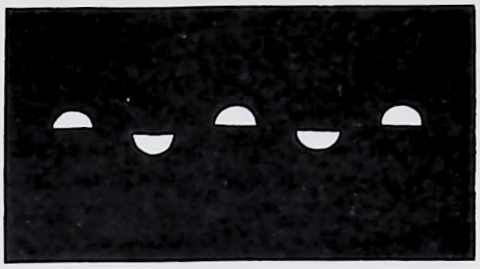


An intermediate setting.



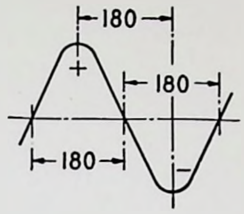
"—the motor must be turned BACKWARD to find it."

then you had to turn the dial the same number of degrees as was necessary when using the condenser. Nothing remained now except to prove finally that the condenser and inductance effects are in opposition by putting the condenser and 7 henry inductance both in series



End view of a neon lamp crossing a dark room in a hurry, just to prove that the plates light alternately as shown in the next figure.

with the neon lamp. The result will be that the light remains without change! By looking up at a regular clock that hasn't been turned into an oscilloscope



One type of neon lamp which may be used as an indicator. Plate 1 lights on the positive half of the cycle, Plate 2 lights on the negative half of the cycle. See also photo at head of this paper.

we find that no more can be done tonight, so more later.

(Continued on page 10)

Using That $2.85 Oscilloscope

In Curing Hums and Ripples

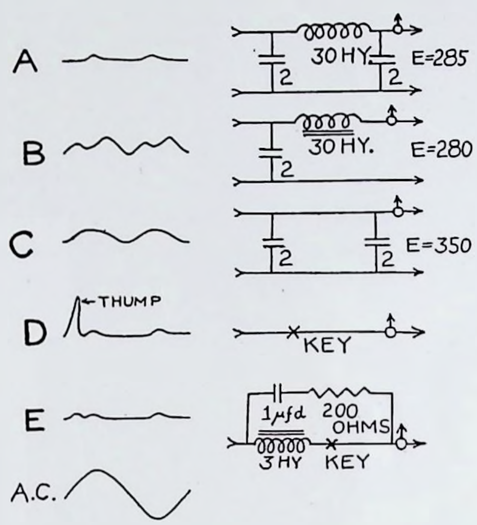
By John L. Reinartz*

Now that we've built the oscilloscope (February "Modern Radio") and used it to "see" power factor (March) let us see how it may be used to discover and correct difficulties in an ordinary filter-rectifier system.

First we want the oscilloscope set up as in the first article, using that mirror arrangement by which we could see what AC looked like. (We are all in the same boat, we have to use things over and over) so we tear our nice panel mounted near oscilloscope (March) apart and set it up as in the first (February) article. This will give you practice in patience, which is something you are going to need lots of anyhow.

As you know there is a very simple way of telling when you have a well filtered plate supply, by using a voltage divider and putting your headset across a few volts of the output of your rectifier. Unfortunately this will only indicate whether you have a hum. It won't tell you how bad it is. You can't actually see it. THIS is what we shall do in our present experiment, we will again take that choke coil arrangement and set it up so that the tiny mirror reflects the light spot onto the mirror of the motor which we have set going. The choke is now connected right into the supply line from the rectifier as shown in figure one, at the place marked X. The filter output goes to the transmitter as usual, and you key the set as usual. Then with the lights out (for this has to be done in the evening so that you can see the reflection on the ground glass screen) you LOOK at what the rectifier and filter say is d. c. Perhaps it is! In my case it was really fairly good, so to indicate how bad it might be, I removed some of the filter parts.

Illustration A shows how a rectifier-filter should work; the small humps can be neglected. There is no disturbance in the broadcast receiver in the same room from this little ripple, still they do it does tell us that the filter COULD be just a little better if we wished to go the whole way. It is interesting to note that the peaks occur at just the peaks corresponding AC humps of the complete cycle which is drawn along under it for refer-



Each filter diagram has beside it the curve which appears on the oscilloscope screen when that filter is used. The original a.c. wave is shown below.

The O with the arrowhead shows where to cut the line and run leads to the oscilloscope coil.

ence. Notice that the filter is conventional. We now start removing some of the circuit components just to see what we get for output. Let's first remove the condenser C2 after the choke. Maybe we don't need it and have it there just to take up room! Uh! The picture (B) says different; it has several humps, all much more pronounced than we had before we removed the condenser. Notice that one of them is smaller than the other, this is a resonant effect in the choke coil and indicates a harmonic, the fundamental being the larger hum, while the smaller is its second harmonic, evidently we can't spare C2.

Well, let's remove the choke, leaving the condensers in the circuit, probably

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we won't have any harmonic effects that way, right the first time. But look at the humps; at least as bad as before except that there is only one for every half cycle, also it is nice and symmetrical, the same on both halves, the low always occurring at the place where the alternation occurs.

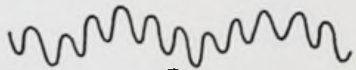
Yes, you may try other combinations, especially the ones that are pets, I was going to say pests only it doesn't sound good. Usually we always come back to the tried and true circuits.

One of the interesting things this device brings to light along with the ability for us to see the effect directly is shown in figures A, B and C this is the effect on the voltage output of the rectifier when we do things with the choke or capacity that we use in the filter, when we have only capacity in the filter we invariably obtain higher output voltages than we do when we use a choke, also we improve the voltage somewhat when we add the second condenser after the choke. Here is where we can do most of our experimental work to determine which choke has the least effect on the output voltage and yet gives us the smoothest output as shown by our oscillograph. Some of the chokes you will try will not have the ripple shown in figure B and others will have three instead of two such ripples which means that in addition to the fundamental they will have both the second and third harmonic in evidence. Some of these "harmonic generators" are responsible for the curious notes we hear from some C. W. (?) stations. Perhaps you would like such a note. If so, here is your chance to go after it and KNOW you have it when you see it in the little ground glass screen. Perhaps you want to know why we have the 60 cycle curve under all these pictures. It is for the purpose of showing the result with reference to the 60 cycle supply line, if you had two of the vibrators, one connected to the supply line and one in the test circuit and both focused on the motor mirror and from there to the screen you would be able to see the "a.c." curve and one of the others at the same time. This may give you a new idea, for a two-element oscilloscope. Carry it out; you will have lots of fun, also grief.

Seeing Filter and Key Thumps

If by this time the wife don't start objecting because you must have the room dark for these tests we will see what there is to be seen regarding key clicks. I know we don't have to do it this way, but if we wish to SEE them go through their paces it is the only way without spending a lot of money. (By the way we don't hoard it because we haven't it.) With the key connected into the positive high voltage line to the transmitter we obtain the hump shown in figure D. We can bring this picture on the screen any time at all by just pressing the key. Sometimes it's even worse, depending on where the voltage antinode was when we gave the key a pat. Here is where you can start putting your pet anti-key-click circuits to a test. Some of them will be good, others will be not so good and it's a fine chance to try them all out. In figure E we have our own pet anti-key-click circuit. It seems to do the job quite well and doesn't bother out radio broadcast receiver in the same room. All this experimental work has taken some time and if it isn't too late you can shift the oscilloscope over on to the receiver output terminals and watch some of the

F



G

F shows the curve seen on the screen when the oscilloscope is fed from a receiver with a c.w. note tuned in and heterodyned.

G shows the result for a signal received from a transmitter with a poor filter.

curves that make their appearance when you set the receiver to howling.

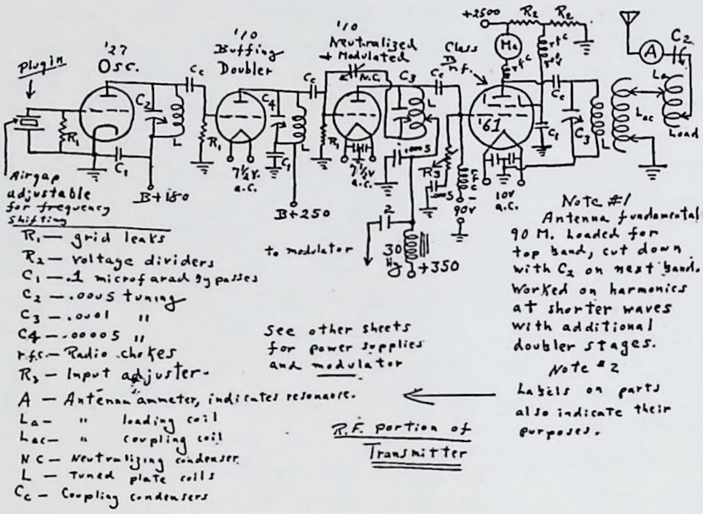
This should be enough from me on the subject of that oscilloscope so I will call this "fini" and see you through the pages of "Modern Radio" on the subject of losses in transmitting inductances in some other issue.

Passing the New Radiophone Examination

"Modern Radio" has no fear that the new radiophone restrictions will decrease amateur voice communication. The phone amateur will regard the new auxiliary radiophone examination as a challenge—for what's the good of a game unless there is an obstacle to overcome?

What It's About

The "top" waveband, next to the broadcasting stations, still contains some radiophone territory which may be used



Your diagram will not be beautiful, but should be reasonably free from errors, and carry ample notes. Don't try to put everything on one sheet; it can well be divided as suggested by the various pen-sketches herewith.

on an ordinary amateur license, though the territory is reduced to the range 1,875 to 2,000 kc. This provides more vacant space to prevent interference with broadcast reception.

The five meter band also continues to be generally available for radiophone in the range 56,000 to 60,000 kc. This fine short range band is—except for some pioneer work with the key—apparently a phone band by right of first occupation. Will our old 2,500 mile "freaks" recur with voice?

The twenty and eighty meter bands are ENTIRELY CLOSED to voice work unless a "special auxiliary" examination for an "unlimited" amateur radiophone operator's license has been passed. There are then available:

In the twenty meter band the range 14,150 to 14,250 kc.

In the eighty meter band the range 3,900 to 4,000 kc.

The Requirements

The candidate for the "unlimited" voice operator's license can avoid the examination if he holds a broadcast operator's license, but even so must obtain a pair of forms 756 to be filled out in application for an amateur operator's license with proper remarks thereon. Also amateurs previously licensed to work voice in the twenty meter band need only forward their operator's licenses for notation. There appear to be no other exceptions save that examinations by mail are provided for those at distant points. Others are supposed to treck to the supervisor's office, or to meet him otherwise, and there to do two things:

1. Show evidence of having operated an amateur station for a year. (Note: " . . . in the case of amateurs holding a temporary amateur operator's license, evidence must be submitted to show that the holder of the license has oper-

ated amateur stations for a period of at least one year.")

2. Pass the examination.

The Examination

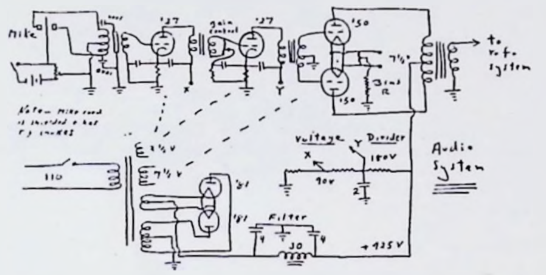
Nobody can provide a cut-and-dried set of correct answers to an examination. One can, though, run through a representative list of questions and give reasonable answers to them.

1. Schematic diagram of transmitter and receiver, including power sources, speech input, modulation system, antenna and ground, with name and purpose of each part indicated.

Well—that will not go on one sheet—and if we scribble all the information on the diagram it will look like a Zeppelin crash. Let's cut the thing up and use numbers as in a magazine diagram. The examples herewith will not fit your station, but will suggest the mode of procedure. See sketches.

2. (a) Explain briefly the operation of the r.f. portion of the transmitter.

Ans.—The output of the crystal oscillator is amplified through the other tubes, one after the other, but continues as a "c.w." (unmodulated)



When something is omitted it's better to add a note than to mess the sketch up with erasures.

signal. until it reaches the modulated amplifier. At this point it is modulated (moulded) by the audio input from the final audio tube which is called the modulator. Thereafter it continues through the system and to the antenna as a modulated (radiophone) signal.

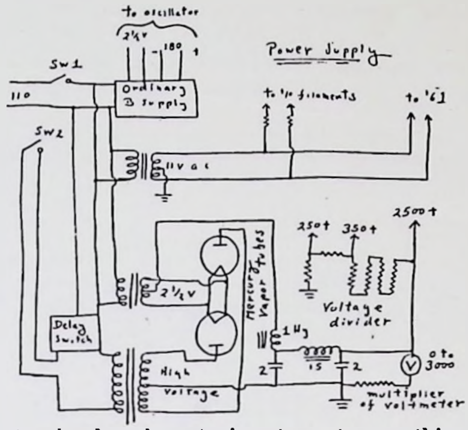
(b) Explain briefly the operation of the a.f. part of the transmitter.

Ans.—Voice waves strike the microphone diaphragm and its motion causes current changes through the microphone. These current-changes are fed through the primary of the "modulation transformer" whose secondary feeds the grid of the first audio tube. The rest of the system is simply a high-quality audio amplifier, the last tube of which is called the "modulator". Its output is fed to the plate circuit of the "modulated amplifier" of the radio system as explained in answer 2 (a). To give proper modulation the amplification of the audio system is adjusted by means of a "gain control", which is a potentiometer placed across the grid circuit of the first or the second tube.

3. (a) Draw a diagram of, and explain briefly the function of a piezo-electric crystal oscillator as an integral part of the above transmitter.

(Aha—the overlaps have begun. It isn't possible to answer (a) without repeating some things that were said before. Why repeat? Instead, we will write—)

Ans.—The diagram appears as part of the main transmitter diagram. The crystal oscillator is simply a tuned-plate-tuned-grid oscillator in which the crystal itself acts as the tuned grid circuit. It does this because it is able to vibrate electro-mechanically at a radio frequency. The reason for using the crystal instead of a coil and condenser in the grid circuit is that a properly cut quartz plate sticks very stubbornly to one rate of oscillation, thereby controlling the oscillation frequency of the tube closely. The output of this tube is fed to the next grid and so on, the crystal thus controlling the frequency of the whole transmitter, although this frequency can be changed slightly by temperature, plate-tuning, plate-voltage, filament-voltage and by moving the upper electrode of the crystal holder to or from the crystal.



Lots simpler than trying to put everything on one sheet.

(b) Name and describe the use of the auxiliary apparatus to be used to insure operation of the transmitter within a frequency band assigned for amateur radiotelephony.

(This is a sort of a catch question. It does NOT refer to crystal ovens but to auxiliary equipment, not a part of the transmitter. Therefore we answer—)

Ans.—The simplest device for finding the transmitter-frequency is a tuned circuit (coil and variable condenser) called a wave meter and equipped with a lamp (filament or neon type) which shows when current is flowing in the wavemeter circuit. The wavemeter is placed near the transmitter and adjusted until the lamp is brightest, showing that it is in tune with the transmitter. The frequency is then found by reading the wavemeter dial, or using a chart which is furnished with it. More accurate wavemeters have a milliammeter instead of a lamp. Some types have neither meter nor lamp, and depend on the "reaction method", which means that one finds resonance by looking for some meter in the transmitter (tuned circuit or grid meter) to "dip" at resonance. More accurate methods depend on the use of a small oscillator which is called a "monitor", "oscillating wavemeter" or "calibrated driver". There are many ways of using these things but in general the extra oscillator, and the station receiver are all adjusted to the same frequency so that one may hear the lowest possible note (sometimes called "zero beat") in a headset connected to the receiver. The frequency is then read as in other wavemeter work. It is also possible to use the station receiver to compare the transmitter frequency with that of some distant station whose frequency is accurately known. Some stations send "standard frequency" signals for this purpose.

4. (a) What causes frequency modulation in a radiotelephone transmitter?

Ans.—If the plate, screen, or grid voltage of an oscillator is changed its frequency will change, even though it is crystal-controlled. Therefore if the oscillator is voice-modulated in any way its frequency will jump about with the voice, causing a broad-tuning signal with reduced range. This is frequency modulation.

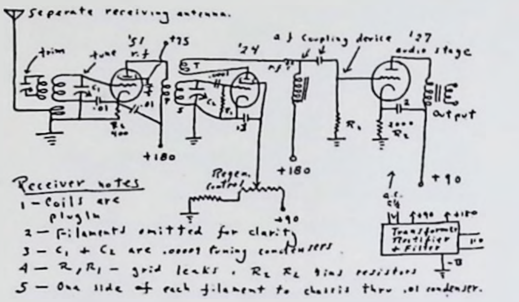
Changes in the load on the oscillator can also cause frequency modulation, therefore modern transmitters do not modulate either the oscillator or the first r.f. amplifier stage. See the transmitter diagram, also answer to part b of this question.

(b) How is frequency modulation prevented?

Ans.—The tubes between the modulated amplifier and the oscillator are arranged so that they not only amplify but also prevent feedback of modulation and other disturbances in the latter tubes from reaching the oscillator and disturbing its frequency-stability. A tube working in this way is a "buffer amplifier". It must be a screen-grid tube, a neutralized triode, or a frequency-doubling triode. The first two also require shielding to be thoroughly protected against feedbacks, exactly as would be necessary in a broadcast receiver. All three types require bypassing and filtering, or separate B and C supplies to prevent feedbacks from the audio system through the power supplies.

5. (a) Define amplitude modulation.

Ans.—This is the ordinary sort of modulation which varies the carrier amplitude (voltage and current) "in a voice frequency manner", but does not change the carrier frequency.



Since you've already drawn two rectifier-filter systems the supervisor will forgive you for not doing it again here.

(b) Define percentage of modulation.

(PLEASE do not give a memorized mathematical answer. Better try something like this—)

Ans.—In correct modulation the carrier is swung upward as much as downward, that is the "positive peaks" (upswings) are equal to the "negative peaks" (downswings). If the downswings are just great enough to carry the carrier to zero, and the upswings are (obviously) just high enough to carry it to double the non-modulated value, we say that we have "100% modulation". Smaller percentages are similarly computed—for example, if the upswing increases the carrier (voltage and current) by one-half we say that we have 50% modulation.

(c) Why is 100% modulation desirable?

Ans.—Because it places the largest possible amount of signal on a given carrier—in other words, it is the most efficient way to use the carrier.

(d) Why is over-modulation undesirable?

(Now as a matter of fact over-modulation is sometimes very useful—think how nice it would be to have all the hooraw advertising matter mangled by over-modulation!)

Ans.—Because it produces audio distortion and sometimes r.f. harmonics as well.

6. What is the purpose of a buffer amplifier?

Ans.—This has been answered under 4 (a) and 4 (b).

7. Describe briefly Class A, B and C amplifiers.

(Compromising between incompleteness and volubility we have—)

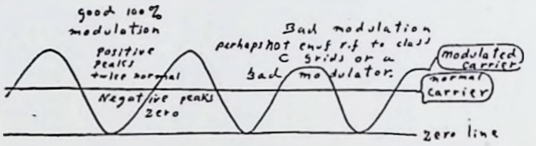
Ans.—A Class A amplifier works practically distortionlessly with plate output proportional to grid input, but at so low a power level that the plate current is steady and there is no grid current. The bias is such as to permit a steady plate current, of about the value found at the center of the straight part of the "characteristic curve"—meaning the grid-voltage, plate-current curve.

A Class B amplifier is a distortion amplifier whose plate output is also proportional to the grid input, but with an increased power level, causing varying plate current and considerable grid current. The bias is such that if the a.c. input is removed from the grid the plate current drops to about 5% normal. This is at the "lower bend" of the curve. The distortion must be removed by the use of a proper output transformer (in the r.f. case), or the use of both a proper transformer and a push-pull connections in the audio case. Since the grid input varies, bias should not be taken from a grid leak—nor should there be a grid leak.

A Class C amplifier is a distortion amplifier which is ordinarily operated with a steady r.f. input, and a modulated plate-voltage. The r.f. output is proportional to the plate-voltage. There is a considerable grid current and since the r.f. input is steady a grid leak is the simplest source of bias, though bias may be obtained otherwise. If a leak is used it should have the resistance recommended for an oscillator in the tube circulars. If a battery or other fixed bias is used it should have about twice the "cutoff voltage" (plate-voltage divided by the mu of the tube equals the cutoff voltage). Since the bias is beyond cutoff the point does not appear on the characteristic curve at all.

8. Name and describe the adjustment for the type of modulation used in your transmitter.

Ans.—(To be revised if using Class B audio or a modulated tetrode.) The tube-to-be-modulated is carefully neutralized without plate-voltage, using a flashlamp connected into a loop of wire and placed against the plate-tank of this tube as an indicator and retuning the tank as adjustment proceeds to make sure that resonance is maintained. The neutralization may then be checked by tuning the modulated-tube-tank while watching a meter in the preceding tank circuit which should not change. Now the plate-voltage should again be connected to the tube-to-be-modulated and the later stages (if any) brought into tune. The antenna should also be tuned in and everything adjusted for maximum output. After this the neutralization should be repeated. Now the stages AFTER the modulated tube (Class B r.f. stages) have their input reduced so that the antenna current is exactly one-half as much as before. All the tank circuits BEYOND the modulated amplifier tank should also drop 50%. (All this adjustment does not apply where there are no r.f. amplifiers after the modulated tube.) Now a steady smooth tone (the purer the better) is fed into the microphone and if everything is right it will be possible to cause 100% modulation before overloading takes place in either the radio or audio system. The overload indications for both systems have been mentioned before but a listening test is also needed. If a pure tone is used the modulated-tube tank and the tanks thereafter will show a current increase of 22% at 100% modulation.



Just thrown in for good measure, to make up for other oversights.

9. Give three or more major sources of audio frequency distortion in radiotelephone transmitters.

Ans.—Take your pick from the following:

Microphone—Badly designed, used with incorrect current or spoken into wrongly, room resonance or echo.

Transformers in Audio System—Badly designed, damaged by misuse, saturated by too much plate current, incorrectly chosen.

(Continued on page 15)

Short Circuits

According to our well-thumbed dictionary an amateur is one who does a thing for the love of it, but does not profit from it. This would seem to include radio manufacturers.

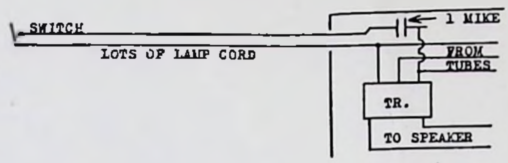
There must be something to it; one seldom sees a sick spinach.—"Hartford Times".

A competent expert is a man whose opinion on any general question relating to his subject is right about 50% of the time.

Who remembers the old time Baldies which had to be taken off the ears to let the wearer pass through a doorway?

Why do the newspapers want Henry Ford to fix up the depression? Has General Motors given it up?

David Moore of Hartford has devised a Pepsodent Eliminator and Crooner Killer; he says it is legal to kill crooners in one's own home. The diagram is easily followed; when the switch is closed the low notes become vague mumbles and



the higher ones disappear entirely—a sort of combined tone and volume control which is quick enough to operate before the room is all full of wails, sobs, toothbrushes and gargles. Just enough output remains to warm the listener when it's time to take off the muzzle.

Specialist: A doctor who sleeps all night.

(Continued from page 14)

Tubes—Wrong bias voltages, insufficient bypassing for audio, feedbacks either regenerative or degenerative, excessive grid swings causing overloading.

Output Condition—Bad impedence match between modulator and modulatee, inadequate audio power from modulator, modulatee not linear because of wrong bias, r.f. input, or load condition, or poor neutralization.

10. (a) Why is it important to prevent the radiation of radio frequency harmonic waves?

(Dear—dear—how nice it would be if the commercial c.w. people only knew this.)

Ans.—To prevent interference with other services.

(b) How may these radiations be supressed?

Ans.—By the use of sharply tuned circuits, or by methods of coupling which discriminate against higher frequencies, especially by capacity couplings, selective transmission lines and wavetraps. The last is wasteful of power.

(c) What is shock excitation?

(Private answer—a carry-over from the spark days.)

Ans.—When a tuned circuit (such as a receiving antenna or a receiver) is set into oscillation by non-resonant electrical impulses it will oscillate at its own natural frequency, and we say that it has been "shock excited".

(d) How may radiotelephone interference in broadcast receivers be eliminated?

(Private comeback—what year was the receiver made in?)

Ans.—By the use of wavetraps in the receiving antenna, tuned to the frequency of the sending station, also by keeping the transmitting station off the air between 8:00 a. m. and midnight. In some cases the interference arrives via the power lines and relief may be obtained by means of bypass condenser on the line at receiver, transmitter, or both.

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In addition to the parts shown below NATIONAL CO., INC., makes a full line of Transmitting Condensers, Parts and Transformers for Every Kind of Broadcast Receiving and Short Wave Circuit, Amplifiers, Power Supplies, the NATIONAL NC-5 Short Wave Converter—most powerful made, and the famous SW-45 Short Wave Receiver. Write for our catalog sheets No. MR-3-32.

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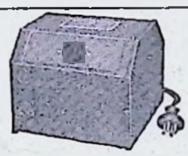

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