Radiotron CX-340—UX-240

By Robert S. Kruse, Technical Editor

THE tube known as the UX-240 and CX-340 (these double names are a confounded nuisance), differs from the more usual receiving tubes in being able to do several jobs better. It is a first rate tube for high-distortion audio amplification such as is required for amateur c.w. work and at the same time is excellent for resistance coupled audio amplifiers such as are used in broadcast receivers for mini-

THE NEW TUBE
(Photo Courtesy Radio Corporation)

mum distortion. In addition to this it has some interesting advantages as a detector, especially for amateur c.w. work.

The UX240CX340 (I shall call it the 240 hereafter and save time) differs from the 201-A type in having a higher plate impedance, while the filament remains the same; that is to say, a ¼-ampere, 5-volt thoriated tungsten wire of the so-called "X-L" type.

AS AN AMPLIFIER WITH TRANSFORMER COUPLING

When another amplifier tube is suggested we naturally think—"What excuse is there for still another kind? Aren't 7 kinds

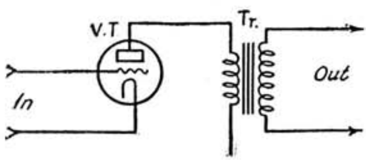


FIG. 1—THE USUAL TRANSFORMER-COUPLED AUDIO STAGE

It can be made into either a high-quality stage or a c. w. distortion stage by using the 201-A and the 240.

enough?" It happens that there *is* a reason for another sort and as was suggested above it can serve the double purpose of a maximum-distortion amplifier and a minimum-distortion amplifier.

When as in Fig. 1 a tube works into an audio transformer the results that are gotten depend roughly on:

The amplification constant of the tube. (Mu)

The plate impedance of the tube. (r_p)

The impedance of the transformer. (Z)

No one of these makes the thing good or bad. We used to think that as long as Mu was large everything was lovely. By that test the 240 would be a wonder, for it's Mu is (as shown by Fig. 2) very large as compared with that of the 201-A. Now suppose that in Figure 1 we start out with a good audio transformer such as the Amertran or

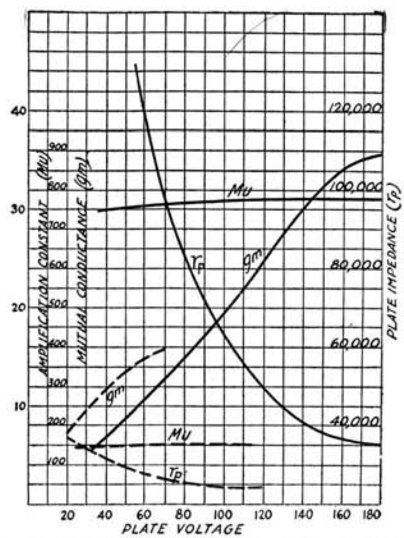


FIG. 2—SHOWING EFFECT OF CHANGING PLATE VOLTAGE ON THE 201-A AND 240 TYPE TUBES

The solid curves are for the 240 and the dashed ones for the 201-A. The higher curves for the 240 do not indicate that it is always best, since one of the curves (r_p) by its height introduces difficulties which prevent transformer coupling.

similar transformer and with a 201-A tube. We feed an amateur c.w. signal (1000-cycle beat note) into the combination and get a certain amplification. Then we try feeding some of WGY's excellent music thru the device and find that the same amplification stays with us on other notes; in other words that we have a "high grade" amplifier for broadcast reception but one that is entirely *too* good for c.w. work because all notes come thru. Suppose now we take out the 201-A and put in a 240. We will find that the 1000-cycle amateur c.w. signal will be materially louder but that the broadcast music will be rather terrible. Low notes will be weak and there will be a strong tendency to blare when we strike 1000 cycles or thereabouts.

It looks as if by a simple shift of tubes we have turned a good broadcast amplifier into a good c.w. amplifier, which is naturally

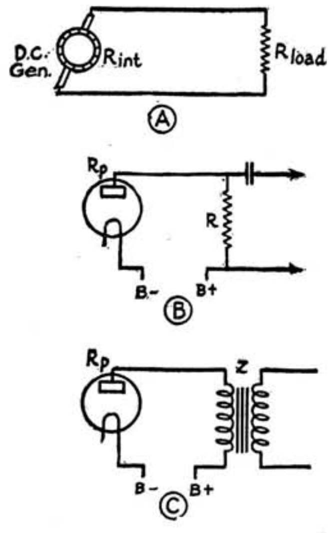


FIG. 3—THE OUTPUT RULE, SHOWING HOW THE RIGHT COUPLING DEVICE IS CHOSEN FOR AMPLIFIERS TO GET MOST AMPLIFICATION AND MOST, OR LEAST DISTORTION AS ONE MAY CHOOSE

terrible for musical purposes. This is the fact and the explanation can be seen from the curves in this paper.

Suppose that we first consider what goes on in the circuit of Fig. 1. Whatever audio voltage comes into the tube V.T. is amplified by the tube by the number of times represented by the "Mu" of the tube, that is 6 or 8 for the 201-A and 30 for the 240. This is voltage in the plate circuit and the next problem is to get it into the audio transformer. For the 201-A that isn't hard tho it has taken manufacturers a long-long time to get up the courage to make transformers large enough. The reason for the size is NOT that much power is to be handled. Quite the contrary, the power is nowhere near enough to warm up the smallest of audio transformers. The reason lies entirely in the good electrical rule which is sketched in Fig. 3. At A we have a direct-current electrical generator. If the armature has a certain resistance which we will call R int. (internal resistance) we will find that the generator is giving the most output when the load resistance (R load) has the same value. If the load resistance is higher the current drops off; if the load resistance is lower the current rises but the voltage drops off and the generator does less and less work outside tho it may heat inside.

Now if we carry the same rule over to vacuum tube amplifiers as in B we find that the tube gives the most output when the load resistance R is equal to the plate impedance r_p. In the same way we find that in the transformer-coupled amplifier at C the out-

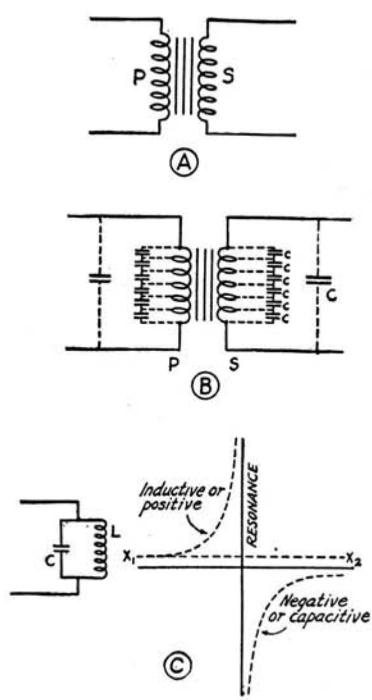


FIG. 4—THE AUDIO TRANSFORMER, SHOWING HOW IT MAY BE MADE TO DISTORT OR GIVE HIGH QUALITY DEPENDING ON THE TUBE USED

A—Usual picture of transformer.
B—Distributed capacity taken into account.
C—Effect of distributed capacity in creating a peak when using a high impedance tube ahead of the transformer.

put is greatest when the impedance Z of the transformer is equal to the plate impedance r_p. In the same way we find that in the transformer-coupled amplifier at C the output is greatest when the impedance Z of the transformer is equal to the plate impedance r_p of the tube.

One may think—"That all sounds well but what has it to do with amplifier distortion?"

Simple enough. Let us look at Figure 4 and we can explain it. We usually think of an audio tansformer as being like Fig. 4A. Now that is not all of the story. The transformer not only has windings but these windings have distributed capacity and the complete diagram is that of Fig. 4B. Now

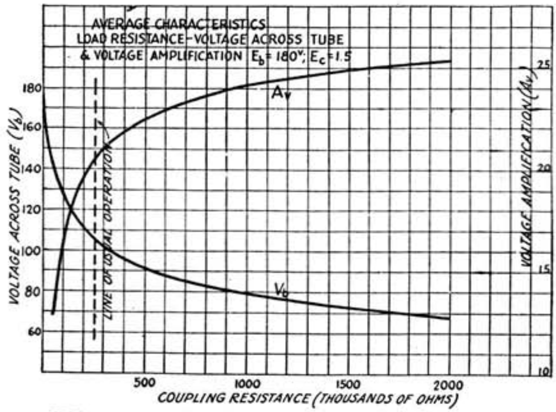


FIG. 5—EFFECT OF DIFFERENT COUPLING RESISTANCES

This shows the imperative need of a high coupling resistance. Unfortunately it does not show that a low coupling resistance and low voltage are even poorer than a low R and high voltage.

unless the resistance is extremely high a circuit with both inductance and capacity is tuned. This one is. In fact if we take the transformer off *by itself* and measure it "looking into" the primary terminals we will find that it acts like the parallel-tuned circuit of Fig. 4C. If one feeds it a low frequency the affair will show a very low impedance which rises rapidly at resonance, reverses at resonance (still high tho) and then drops again as we leave resonance. This simply means that at resonance the transformer could be used as a very high impedance load but that off resonance it would fall rapidly and have a much lower impedance.

For the sake of brevity we will not start to take the transformer apart but let it go at that and get ahead.

Suppose that we used the transformer first with the 201-A tube. This would almost swamp the resonance peak we have just talked about.

WHAT CAUSES THE PEAK TO COME AND GO

Suppose now that we take the Amertran just discussed and connect it to a 201-A. Our diagram now changes abruptly and becomes that of Fig. 4D. The Amertran has a nice high impedance and therefore the moderately low r_p of the 201-A acts like a resistance load across the primary. The effect of the capacities of 4B is swamped out, the peak goes down and the hollows come up and we arrive at a nice flat curve, just as we found in the test a bit ago.

Now we pull out the 201-A and substitute a 240. The r_p of the 201-A was 22,000 ohms at 40 volts. That of the 240 is 180,000 ohms at the same voltage. Practically speaking, we have taken the load off the primary. The effect of Fig. 4C gets full opportunity to go to work. This means that off the natural resonance of the transformer we get little amplification while on the peak the transformer acts like a high impedance (200,000 ohms perhaps), loads up the tube and takes power from it. We get good energy transfer at the peak voltage, poor transfer at other voltages and our "good" music amplifier has become a "good" c.w. amplifier. It is a beautifully simple way to shift from purpose to purpose.

AS A RESISTANCE-COUPLED AMPLIFIER

In a resistance-coupled amplifier the amplification per stage is usually very, very poor. Generally speaking 3 stages are not equal to two stages of transformer, tho the quality may be a bit better if we are concerned with music. The cause of this is simple also. With transformers the per-stage amplification is the Mu of the tube times the transformer ratio—for instance 7 times 2½ or 17, less a very little that accounts for the losses. In the resistance amplifier we have the opposite condition, the per-stage amplification is *less* than the Mu of the tube, in fact we can hardly hope to get over 19 from a tube with Mu of 30 while the 201-A tube cannot be expected to give much over 5. Since it isn't much of a trick to obtain first-rate transformer amplification *with high quality* from the 201-A at the rate of 15 per stage and no trick at all to get 12, this puts the 201-A out of the running as a resistance-coupled tube.

The curve of Fig. 5 shows that the 240 under the same conditions will give good per-stage amplification so that one now has the choice of a high-quality transformer amplifier with 201-A tubes, a distortion amplifier with 201-A tubes and peaked transformers, a distortion amplifier with 240 tubes and high-quality transformers, a high-quality amplifier with 240 tubes and resistance coupling, and finally a super-distortion arrangement with peaked transformers (old style) and the 240 tubes. The last provides entirely too much distortion to suit me, even for the reading of crystal-stabilized signals.

AS A DETECTOR

All of the things mentioned apply with additional strength to detection. Here the plate impedance is even higher than before because the gridleak and condenser add to the ordinary bias. (This is why some good transformer makers make a special type to follow the detector.) Therefore the resonance-peak effect of Fig. 4 gets an especially good chance.

My pet amateur receiver at this moment is a 240 detector followed by a "good" transformer and then by a 201-A as will be explained in a moment.

THE LAST AUDIO STAGE

Since the 240 cannot feed into an ordinary audio transformer without manufacturing peaks it certainly should not be expected to feed into a headset or loudspeaker, as these have even smaller impedance and horrible distortion is bound to follow. I find that even the 1-audio arrangement just referred to will give more of a peak than seems useful if both the detector and the amplifier are 240s. When more stages are used the peak becomes too strong.

In broadcast reception one naturally wants to keep the peaks down and the hollows up, therefore the correct combination is one or several 240s feeding into 250,000-ohm resistances and coupled to the next tube thru condensers with capacity between .05 and .005 microfarad. The last tube (which is to feed the loudspeaker) should be a normal 201-A, 112, 171 or a 210 with an output transformer. Anyone who prefers to do his broadcast reception with transformer coupling is welcome to keep right on with the usual 201-A tubes down to the output tube. There will be at least two of us.

MISCELLANEOUS

Because of the high plate impedance of the 240 the coupling resistance should have a value of 250,000 ohms and the B battery should supply from 135 to 180 volts of which about 110 will reach the tube. The amplification will be about 20 which compares well with high-grade 201-A stages, transformer coupled.

The coupling condenser of the resistance-coupler should have a value between .05 and .005 microfarads and be of the very highest grade. Paper condensers are probably not nearly good enough and any but the best mica condensers are likely to fall into the same class. The insulation resistance must lie above 100 megohms, otherwise the B voltage gets to the grid, likewise there is power loss in the condenser. When using a "B sub" one sometimes runs into the nuisance of a steady howl or rattle and gets rid of it by dropping the coupling capacity or using a low-resistance leak on the next tube. This is hardly good practice. With battery plate supply or a high-grade B sub

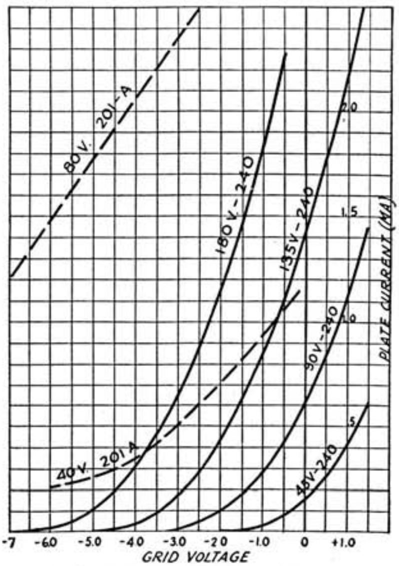


FIG. 6—THE USUAL "STATIC CHARACTERISTIC" CURVES

These curves are more a matter of custom than usefullness to the purchaser of tubes. In this case they are excused by the comparison between the 201-A and 240.

it is not necessary. This is one of the main defects of resistance-resistance and impedance-resistance coupling. It is largely avoided by going to resistance-impedance coupling which is NOT the same as impedance-resistance but the exact opposite.

For detection with leak and condenser the 240 is used normally, for "plate detection" these are dropped and a C bias of minus 3 to 4½ volts is used.

SPECIAL NOTE

When using the 240 for distortion amplification or detection it has a transformer primary in the plate circuit. These do NOT have a resistance of 250,000 ohms (¼ meg) but a rather low resistance and therefore the tube should be supplied from a 90-volt battery which is also correct for the 201-A tubes used in the following stage of audio.

One other matter. If a resistance-coupled amplifier "motor boats" with battery supply the trouble probably lies in a high-resistance cell in one of the battery blocks or in the use of a long lead to the batteries. The cure is to make sure of the batteries (even new ones are not all good) by making a momentary short-circuit test thru a 10-ampere meter and also to provide a 1-microfarad B bypass in the set.

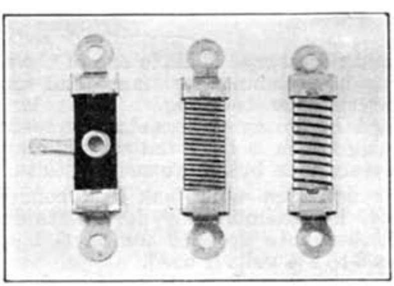
Note:—

A CX-340 tube was used to replace a 201-A in the c.w. receiver at 1MK, the A.R.R.L. Headquarter's station and has greatly relieved interference from power leak and street car noises. A UX-240 has done similar work at 1OA, the writer's station.—Tech. Ed.

Handy Resistor Units

THERE are many uses for small resistor units about the average amateur station and in many cases the man finds it necessary to buy a variable unit as he is unable to obtain a fixed one. This not only calls for a greater outlay of money but the variable unit usually finds its way to the panel where it needlessly crowds other instruments and also invites a certain amount of adjustment which is not necessary.

For the amateur who is just starting up with simple apparatus and is using a step-down toy or bell-ringing transformer that is not center tapped, there is a 200-ohm unit that is tapped at the center. This will replace the two Christmas tree lamps which are used so commonly for the obtaining of the electrical center tap. It has the advantage of being considerably smaller and may placed directly across the tube socket



terminals. Thus, it will not only save space but will also save time in its installation. They may be employed for the same use in conjunction with power amplifiers that supply the filament of the last tube (usually a UX-210) with a.c.

In crystal control circuits, it is quite commonly the practise to use a couple of 210s and a 203-A or two. Instead of using separate filament lighting transformers, it is quite possible to use only one and insert resistors between the filament of the fifties and the 210s. If two of the smaller tubes are used, it will be necessary to use a resistance of one ohm to give the required voltage drop of 2.5 with a current of 2.5 amperes. In order to keep the center tap properly balanced, two half-ohm units should be used, one in each leg of the smaller tubes' filament. If only one 210 is used, the resistor should have twice this value.

The three units shown in the illustration are the center tapped, 200-ohm one and the half and one-ohm sizes. The high resistance one is wound with enameled wire and may be obtained either with the tap or without it. The other two are wound with strip and there is no reason why you couldn't make contact to it at any place to obtain lower values of resistance.

The units may be had in various sizes ranging from 1000 to ¼ ohms. The manufacturer is the Carter Radio Company of Chicago, Ill.

—H. P. W.

6OI Wins Modesto Wouff-Hong

BECAUSE of a breakdown in the official reporting arrangements for the Pacific Division Convention recently held at San Jose, we had to cook up our own story here in the office from memory and we regret to say we omitted one very important event: the award of the Modesto Radio Club's beautiful Wouff-Hong Trophy to 6OI of Stanford University, California, as the best all-around amateur station in the Pacific Division.

Those not familiar with this trophy are invited to see page 27 of *QST* for January, 1925. It is made from the melted-down plates and grids of some five hundred burnt-out transmitting tubes contributed by amateurs all over the country, a most fitting emblem for the transmitting ham. Each year it is awarded at the Pacific Division Convention to the best "6", to hold until the next convention. The rules give a maximum weight of 35% to DX in miles per watt, 25% to traffic handled, 20% to operating ability, and 20% to the proportion of the apparatus which is home-made. A year ago at Santa Ana the first award was made to Smith of 6BUR and now it goes to 6OI, with 6BJX as runner-up.

6OI is owned and operated jointly by Brandon Wentworth and Phil Scofield. The award will be a popular one, for everyone admits the excellence of this station and its work. 6OI has communicated with almost every civilized country on earth and many uncivilized ones, and was able to present to the judges a complete log that was a model of perfection and a huge stack of cards attesting the work done. Congrats, 6OI!

K. B. W.