DANGER! High Voltage

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When is there high voltage across that tank condenser? And when may it be touched without danger? It will pay to read!

BY eliminating the d.c. plate voltage across the tuning condensers in amplifier plate circuits, the voltage rating of the condenser can usually be reduced greatly. This reduction in the voltage rating may reduce the cost of the tuning condensers as much as 50% in some circuits.

While few hams seem to know what circuits to use to remove the d.c. voltage from across the tuning condenser, the circuits are extremely simple and used in many transmitters, although seldom for this very reason. And just to the opposite, many hams use plate blocking condensers to "remove" the d.c. from the tuning condensers, while in reality, they are actually putting d.c. across the tuning condenser by using the "d.c. blocking" condenser.

Generally speaking we can say that if the tuning condenser is connected directly across the tuning coil, no d.c. voltage can appear across the condenser because the coil is a d.c. short circuit across the condenser. (If the rotor of a split stator condenser is grounded, this may not be true.) If the condenser is not connected directly across the coil, usually a d.c. voltage will appear at, and hence across it.

In Fig. 1 is the simplest type of circuit employed in amateur transmitters. The plate voltage is applied at the cold end of the coil and is series fed to the plate. The tuning condenser is connected across the tank coil. The accompanying d.c. equivalent circuit shows that no d.c. voltage can appear across the condenser because both ends of the coil are at the same d.c. potential, V_p. As a result the only voltage across the condenser is the r.f. voltage V_{rf} appearing across the tank circuit. Naturally, the condenser has d.c. on it and it must be insulated from the chassis to prevent grounding the plate voltage. Also for safety's sake, the shaft extension to the dial should be insulated to avoid possible shocks from dial set-screws, etc.

In Fig. 2 the rotor of the condenser is grounded and a by-pass condenser from the cold end of the coil to ground is employed. This type of circuit removes the d.c. from the rotor side of the condenser, but in doing so, applies the full d.c. plate voltage to the tuning condenser. While this circuit is employed very much in radio receivers, it is not suitable for high-power transmitter stages because the voltage rating of the condenser must be increased to allow for the plate voltage. The d.c. equivalent circuit in Fig. 2 shows that the plate voltage is connected across the condenser. Therefore, the condenser must be rated to withstand the r.f. voltage across the tank coil plus the d.c. plate voltage. Since in most circuits the r.f. voltage is equal to or slightly less than the d.c. plate voltage, it follows that the voltage rating of the condenser must actually be doubled.

In some hook-ups, the use of a circuit having a d.c. blocking condenser may actually keep the d.c. off the tuning condenser. Fig. 3 is an example of this fact, yet by way of contrast in Figs. 9 and 11, the blocking condenser itself does not keep the d.c. off the tuning condenser.

The d.c. is kept off the tuning condenser in Fig. 3 because the coil can be connected across the tuning condenser, not because of a d.c. blocking condenser.

How the indiscriminate use of a blocking condenser may sometimes lead just to the opposite of what is desired is shown in Fig. 3-A. Instead of connecting the coil directly to ground, the unthinking ham may decide to use a blocking condenser in series with the coil, while still grounding the condenser in order to decrease the voltage across the latter. The d.c. equivalent of the circuit shows that by removing the grounded end of the coil and substituting a condenser, the high end of the coil immediately assumes approximately the same d.c. voltage as the plate of the tube.

In order to explain this phenomenon, we must go back to the elementary electricity dealing with voltages and charges on condensers. When two condensers are in series and connected across a battery, the same number of electrons must flow into each condenser until each one is fully charged. Only identical quantities of electrons can flow through the circuit because it is a series circuit.

Elementary electrical principles state that the product of the voltage (V) times the capacity (C) equals the charge (Q), or in terms of a formula: Q equals $C \times V$. Turning the formula around we have: V equals $\frac{Q}{C}$. According to this, the voltage is inversely pro-

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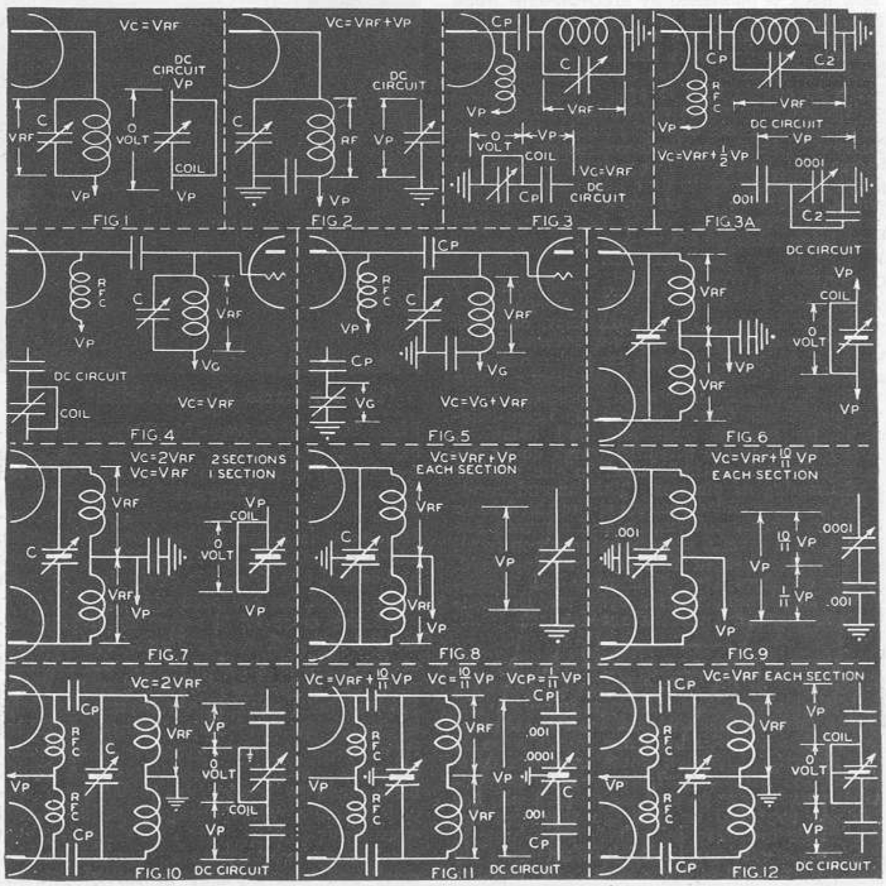

readings are the same, or nearly the same, at all audio frequencies. The circuit shown should make this possible—but it would be best to make a check run before assuming it to be so.

Suggestions

As mentioned before, it is the writers thought that it will be best for any builder to make a trial assembly of the unit before building it up in a can. In doing so there are any number of possible modifications, and no doubt some real improvements, that can be made. There is almost nothing in the circuit which can not be altered in one way or another. The tubes used were simply those available—and almost any others, the six-volt series, the metal tubes, or the glass equivalents, can be used. Multiple purpose tubes might be utilized—for instance, a 2B7 in place of the first 56 and 57 (this would require a smaller meter for M and possibly other changes). The input circuit is certainly subject to some experimentation. That given in Fig. 1 uses an antenna and ground connection. If insufficient pickup is obtained in this way the circuit of Fig. 4(a) can be used—although it has the disadvantage that the use of a tuned circuit will probably require plug-in coils (although a tap arrangement might do). The circuit of Fig. 4(b) can be used if desired, but requires more power. (In each of these the resistor, of course, functions as an input control in the same manner as did C_1 of Fig. 3.).

It is even possible—and might be worth considering—to place the first rectifier right in the transmitter, thereby obviating need of the r.f. leads. The output circuit may also be modified to suit convenience—or more likely to suit whatever meter is available. This may require a change in the output tube complement. The 56 will give a very uniform characteristic for a 5 mil meter, and a satisfactory one with a 10 mil meter. However, putting a pair of 56's in parallel will give a straighter characteristic when the 10 mil meter is used.

Then there is the design and adjustment of the timing circuit. As previously noted the upward swing of the needle is determined chiefly by the constants of the meter, while the downward swing is determined by the constants of the parallel circuit. There is wide divergence of opinion as to the best characteristic. Obviously it should not be too slow—but at the same time it should be slow enough for easy reading. The best answer to this is to try different combinations of capacity and resistance until you find one to suit yourself. The values indicated in the circuit are meant as illustrative rather than as necessarily the best choices for a permanent setup. Inspection of manufacturer's literature shows values that vary from .005 mfd. to .25 mfd., and from .025 megohms to 50 megohms—which allows plenty of room for experiment. If desired the switch S can be made a part of the permanent setup. -30-

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portional to the capacitance of the condensers when they are in series. This relationship is true for a.c. and d.c.

If in Fig. 3-A we assume that the plate blocking condenser is .001 mfd.; the tuning condenser .0001 mfd.; and C_2 equal to .001 mfd.; we have the following voltage relationships insofar as d.c. is concerned. (Note that the values are typical for high-frequency circuits.) The voltage across C_P will be approximately ½ V_P, and the voltage across the C and C_2 parallel combination will be approximately ½ V_P. If C_2 were omitted (coil not grounded), the voltage across C would be 10/11 V_P. While circuit 3-A may seem a bit odd for transmitter circuits, it is used in push-pull circuits minus condenser C_2 as shown in Fig. 11.

When the tank circuit is transferred to the grid circuit of the following tube as illustrated in Fig. 4, the relationship is the same as for in the plate circuit. Compare circuits of Figs. 1, 3, and 4. In all cases the only voltage across the tuning condenser is the r.f. voltage because the coil is connected directly across the condenser and thus forms as d.c. short.

If the circuit of Fig. 2 is transferred to the grid as shown in Fig. 5, the d.c. voltage again appears across the tuning condenser. However, in this case it is the d.c. grid voltage or bias of the following tube. Ordinarily this grid voltage is quite low, although in certain circuits using high grid driving power it may be nearly equal to the plate voltage of the driver tube. If a condenser is used in this circuit it must be rated to withstand the maximum d.c. grid bias (under load conditions) plus the r.f. voltage.

The double-ended or push-pull amplifiers are similar to the single-ended, except that the r.f. voltage from plate to plate is twice that found in the other type. In Fig. 6 we have a push-pull amplifier using a single-section condenser. From a d.c. viewpoint, there is no voltage across this condenser. When the amplifier is operating, the total r.f. voltage across both halves of the plate coil is across this condenser, and it must be designed to withstand this voltage.

The use of a double section condenser has no effect upon the voltage across the both sections as shown in Fig. 7. However, each section of the condenser has but one-half of the total r.f. voltage across the coil. In this respect, each section of the condenser need have only half the voltage rating needed in Fig. 6.

Fig. 8 shows the push-pull circuit most commonly used in ham transmitters when a split condenser is available. In this circuit the full d.c. plate voltage is applied to the tuning condenser. As a result each side or section of the condenser must be able to carry the d.c. plate voltage plus the r.f. voltage. (*Turn the page, please*)

The use of a d.c. blocking condenser in the ground circuit as shown in Fig. 9 does not change the condition of Fig. 8. Contrary to what most hams believe, the blocking condenser does not appreciably change the d.c. voltage across the tuning condenser. If a .001 blocking is used and the tuning condenser has a capacity of .0001 for each side the voltage across the tuning condenser is 10/11 of the plate voltage. There has been a reduction of but 1/11 or 9%. For all practical purposes, we can state that the condenser must be designed to withstand the d.c. plate voltage plus the r.f. voltage.

When parallel plate feed is employed as shown in Fig. 10, the d.c. voltage is effectively removed from the tuning condenser. As shown in the equivalent d.c. circuit, the plate blocking condensers are subjected to the d.c. plate voltage. Since the coil is grounded at the midpoint, no d.c. voltage can exist across it and the tuning condenser. Consequently the tuning condenser need withstand only the r.f. voltage.

By grounding the rotor of the condenser only, the d.c. voltage is placed on the tuning condenser as shown in Fig. 11. The d.c. circuit shows that for .001 mfd. blocking condenser and .0001 mfd. tuning condensers, 10/11 or 91% of the d.c. plate voltage is placed across each section of the tuning condenser. When this arrangement is employed, plan on a condenser that will handle the d.c. as well as the r.f. voltage.

Combining Figs. 10 and 11, we get a circuit as shown in Fig. 12. This circuit is the same as Fig. 10 except that a double section condenser is used with a grounded rotor. Since the coil is also grounded, no d.c. voltage appears across the tuning condenser, so it must have only sufficient voltage rating to withstand the r.f. voltage across the tank circuit.

When designing transmitter tank circuits it is well to take the beforementioned factors into account, for by eliminating the d.c. voltage from the tuning condenser, condensers with smaller plate spacing may be used with equal effectiveness. However, it is not the purpose of this article to recommend the use of a circuit only because the condenser may have a lower voltage rating. There are many other factors in the design of transmitter tank circuits, and sometimes to obtain other benefits it may be impossible to keep the d.c. voltage off the tuning condenser. If these benefits are of sufficient value to offset the increased expense of the condenser required, then it is advisable to forget about keeping the d.c. voltage off the tuning condenser.

In many transmitters built by the writer and many of those described in radio publications, it is possible to save considerable money by keeping the d.c. voltage off the tuning condensers—and this can be done without sacrificing transmitter performance.

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Model KW Rig

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to the various units. The one big bug in amateur class B phone transmitters, that operate on high power from the house mains, is the blinking of the lights caused by the rise and fall of the plate current to the modulators. The type 250th tubes make excellent audio modulators in either class AB or B, and the former was selected to reduce the range of plate current swing normally encountered in the latter application. The total plate current *variation* is reduced to less than 100 ma. and there is no blinking of lights. Of course there are other factors that enter into the design of good regulation and these will be covered in later paragraphs.

The modulators are shown in the lower window where observation may be made in the same manner as was described for the final. The two modulators operate at an orange color and circuit balance may be observed as before stated. It is imperative to use separate power supplies to the final and to the modulators if maximum performance is to be realized. The plate current to the modulated amplifier does not vary more than 1 ma. in this transmitter when operating on phone at maximum input and this is made possible by using choke-input filters to all stages and by the use of class AB modulators.

There are several ways that we can attack the problem of wiring; point to point, cabled, and haywire. The latter does not insure efficiency and should be disregarded. Point-to-point wiring is best adapted to r.f. circuits, and cables are well suited in carrying the power leads and those that terminate at the meter panels. The writer uses automotive ignition cable for these latter connections and they are designed to withstand a 10,000 volt breakdown. Filament cables are made to the larger tubes with number 10