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Regulating Properties of Wet Electrolytic Condensers

By the Engineering Department, Aerovox Corporation

THE leakage current of electrolytic condensers has been put to work. It has been a common experience in the evolution of radio that a new development was found to have some undesired feature which eventually was turned into a useful asset. Examples of this are easy to enumerate; regeneration is one of them. Even motorboating has been put to good use in the multi-vibrator. Similarly, the leakage current of an electrolytic condenser was thought to be undesirable by many. It has been shown several times in these pages that it is not the leakage which causes any harm and that the increased power factor is not due to the leakage. The power factor is due to an apparent series resistance which seems to be in the film, formed on the anode. Let us now confine our attention to leakage.

A new type of wet electrolytic condenser has been made available. This type of condenser has such leakage properties that it can be used to prevent undesired rises in voltage when a radio receiver is first turned on. Yet, it operates as a normal condenser with a power factor of 10 per cent. and a very low leakage during the normal operation of the receiver.

THE NORMAL "WET" ELECTROLYTIC CONDENSER

Few users are familiar with the leakage characteristics of the ordinary variety of wet electrolytic condensers.

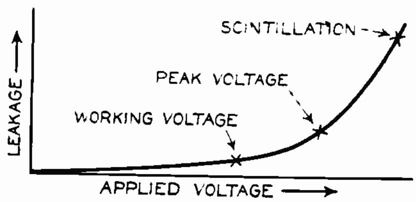

Fig. 1

Under normal operation at its rated voltage the leakage is very low but what happens when the voltage is increased? The curve of Figure 1 shows the relation between leakage and applied voltage. When the voltage is increased beyond the normal peak voltage, the current rises, first slowly then faster until a point is reached where the condenser "scintillates". Scintillation consists in the repeated breakdown of the insulating film, which is formed on the positive foil. After the breakdown the film is formed again, it breaks down again, forms again, etc.

This scintillation does not ruin the condenser; when the voltage is lowered again and the normal operating voltage re-applied the condenser will work the same as before. These self-healing properties are confined to the wet electrolytic condenser. The dry type exhibits no phenomenon of scintillation and it is ruined if the film ever breaks down.

Referring to Figure 1 again, note that the characteristic of the wet electrolytic condenser is not a straight line and that the device does not follow Ohm's Law. It is a non-linear impedance, similar to a vacuum tube or a rectifier. Indeed, the wet type could be used as a rectifier. Still referring to Figure 1, note that the increase of leakage current with the increase in applied voltage is rather slow. When the voltage rises fifty volts or more above its normal value the leakage will not increase enough to check this rise. In order to do this, the leakage would have to rise rather suddenly at some critical value of voltage.

The shape of the leakage characteristic can be changed by varying the composition of the solution inside the

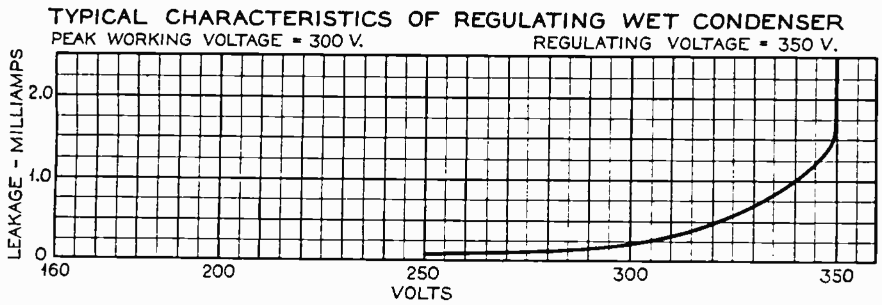

Fig. 2

wet condenser. After considerable research a condenser with the desired characteristic has been developed.

REGULATING TYPE WET ELECTROLYTIC CONDENSERS

Figure 2 shows the relation between the applied voltage and the leakage current for the new regulating type wet electrolytic condenser. Note the steep rise of the curve at a point 50 volts above the normal rating. This condenser does not exhibit any scintillation. At the operating voltage of 300 volts, the leakage is very low and the power factor is 10 per cent. This corresponds to a series resistance of 7 ohms at 120 cycles. When the voltage is increased above 300 volts, the leakage first rises slowly but at 350 volts there is a steep rise. In fact, the increase in current is so fast when the voltage keeps increasing, that it is practically impossible to impress any potentials higher than 350 volts across the condenser.

When one tries to impress higher voltages the result will be that the current rises until the voltage drop in the circuit is large enough to reduce the potential across the condenser to 350 volts.

The curve shows the characteristic of a 300 volt condenser. There are condensers of different voltage ratings but they all have their sudden rise in leakage current at 50 volts above the rated voltage.

When using the regulating type of condenser it should be remembered that the unit was not designed to carry this increased leakage current for a considerable time. They are intended to be operated at their rated voltage except during short periods such as the heating up of the tubes in a radio receiver or amplifier.

APPLICATIONS

When a radio set is turned on, the rectifier heats considerable faster than the rest of the tubes. During this period the tubes are not drawing any current and there may not be any drain on the power supply except that of the filaments and the voltage divider. Many of the newer sets, if they have a voltage divider at all have one of the low drain type because it has been found that the receiver can be made to operate even when the voltages vary widely. The omission of the voltage divider is purely a matter of economy.

What happens during these few seconds when the B-supply has no drain? The result is that the large condensers in the power pack will be charged to the peak voltage of the transformer secondary and since there is no current, there is no voltage drop in the filter and the speaker fields so the same peak voltage is applied to all of the smaller tubular condensers and all the other equipment in the receiver.

Usually the large electrolytic condensers in the power pack withstand this voltage surge well enough. It is the tubular condenser that suffers the most. When the rating of the transformer secondary is 350 volts, the peak voltage would be 490 volts, approximately. Under normal operating conditions there is enough drop in the filter to reduce the B-supply to approximately 300 volts by the time it reaches the tubes and the smaller by-pass condensers. A tubular condenser of 400 volts rating seems ample for the purpose. But, as was shown above, the voltage actually rises to 490 during the heating up period and it depends on the quality of the condenser whether it will withstand this overload.

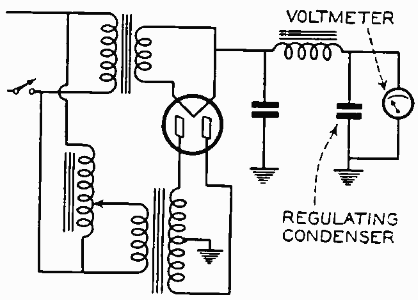

Fig. 3

This danger can be completely eliminated by the use of the regulating type electrolytic condenser. In whichever circuit it is placed, the voltage cannot rise above the regulation voltage.

A special demonstration set-up was made in order to show the amount of regulation obtainable. The essential circuit is shown in Figure 3. A power pack was built up with a variable high voltage supply to the rectifier while the rectifier filament voltage was kept constant. The secondary of the high voltage transformer could supply as much as 1,400 volts. Its primary was connected to the line through a variable autotransformer so that any voltage up to 1,400 could be applied to the plates of the rectifier. When the voltage across the primary of the high-voltage transformer was 30 volts, the voltmeter across the output of the filter showed 350 volts. The applied voltage was then increased fourfold, making the primary voltage 120 and the secondary somewhere near 1,400. Under this condition the voltmeter across the output of the filter showed 353 volts. This is certainly a remarkable experiment, since no practical circuit would subject a condenser to such extreme overloads.

It is very important that the regulating condenser be connected across the output of the filter and not immediately after the rectifier. If the regulating condenser were placed at the input of the filter it would result in an enormous peak current which has to pass through the rectifier. Very probably the rectifier will be ruined in that way. The regulating type of condenser can be placed after the first choke or after the second one, if there are that many.

Another important point to watch is the correct rating of the condenser. Under no circumstances should the voltage be allowed to rise so that the condenser is operated in the regulating range when the apparatus is in normal operation. Care should be taken that the regulating feature is utilized only during the heating up period, since a prolonged heavy current through the condenser will result in too large a temperature rise.

USE IN MULTI-SECTION FILTERS

Some readers may wonder which is the preferred location for the regulating type condenser in a multi-section filter. Shall it be the second condenser or the third one and why? Figure 4 shows a circuit of a power pack employing a two section filter and the values of currents and voltages under normal operations are indicated. Being a typical six tube superheterodyne with a single output tube, the total current is approximately 80 milliamperes. The voltage at the output of the filter is 270 volts. Across C2 the potential is 415 volts and there is 440 volts across C1. The rating of the transformer is 350 volts each side of centertap. These values were measured from an actual receiver.

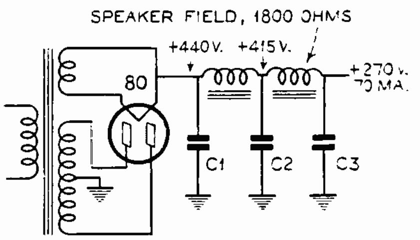

Fig. 4

This set did not have a voltage divider and the condensers were dry electrolytics. When the set is turned on, the voltmeter reads 500 volts for about 10 seconds regardless whether it is placed across the condensers C1, C2, or C3 or across any of the tubular bypass condensers even those which bypass the screens! When C3 is replaced by a regulating type condenser it can be one which is rated at 300 volts because the voltage will not normally rise, or even approach 350 volts where the regulating action starts.

If such a condenser is used there, the voltage across C3 will be 350 during the heating up period (instead of 500) and this is well within the rating of the other condensers. It is true that the potential across C1 and C2 will be somewhat higher than normal but these are generally designed to stand this sort of thing.

If the regulating condenser is placed at C2 it will have to be one which can normally operate at 415 volts without entering the regulating range. Its regulation should certainly not start lower than 450 volts. The result would be that during the heating up period the voltage will be 450 everywhere instead of 350 with the regulating condenser at C3. It is very obvious that the output of the filter is the preferred location.

The above is true even if the filter does not have such large differences in voltages across its condensers. Assume for a moment that the same receiver used a dynamic speaker which had an independent field supply. The field could then be replaced by a choke of rather low resistance and to get the same output voltage, the transformer secondary rating need be only 300 volts.

Employing a regulating condenser with a 300 volt rating and placing it at C3 would result in limiting the voltage to 350 at the output of the filter. Also, when placing it at the location C2, the output voltage will be 350 volts. In the first case, the voltage drop before the regulating condenser is divided across two chokes, while in the second case, the same voltage drop will be across the first choke only. It is easy to see that in the second case the regulating condenser has to draw a much heavier leakage current in order to get the same voltage drop across the one choke. This results in more wear and tear on the condenser as well as on the choke. So, also in this case the output of the filter is the preferred place of the regulating type wet electrolytic condenser.

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3GL5	8-8-8	450	1⅜x4¼	2.40
3GL250	8-8-8	250	1⅜x3¼	2.10
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