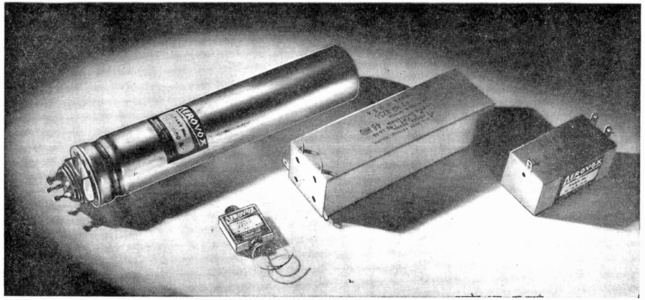

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ERRATA: List prices of the three dual section Type PM condensers listed on page 4 of the July Research Worker applied to Type PM5-525 volt surge peak condensers instead of PM6-600 volt units.

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Important Features In Design of High Voltage Transmitting Filter Condensers

By the Engineering Department, Aerovox Corporation

IN the April 1934 issue of the Research Worker we covered briefly certain phases regarding the use of condensers in high voltage filter circuits. The point of major importance discussed in that issue was the effect which takes place when several condensers are connected in series across a source of d.c. voltage. As we explained when several condensers are connected in series across a d.c. source the voltage distribution may be very non-uniform resulting in one condenser having very little voltage across it and others being seriously overloaded.

The best arrangement is to use a single condenser designed to operate at the voltages required. Such a condenser, if properly built, will have adequate insulation between the plates and will be impregnated and sealed in a manner which will insure long life.

There is little question that the most superior type of condenser for high voltage use is the oil-impregnated oil-filled unit. Such condensers are able to withstand considerably greater stresses than other types, and they show up especially well under conditions of operation which involve the generation of any considerable amount of heat.

We feel it would be worth while here to discuss the oil-impregnated oil-filled condenser with particular reference to its advantages over other types of condensers. In almost all cases users will find it desirable to use the oil-impregnated oil-filled type condensers for high voltage circuits because of their ability to dissipate heat, and to adapt themselves automatically to varying temperatures.

Oil-Impregnated oil-filled condensers in round aluminum cans designed for high voltage transmitting use.

Before discussing specifically the properties of the oil-filled oil-impregnated condensers which makes them especially suited for high voltages it will be necessary to indicate the three types of condensers which might possibly be used on high voltage.

Then later, when we compare the various types, the advantages of the oil-impregnated oil-filled unit may be clearly understood.

A type of condenser which has been used to some extent for high voltage work is the wax-impregnated wax-filled type. Such condensers are still being used to a considerable extent, although this type is least suited for high voltage work. In the first place they are frequently made with kraft condenser paper, and this type of paper has been found, as a result of many life tests, to deteriorate at high temperatures much more rapidly than pure linen papers. At the high temperatures employed for impregnation, the wax is very fluid, but at temperatures within the operating range of the condenser the wax is hard. After impregnation such condensers are usually put through a cooling cycle and then they are placed in a container, the container is sealed with pitch and the cover soldered in place.

Now let us see what happens when this type of condenser is used in a high voltage filter circuit. In such a circuit a relatively large amount of alternating current may be present across the first condenser, and this current will cause the condenser to be-

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come heated. This heat combined with the heat absorbed by the condenser from the surrounding tubes, chokes, etc., may produce a very appreciable rise in the temperature of the condenser and cause the condenser section to expand. As a result of the expansion, small voids may appear within the condenser section. When the condenser cools down it is seldom that contraction will take place in such a manner as to eliminate these voids. As a result the continual expansion and contraction which takes place as the system is turned on and off has the effect of increasing the number of minute voids which may be present in the condenser section. The final result is that the section breaks down.

Another factor of importance is that wax-impregnated wax-filled condensers are not hermetically sealed, and hence they will in time absorb moisture. Moisture will be absorbed no matter how well the unit may be sealed with pitch and even though the unit may be housed in a tin can, since it is seldom the cans are hermetically sealed. Life tests on wax-impregnated condensers sealed in metal containers with pitch have indicated that moisture absorption is an extremely important factor, and that in fact condensers rated for operation at 200 volts will break down at very low voltages in the order of 50 volts if they are allowed to absorb moisture. Tests of this type have been conducted on various makes of condensers not only in the laboratory of the Aerovox Corp. but also in the laboratories of many large companies and have indicated that moisture absorbtion is a common cause of condenser failure.

There is little question, therefore, that wax-impregnated type condensers are not the best type to use for high voltage work. While it would be possible to seal such condensers hermetically to eliminate the effect of moisture there would still be present the serious disadvantage, as pointed out previously, of the effects which take place as this type of section is heated and then cooled during the normal cycle of its operation.

A second type of condenser which overcomes some of the disadvantages of the wax-impregnated type, but which is still not the best type for use on high voltages is the so called oil-impregnated wax-filled unit. In this type of condenser oils are used to impregnate the section instead of wax. After the section has been thoroughly impregnated in oil it is given a coating of wax after which it is placed in a container and then filled with pitch in essentially the same manner used in the manufacture of wax-impregnated wax-filled condensers. Since the oil in the section is mobile it is able to adapt itself more readily to the changes brought

Oil-impregnated oil-filled transmitting condenser in a seamed metal can.

about by the expansion of the condenser when it becomes heated. However, this type of condenser has the disadvantage of "bleeding" quite readily; that is, there is a tendency for the oil to seep out of the section as a result of the expanding-contracting cycle.

Furhermore, such condensers, as in the case of wax-impregnated wax-filled condensers, are usually not sealed hermetically and hence can absorb moisture just as readily the wax condenser. Fundamentally the only distinct advantage this type of condenser has over the wax type is that with oil impregnation the section is somewhat more able to withstand high voltage stresses, and as a result usually proves to be superior in performance over the wax type condenser. This assumes, of course, that in both cases the condensers are properly assembled and impregnated.

The foregoing will, we hope, serve to indicate the limitations of two types of condensers and perhaps enable the reader to appreciate more fully the advantages of the oil-impregnated oil-filled types of condensers about to be discussed. The oil-impregnated oil-filled units are undoubtedly the best type of condensers for high voltage work. But why this is so can best be appreciated by a comparison of its characteristics with the characteristics of other available types of condensers.

The advantages of the oil-impregnated oil-filled type condenser can best be brought out by first briefly describing the Aerovox type oil condenser for use on high voltages. By means of a brief summary of the manner in which this condenser is made and constructed the reasons for its superiority will be more readily apparent.

First, all these condensers are made using a pure linen paper spacer rather than kraft paper. Obviously linen paper as well as kraft can be used for wax-impregnated wax-filled condensers, although, as a matter of fact, such condensers are invariably made with kraft paper in order to keep down the cost. The use of linen paper exclusively in the manufacture of high voltage oil type condensers is a matter of considerable importance since the deterioration of linen paper at high temperatures is much less than the deterioration of kraft paper as previously mentioned. Hence, in types of condensers designed for services which may generate fairly large amounts of heat, the use of linen paper is much more preferable.

After the section has been wound, it is impregnated in oil under controlled conditions of

temperatures and vacuum. The sections are then placed in containers, the terminal connections made, and the containers filled with oil. After this, the container is then hermetically sealed.

In all types of oil impregnated oil filled condensers the design must be such as to prevent any movement or "fluttering" of the plates during operation. In the case of condensers in rectangular cans, described in some detail in the following paragraphs, clamps are used for this purpose. In the case of condensers in round cans the round shape of the section itself supplies practically all the clamping action required. In addition, the last few turns on all round sections have extra reinforcement.

In the case of Aerovox high voltage oil condensers in round cans the seal is made by turning in the can to form a seal with a soft gasket which fits into a groove around the rim of a molded bakelite cover. In this cover are also molded molded the two terminal studs which serve as the terminal connections. Since the terminal studs are molded in place, and the can is spun tightly into a soft gasket, the result is a hermetically sealed unit.

In the case of high voltage oil condensers in rectangular cans the procedure is first to place the sections in clamps after which the necessary connections are made to the terminals and then the cover is double-seamed in place. These condensers are provided with substantial size "stand off" type insulator terminals made of molded bakelite. By means of gaskets and a special type of terminal structure these terminals are fastened to the can in a manner which makes a moisture proof and oil tight seal. Therefore, in this type of condenser, also, a hermetical seal is obtained.

The effect of the hermetical sealing used in all these types of high voltage condensers is to completely eliminate any possibility of moisture absorption at any time during the life of the condenser. To make an oil-impregnated oil-filled condenser that is not hermetically sealed can only be considered poor engineering; it is certainly poor design to go the expense and trouble of making up an oil condenser without making certain that the sealing is such as to assure longest possible life.

With the above discussion of the oil-impregnated oil-filled condenser in mind we are in a position to show why such condensers are so greatly superior to other types of condensers, especially where the operation of the condenser involves the generation of considerable heat as may frequently be the case where the condenser is used as a filter unit in a high voltage rectifier system.

From the above it will be apparent that, since the container is filled with oil the condenser section itself is completely immersed in this oil bath during its entire life. Since the oil used for impregnation and the oil used for for filling are the same, no harm results from any flow of oil in or out of the section during the operation of the condenser. In fact, this is exactly what takes place and it is a major factor contributing to the superior performance of the oil impregnated oil filled type of condenser.

As the section becomes heated due to the current flowing through it the section and the oil within the section as well as the oil around the section expand. As a result additional oil will be forced into the section as the section expands, and this action functions always to maintain intimate contact between the oil and the two electrodes of the condenser, and to prevent completely the creation of any voids within the section. As the section cools and contracts this oil is forced back into the can. This cycle of oil flow into and out of the section occurs during every cycle of heating and cooling throughout the life of the condenser. It would be difficult to overstress the importance of this factor.

Furthermore, it will be apparent from the above that the advantages of the oil-impregnated oil-filled condenser are not obtained simply by impregnating the section in oil. These advantages are only fully realized when the section is completely immersed in an oil bath; a little extra oil in the bottom of the can by no means constitutes oil filling. The section itself must be completely immersed in the oil bath. It is only such conditions that the condenser functions as it should during the cycles of alternate heating and cooling.

We trust this discussion has served to clarify the readers mind with regard to the features and characteristics of the various types of condensers, and to indicate the importance of oil-impregnation and oil-filling for condensers designed for high voltage duty where long life under conditions of varying temperature are desired.

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