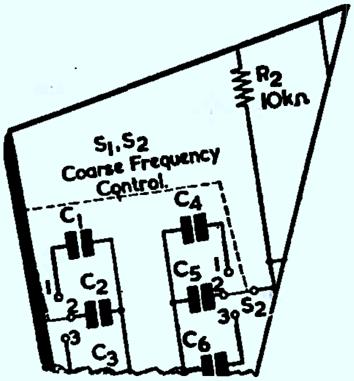

New Life for Mains-Battery Portables

SUGGESTED CIRCUIT No. 178

By G. A. FRENCH

THE ADVENT OF THE TRANSISTOR portable radio has, because of its low battery running costs, made the earlier valve portable receiver virtually obsolete. In consequence, valve portable receivers tend nowadays to be relegated to the store-room or to be otherwise disposed of. However, quite a number of the valve portables which were popular some years ago are of the mains-battery type, being capable of operation from the mains as well as from internal batteries. Whilst these sets are unattractive for battery use, they are still capable of giving excellent results when run from the mains, and they can be employed as mains-only receivers in which there is no need to have batteries fitted. As such they can be more than adequate for bedside use, as a "second set" or, indeed, for all normal domestic listening.

Unfortunately, the mains-derived filament supply circuit employed in mains-battery receivers employs components which are liable to offer reduced performance with age. Should one of these components eventually fail, causing the receiver to become unserviceable when operated from the mains, there is a tendency to look upon the set (already unattractive as a battery portable) as though it were finally "worn out", and it becomes relegated, like its battery-only counterpart, to the attic or store-room.

In this article the writer will first briefly describe the mains filament supply circuitry of conventional mains-battery portables intended for medium and long wave reception, and will then discuss the components which may cause failure whilst operating from the mains. The provision of a modified filament circuit for mains operation will finally be described, the latter forming this month's "Suggested Circuit". The modified circuit may be used with a chain of 25mA valves (such as the DK96, DF96, DAF96 and DL96 line-up) and it overcomes many of the filament supply problems inherent in the mains-battery type of receiver. It must be emphasised that the circuit modifications require some basic experimenting and design work, and that it would be advisable to have the service sheet for the receiver available in order that its circuit and component values may be ascertained. *It must also be pointed out that it is very easy to accidentally burn out the filaments of 25mA valves, and that the modification described later in this article should not be attempted unless the constructor fully understands the principles involved and feels competent to carry out the changes required.*

Mains-Battery Receivers

The conventional type of mains-battery receiver employs four valves in a superhet circuit, with their filaments connected in series. The nominal filament voltage for three of the valves (the frequency-changer, i.f. amplifier and diode-a.f. pentode) is 1.4, whilst that for the fourth valve (the output valve) is 2.8. The output valve has a centre-tapped filament which enables it to operate also at 1.4 volts in a battery-only circuit. A typical filament chain in the 25mA range is shown in Fig. 1, but it should be mentioned that the order in which the valves appear in the chain will differ according to receiver design. It is usual to have fixed resistors across some of the filaments in the chain, but these are not shown in Fig. 1, as their position varies in different receivers. Such resistors are fitted to bypass the anode and screen-grid currents of valves higher up in the chain, as these currents could otherwise flow through the filaments concerned and, thereby, over-run them.* It is conventional practice, also, to have one or more decoupling capacitors between chassis and the junctions of filaments, these being either electrolytic components with high values to provide a.f. decoupling, or paper or ceramic components of around 0.1μF to provide r.f. and i.f. decoupling. These additional components do not affect the present discussion, and the supply requirements of the filament chain are that 7 volts be applied across it, whereupon a current of 25mA will flow. The 7 volts is, of course, given by the sum of three 1.4 volt filaments and one 2.8 volt filament. When, in Fig. 1, the mains-battery switch S_1 is set to the "Battery" position, the filament chain is applied to the terminals of a 7.5 volt battery (which, when new, offers a somewhat higher voltage than the 7 volts required). At the same time, the receiver h.t. circuits are connected to the terminals of a 90 volt battery.

For mains operation, one side of the mains supply connects direct to chassis. The other side of the mains supply is then applied, via series resistor R_5, which is shown with the typical value of 470Ω in Fig. 1, to a half-wave selenium metal rectifier. A rectified voltage appears across reservoir capacitor C_2 which normally has a value of around 40μF. A series of voltage dropping resistors then follows,

* The function of bypass resistors in filament chains was discussed in detail in "In Your Workshop" in the March 1965 issue —Editor.

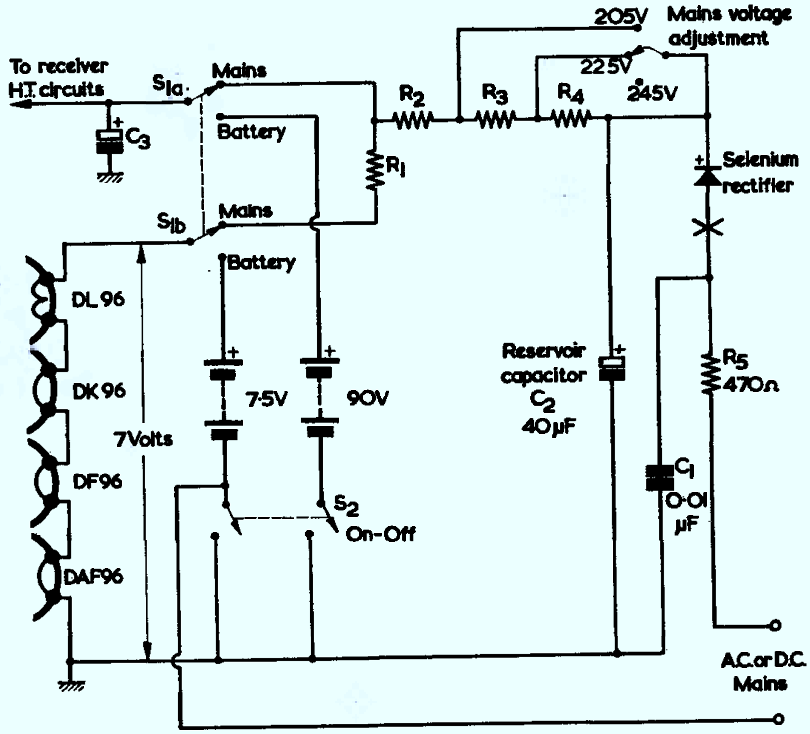

Fig. 1. The basic h.t. and filament supply circuits of a typical mains-battery receiver. The nominal voltage rating for the four filaments is 7 volts, as shown. Capacitor C_1 is an anti-mains modulation component, whilst C_3 is an h.t. smoothing and bypass capacitor. It is assumed that the receiver has a mechanical interlock which prevents S_1 being switched to "Battery" unless, for instance, the mains plug is inserted into a suitable receptacle on the receiver cabinet. Of the valves, the DAF96 is the diode-i.f. pentode, the DF96 the i.f. pentode, the DK96 the frequency-changer, and the DL96 the output pentode

an h.t. voltage of slightly less than 90 volts being drawn off at the junction of R_2 and R_1. The final dropping resistor, R_1, allows 25mA to flow to the filament chain via the appropriate contact of the mains-battery switch. A simple adjustment for mains voltage will also be provided, and this usually takes up the form shown in Fig. 1, in which some of the dropping resistors are short-circuited for lower voltage mains supplies.

Component Failure

When a circuit such as that of Fig. 1 is in use over a number of years, it is possible for two things to happen. The first of these is that the capacitance of the reservoir capacitor gradually falls with time, and the second is that the forward resistance of the selenium rectifier gradually increases. Either of these defects will cause a reduced rectified voltage to appear across the reservoir capacitor, and the eventual result can be that this falls to so low a level that there is insufficient voltage for the valve filaments. The receiver then stops working. In the writer's experience, the first casualty in cases of this sort is usually the oscillator section of the frequency-changer: this ceases to oscillate on one or both bands and the set becomes "dead" as a result. It has also to be remembered that there is very little filament voltage "in hand" with these receivers so far as mains supply voltages are concerned. If, for instance, circuit conditions are such that a valve filament receives its correct voltage of 1.4 with a 250 volt mains input, the filament voltage becomes 1.26 only should the mains voltage drop to 225 volts.

Should it be found that a mains-battery receiver has low filament voltage when run from the mains it is a good plan, firstly, to replace the existing reservoir capacitor with a new component of the same value and voltage rating. If this process does not bring filament voltage to the correct level, the rectifier should be replaced by a new selenium unit of the same type. If a new selenium rectifier of *different* type, but with adequate voltage and current ratings, is fitted it would be advisable to temporarily insert a 500Ω variable resistor in series at the point marked with a cross in Fig. 1, bringing this down, when performance with the new rectifier is being checked, from maximum to minimum resistance until the potential across the filament chain reaches the requisite 7 volts. This precaution is desirable because the new rectifier may have a lower

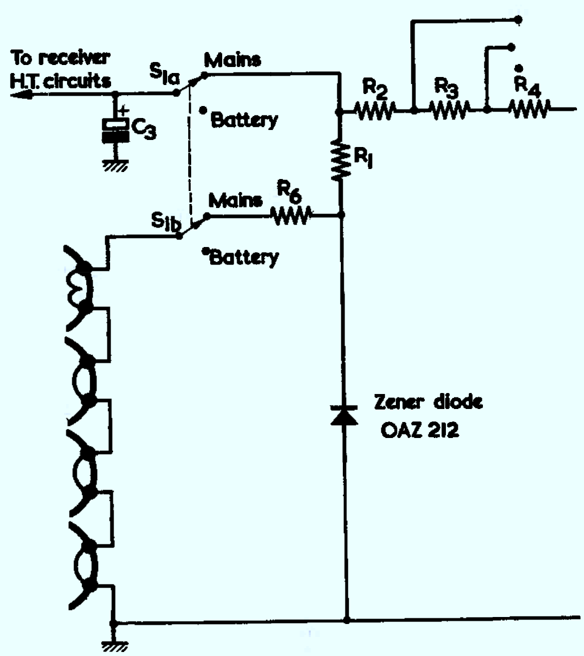

Fig. 2. Modifying the circuit of Fig. 1 for zener diode filament voltage stabilisation. Components and wiring not shown remain unmodified

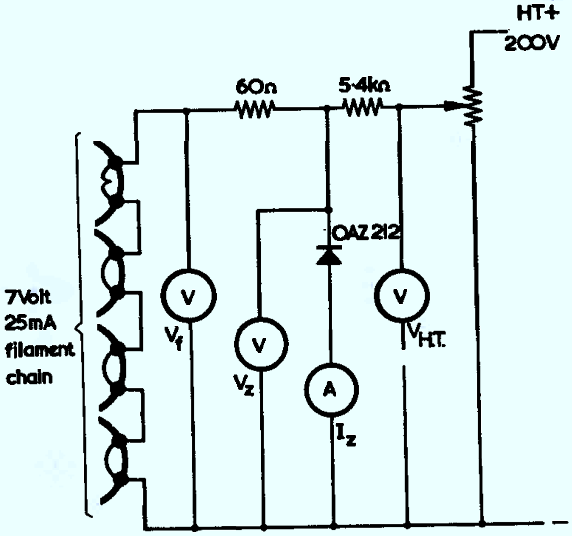

Fig. 3. The experimental circuit employed to check the usefulness of the OAZ212 for filament voltage stabilisation. The value of the potentiometer is not shown, as its only function is to provide a variable h.t. voltage. (The resistor shown as 5.4kΩ was a nominal 5.6kΩ component)

forward resistance rating than that for the one it replaces. If extra series resistance is needed, this fact will be indicated by the final setting of the variable resistor, which can then be replaced by a fixed resistor of the requisite value.

It is possible to burn out the filament of a 25mA valve merely by connecting a charged electrolytic capacitor to it. In consequence, no circuit alterations should be made to a mains-battery receiver switched for mains operation until the set has been switched off for several seconds in order that any electrolytic capacitors in the circuit may discharge. For the same reason, no valve should be removed or replaced until the set has been switched off for several seconds.

Circuit Modification

Whilst the procedure described above is frequently all that is required to bring a mains-battery portable into full working use as a mains receiver, it is obvious that greater reliability would be given by introducing some means of filament voltage stabilisation. This would obviate the dependence on mains supply voltage for correct filament voltage, and would also overcome the gradually falling filament voltage which results from age in the h.t. rectifier and reservoir capacitor.

A very simple and effective method of filament voltage stabilisation is illustrated in Fig. 2. Resistor R_1 is now terminated in a 9 volt zener diode type OAZ212, from which a further resistor, R_6, connects to the filament chain. The voltage across the zener diode remains very nearly constant despite changes in mains voltage or in the performance of the rectifier and reservoir capacitor, and the receiver becomes capable of giving a far more reliable long-term performance in consequence. Added to this is the fact that all valves run at the correct design filament voltage and therefore work under optimum conditions, both with regard to circuit operation and useful life. In order to provide a stabilising current for the zener diode, the values of R_1, R_2, R_3 and R_4 have to be reduced, and this point is discussed later.

To check the efficacy of the zener diode in a circuit of this nature, the writer assembled the test set-up shown in Fig. 3. The voltage appearing at the reservoir capacitor in a mains-battery receiver is usually of the order of 200, and so it was decided to obtain readings at this voltage and below. The results are shown in Fig. 4, which shows the curves given by the Fig. 3 circuit for zener voltage (V_z), filament chain voltage (V_f) and zener current (Z_z) at varying h.t. voltages tapped off by the potentiometer. At 200 volts, filament chain voltage is 7.1 and zener current is 11.5mA. At 156 volts, filament chain voltage is 6.8 and zener current is 2mA. Below 156 volts the zener diode starts to lose control and filament chain voltage begins to drop noticeably, being approximately 6.4 at 140 volts. It is obvious that the OAZ212 achieves minimum slope resistance after 2mA, as is confirmed by the published curves for this diode. The maximum direct zener current for an OAZ212 is 50mA, and the currents indicated in Fig. 4 are well below this figure.

The curves of Fig. 4 illustrate the fact that good stabilisation of the filament chain voltage is possible when zener current exceeds 2mA. The range of good stabilisation shown, 156 volts to 200 volts (at 11.5mA zener current), is a little greater than would be required in most practical instances. In consequence, the circuit of Fig. 3 could be adjusted so that zener current under the maximum reservoir capacitor voltage conditions likely to be encountered is, say, 10mA; whereupon good stabilisation will be achieved for reservoir voltages between the range covered by the ratio 194 to 156, or 1 to 0.8. (In Fig.

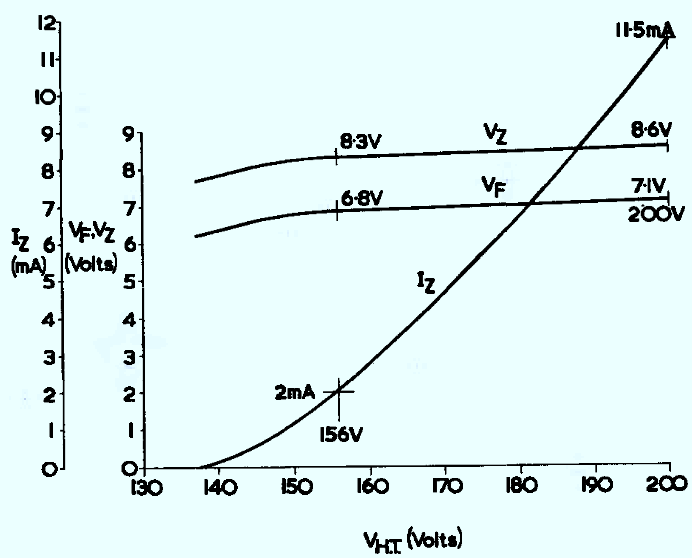

Fig. 4. The results obtained with the circuit of Fig. 3

4, 10mA corresponds to 194 volts.)

If, after bringing a mains-battery receiver into good condition for mains operation (this process including, if necessary, the fitting of a new reservoir capacitor and rectifier), it is decided to incorporate the zener diode circuit of Fig. 2, the writer would suggest that the following procedure be adopted. It is first of all necessary to find the voltage at which the particular OAZ212 that is to be used stabilises. This step is needed because the tolerance on the zener voltage of this diode is $\pm$ 15%. (There is little point, incidentally, in employing a 9 volt diode with a closer tolerance, such as the $\pm$ 5% OAZ207, because the latter will be more expensive and it will still be necessary to find its actual zener voltage.) The zener voltage may be found by passing any current between 5 and 10mA through the diode and measuring the voltage across it. Once this voltage has been found, the value of R_6 can then be calculated and a physical resistor fitted. If, for example, it is found that the actual zener voltage is 8.5, then it is necessary for R_6 to drop 1.5 volts at 25mA. From Ohms Law, the resistance required for R_6 is 60Ω. A resistor of this value should then be fitted in the R_6 position.

It is next necessary to reduce the values of R_1, R_2, R_3 and R_4 (or the resistors in whatever equivalent series resistor chain is fitted in the receiver being modified) and this process may be conveniently carried out by connecting additional resistors in parallel with those already in circuit. If it is intended to work to a zener current of 10mA under the maximum reservoir capacitor voltage likely to be given then it is helpful to remember that, under this condition, R_1 passes 35mA whereas previously it passed 25mA, and that R_2, R_3 and R_4 will pass about 45mA whereas previously these resistors passed about 35mA. (The currents quoted for R_2, R_3 and R_4 assume 10mA h.t. current, which is a typical figure for receivers of this nature). Thus the parallel resistor needed across R_1 could well be of the order of 2.5 times its present value, whilst the parallel resistors needed across R_2, R_3 and R_4 could well be of the order of 3.5 times their present value. However, these figures are only intended as a guide and it is recommended that the resistor values be adjusted empirically such that the required zener current will flow under maximum reservoir capacitor conditions as monitored by a meter inserted in series with the zener diode. The parallel resistors initially added should have values higher than is given by the simple relationship just mentioned, these being reduced experimentally until the desired circuit conditions are obtained. When the adjustments are complete the h.t. voltage available at the junction of R_2 and R_1 should be of the order of 85 volts. It should be added that the h.t. rectifier employed must be capable of passing the zener current in addition to the h.t. and filament current. Assuming a maximum of 10mA zener current, the rectifier should be rated at at least 45mA.

Final Points

Several final points need to be mentioned.

The first of these is that the filament chain may have a thermistor such as the Brimar CZ10 connected across it. This component presents a low resistance in the event of a break in the chain due to a filament burning out or any similar reason, and it ensures that an excessively high voltage does not then appear on filaments above the break. The thermistor is not needed when the zener diode is in circuit, as the latter will perform the same function. The thermistor can, therefore, be removed.

A second point is that a zener diode stabilising circuit could also be used with mains-battery receivers having a 50mA filament chain. The writer has not, however, checked this application, although the introduction of the zener diode could follow the same procedure as has been described for a 25mA filament chain. It would be necessary to use a zener diode having a maximum zener current rating greater than that which would flow should the filament chain become open-circuit. In consequence, the OAZ-212, with its maximum zener current rating of 50mA, would not be suitable for use with a 50mA filament chain.

Finally, it should be pointed out that all adjustments to filament voltage should be made with the receiver switched on in the usual manner, so that the normal h.t. current is drawn by the valves.

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