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Power Supplies

PART 2

By the Engineering Department, Aerovox Corporation

A discussion of power supplies would not be complete without a consideration of modern automobile receivers. The systems in use at the present time include: motor-generators, dynamotors, sychronous and non-synchronous vibrators. The majority of automobile-receivers obtain their B— power from the car battery by means of a vibrator system.

NON-SYNCHRONOUS VIBRATORS

The non-synchronous vibrator consists of an armature which is kept in vibration by an electromagnet on the same principle as the buzzer. At the same time the armature serves as a commutating switch, continually reversing the primary current. The action is best illustrated by Figure 1. This diagram shows only the vibrator itself with the transformer and r.f. filter. When the switch is closed current will flow through the lower half of the transformer primary and then through the magnet windings. The armature is then attracted and contact A will touch contact B, thereby short-circuiting the electromagnet. The armature is then released again and swings back until contact A touches contact C. Meanwhile the electromagnet is attracting it again so that it keeps on vibrating at its own natural frequency and alternately touching contacts B and C. Now when contacts A and B are closed, the lower half of the primary is directly across the car battery, which will result in a heavy current from the centertap downwards. When A touches C, the upper half of the primary is across the battery and a heavy current will flow from the centertap upwards. These two impulses might be considered as alternating current although not of a perfect sine-wave form. An alternating voltage will be induced in the secondary which is rectified in the usual way by means of a full-wave rectifier tube. Type 84 was especially designed for this service; in the metal tube line the 6X5 serves the same purpose.

There are some special precautions to be taken in the design of vibrator systems. When the contacts A and B close there is such a sudden increase of current that a high voltage peak is induced in the secondary. The same is true when the other contacts close.

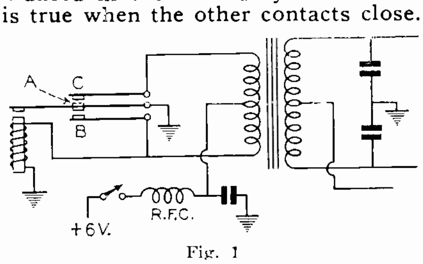

Fig. 1

Furthermore, sparks are likely to appear at the contacts. Various ways have been devised to eliminate the interference caused by the vibrator. Buffer condensers are generally placed across the secondary and sometimes across the primary. Other manufacturers connect a center-tapped resistor across the primary. The buffer condensers will absorb the sudden charges and thereby improve the waveform. Yet this alone is not sufficient to insure noise-free reception. The B-supply filter may conatin an r.f. filter in addition to the regular a.f. filter and the filament circuit may be filtered too. Also, the filament circuit should not have any part in common with the vibrator circuit—except the battery, of course. A typical circuit of an automobile power supply using a non-synchronous vibrator, is shown in Figure 2. This circuit includes center-tapped resistor across the primary and the usual buffer condenser across the secondary. Sometimes two condensers are connected across the secondary with the center-tap grounded. The values of these condensers might be in the neighborhood of .01 mfd. They must have a high voltage rating.

Note the r.f. filter in the B-supply filter. There are also two filters in the filament supply. The first, consisting of RFC1 and C1, serves to eliminate the interference caused by the vibrator, while the other section, consisting of RFC2 and C2 is intended to eliminate ignition nterference. In addition to all these precautions, both the vibrator and the power supply must be carefully shielded.

SYNCHRONOUS VIBRATORS

The armature of a synchronous vibrator closes another set of contacts which serve to rectify the current in the secondary. Figure 3 shows the diagram illustrating the principle. When the armature moves downwards it not only closes the primary circuit but also the secondary; when it moves up, the other halves of both the primary and secondary are closed. Buffer condensers are again employed in the secondary to improve the wave form. The usual r.f. filters and a.f. filter are used like in the other vibrator systems.

AEROVOX PRODUCTS ARE BUILT BETTER

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A modern power supply with synchronous vibrator is shown in Figure 4. This receiver works from a 6-volt battery but employs two volt tubes. They are placed in series parallel. Another peculiarity of Figure 4 is the separate C-supply. An extra winding on the transformer supplies an alternating voltage to a -30 tube connected

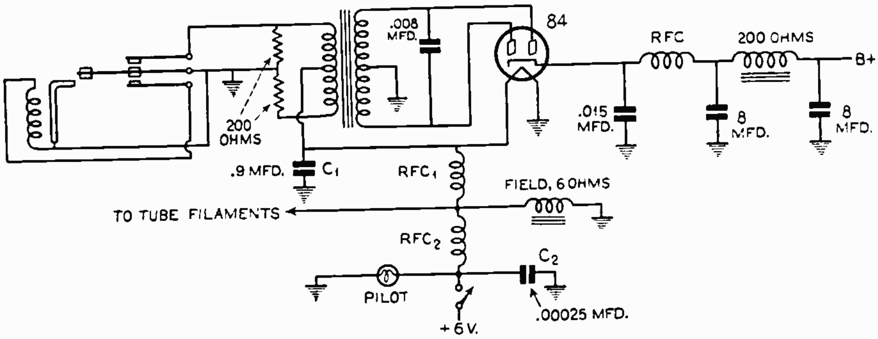


Fig. 2

as a diode rectifier. Two different bias-voltages are so obtained. The only filters in the C-supplv are resistance-capacity filters.

SPECIAL POWER SUPPLIES

Some of the following schematics were not taken from any existing commercial receiver or amplifier but they are included in the discussion because they are of interest to the amateur and the serviceman is bound to meet them sooner or later. Some other arrangements described below

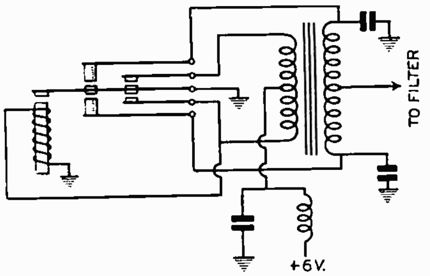


Fig. 3

have been used in the larger radio receivers and P.A. amplifiers.

The first system that deserves our attention is the bridge-rectifier. Figure 5 shows a typical bridge-rectifier employing four type 5Z3 tubes. Of course, any similar rectifier tube could be employed, such as the 81, 82, 83, 80, etc. This system has certain advantages, especially for the amateur who has limited equipment. When the rectifiers are connected as in Figure 5, either tube 1 and 3 or tube 2 and 4 are conducting. Two tubes are thus in series and the voltage supply can then be twice the maximum rating for one tube. Voltages of 1000 and over could be rectified with inexpensive high-vacuum rectifiers instead of using the high-voltage gas-filled types. However, a filament transformer with three different windings is required. Tube 3 and 4 can be supplied from the same 5-volt winding but the others must have separate windings. Transformers for this purpose are available from most of the transformer manufacturers.

Another advantage of the system is that the secondary does not need to be centertapped.

Bridge rectifiers of the copper-oxide type are still in use for the speaker field supplies. These are generally mounted all in one row which apparently has caused some confusion among many servicemen who have difficulty identifying the terminals. However it is easy: the "ring" of rectifiers of Figure 5 can be

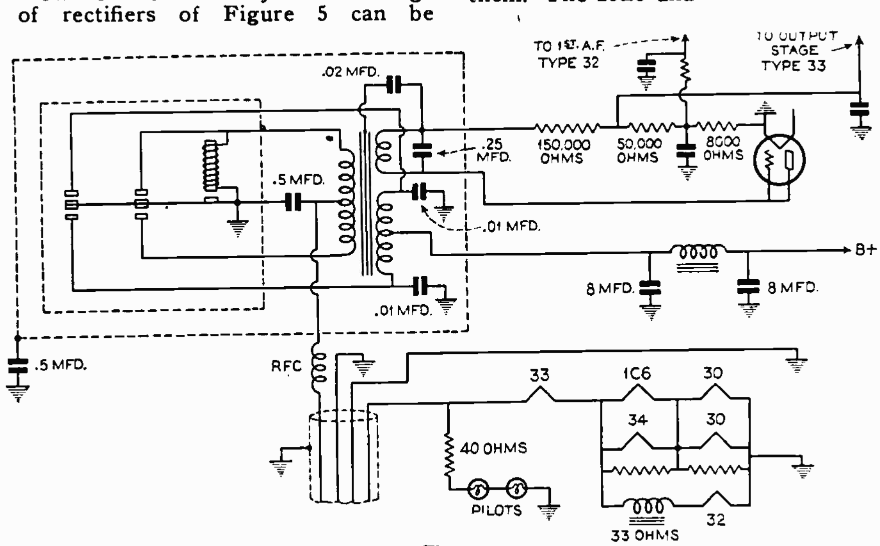


Fig. 4

considered cut at the junction between rectifier 3 and 4. Then straightening out the series of rectifiers, we obtain the circuit of Figure 5A where the tubes have been replaced with the symbols for the metallic rectifier. Some of the commercial copper-oxide rectifiers have only four terminals. In that case the terminals are as in Figure 5B; the connection between section 3 and four is then made by the bolt which holds the assembly together. Small rectifiers used for measuring instruments are generally mounted the same way and their terminals are arranged as in Figure 5B.

The second special circuit to be discussed is the voltage doubler. A fundamental circuit of the voltage doubler is shown in Figure 6. Many people become confused when drawing or tracing a doubler circuit. Therefore we shall briefly explain the action. Rectifier A will conduct when point P becomes positive with respect to point Q. During this time the condenser C1 will be charged up. During the next half cycle, rectifier B is conducting and condenser C2 is charged. These charges are such that they are in series and they can discharge only through the load R. In order to collect enough of a charge to keep the voltage up during discharge it is necessary to have large condensers. The voltage of the supply will drop considerably when too much current is drawn. This circuit can be used to obtain double the voltage from a transformer secondary or directly from the line. In the diagram of Figure 6 two different rectifiers are shown which must have a transformer with two different windings to supply them. The 25Z5 and 25Y5 tubes have been made available for voltage doubling service. They consist of two rectifier sections with insulated cathodes; so no transformer is necessary. A transformerless power supply, (which will work only on a.c.) is shown in Figure 7.

A 25Z5 is used as the rectifier; suitable output tubes for the purpose are the types 18 and 12A5. With these tubes it is possible to obtain a maximum output of 3 watts. This circuit would probably be more popular if it

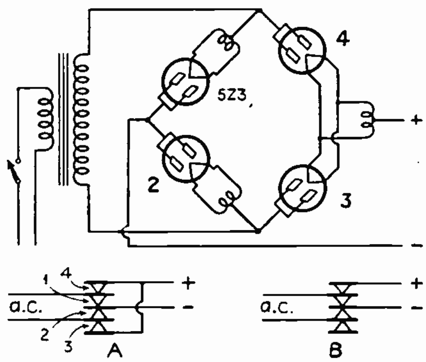


Fig. 5

were not for the grounding difficulties. The chassis becomes 110 volts negative with respect to one side of the line. Accidental grounding of the chassis must be prevented as much as possible. A series condenser should be placed in the antenna lead and also in the ground lead if a ground is used. At the present time the use of voltage doublers directly from the line seems to be restricted to field supplies for dynamic speakers.

The amateur frequently employs voltage doubling to advantage. In his case a transformer would be employed which eliminates the grounding difficulties. Any part of the circuit can be grounded without danger. A transformer with a 700 volt secondary could deliver over 1400 volts, depending on the drain, with two rectifiers of the 5Z3 type. Two different filament windings are required and the maximum current is only half that of the same transformer delivering 700 volts.

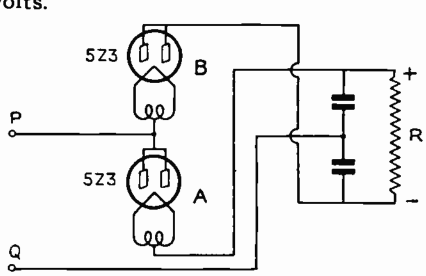


Fig. 6

Some of the larger receivers which utilize class AB output stages need grid-bias supply which does not fluctuate with the drain of the tubes. One way whereby this can be done is by means of a separate C-supply. To utilize this method the system has a transformer with an extra winding which is connected to a -45 tube rectifier. The circuit is shown in Figure 8; different windings deliver voltages to the grd and plate. These voltages are in phase and in the required proportion. Careful filtering is necessary because amplifiers of this type generally have considerable gain. Fortunately there is practically no drain on the grid-bias supply which makes it easier to filter.

Note that the filter for the plate supply has a tuned section and that choke input is employed.

Figure 9 shows another way of obtaining an extra voltage supplv for the grids. In this case the same transformer secondary serves a double purpose and this is indeed voltage doubling. An extra rectifier tube—which must have its own filament winding—is connected to one side of the secondary "in reverse" i.e. with the filament tied to one of the high voltage terminals and the plate to the input of the filter. This makes the extra tube conducting during the half cycle that the corresponding section of the other rectifier is not conducting.

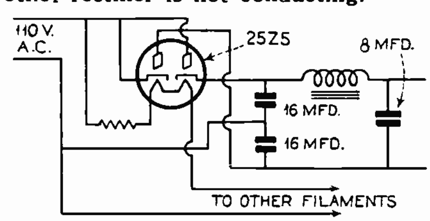


Fig. 7

Very little current need be drawn by the C-supply so that it need not unbalance the transformer drain too much. Some transformers have been made with an extra tap for grid-bias supplies. In that case, the filament winding of the extra rectifier connects to this tap. The rectifier employed is sometimes an 82 or a 45. A 2½ volt filament is preferred because it is easiest to find a transformer with an extra 2½ volt winding. In general, any tube could be used which is directly heated. One must be sure to apply C-bias at the same time that plate voltage is applied or earlier. Some safety device should be employed so that the plate circuit will open if the bias supply should fail. A fuse in the plate circuit of the power tubes wll generally be satisfactory.

MAXIMUM OUTPUT OF POWER SUPPLIES

Some readers have requested information on the rating of a power supply. What is the maximum voltage and current obtainable from a given apparatus? If the question is put in this way, the answer is simple. There are several parts in your equipment, a power transformer. a rectifier tube, condensers and chokes. The power transformer delivers a fixed voltage to the rectifier. Curves of the rectifier's performance have been published by the tube manufacturers. These curves show the voltage to the input of the filter for a given transformer voltage and a given size of input condenser. The voltage varies with the current

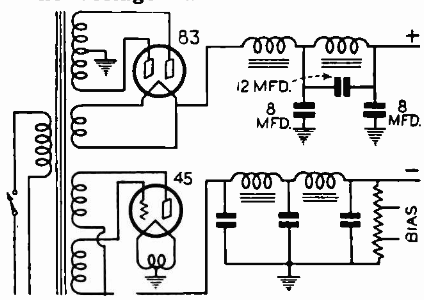


Fig. 8

drawn by the load. So, if one knows how much the load will draw, the voltage delivered by the supply is equal to the voltage shown by the curves minus the drop in the filter.

There is another way to look at it. The transformer, the tube and the chokes all have their own maximum current rating. The lowest of these ratings is the maximum current rating of the power supply. The voltage is determined as in the above paragraph.

When one wishes to design a power supply to satisfy certain requirements the procedure is as follows. First determine the maximum total current drawn and the voltage required. Then a choice of circuits is to be made. When it is known how many filter sections are to be employed one can determine the type of choke and the voltage drops in them. The sum of the total voltage required by the load and the voltage drops in the chokes determines the required output of the rectifier. The manufacturer's curves again will indicate the required secondary voltage and the size of the input condenser. In general, a transformer with the exact voltage may not be available. The one with the nearest higher rating can be used. The

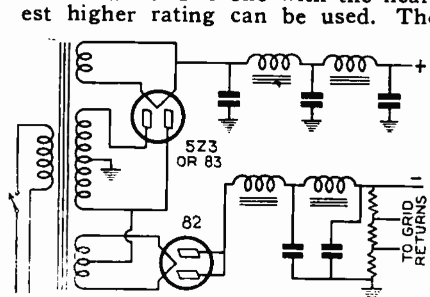
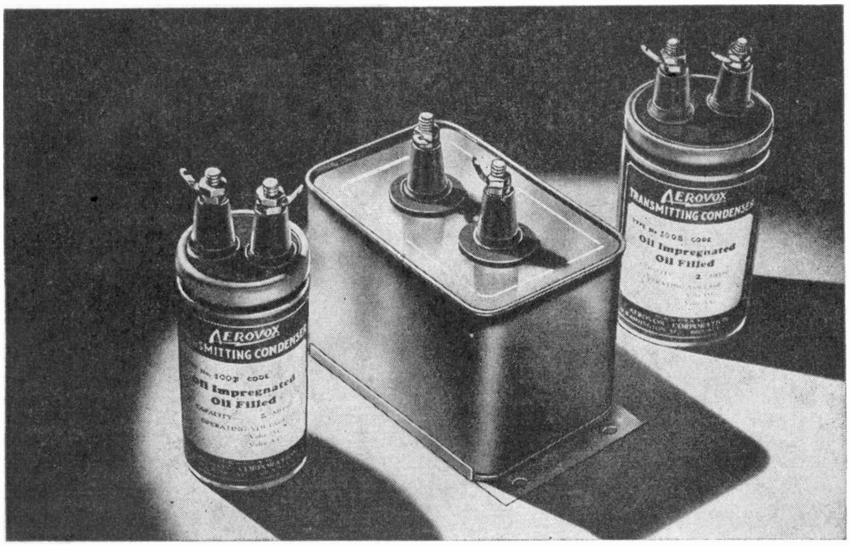


Fig. 9

excessive voltage can be taken up in chokes with higher resistance or a smaller input condenser can be selected which is a way to obtain the necessary voltage adjustment. Input capacities of less than 1 microfarad will generally be required if the voltage is to be dropped apprecíably.



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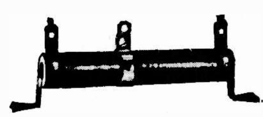

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