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Vibrator Power Supplies

What They Are And How They Work

BY BYRON GOODMAN,* W1JPE

DURING the past five or six years there has been an increasing interest in the amateur ranks in portable, mobile and emergency operation. The AEC, the ARRL Field Day, and the increased activity by u.h.f. mobile units have all contributed to an increasing consciousness of the peculiar problems and enjoyment connected with the construction and operation of compact, self-powered transmitters and receivers. It is not unreasonable to predict a future when 75% or more of the active amateurs in the country will have equipped themselves for self-powered operation of one kind or another, even if the gear is low-powered and necessarily limited in its range. It can consist of either the regular station equipment, capable of ready transportation or installation in a car, or it can be a separate unit used only in an emergency or on field trips. In any event, its design revolves around the power supply that is to be used.

A gasoline-powered generator is undoubtedly the ideal answer to the power problem, but its cost and size limits its use to deluxe installations that can hardly be considered to be within the reach of the average amateur. Many excellent designs have been built around dry battery power, but the input is necessarily limited to the flea-power class and the more power one draws the shorter will be the life of the battery. By far the most logical and common source of primary power is the 6-volt storage battery found in every automobile, and this boils down the power supply to either a motor-generator or a vibrator power supply. It is the purpose of this article to show how vibrators work and to mention a few factors influencing their operation.

Principles of Operation

The vibrator power supply was developed for automobile broadcast receivers as a substitute for the dry batteries used in the first automobile receivers. Since its introduction it has been improved and made so dependable that it finds universal use in automobile b.c. receivers and widespread use in mobile transmitter and receiver applications up to demands of from 60 to 80 watts at 400 volts. Its major usefulness for amateurs is in the power class around 30 to 40 watts at 300 to 325 volts, although vibrator supplies are made in many sizes down to one that will operate from flashlight cells and furnish 10 ma. at 90 volts.

In effect the vibrator is simply a fast magnetically-operated reversing switch that gives an a.c. that can be stepped up through a transformer, rectified and filtered. Fig. 1-A shows the connections for a reversing switch that, if it could be thrown back and forth fast enough, would allow the d.c. input to be changed to a.c. and stepped up through the transformer. There was a forerunner of the vibrator that consisted of a reversing switch driven by a small electric motor, and the old synchronous rectifier of early c.w. days was a motor-driven reversing switch of this type used as a rectifier. However, the motor wastes more power and is heavier than the vibrator type of reversing switch, and hence the over-all efficiency and lightness of the vibrator can be made higher. By putting two primary windings on the transformer, as in Fig. 1-B, a s.p.d.t. switch can be used for reversing, and the simplicity of this connection has made its use standard practice in vibrator design.

There are two general classes of vibrator supplies, the self-rectifying (synchronous) and the tube rectifier. These two types are shown in Figs. 2-A and 2-B respectively. The self-rectifying type has a separate set of contacts that reverses the current flowing from the secondary in synchronism with the reversals of current in the primary, while the other type uses an ordinary full-wave tube rectifier to obtain unidirectional current flow in the output circuit. The tube must have good insulation between cathode and heater, and several types are available. Proper battery polarity is necessary when using the self-rectifying type of vibrator — with the tube rectifier it makes no difference which way the battery is connected. Most of the self-rectifying vibrator units are now built so that they can be reversed in the socket, thus doing away with any necessity for reversing the leads from the battery.

To reduce surges in the circuits and to cut down the arcing and consequent wear of the contact points, a condenser can be connected across the contacts in the primary circuit. However, since it takes a large capacity to be effective at this low voltage, the condenser *C* (Figs. 2-A and 2-B) is connected across the secondary where a smaller value can be used. The action is the same, since the capacity is reflected back through the transformer to the primary. The value of this condenser is of considerable importance in proper vibrator operation, and it will be taken up later in greater detail.

The actual vibrator is somewhat similar to a

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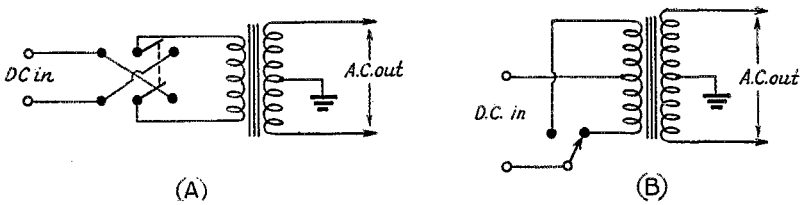

Fig. 1 — The sketch at *A* shows how d.c. can be changed to a.c. and stepped up to a higher voltage by means of a reversing switch. The frequency of the a.c. is of course dependent on the number of reversals per second of the switch. The switching can be simplified by using a double primary winding as shown at *B*.
A vibrator is simply a magnetically-actuated switch of the type shown in *B*.

buzzer with some extra contacts on the armature, although the manufacturing tolerances are, of course, much closer and the contact material is vastly superior. The energizing coil for the armature, or "reed," can be connected in several different ways, but most of the present ones are connected in "series" (Fig. 3-A) or in "shunt" (Fig. 3-B). The connection of Fig. 3-C is the same as that of a buzzer, but it is impractical for high-efficiency use because it gives a pulsating d.c. similar to that obtained from a half-wave rectifier.

Vibrators have been built to operate at frequencies ranging from 85 to 165 cycles per second, but the present tendency is toward standardization around 115 cycles per second. Obviously the filter design will be dictated by the frequency and the load requirements, as in the case of other power supplies.

The Buffer Condenser

The condenser *C* of Figs. 2-A and 2-B is called the "buffer condenser" and its value is important to the proper operation of the vibrator. With no condenser connected across the secondary of the transformer, instantaneous voltage peaks caused by the kick-back voltage induced by the collapsing flux on "break" will occur at the start of each cycle that may cause insulation breakdown in either the transformer or the filter condenser. On the other hand, if the buffer condenser is of too high a value, it may cause excessive hum in the output and it will cause more rapid wear of the vibrator points. Complete vibrator power supplies of reliable makes have the buffer condenser adjusted to the proper value and, if for any reason they have to be replaced, this value should be duplicated exactly.

A home-assembled vibrator power supply should have the buffer condenser adjusted properly when the unit is first built. This can be done by using an oscilloscope to watch the output waveform (a method outside the scope of this article but which is described in any vibrator service manual) or more simply through the use of a 0–10 ammeter in series with the battery line. The load is disconnected from the supply (this includes the rectifier tube in the case of a tube type or the filter in the case of a self-rectifying type) and the value of condenser is adjusted until the drain from the battery is a minimum. The proper value will usually be between 0.005 and

With the interest in portable and mobile operation running the highest in amateur radio's history, anything dealing with the power supplies for such units should bear reading by every active ham. This is not a how-to-build-it article, but it is a résumé of vibrator operation and adjustment that should clear up most of the questions you have had about vibrator power supplies.

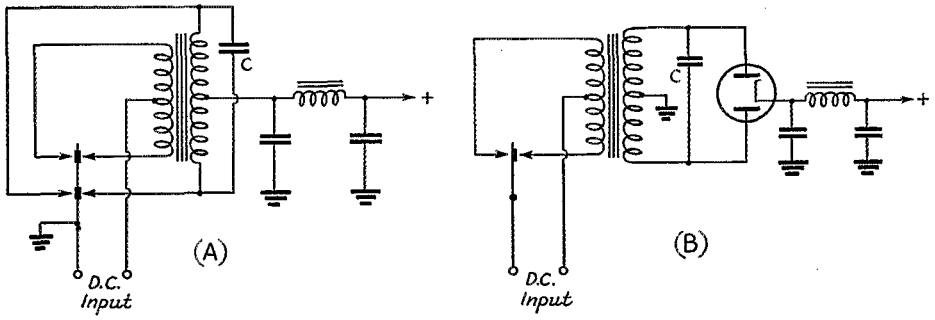

Fig. 2 — The two basic types of vibrator power supplies are shown at *A* (self-rectifying) and *B* (tube rectified). The value of the condenser *C* plays an important part in the proper operation of any vibrator power supply, as explained in the text.

TABLE I — VIBRATOR POWER SUPPLIES

Manufacturer's Type No.		Output		Rectifier	Output Filter
Am. Television and Radio Co.	Mallory	Volts	Ma.		
VPM-F-7		90	10	Syn.	Yes
	VP-551 [1]	125–150–175–200	100 max.	Syn.	None
	VP-540	250	60	Syn.	Yes
	VP-552 [2]	225–250–275–300	50–65–80–100	Syn.	None
	VP-555	300	200	Tube	Yes
VPM-6 [3]		250–275–300–325	50–75–100–125	Tube	Yes
	VP-557	400	150	Tube	Input condenser furnished

All inputs 6.3 volts d.c.

[1] VP-553 same with tube rectifier.
[2] VP-554 same with tube rectifier.
[3] Also available without filter.

0.03 μfd. If two values of condenser give the same minimum drain, it is safer to use the higher value of capacity. The buffer condenser should be one rated for at least 1600 volts d.c. working voltage, and oil-filled condensers are recommended by all vibrator manufacturers.

Hash Suppression

There is, of course, considerable r.f. "hash" caused by the vibrator because of the transients existing in the circuit and, if this is not eliminated, it can cause considerable interference in a receiver or on the carrier of a transmitter. The buffer condenser can be split up into two condensers of twice the value of the single unit with the center tap connected to ground, but this is not enough to remove all of the hash. Vibrator manufacturers say that the only way hash can be removed is by proper electrostatic and magnetic shielding, proper grounding and thorough r.f. filtering of the leads to and from the vibrator pack. Commercial units are usually filtered and shielded to a satisfactory degree, and the home constructor may have to do considerable experimenting before all of the hash is removed from his supply. R.f. chokes are usually placed in the "hot" battery lead and in the positive output lead, along with an r.f. by-pass condenser on the pack side of each of these chokes. The battery-lead choke must be of a low resistance to avoid large voltage drops, and it is usually made of from 50 to 200 turns of No. 12 to 16 wire. The by-pass condensers range from 0.5 to 1.0 μfd. Chokes and condensers will not eliminate hash caused by improper grounding and shielding, however.

General

A good vibrator unit will start with less than 5 volts applied to it, and any vibrator that re-

(*Continued on page 95*)

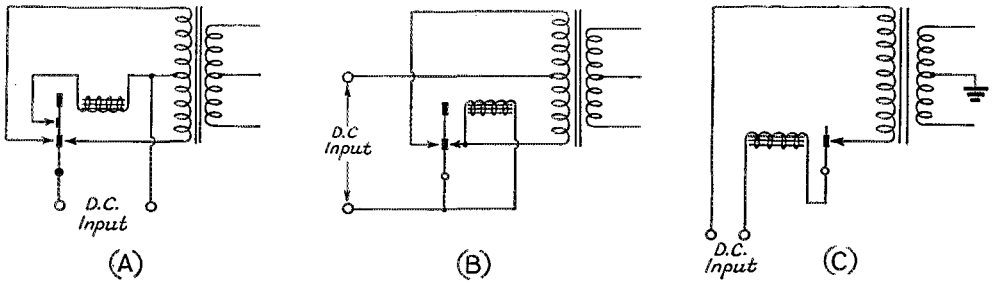

Fig. 3 — Several possible ways of exciting the armature of the vibrator are shown here. The system at *A* is called "series-connected" and that at *B* is "shunt-connected." Some of the old types of vibrators were connected like a buzzer, as in *C*, but they operate at low efficiency and deliver an output similar to that from a half-wave rectifier.

stand that there were quite a few stations on 7 Mc. along the coast that did good work until 7 Mc. began skipping. (Unfortunately 7 Mc. is generally not usable for work within the state after 5–7 P.M. these days.) W5CVQ and W5ZG are known to have been active on this band.

"The Adjutant General of the State of Texas was standing by and listening to all work done from a NC200 receiver placed in his office in the capitol building. Gen. J. Watt Page is also head of the Texas Defense Guard, and was in personal contact through our net with the work being done by the guard in the emergency. A great deal of good-will was created for the hams through this radio network operation. All officials of the guard and of the State Legislature here in Austin are overflowing with praise for the hams. We have been handling considerable traffic recently for the Governor of the State, also."

Organization and preparedness — those are the needed things. The 45 member-stations of the TDG/AARS net and the other amateurs of Texas demonstrated that they were both well-organized and fully prepared. FB, OM's!

— *C. B. D.*

Vibrator Power Supplies

(*Continued from page 46*)

quires much more than this to run should be considered doubtful. A vibrator that requires 5.5 volts or more is definitely "bad." If the vibrator is connected to a constant load, the output voltage should not vary over any appreciable range, and if it fluctuates more than 5% one should start looking for trouble. If the supply is homemade and doesn't give rated voltage at the desired current drain, it doesn't necessarily mean that the vibrator is no good but it probably indicates excessive drop in the battery lead or through either the r.f. chokes or the filter choke. However, fluctuating output voltage is a good indication of a poor vibrator unit or a poor connection, probably at the battery terminals. Vibrator manufacturers recommend that the specified value of the buffer condenser never be changed in a manufactured pack, that no attempt be made to repair a vibrator by filing contacts or bending the springs because they have both been adjusted at the factory, and that a vibrator never be replaced until one is sure that the vibrator is the defective component.

There are two factors affecting the choice of self-rectified or tube-rectified vibrator power supplies. If the circuit used is one where the filter choke can be connected in the positive lead and where the negative can be returned to one side of the tube heaters, the self-rectified vibrator supply is the logical choice, although the tube type can be used. However, if bias for some tube or tubes is obtained through a drop in the negative lead, thereby eliminating the possibility of returning the negative lead to ground, the tube rectifier type must be used.

The regulation of an average vibrator power supply runs a little less than 25% from rated full load to no load with a constant input voltage of

6.3 volts. The regulation becomes something worse than this if the input voltage varies appreciably over the no-load/full-load range. As a result it is well not to skimp on the voltage ratings of by-pass and filter condensers that are used. On the other hand, it is common sense to allow for plenty of safety factor in any portable or emergency rig, and the regulation of a vibrator supply is no good argument against its use as long as one designs his equipment for a supply of this type.

It is not good practice to overload a vibrator supply. They are designed to work over a wide range of battery voltages (5.5 to 8.0 volts) because the charging generator will boost the battery voltage considerably while the car is running, but the power drain on the output of the supply should never exceed more than 8% or 10% of the rated output with 6.3-volt input. Heavy overloads will cause rapid wear and sometimes sticking of the contacts, and this latter will usually result in a burned-out vibrator unit unless proper fusing of the unit is provided.

The light weight and good over-all efficiency (from 65% to 75%) of the vibrator power supply makes it well worth considering by any amateur interested in a compact emergency or mobile power supply. Table I lists some of the vibrator power supplies that are available and, although the list is not as complete as that shown in the 1942 *Handbook*, it will serve to show what can be had in this type of supply. It should be unnecessary to stress again the importance of preparation for the future by as many amateurs as can afford it. When Maj. General J. O. Mauborgne says, as he did in the September *QST*, "U.h.f. portable or movable *self-powered* apparatus will be of extreme value in the future, and every amateur possessing such apparatus in working order will be mighty glad he has it," any amateur who is on his toes doesn't have to be hit over the head a few times to get the idea.

I.A.R.U. News

(Continued from page 50)

operating in the black, thanks to the coöperation of its members. Its *Ham Chatter* appears regularly, the latest issue carrying a list of nearly one hundred ZS amateurs on active service. Amateurs have also sponsored and furnished instructors for a signal training school to provide radio operator and technician personnel for the air forces.

QSL CARDS

THERE are a few QSL cards on hand at Hq. for the following stations, at one time located on Pacific Islands. If anyone knows the present whereabouts of the operator of any station listed, ARRL Hq. would appreciate the dope on a postcard.

KC6IDB, CKM, BVL; KD6OU, QHX; KD4HHS, GYM, OPJ; KE6QAC; KF6DHW, OWR; KH6KKR.

NOTES

"CQ PK," official organ of our Netherlands Indies friends, appears in de luxe style for