By JOHN W. STRAEDE

BEAT-FREQUENCY OSCILLATOR

An Excellent Instrument for the Advanced Serviceman

THE type of audio-frequency oscillator described in this article consists essentially of two high-frequency oscillators, the alternating voltage outputs of which are mixed, i.e., added together and rectified, the resultant being an alternating voltage the frequency of which is the difference between the frequencies of the high-frequency oscillators.

Audio-frequency oscillators have many uses, such as measurement of frequency response of an amplifier or a.f. section of a receiver, signal for locating rattles, squeaks and buzzes in radio cabinets and auditoriums (including ordinary rooms), alternating voltage source for measuring impedance of a loudspeaker, microphone, pick-up or cutting head. They also form part of the equipment for measurement of loudspeaker and microphone response. An accurately calibrated variable-frequency oscillator can be used as a source for measurement of inductances and capacities by resonance methods. (In later articles it is hoped to describe auxiliary equipment and procedures for some of the above).

This particular beat-frequency oscillator has a number of constructional and circuit features making it very useful for the experimenter, radio serviceman, teacher and amplifier enthusiast.

The beat-frequency oscillator is compact and easily carried around.

CONSTRUCTIONAL FEATURES

The entire job is very compact, the case measuring only 10 x 7 x 7 inches. The small size is due mainly to the employment of only four tubes (one each 6K7-GT, 6J8-GT, 6V6-GT and 6X5-GT). Bantam type tubes are employed but there is enough room for full size "G" types—a 5Y3-G rectifier was used in one version. Controls are only 3 in number: Zero set, Tune (frequency control) and Volume.

Ordinary radio parts are used throughout except that a slight modification is required of the one-gang condenser if the instrument is to be most useful.

With the exception of the 2000-ohm filter, all resistors are of the carbon type. Ordinary shielded coils in cans 1½ x 1½ x 3 inches high, are the only ones used. No modification is necessary except that a few small condensers and resistors are squeezed inside the cans to facilitate shielding.

Probably the weakest part is the output transformer, although here again the sacrifice of some volume enabled fair results to be obtained.

CIRCUIT DETAILS

The 6K7-GT (which can be replaced by 6U7-G or 6D6) is employed as a fixed frequency oscillator using an electron-coupled output circuit so that signals applied to the plate from an external source will have little or no effect on the oscillator frequency. *It is highly desirable in the design of beat-frequency oscillators that there be as little coupling (or energy transfer) as possible between the tuned circuits,* otherwise waveform distortion and *locking-in* occur when low output frequencies are required. Locking-in means that the two high-frequency oscillators jump into synchronism so that no output beat signal is produced.

The variable-frequency oscillator consists of the triode portion of the 6J8-G—here the circuit is very similar to that of a conventional superhet—electron coupling being provided in the hexode portion of the tube.

Production of reasonably good wave form requires that at least one oscillator output be free from harmonics and that no overload occurs in the output stage.

By having the fixed frequency oscillator barely oscillating, that is, working at low signal level, its wave form is fairly pure, a plate-to-ground condenser discriminating against any harmonics that might be produced.

Inverse or negative feedback is employed over the output stage to reduce any distortion produced by the 6V6. Theoretically the amount of feedback varies with the setting of the volume control in the circuit shown, an effect which would cause a slight change in frequency response between low and full volume. However the change is a very minor one indeed, as the output is provided with an almost constant resistive load consisting of a 10,000-ohm resistor and a 0.1 microfarad fixed condenser.

To prevent too great attenuation of the lower frequencies the cathode by-pass condenser was made unusually large—100 μf being used.

Space was saved by omitting the usual power choke and employing a

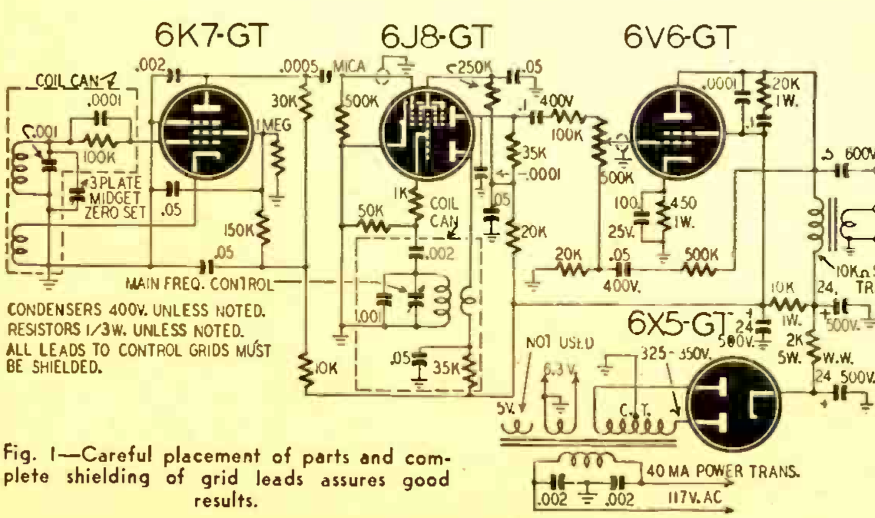

Fig. 1—Careful placement of parts and complete shielding of grid leads assures good results.

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correct polarity of one or more feedback coils (the plate windings) may prevent oscillation, one test for lack of oscillation being the absence of a negative voltage on the innermost grid of the tube concerned.

Another possibility is that the frequency difference of the oscillators may be so high that the sound is inaudible. This is the usual fault and is due to the small .001 μf condensers having incorrect values. Try shunting *one* of them at a time by .0001, .0002, and .0003 μf condensers. As a last resort a trimmer or padder condenser may be needed, but that is very undesirable as they do not stay put sufficiently and cause bad drifting especially when the weather varies.

ADJUSTMENTS FOR QUALITY

Once the oscillator is working, the next step is to obtain good wave-form by reducing the shunt resistor between the 6K7 screen and chassis. Try shunts of 1, .5, .25, .1 meg., etc., until oscillation stops. Then connect in the smallest standard size that allows operation. This adjustment should be made at a fairly high frequency, say around 1000 or 2000 cycles and is facilitated if a cathode-ray oscilloscope is at hand to observe the waveform. Now the oscillator tuning control should be manipulated to determine the lowest possible frequency that can be produced. If locking-in occurs at too high a frequency, it may be due to imperfect grounding of coil cans, insufficient screening around gang, presence of r.f. in the output (cured by shielding of 6V6 together with a .00025-μf condenser from 6V6 plate to chassis) or an open by-pass condenser somewhere. Reduction in size of the 6K7 coupling condenser from .0005 to .0002 μf (or smaller) may help keep the circuits independent.

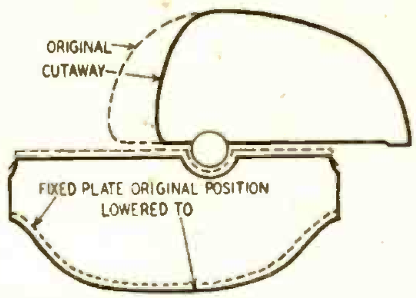

Fig. 3—How the condenser plates are shaped.

The particular oscillator shown had a wooden case and provided frequencies lower than 10 cycles per second. When a metal case is used, even lower frequencies can be obtained but care in shielding and wiring layout is most important. Frequency response of the output can be adjusted slightly by varying the capacities of the four condensers associated with the 6V6.

Calibration is best performed against an already calibrated oscillator by means of *Lissajou figures* on an oscilloscope, but other methods such as by beats and by bridges are also possible. Very accurate calibration at 20, 30, 45, 60, 90, 120, 150, 180 cycles can be obtained from an accurate 60-cycle supply.

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2000-ohm 5-watt resistor instead. Large filtering condensers and the extra filtering for the 6V6 screen also help. Ground returns are made to the No. 1 pin of the associated tube, all No. 1 pins being connected directly to the chassis by a short length of thick copper wire.

The plan view (Fig. 2) shows the general layout, with two tubes at each end (note the separation of 6K7 and 6J8) with a small vertical (40 milliampere) power transformer in between.

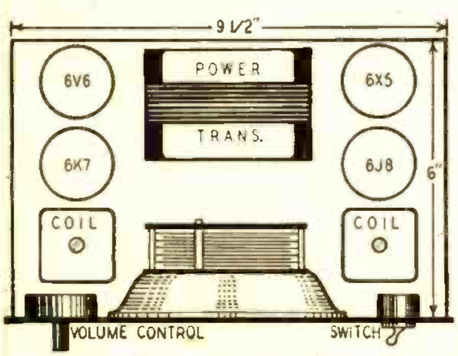

Fig. 2—The above layout should be followed.

Before any parts are mounted, the grid leaks and condensers must be connected inside the coil cans, the 6J8 triode decoupling arrangement also going inside a can if there be room. Chassis depth is only 2 inches, though this can be increased to 2¾ inches if bantam tubes are used.

The main variable condenser moving plates are filed away at the end which first meshes, as shown in Fig. 3, and the fixed plates are shifted farther from the shaft. The idea is to have only a very, very, slow increase in capacity at first. Half the moving plates are to be removed—usually they can be pulled out without much trouble.

The front panel is of Masonite with a crackle-black finish. A bracket going right across the back of the panel carries the dial, dial drive and variable condenser. Four thick metal-braid leads run from the condenser to the chassis.

The dial drive consists of a large pulley on the condenser shaft with a quarter-inch diameter spindle fitting in a hollow bolt in the lower right-hand end of the panel. To provide a good grip for the dial cord, a strip of adhesive tape is wrapped around the end of the spindle.

The zero-set 3 plate condenser must be shielded by a screen of steel, brass or copper.

ADJUSTING THE OSCILLATOR

If the oscillator fails to produce a sound when a PM speaker or a pair of phones is connected to the output there may be several explanations. In-