THE ELECTRONIC ORGAN

PART SEVEN

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VIBRATO: ELECTRONIC AND MECHANICAL METHODS

MODERN instruments rely greatly on the use of vibrato. This is partly because vibrato is an essential ingredient of romantic music; partly because it enhances the effect of certain tone qualities which would otherwise sound very dull and monotonous; and partly because it is a fashion or symbol of the times.

The word *vibrato* is of comparatively recent origin. It covers a multitude of sins because it can be frequency modulation, amplitude modulation, or a bit of both. Strictly speaking vibrato is equivalent to the tremulant on a pipe organ, first applied by the French; the word tremulant is a corruption of their expression *tremblant*. Because pipes are very sensitive to pressure changes, the device as normally fitted shakes the wind supply to certain selected ranks of pipes and this causes a considerable change in pitch, though not so much in volume. The effect is very agreeable if carefully used and when produced electronically, vibrato should give an equivalent result.

In some instruments only the volume is varied cyclically, and this is described as *tremolo*; an expression of Italian origin, intended to refer to the human singing voice. It is not so effective on organs as vibrato.

METHODS AVAILABLE

We can introduce the vibrato effect in two ways; either something can be done to the circuit to alter its characteristics as required; or a mechanical device can be applied to a loudspeaker to produce the desired result.

On account of the stability in tuning so easily attained with transistor generators, it is not always easy to swing the oscillators to the required extent. Further, in a frequency divider organ, all notes down to the lowest will be modulated, and as the frequency of vibrato commonly lies between 5 and 6Hz, pedal notes of 16ft pitch may be so modulated. This produces a most objectionable effect.

An alternative electrical method is to use a phase shift circuit following the generators, a necessity if these are of the vibrating reed or gear driven iron wheel type, since generators cannot be made to go off pitch. In such phase shift circuits, the pass band can be so adjusted that the bass is not modulated.

The last method, mechanical control of the sound waves, is the most effective from a truly musical point of view. Although only recently becoming popular, and heralded by some makers as a new invention, it is the oldest type of vibrato and was actually used in reed organs over 100 years ago! The forerunner of the present methods was the Everett Orgatron of 1935, whilst John Compton took out a patent for a rotating horn loudspeaker in 1936. Today, Donald Leslie's design is widely used in various forms, although the rotating unit devised by Jerome Markowitz in 1940 is a standard part of the American Allen organs; and more recently, there is the Compton Rotofon—an almost identical arrangement.

The foregoing represent all the means at present in use, although some ingenious alternatives have been proposed. So let us examine them in turn.

ELECTRONIC METHODS

In the majority of types of electronic organs which are likely to interest readers of this magazine, a Hartley type of oscillator is used as a prime oscillation generator. Although we will deal with transistor methods exclusively so far as the PRACTICAL ELECTRONICS organ is concerned, it must not be forgotten that there are thousands of valve organs in existence; therefore we show one transistor and one valve circuit in this article.

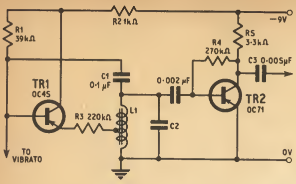

Fig. 7.1. Typical Hartley oscillator tone generator, with buffer and shaping stage to drive dividers

Because a transistor is substantially current operated, it is harder to produce a large change in the bias than in the case of a valve; and the "slope" of a transistor is entirely different from that of a valve. In Fig. 7.1 is shown a popular type of Hartley oscillator for organs. Other types vary only in detail. Differing voltages, etc. are merely due to the use of different kinds of transistor.

The base is the most sensitive element to modulate, so we find a connection which is normally floating, that is, not connected to anything, but which may be connected to a varying voltage supply through a high resistance which will not divert current from the oscillating circuit. Since the circuit shown delivers only a few volts to the load, it is possible to alter the frequency by injecting a few volts into the existing base bias. But this will very much depend on the kind of transistor used. It has long ago been found that there is an optimum value for the frequency of vibrato so produced, and this is about 8Hz. Many people prefer a slower rate of modulation, consequently vibrato oscillators are adjustable for frequency.

It is most important that the vibrato waveform be as sinusoidal as possible, otherwise harmonics may be injected into the oscillator proper and also, the swing must be equal either way. A sine wave vibrato is therefore desirable. This also has the merit that the rise and fall of the sound is truly continuous and is not held up at all during a cycle as can happen with a square wave multivibrator. The phase shift RC oscillator is widely used to provide the vibrato modulation but this kind of oscillator requires high gain transistors.

BRIDGED-T CIRCUIT

A very successful circuit is the tuned bridged-T shown in Fig. 7.2. This was originally described in the Wireless World for December 1962 by Mr F. Butler, and can be adjusted to give the frequency for vibrato modulation as shown in the diagram.

One point to note with this circuit is that the feed resistors form part of the oscillator proper, so all must be wired up (probably 12) before tuning. Advantage can be taken of this arrangement to vary the degree of vibrato for different oscillators if desired by raising or lowering the value of these resistors until the effect is judged most pleasing. There is provision for altering both the amplitude and the frequency, and since this latter is very low, the controls can be brought out to the console stop panel without trouble. The effect of this oscillator on the signal from a tone oscillator is shown in Fig. 7.3.

Turning now to the kind of circuit which follows a tone system, which in itself is not made to alter in pitch or volume, and is therefore applicable to any kind of electrical tone source, it is found virtually impossible to achieve the same simplicity circuit-wise and the simplest arrangement is given in Fig. 7.4. Unfortunately valves are required for this purpose, but there seems little reason why the circuit should not be transistorised. Filters are shown in the output stage to remove the switching transient and also to attenuate the bass.

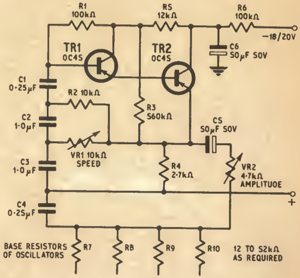

Fig. 7.2. Bridged-T vibrato sine wave oscillator

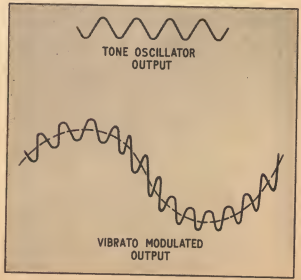

Fig. 7.3. Effect of vibrato circuit of Fig. 7.2 on tone oscillator waveform

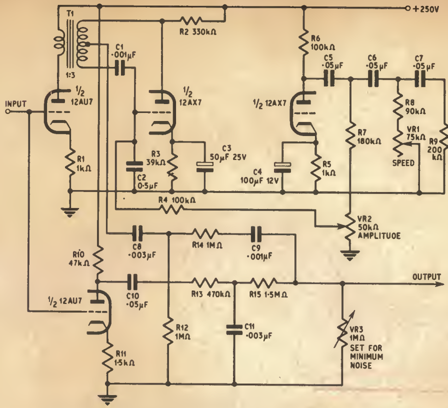

Fig. 7.4. Vibrato circuit suitable for following tone generators of any kind

Such vibratos have been used by Wurlitzer, Kinsman, and Schober, and have the merit that any signal not to be so treated need not be connected to the unit. Thus, one manual need not have vibrato, nor the pedal department, even with a common generator.

MECHANICAL METHODS

Mechanical means for modulating the tone always involve some device which alternately opens and closes the direct radiation path from a loudspeaker. The earliest types used flat paddles revolving in front of a cone, as in Fig. 7.5. This scheme is still very effective, but has the drawback that the vane might stop in such a position that the sound was blocked off. Experimenters who have not tried this very simple idea might like to investigate. The effect is very pleasing, improving of course as the frequency rises. The difference between the fixed rate of rotation and the frequency source will then be greater, since the effect is based on Doppler's theory which states that:

$$f \text{ (frequency at point of observation)} = \frac{V}{V - V_s} \cdot f_s$$

where V = velocity of sound in the medium (air)

V_s = velocity of source

f_s = frequency of source

Unless the vane is shaped to fit the cone, the degree or extent of the vibrato will not be great; and of course some part of the cone will always be exposed and not modulated. Therefore other ideas were investigated.

Fig. 7.5. Rotating paddle vibrato system

ROTATING SPEAKERS AND BAFFLES

Since tremulants are always most effective at the upper frequencies, early attempts involved rotating horn loudspeakers. This does away with the difficult problem of a baffle and ensures a high degree of cut off as the horn turns away. However, current must be fed into the circuit by some means and in the first attempts, slip rings proved troublesome. Then, to extend the response of the loudspeaker further down the scale, the size became a problem. This was solved in the Leslie devices, which are as numerous as they are varied.

Two basic types exist; one which rotates a small loudspeaker without a baffle; and one in which the speaker is stationary and a shaped baffle rotates above or below the cone. A baffle is generally used in this arrangement. The small units which themselves rotate are fed with the signal from a transformer with a

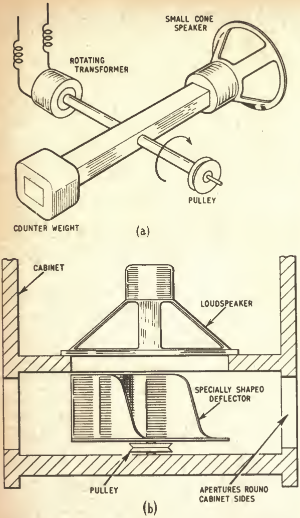

Fig. 7.6. Illustrating the principle of, (a) small and (b) large, Leslie speakers

rotating winding; in the case of the larger units, connections are of course normal. Driving motors may have more than one speed, since except for the American Allen, a.c. motors are used and the speed is not so easily controlled.

Taking the Leslie units first, both patterns are shown in a basic form in Fig. 7.6. The smaller units (Fig. 7.6a) turn rather fast, but produce a very complex radiation pattern which is most effective on high notes. The larger units (Fig. 7.6b) are more generally effective, and some makers fit them inside the console. One obtains true modulation of both pitch and volume, and this is why they sound better than any electrical means of tone modulation. But why they should be so expensive is a mystery.

A rather different approach is taken by the Allen organ company and also the Compton organ company. Here we find several loudspeakers mounted on a circular baffle which must be of large size. This assembly is rotated as a whole inside a large box open at the back and there is no real attempt to make an airtight seal between the rotor and the case. Current is fed in by slip rings. Several channels can be wired

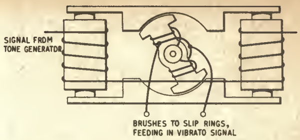

Fig. 7.7. Early Constant Martin tremulant device

into the unit, and because of the large arc described by the loudspeakers, the sound appears to move from side to side rather in the manner observed with a pipe organ when near at hand.

Apart from the main use as a vibrato device, it is found that if the baffle is turned very slowly, the spread of sound has a spacious quality which imparts a suggestion of a large room. Used with reverberation of the right kind it is therefore a useful adjunct to the organ, but it is not effective unless of large size. Of course, electrical vibrato can be added to any of these mechanical devices, when all kinds of effects become possible.

AN EARLY DEVICE

An early attempt to introduce modulation after the tone generators was made by Constant Martin, who used the ingenious little device shown in Fig. 7.7. The signal from the generators passed through the "field" coils on its way to the amplifiers, whilst the vibrato voltage passed through the armature windings, and so was superimposed on the main signals. A small motor drove the armature. ★

Book review

BASIC PRINCIPLES OF ELECTRONICS AND TELECOMMUNICATIONS

By M. D. Armitage
Published by George G. Harrop and Co. Ltd.
390 pages, 5½in × 8¾in. Price 30s

THIS is the second edition of a popular textbook first published in 1961. Completely revised and with a considerable amount of additional text, this book must be a natural choice for the second-year technical student intending to cover the "Principles A" syllabus of the City and Guilds of London Institute's Telecommunications Technicians' Course (No. 49).

As a class work adjunct, or as a tutor text, for those who might sit this examination as external candidates, this will prove more than adequate in covering the syllabus requirements.

Liberally illustrated and with numerous worked examples, each chapter is completed with a set of questions, many of them from part C.G.L.I. examination papers, and answers which are contained at the back of the book. G.M.H.