USING THE WOBBULATOR

METHODS USED TO SWEEP THE FREQUENCY, AND TO CALIBRATE THE DISPLAY

By R. Brown

ANYONE who has had the task of aligning a wide band I.F. amplifier with the aid of a signal generator and an output meter has felt the need for something better. This task is one we all seem to come across sooner or later, and it is one which frequently ends in frustration and a bady finished job. It is here that the frequency swept oscillator, or wobbulator, really proves its worth. Using this instrument, with an oscilloscope, even the most complicated of I.F. strips can be accurately aligned in a very short time.

Curve Display

With a wobbulator we can display, on the oscilloscope screen, the response curve of the amplifier. Any adjustments we make to the trimmers in the amplifier, will alter the response curve, and this change can be seen immediately.

The basic arrangement for displaying the response curve is shown in Fig. 1. The timebase voltage from the oscilloscope is fed into the wobbulator sweep circuit, where it sweeps the frequency of the oscillator across the pass-band of the I.F. amplifier. The output from the I.F. amplifier is detected, and taken to the " Y ", or vertical, plates of the oscilloscope. The "X", or horizontal, deflection will thus be proportional to frequency, while the " Y " deflection will be proportional to the I.F. amplifier gain.

Sweep Circuits

There are three methods which are normally used to sweep the oscillator frequency. One method is to vary mechanically the capacitance of the tuning condenser. This can be achieved by rotating the rotor using an electric motor, the motor being driven by the timebase. Alternatively, a small mechanically variable capacitor can be constructed, and connected in parallel with the main tuning condenser. The capacitance of this unit can then be varied by some form of vibrator—the voice coil of a loudspeaker makes an excellent vibrator.

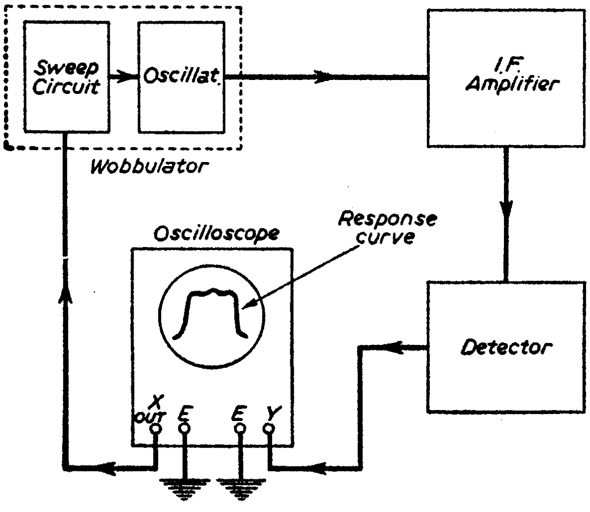

Fig. 1—Displaying the response curve of an I.F. amplifier.

The fault with this type of sweep circuit is that it is very difficult to vary the sweep width—a disadvantage which considerably reduces the usefulness of the instrument. The other two methods of sweeping the frequency are electronic, and do not suffer from this disadvantage.

The first of these electronic sweep circuits is the reactance valve modulator. This is a single valve circuit which is connected across the oscillator tuned circuit. To the tuned circuit it appears as a variable capacitor—a capacitor the value of which varies in step with the oscilloscope timebase.

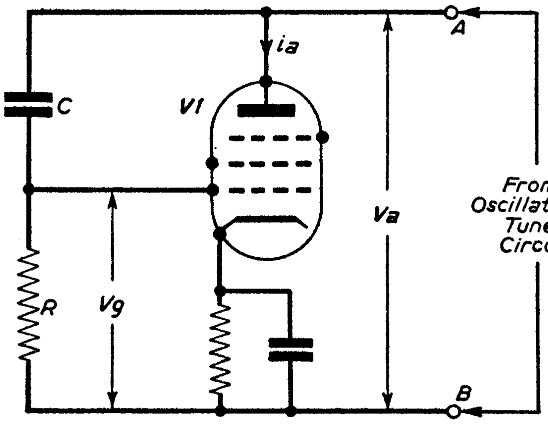

Fig. 2—A reactance valve sweep circuit.

Operation

The circuit of a reactance valve is shown in Fig. 2. When this is connected across the tuned circuit, an oscillating voltage, Va, from the tuned circuit, will appear across A and B, and, therefore, across C and R in series. The value of C is chosen so that, over the frequency band in which the modulator works, its impedance is very much greater than the resistance of R. The current which flows through C and R thus leads the voltage, Va, by almost 90deg. The voltage, Vg, which is developed across R, will be in phase with this current. Vg is the input voltage to the grid of the valve, and the anode current, Ia, produced as a result of Vg will be in phase with it. Thus the oscillating anode current Ia will lead by 90deg the oscillating voltage, Va, which produced it. Thus, as was said earlier the valve looks like a capacitive reactance.

The valve actually looks like a capacitor the value of which is given by CRgm. Thus by varying gm we can vary the value of this capacitor, and, therefore, the frequency of the oscillator. This is done by first choosing a variable-μ valve for V_1, and then applying the sweep voltage to the grid of the valve.

The reactance valve is particularly suitable for narrow sweep working. For large sweep/widths a ferrite modulator can be used. This consists of a small ferrite core, which carries an R.F. winding forming part of the oscillator circuit inductance. The ferrite core is placed in the gap of a Ni-Fe core, which carries the sweep voltage winding and a D.C. polarising winding. This is shown in Fig. 3. How the modulator works can best be seen with the aid of Fig. 4. This shows the upper portion of the B/H curve of the ferrite core.

Calculation

Supposing we first of all apply the D.C. polarising voltage, and let it have a value such that it produces a field strength of 10 oersteds. From Fig. 4 it can be seen that this will produce a flux density of 1020 gauss. The permeability of the ferrite core is given by B/H and is 1020/10=102.

Suppose now we apply an alternating sweep voltage such that it causes the field strength to vary continuously from 7 to 13 oersteds. The flux density will now vary, along the line ABCDA. When the field strength is 6 oersteds, point C, the flux density will be 1180 gauss. This gives a permeability (B/H) for the ferrite of 1180/7=168. When the field strength is 13 oersteds, point A, the flux density will be 1380 gauss. Which gives a permeability of 1380/13=106. Thus the effect of connecting the sweep voltage has been to cause the permeability of the ferrite core to vary continuously from 106 to 168. But the inductance of the R.F. winding is directly proportional to the permeability of the ferrite core. Hence the sweep voltage varies the inductance of the R.F. winding, and as this forms part of the inductance of the oscillatory circuit the oscillator frequency will vary.

Calibrating the Display

Useful as is the display produced by the set up shown in Fig. 1, it does only give us the approximate shape of the response curve. If work of any accuracy is to be done some means of calibrating the frequency and amplitude scales must be provided.

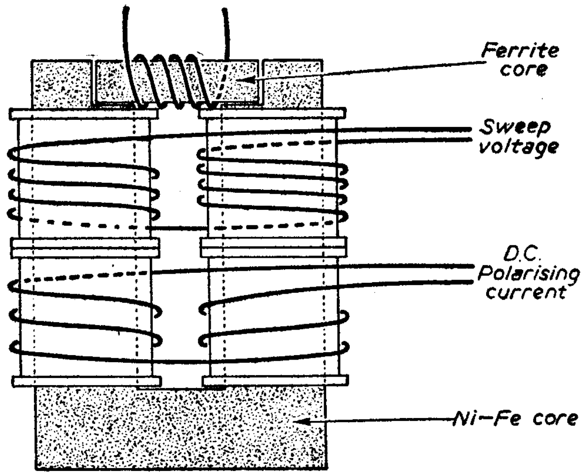

Fig. 3—A ferrite modulator.

There must first of all be some means of determining the position on the display which corresponds to zero output from the I.F. amplifier. It will not always be possible to view the frequencies at which the I.F. amplifier response has fallen to zero, so this cannot be relied upon to provide us with a datum line. The usual practice is to pulse-modulate the oscillator in such a way that it is switched off on alternative scans of the oscilloscope. In this way the oscilloscope will show the I.F. amplifier response on one scan, but on the next scan the oscillator will be switched off, and the oscillator will show a straight line—a straight line which corresponds to zero output from the I.F. amplifier. A rough estimate of the relatives amplitudes of the various points on the response curve can now be made from this display.

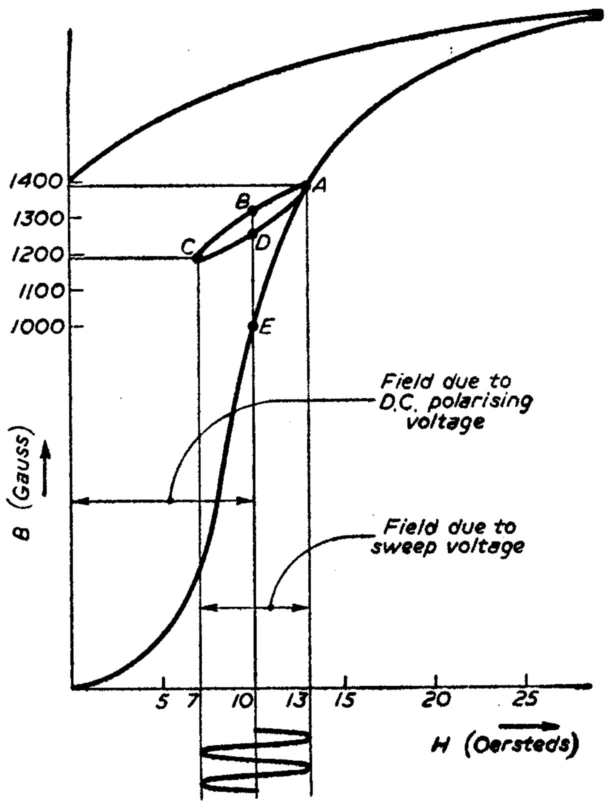

Fig. 4—Hysteresis loop of ferrite core with sweep voltage and polarising fields.

The graticule of the oscilloscope can, however, be calibrated much more accurately if the wobbulator is fitted with an attenuator, or, if an external attenuator is fitted between the wobbulator and the amplifier. This can be carried out in the following way. A line is first drawn on the graticule through the points corresponding to maximum output from the I.F. amplifier. Then the attenuator is used to reduce the wobbulator output by 1dB. A line is then drawn through the new position of the top of the displayed response curve. The output from the wobbulator is reduced in further steps of 1dB, and a line is drawn at each step. The wobbulator output is then restored to its maximum value, and the relative amplitudes of the various points on the display can be measured using the series of 1dB lines that have been drawn.

(To be continued)

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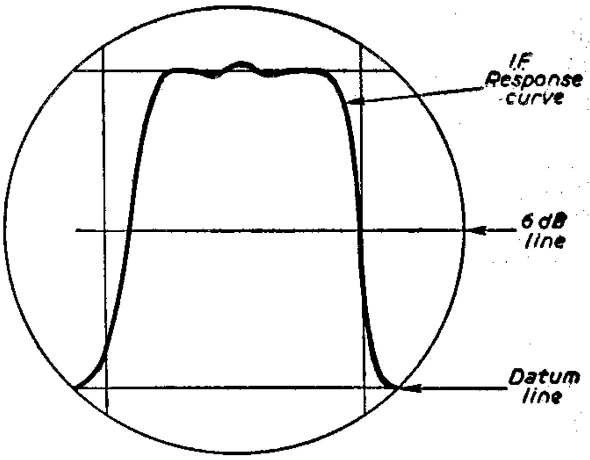

Fig. 5.—Assessing relative amplitudes within the display.

IN the previous article, the y-axis of the display on the oscilloscope was achieved by using an attenuator between the wobbulator and the 'scope. The frequency axis of the display must now be calibrated. This can be carried out in a number of ways. One method is to couple a signal generator into the input of the I.F. amplifier. When the wobbulator frequency coincides with the signal generator frequency a beat will be produced, which will be clearly visible on the display. This is shown in Fig. 6a. If a crystal oscillator, or one of the crystal calibrators used to check the frequency of transmitters and signal generators, is available this can be coupled into the input of the I.F. amplifier instead of the signal generator. If the crystal oscillator has a frequency of, say, 1 Mc/s, or better still 0·25Mc/s, the wobbulator will beat with the individual crystal harmonics, to produce a series of very accurate markers. Fig. 6b shows this. An absorption type wavemeter can be used to produce yet another type of marker. A type of marker which is termed a passive marker. The wavemeter is coupled into the input of the I.F. amplifier, as was done with the signal generator. When the wobbulator frequency equals that of the wavemeter, some of the output from the wobbulator will be absorbed. The input to the I.F. amplifier will be reduced, and a small dip will show up in the displayed response curve (Fig. 6c).

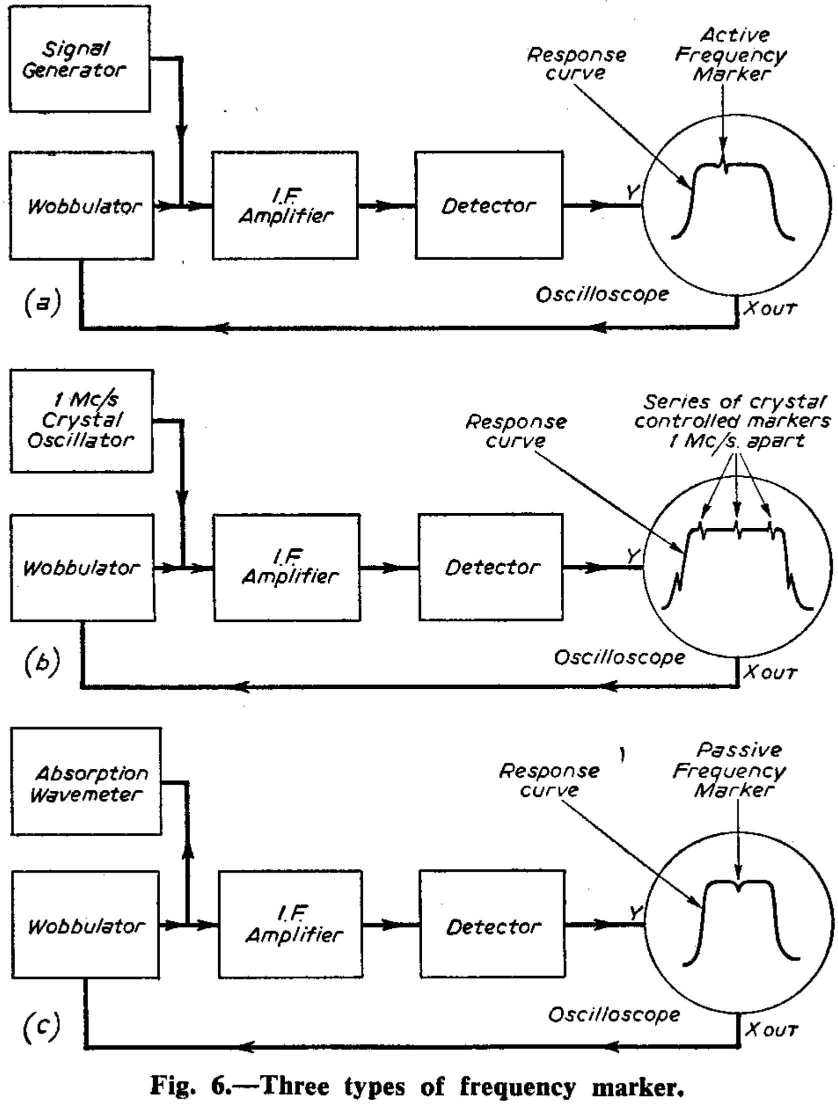

Fig. 6.—Three types of frequency marker.

Frequency markers produced by any of these three methods pass through the equipment under test. The result of this is that their displayed amplitude will depend upon the gain of the equipment under test. If they are adjusted to be of reasonable amplitude on the top of the response curve, it may be very difficult to see them on the skirts of the response. And, if they are adjusted to be easily visible on the skirts of the response curve, they will be so large on the top of the response curve that they will seriously distort the display.

This problem can be solved by using a slightly different method of mixing the frequency calibrating source with the wobbulator output. In Fig. 8, a small portion of the wobbulator output is tapped off and mixed separately with the output from the frequency calibrator. The frequency markers produced are then taken direct to the oscilloscope and mixed with the demodulated output from the I.F. amplifier. The amplitude of the markers is thus independent of the gain of the I.F. amplifier, they are of constant amplitude, appearing on the display even at frequencies right outside the passband of the I.F. amplifier.

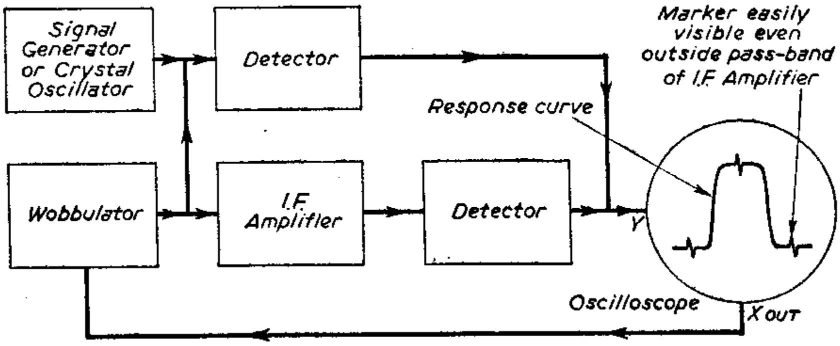

Fig. 8.—Producing markers that by-pass the equipment under test.

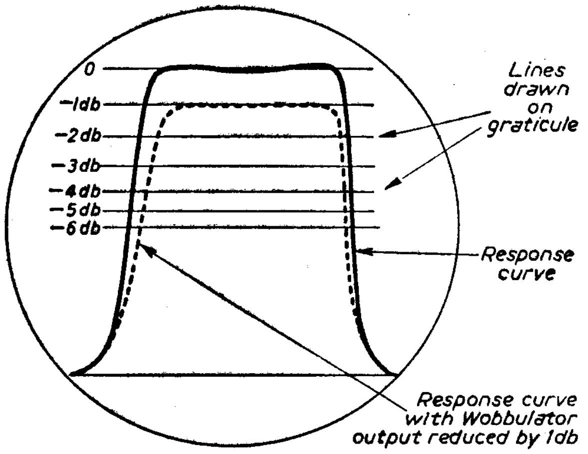

Fig. 7.—Calibrating the C.R.T. graticule using an attenuator.

Intensity Modulation

The distortion of the display, which has already been mentioned, is something which occurs with all of the systems of producing markers that have so far been described. A frequency marker amplitude control is essential; but even if the amplitude of the marker, or markers, is reduced so that it is barely visible the distortion can be a nuisance. This distortion can, however, be avoided provided that one is prepared to go to more trouble and expense when constructing the frequency calibration circuits.

A suitable arrangement is shown in Fig. 9. This is similar to the set up shown in Fig. 8. The beats between the wobbulator and signal generator, or crystal oscillator, are detected, as before; but instead of being taken direct to the " Y " input of the oscilloscope they are taken to a pulse shaping circuit. This pulse shaping circuit converts them to very narrow pulses. These pulses are then used to intensity modulate the oscilloscope. So that the beam is blanked off whenever a pulse occurs. The blank spots produced can be made very sharp indeed, and they give a distinct mark which does not distort the display.

A Word of Warning

Enough has been said to show the very real usefulness of the wobbulator, and the comparative ease with which an accurately calibrated display can be achieved. As with all electronic measurements, however, certain precautions are necessary. The greatest source of possible error is having too fast a sweep speed. If the sweep speed is too fast the voltages in the tuned circuits will not have sufficient time to reach their maximum amplitude, and the displayed response curves will appear to have a lower amplitude than the true response curve. It will also appear to be shifted slightly in the direction of the upper frequency end of the display. If it is suspected that this sort of thing is happening, it can be checked by reducing the sweep rate. If the shape of the response curve changes then the sweep rate was too fast, and it should be reduced until no further change occurs.

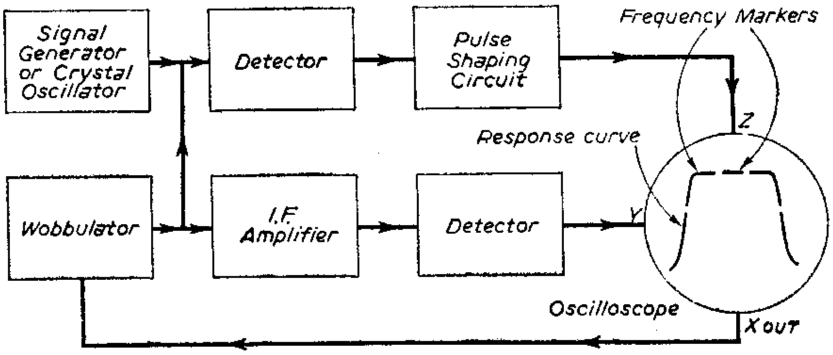

Fig. 9.—Using frequency markers to intensity-modulate the display oscilloscope.