Vintage Radio

Early test equipment - *continued*

As part of a continuing look at vintage test equipment, this month we examine some early modulated oscillators and cathode-ray oscilloscopes.

The need for a source of RF energy for the purposes of adjusting a radio receiver was established in the late 1920s. With the advent of the 'single dial' tuning control, the listener-in no longer had the option/chore of individually adjusting each tuning capacitor for optimum results — but conversely the internal tuned circuits had to be adjusted to 'track' each other properly. This was especially the case with superhets, where need to adjust oscillator tracking is quite crucial. A neutrodyne also had to be carefully adjusted if it was to work properly.

The usual method was in each case to tune to a convenient radio station and then make the adjustments. However it was soon realised that merely to select a suitable radio station was unreliable, particularly if the highest frequency available was only say 1000kHz.

Another important consideration is that convenient signals could often be too strong. So there arose a definite need for a convenient local source of RF signals, at various frequencies.

Early test oscillators

Fig.1 shows the circuit for an early US attempt at an RF test oscillator. The circuit is a basic Hartley oscillator, self-modulated by the high value of grid leak resistor (3M) in conjunction with the 250pF grid capacitor. The value of grid leak in particular will determine the pitch of the modulation tone.

Note the novel means of, quite literally, 'lighting' the 201A valve! The 25 watt bulb in series with the 110-volt supply will pass just under 0.25 amp, a near-enough figure for the purpose.

One could be forgiven for assuming that the fluctuating AC on the valve's filament would superimpose its own form of 50Hz (or for the USA 60Hz) modulation upon the already modulated signal. After all, the 201A was a directly-heated valve. However, if the truth be known, the very early electric sets had very poor filtering indeed and were prone to hum themselves — so what is the problem with the RF oscillator adding a bit more?

TABLE 1: AWA C1070 Oscillator Ranges & Output

Range	X Factor	Frequency	Max RF out
A	1.4	96 - 250kHz	400mV
B	1.0	240 - 600kHz	300mV
C	1.0	0.56 - 1.42MHz	300mV
D	0.5	1.36 - 3.33MHz	150mV
E	0.2	3.12 - 8.10MHz	60mV
F	0.08	7.90 - 20.0MHz	25mV

Another point is that the early speakers were so poor in bass response that they simply didn't work at 50Hz, anyway!

Despite its crudity the early circuit of Fig.1 did have a couple of refinements. It was fully enclosed in a metal box, although the coil should have been shown outside the dotted line, because the coupling between oscillator and set was via stray coupling from the large diameter coil. The other refinement was the use of RF filter chokes in series with the AC mains cord, in order to keep the RF in; otherwise the chord itself acts as a transmitting antenna.

There is no attempt at an attenuation control, and one assumes that the tuning would have been calibrated by hand, using either known signal frequencies or by comparison with a more sophisticated instrument.

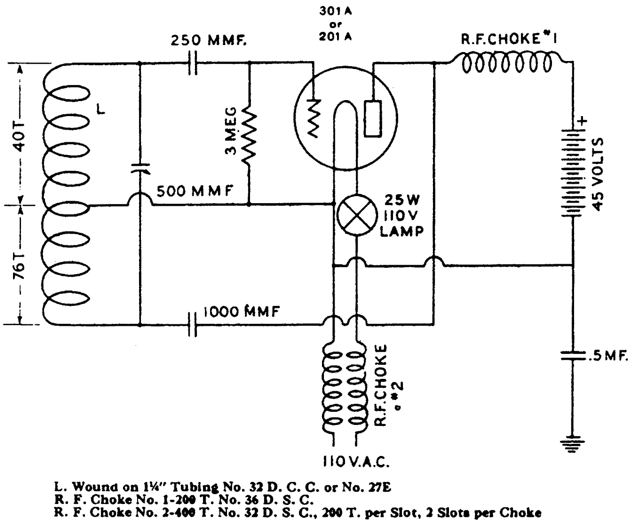

Fig.1: An early modulated oscillator circuit of 1928 or so, from the Radio Service Manual 1930, reprinted in 1984 by Vestal Press, New York.

by Roger Johnson

The AWA C1070

One of the earlier Australian factory-built modulated oscillators is the AWA C1070, which appeared in the literature for 1936. It was described by the manufacturers as '...able to carry out the following tests rapidly and with ample reserve of accuracy'.

Specifically designed for servicemen and 'the trade' rather than the home constructor or experimenter, this instrument was not cheap; it sold for 14 guineas. But amongst its glowing list of claims are:
(1) Determining the stage gain in RF or IF amplifiers;
(2) Testing of valves for performance under working conditions; and
(3) Determination of image ratio, spaced amongst the more mundane jobs such as dial calibration and peaking tuned circuits in superhets and TRF's.

There is some basis of claim for the list of capabilities. Firstly, there is a fully calibrated rotovision dial — which incidentally is the same escutcheon etc. used on the 1935 range of receivers. The calibration accuracy is claimed to be better than 1% on the lower ranges, and within 2% on the others. The frequency coverage is from 100kHz to 20MHz in six switched ranges.

Most importantly, though, is the use of an attenuator, with the output range calibrated from 1 microvolt to 300 millivolts. For the various ranges, a multiplying factor is applied to the attenuator setting per Table 1.

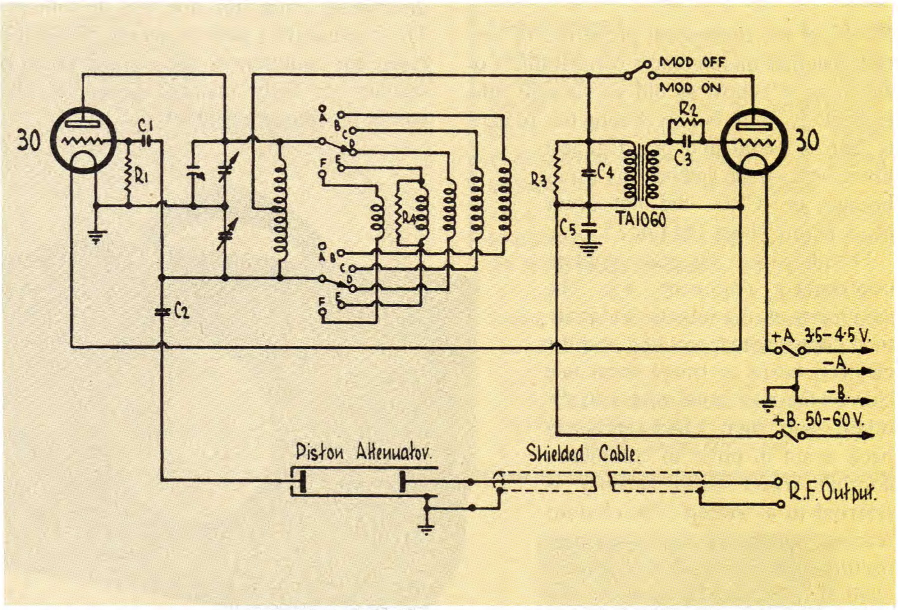

Fig.2: The circuit for the AWA C1070 modulated oscillator, as published by the makers in 1936.

Construction

Like the unsophisticated unit of Fig.1, the C1070 is fully enclosed in a metal case and the manufacturer claimed that leakage cannot be detected except at about 20MHz, where it is less than one microvolt. (Such figures could not be claimed for budget priced instruments for the next 50 or so years, especially ones intended for AC mains operation — regardless of whether they are solid state devices or not!)

To achieve this, battery type valves were chosen, and the dry batteries are fully contained within the case. There is a little panel at the side containing test sockets for convenient checking of the battery voltages.

It is stressed that the special shielded cable must be used, otherwise the attenuation calibration will be disturbed.

The C1070 circuit

The circuit of the C1070 is again based on a Hartley oscillator (Fig.2), with switched coils covering the frequency ranges. The modulation section looks to be a tuned plate oscillator in which the frequency is, according to the text, determined by the air gap of the special modulation transformer.

Presumably grid components R2 and C3 are chosen to prevent squegging, and C4 has been chosen for an optimum LC ratio. The piston attenuator is an elaborate form of a small value variable capacitor. Curiously, no component values were given in the circuit diagram, which is taken from the original manual.

Fig.3 shows how the C1070 looked in a contemporary advertisement, while Fig.4 is a photo taken inside an example that is currently being restored. The modulation transformer and piston attenuator are clearly visible.

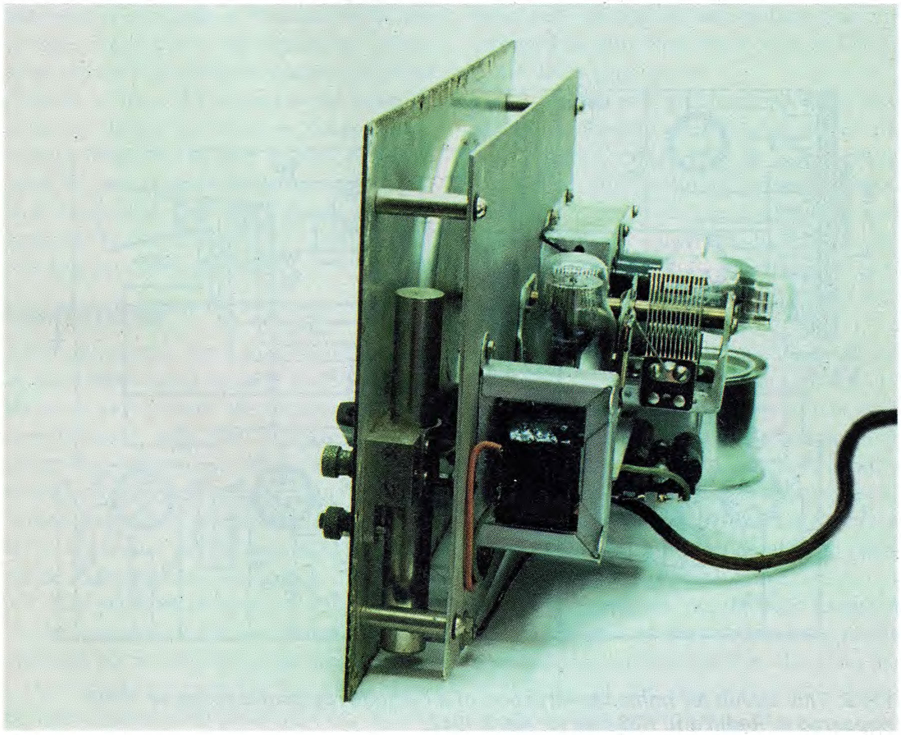

Fig.4: The 'works' of a C1070 removed from its cabinet, for restoration. The piston attenuator is the vertical tube in the left foreground.

Early CROs

No doubt the fluorescent properties of certain materials undergoing a bombardment of electrons is almost as old as vacuum tube technology itself, but harnessing this property into a useful and practical test instrument — the cathode-ray oscilloscope or 'CRO' did not occur much before about 1934 or 35.

Possibly the biggest problem confronting engineers was the development of a reliable and practical circuit which would cause the electron beam to travel from one side of the horizontal plates to the other, and then instantaneously back again in order to commence another trace. Such activity is referred to a 'sweep', for obvious reasons, and the sweep circuit in an oscilloscope is crucial to its practicability. (Because it provides the 'timebase', or time axis for the displayed waveform.)

One of the very early attempts was to use a continuously rotating potentiometer, driven by a small electric motor at constant speed, connected across a high voltage supply. The rotor was connected to one of the deflecting plates, and during its rotation the voltage was closer to one end of the potential or the other, depending upon its instantaneous position. By this dubious means, the horizontal trace was achieved.

The Thyratron

For an oscilloscope to be useful, it needs a reliable and linear sweep circuit, calibrated amplifiers, and a reliable high voltage source. The first of these requirements was achieved in early CROs by the use of the *thyratron*, or gas filled triode.

If we look at the circuit for a home construction CRO of 1942 shown in Fig.5, the thyratron is V3, a type 884. This tube and its octal equivalent were standard fare for CRO's for years to come.

The thyratron valve contains a small amount of ionising gas. At a certain critical voltage between anode and cathode, which can be determined by the grid (or cathode) bias, the gas will ionise and conduct current. Hence, the B+ supply, via resistors R14 and R15, charges up one of the capacitors selected by S3. When this capacitor is fully charged, that voltage appears at the plate of V3.

When the gas inside ionises, it conducts from anode to cathode. The associated capacitor is then discharged, and its voltage drops sharply. Once the anode potential has been removed as a result of the discharged capacitor, the gas de-ionises. The conductivity path is removed, and the capacitor commences recharging. Once it reaches its fully charged potential, the whole process is repeated.

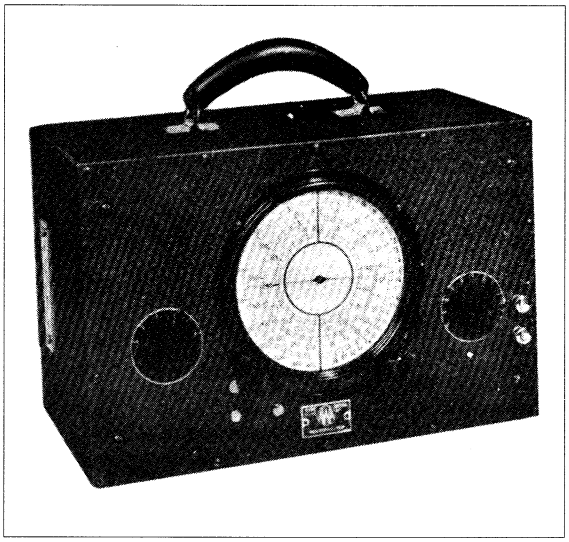

Fig.3: How the AWA C1070 oscillator looked, from a contemporary advertisement.

The 'output', for want of a better term, from V3's anode appears at the horizontal deflection plate of the type 902 CRT after amplification by V4. The opposite plate is earthed.

This fluctuating voltage must as nearly as possible be sawtoothed in shape, and definitely not sinusoidal or any other form of variable shape. The electron beam must travel at a constant speed across the screen, and this can only be achieved if the changes in electrostatic potentials upon the deflection plates are quite linear. Otherwise, distortions occur in the resultant waveforms displayed on the tube.

The frequency at which this occurs depends upon the time constant of R14/15 and the associated C selected by S3. The switching is used in order to select various sweep ranges. In order to generate a linear waveform, which this circuit only approaches, 'R' must be high and 'C' must be low. A high RC time constant means a low speed across the tube.

The limitations of this timebase circuit mean that waveforms above about 20kHz simply cannot be displayed with any form of accuracy, so the timebase circuit was limited to just that.

HV power supply

The CROs of this era required a high negative potential supply for the tube cathode and focus grid, in addition to the more conventional B+. This was achieved using an additional winding continuing on from the normal high voltage winding, and using a separate rectifier valve which is connected in reverse mode. The extra high voltage winding is connected to the cathode, and the load appears between anode and earth. A

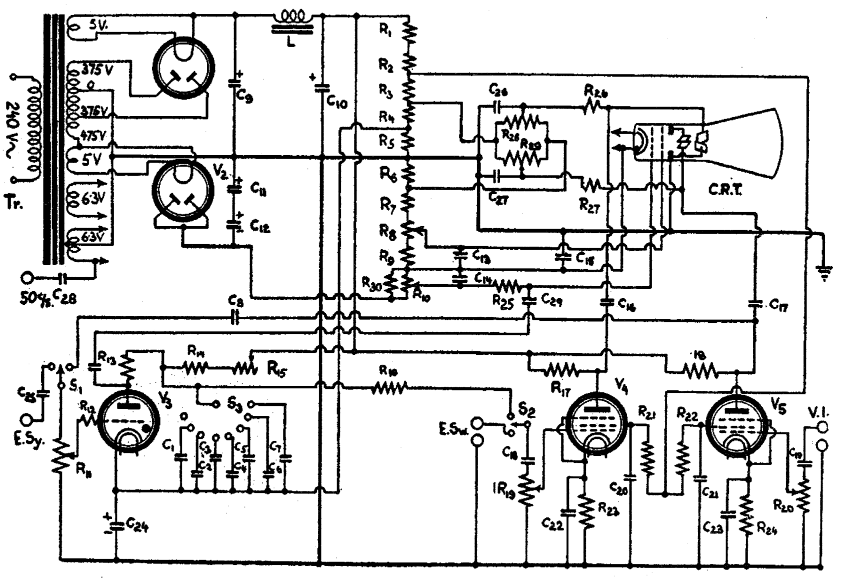

Fig.5: This circuit for home construction of a cathode-ray oscilloscope or 'CRO' appeared in Radio and Hobbies for April 1942.

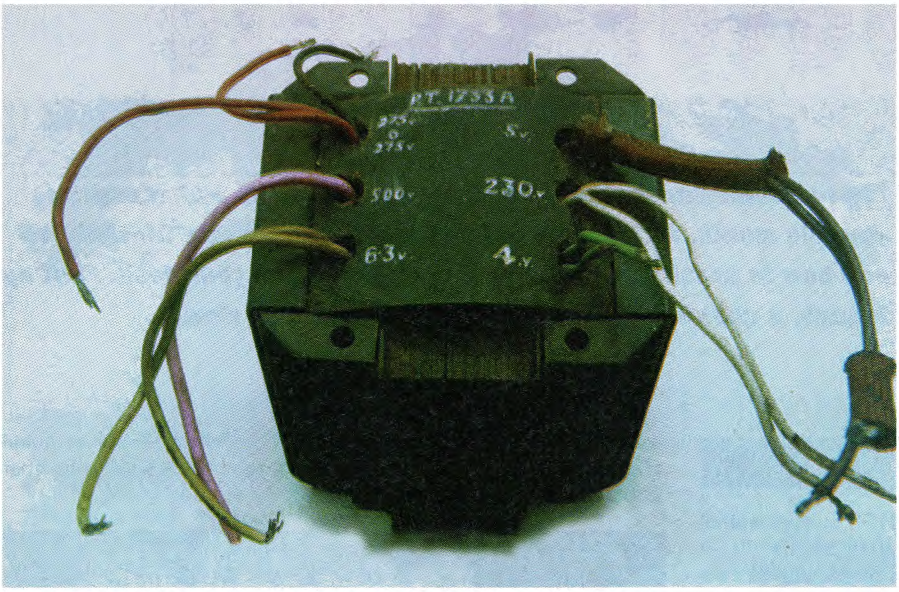

Fig.6: A power transformer designed for an early valve CRO. The additional high voltage winding lead can be seen at centre left.

high negative output voltage is available at the anode.

Notice that separate heater windings are required on the transformer, for the two rectifiers. An example of a transformer with this additional winding is shown in Fig.5.

(For those who are confused about how this works, take heart, because in a future column there will be a complete treatment of diodes, their applications and how they all operate. At this stage, though, please be assured that this circuit does work!)

Back to our CRO. A large negative potential is available at R10 and R30, and progressively down the resistance chain. This negative potential is connected to the cathode of the CRT (cathode-ray tube), in order to charge the electron stream sufficiently negative, so that it may be acted upon by the various focusing and deflection electrodes. The CRT needs its own separate filament supply — yet another winding on the transformer.

Limitations

All oscilloscopes, from these humble types to the latest digital storage varieties, have the same requirement: the timebase must be synchronised with the incoming signal. Otherwise, the trace produced would be a haphazard jumble. Internal 'Sync' on our subject instrument was achieved by the pot R11, connected via S1 and C8 from the anode of the vertical amplifier to the grid of V3. This fed some of the signal to be viewed to the thyratron grid — which worked, although not as reliably as one would like.

As you can see from Fig.4, a single stage of uncalibrated amplification (V4, V5) is used for each of the horizontal and vertical inputs to the CRT. The tube in itself has a frequency response limitation, and the gain of the amplifiers falls drastically above about 100kHz. The output of each stage is connected via C16 and C17 respectively, to their various deflection plates.

Whilst nowadays we may look at one of these early CROs in stunned amazement, 60 years ago they were drooled upon. As has been previously stated, the frequency range was limited to 20kHz, or in the audio range only. The amplifiers were not calibrated, and neither was the sweep. Not only that, there was no facility for DC signal input!

Despite all this, technicians of the day would use them to compare one waveform with another, rather than as a measuring instrument for obtaining precise results. Much more use of the horizontal input was made, whereby circular and elliptical traces were obtained, and duly interpreted. This is a forgotten art, and perhaps worthy of further explanation in the future.

Perhaps the biggest limitation was one of size. The most common CRTs were the 1" type 913, the 2" type 902 and the 3" type 903. Those three types represented about the limit of tubes for the home constructor, mainly because of cost — not just for the tube itself, but also the associated circuitry and hardware required. The transformers required to operate a larger tube were prohibitive.

The foregoing was not intended to give a detailed account of the two test instruments we've discussed, but rather to illustrate the technology of the day and give you an insight to their performance. ❖