Several observations similar to those of Fig. 15, however, revealed that important noise generally appeared in the sole current pulses, but that high noise in the cathode current pulse usually appeared only simultaneously with noise on the anode voltage pulse. Consequently, the variations of the anode voltage caused by noise at the sole seem to be the main reason of excess noise in these cathode optics. In that case the impedances of the circuits formed by the connectors and capacitors of the electrodes, particularly those of cathode and sole, are exceedingly important.

An example of a noisy sole current pulse and a noise free cathode current pulse is shown in Fig. 17, which presents oscillations or noise immediately before starting current is reached. In this case, the secondary emission and noise at the sole are increased with increasing anode voltage, but not yet to values such that anode voltage and cathode current are affected.

As the agreement between measured and calculated currents was good, the starting currents high and the noise from the cathode low, we can for good reasons suppose that these cathode optics emits an electron current very closely corresponding to the Brillouin steady flow for this geometry.

There is much more to be said about crossed-field devices with this geometry. However, I hope that the examples mentioned might have given some explanation of connected problems, and perhaps in certain cases contributed to their solution.

Acknowledgement

The author gratefully acknowledges the technical genius of K.R. Nygren in his assistance during the measurements and in the treatment of obtained measurement data.

The coaxial crossed field tube

J. Arnaud*

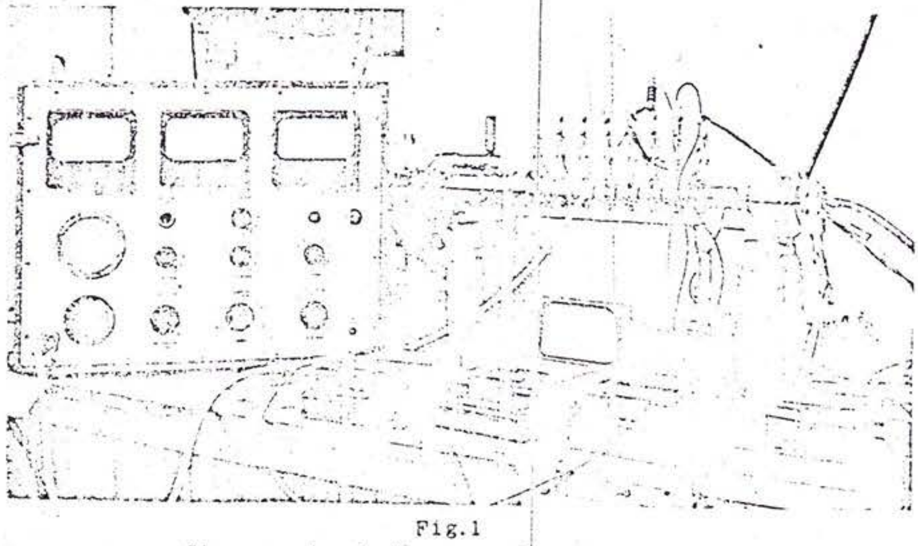

Fig. 1

Photograph of the coaxial optical system

In the coaxial crossed field tube** the magnetic field is not uniform but created by a large current flowing in a cylindrical rod; the delay line and the sole are also coaxial cylinders. Two possibilities exist: the delay line may be the inner or the outer conductor; in the 'L' band and at higher frequencies the size of an inner delay structure would involve too large a current; this solution would be interesting only for lower frequencies. The tube which will be described here is an experimental pulsed forward wave amplifier operating in the 'L' band; it is designed to give an output power of 0,6 MW; the beam impedance is very low, the cathode current being 53 A for a cathode volt-

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age of 28 kV; it results from this, that the delay ratio is unusually high for this peak power: it is 13 in the middle of the band. The copper stub in which the current flows constitutes also the sole the diameter of which is 14 mm. The line diameter is 32 mm and its length is 64 cm or 39 delayed wavelengths.

Let us consider at first the gun; the cathode is an oxide cylindrical cathode having the same size as the sole, and a length of 10 mm. An optical system has been built to study the perveance and the noise condition in such a gun; it is shown in Fig.1. One sees mainly the set of anodes with which is measured the anode current distribution and the noise amplification along the beam; at the left is the heterodyne voltmeter which measures the noise spectrum. The currents and the noise is plotted versus the magnetic field in Fig.2, the noise modulation corresponding to a bandwidth of 4 KHz; the most important result is that the beam is noiseless up to B/B_c = 1,4; consequently, the transmission collector current over cathode current is very near 100% in the range of B/B_c 1 to 1,4.

Fig.3 the noise modulation of the collected current for a bandwidth of 4 KHz is plotted versus the distance to the gun; the dotted lines correspond to a small initial noise; on the contrary the full lines show that for high magnetic fields the beam is saturated by noise even near the gun.

Let us now consider the delay structure; the perimeter being 10 cm this implies the use of a double ladder line. The mean power to be dissipated being 1 to 6 kW, this implies water cooling of the bars themselves; the bars are copper pipes of 3 mm external diameter curved

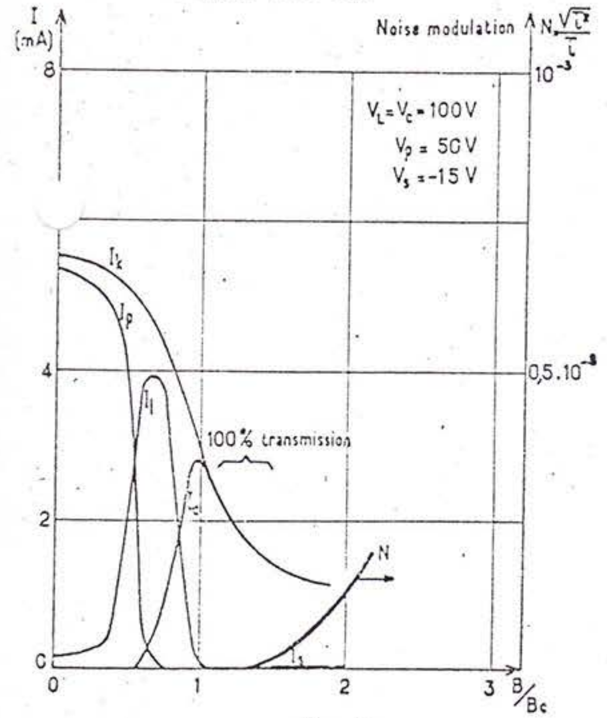

Fig.2
Currents on the electrode and noise modulation versus the magnetic field

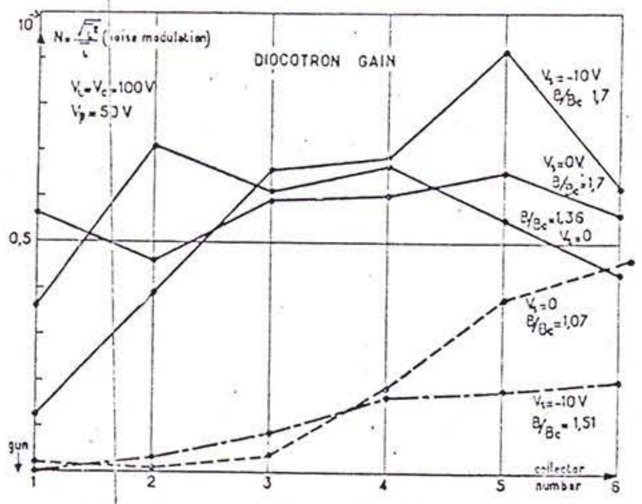

Fig.3
Noise versus the distance from the gun (diocotron effect)

according to a half circle. They are shown in Fig.4 which is a photograph of the cold test system. One sees the central cylinder figurating the sole. The coupling impedance is shown in Fig.5 versus the angle at left; the variation is rather important; the mean coupling impedance is plotted versus the wavelength at right on the same figure. If we take into account to width of the structure we find that this is an usual value.

We found that it is necessary to strap together

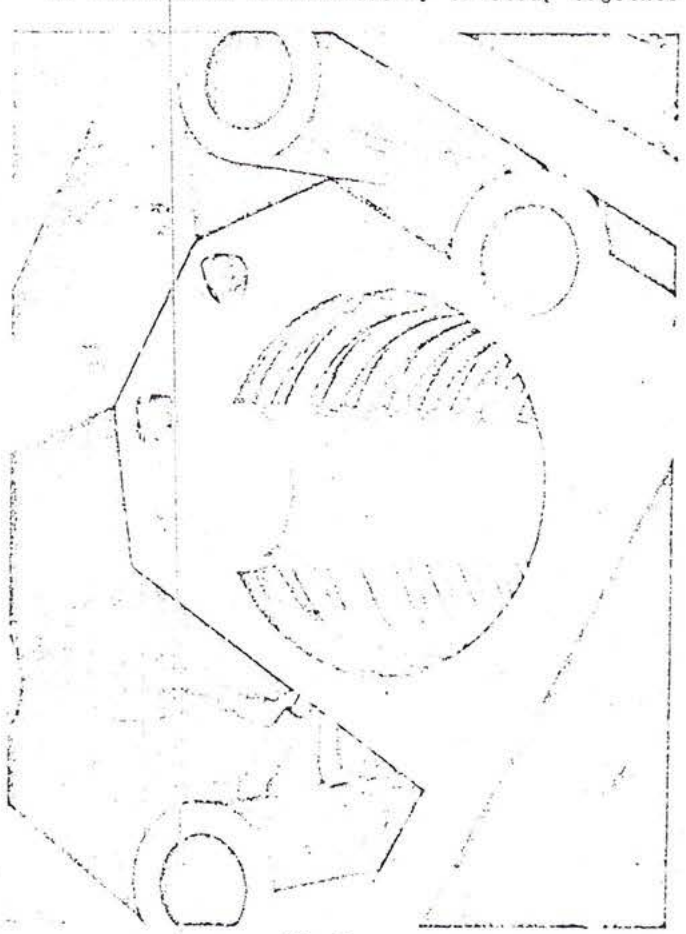

Fig.4
Delay structure for cold tests

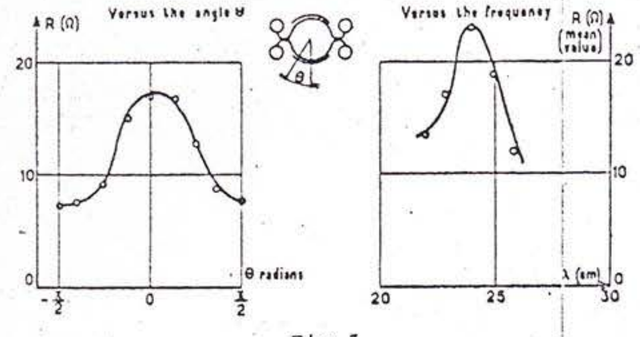

Fig.5
Coupling impedance versus the angle and versus the wavelength

the two ground pieces of the two ladder lines to suppress the antisymmetrical mode from the useful band. The dispersion curve is shown in Fig.6. The attenuation and the power radiated on the sole are plotted in Fig.7.

A sketch of the tube is shown in Fig.8. A photograph in Fig.9 and a general view of the tube in operation in Fig.10. The current in the central stub is a 50 Hz current supplied by a transformer. A peak current of 9000 Amp may be obtained by this means, as shown in Fig.11.

Fig.12 shows the efficiency and the gain versus the frequency; the bandwidth is greater than 16%; the efficiency is not very high probably because the circuit losses are not negligeable in a so very long circuit. The signal to noise ratio is everywhere better than 20 dB. The signal to noise ratio may be higher than 25 dB with a gain of 18 dB, and more than 30 dB with a gain of 13 dB.

Fig.13 shows the sensitivity of the phase shift between the output and the input to the applied voltage, expressed by the factor K. It lies in the bandwidth between 0,05 and 0,1, which is rather small value for a TPOM.

In conclusion the tests done on a coaxial

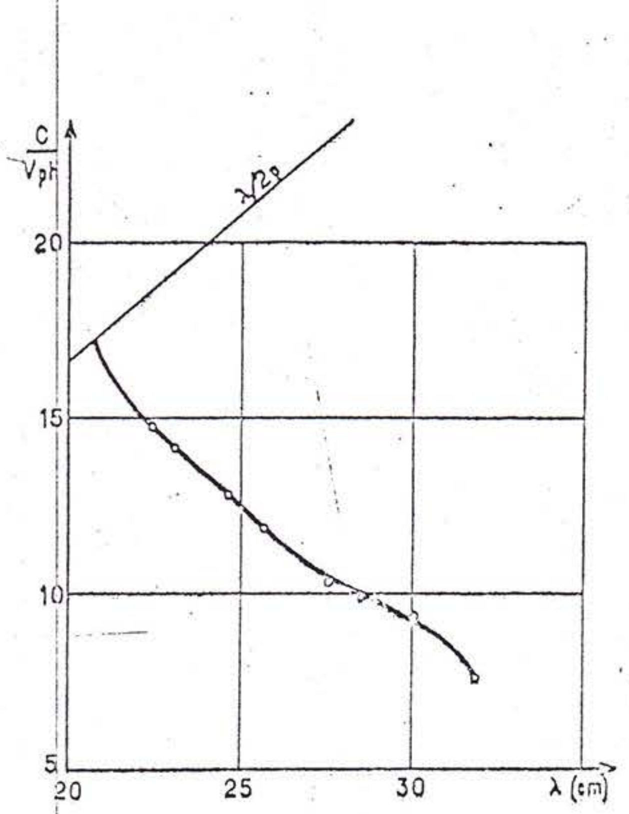

Fig.6
Dispersion curv

TPOM show that this type of tube operates as well as a TPOM with the main advantage of a very low beam impedance which corresponds to a shorter delay line and lower voltages. In this tube no special attempts have been made to reduce the fast mode, so that the gain was limited by the spurious oscillations due to the excitation of this fast mode. However, the measurements on the noise of the gun show that this tube has a much lower background noise. Moreover it seems easier with a coaxial structure to reduce the excitation of the fast mode, so that this structure must be capable of higher gain.

But the main advantages of this type of tube

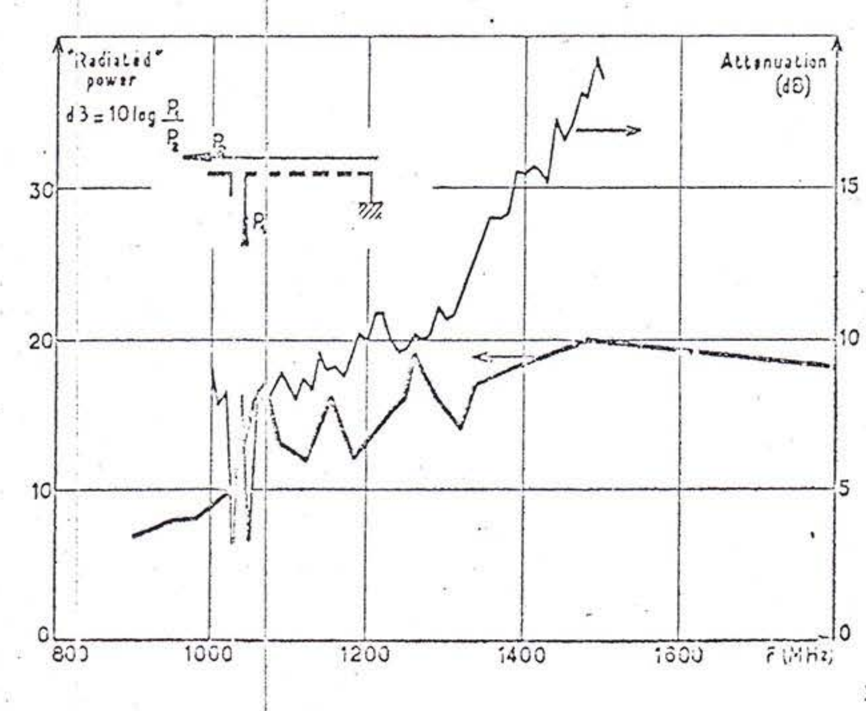

Fig.7
Fast mode excitation versus the wavelength

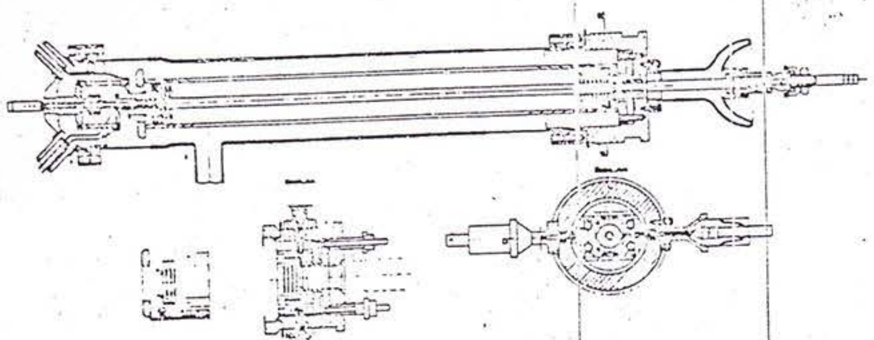

Fig.8
Sketch of the coaxial tube

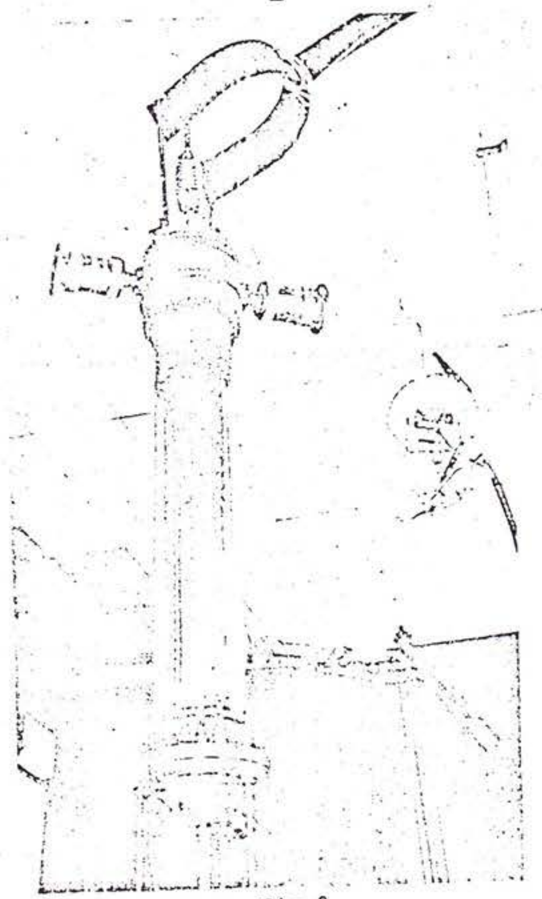

Fig.9
Photograph of the tube

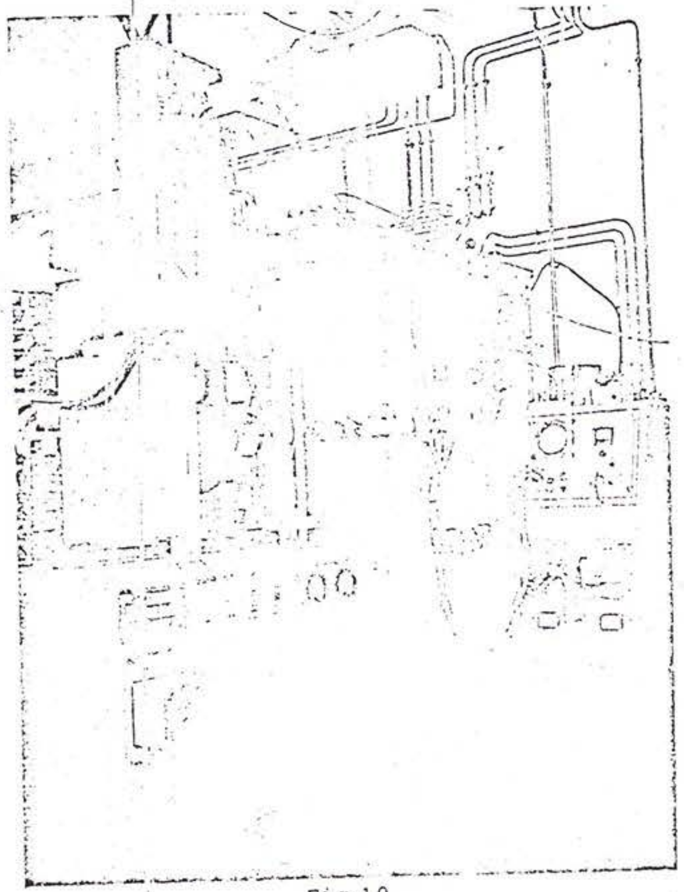

Fig.10
Photograph of the tube in operation

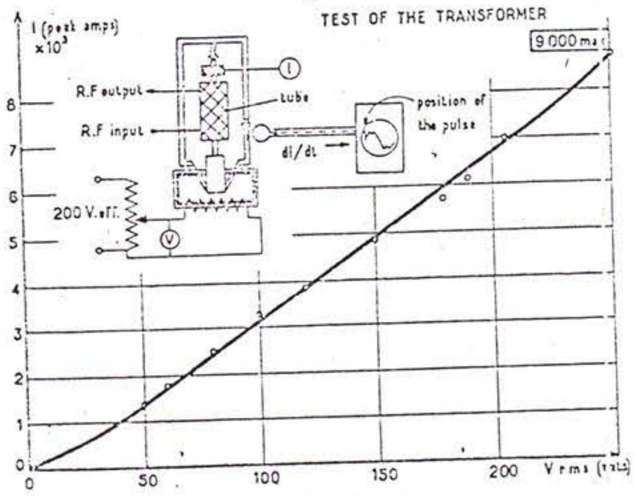

Fig.11
Peak current obtained from the secondary of a transformer versus the primary voltage

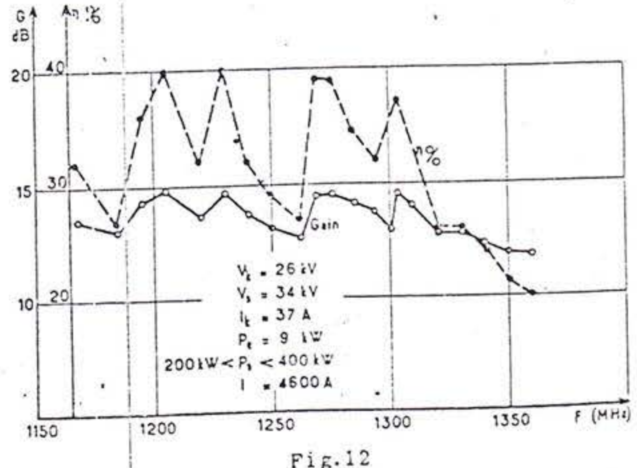

Fig.12
Efficiency and gain versus the frequency

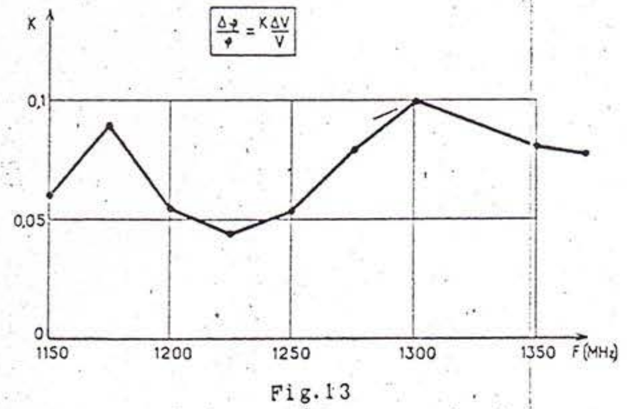

Fig.13
Coefficient Δφ/φ : ΔV/V versus the frequency

would appear mainly for very high peak powers, for instance 50 MW in 'L' band since the sole edges are suppressed and the collector easier to design.

Although an evaluation would be necessary in each particular case it seems that the coaxial tube presents some technological advantages over the classical TPOM.

At frequencies lower than those of 'L' band, practical c.w. tubes may be built; at higher frequencies the current in the stub should be applied by pulses, to decrease the mean power dissipated; such short pulses are possible because the self inductance of the stub decreases according to the size of the tubes.

Backward-wave tube feedback oscillators

K. Kakizaki*

Introduction

The backward-wave oscillator which has been used mainly for test equipment and radar use, is considered inferior to the klystron for communication use, because of its instability.

However, recently FM communication has come to require more frequency shift range and better frequency linearity. In order to meet this requirement, we made an experiment on the backward-wave tube feedback oscillator, where the backward-wave tube behaves as an amplifier and a band-pass filter inserted on the way of an external feedback circuit is of use to stabilize the frequency. The negative dispersion characteristic of the backward-wave circuit results in good linearity over a wide frequency range.

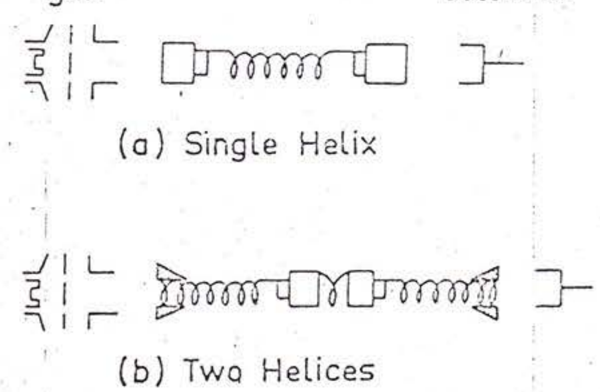

Fig.1
Backward wave amplifier

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The papers on the behaviour of backward-wave oscillators with external feedback circuit were published in which frequency stability was mainly discussed [1], [2]. In this paper we deal with them from viewpoint of modulation sensibility and large tuning range.

There are two types of experimental tubes, a single helix type and a cascade helix type (Currie type). In both cases, the measured tuning curves of the experimental amplifiers show a tuning range from 5,400 to 7,100 Mc/s with voltage variation from 680 to 1500 V.

The types of the filter used in the experiment are as follows:
1. Single stage type,
2. three stage maximally flat type,
3. three stage delay flat type.

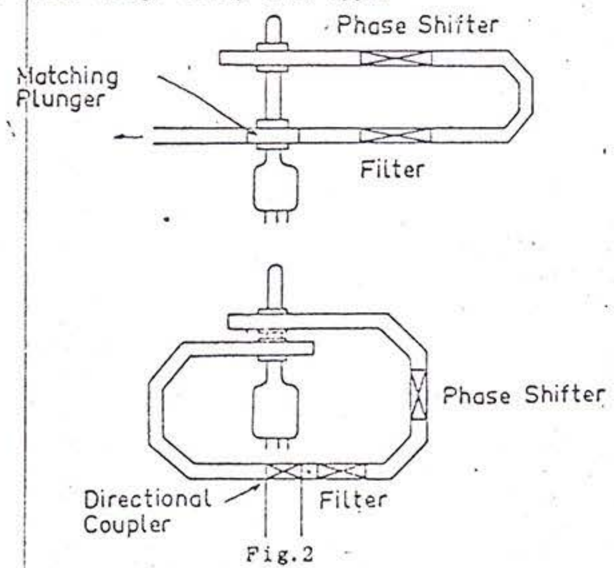

Fig.2
Feedback circuits