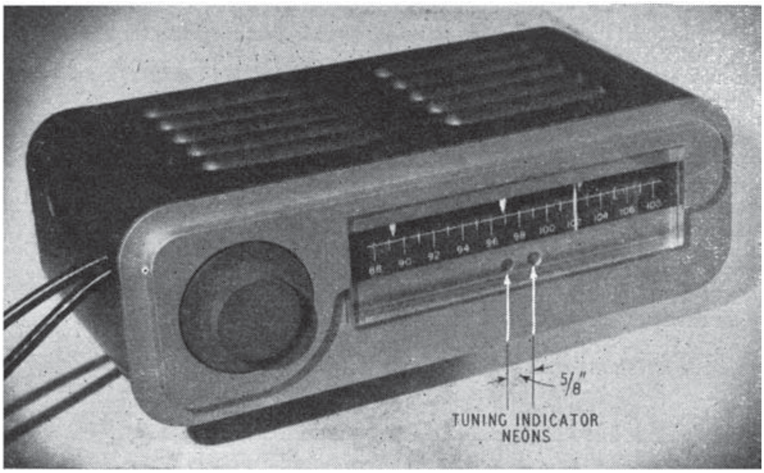

NEON F.M. TUNING INDICATOR

By

JOHN D. COLLINSON*

High Sensitivity with Indication of + or –

TO the listener interested in high-quality sound reproduction a frequency-modulated v.h.f. broadcast system approaches the ideal. In contrast to the medium–wave a.m. service, it is difficult to design an f.m. receiver with a poor audio–frequency response. A wide frequency response in itself, however, is of little value if impulse noise is allowed to obtrude on the programme, or if non-linearity distortion in the receiver mangles the signal before application to a "$D_{tot} \ll 0.01\%$" high-fidelity amplifier.

Both noise and distortion can be kept to low values in well designed and aligned receivers, but the user must play his part in getting the best performance from any given set by tuning it in correctly.

If a receiver is correctly designed and aligned so that the i.f. pass band and the discriminator characteristic are symmetrical, and the i.f. signal produced by the received unmodulated carrier is exactly in the middle of the pass band, impulse noise will be fully rejected.

The phase-modulated components of the noise, being evenly distributed throughout the passband, correspond to a signal whose mean frequency is that of the midpoint of the passband, so that the discriminator output is zero. If the carrier is mistuned a standing d.c. will appear at the discriminator output which reduces to zero for the duration of the noise. Thus an audio signal will appear proportional to the amount of standing d.c., which in turn is proportional to the amount by which the carrier is mistuned.

Sources of Distortion

Non–linearity distortion can arise both in the i.f. amplifier and the discriminator. If the carrier is mistuned, large deviations can swing the signal past one side of the flat top of the i.f. amplifier pass band. Amplitude variations are removed in the limiter stage, but phase changes occur at the same time. When demodulated the audio signal will be asymmetrical, showing the presence of added even harmonics. The discriminator will add its quota of distortion as it is only linear over a limited range on either side of zero output, so that if the carrier is mistuned it must deviate more into the non-linear region.

From the foregoing we may conclude that in the absence of a tuning indicator, the user may resort to two stratagems:– (a) await the passage of an unsuppressed motor-car, then hurriedly tune out its ignition noise, or, (b) tune for minimum intermodulation during loud passages in the programme. With either method, the correct tuning point tends to be elusive, and some form of indicator is essential, if only to stop doubt gnawing at the mind of the technical purist.

As the negative voltage at the limiter grid is proportional to the signal strength, it would appear that it might be applied to a "Magic Eye" in the same manner as the a.g.c. voltage in an amplitude modulation receiver. Tuning for minimum shadow angle should then give the correct tuning point. However, the main requirement of an i.f. amplifier in a

* The Acoustical Manufacturing Co., Ltd

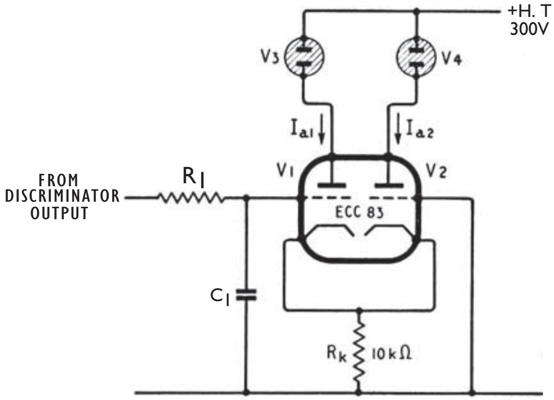

Fig. 1. Complete circuit diagram of neon tuning indicator. V3 and V4 are miniature uncapped neons (Hivac, type CC11L). These are also available with M.E.S. cap and designated CC10L.

frequency-modulation receiver is that it shall have a flat frequency response over some 200 kc/s bandwidth; thus the mid-point is indeterminate. Any attempt to get a well defined peak at the limiter grid will degrade the phase response of the i.f. amplifier, which introduces odd-order distortion in the audio signal. It is therefore necessary to provide a separate high-Q circuit, tuned exactly to the middle of the i.f. passband, to rectify the resultant signal and to feed that to the indicator. This throws a heavy responsibility on the stability of the auxiliary tuned circuit, and such an indirect approach seems unwise.

A better method is to indicate zero d.c. output from the discriminator. Indicating nothing, however, presents its own problems. One of the best solutions is to use a centre-zero meter. This not only shows the correct tuning point, but whether the set is off-tune, and the direction in which it is off tune, without having to alter the tuning control. It has the disadvantage that as the demodulator currents are small, a valve voltmeter circuit has to be used, which together with the cost of the meter movement itself is uneconomical, not to speak of the difficulties of finding a meter which " blends with the *décor* of one's home."

A simple and reliable circuit has been developed (Fig. 1) that gives a visual indication of the correct tuning point which may be interpreted in the same manner as a meter. It consists basically of a cathode coupled amplifier in which one grid is taken to a reference potential, in this case zero d.c. or earth. The other grid is taken to the output of a Foster Seeley discriminator. If both potentials are equal, then equal currents flow in both valves. If the potentials are not equal, e.g. V1 grid is positive to earth, then I_{a1} increases, making the common cathodes more positive. The negative potential between V2 grid and its cathode is increased, and I_{a2} decreases. The current flowing in each valve is indicated by the brilliance of the two miniature neon lamps in series with each anode. With the type of neon specified the light output is approximately 0.25 lumens per mA.

The human eye is not particularly good at estimating absolute light output, but it is very much better at estimating the relative output between two lights closely spaced. This ability is aided in the circuit arrangement used, as the eye has not merely to compare the brilliance of a light against a fixed reference, but against one varying in the opposite direction (Fig. 2) Thus, by tuning the receiver until both neons are of equal brilliance, a very sensitive indication is given of zero output from the discriminator. In practice the sensitivity of the system can be such that provided both neons are obviously alight, the tuning error has negligible effect on the receiver performance.

The indication given by the plain neon lamps is not ideal as the glow surrounds only one of the parallel electrodes on d.c., and when viewed from the side, the random change of glow position is distracting. For this reason it has been found better to view the neons end-on via a low-loss diffusing screen. A suitable material is $\frac{1}{16}$ in opal Perspex (I.C.I. Colour No. 030). When mounted close together the glow from one neon may be screened from the other by a light-coloured opaque sleeve over the body of the bulbs, the light colour helps to reflect the light forward through the diffusing screen.

The performance is determined by the choice of valve, the common cathode resistor, and the h.t. supply. The standing bias on the valve grids must be chosen so that the current through the neon is limited to about 0.7mA in the unbalanced condition. The cathode load resistor determines the see-saw action which takes place when the receiver is mistuned. With finite values of μ and R_k the anode current changes will not be equal and opposite, but unbalnced is immaterial as it reduces to zero at the working point. In practice the small current demand allows a high value of R_k to be used and this performs the dual function of bias and cathode load resistor.

The components C_1R_1, whose time constant is comparable to the period of the lowest frequency likely to be encountered, are used to filter the audio

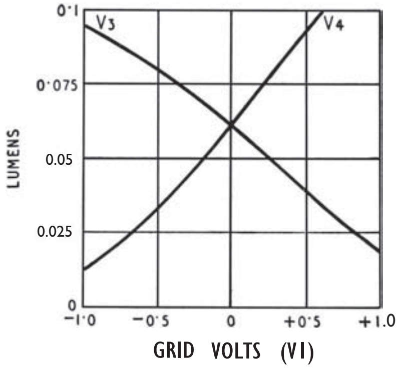

Fig. 2. Light output of neons plotted against discriminator output voltage for circuit of Fig. 1.

signal from the discriminator output. Without this filtering both neons will appear to brighten simultaneously with a heavily modulated signal, thus obscuring the d.c. component.

With the typical circuit shown in Fig. 1 connected to the output of a Foster-Seeley discriminator, there is a clear indication of the correct tuning point within ±3 kc/s. The only difficulty anticipated was the fact that as the indicators show equal brilliance in the absence of a carrier, it was thought that steps would have to be taken to suppress the indicators when the limiter grid current was low. However, this proved unnecessary as one or other indicator is extinguished before the wanted carrier is heard.

There is no reason why this indicator should not be used with a ratio detector provided that it is of the balanced type, but the d.c. output per kc/s of deviation will be considerably less than that of a Foster-Seeley discriminator.

"Band II F.M. Tuner Unit"

ALL the coils specified on p. 374 of this article in last month's issue can also be supplied by Wright and Weaire Ltd. The" Waearite" type numbers are:-

Aerial coil L_1, L_2	757
R.F. choke L_3	758
R.F. coil L_4	756
Oscillator coil L_5, L_6	755
1st i.f. coil L_7, L_8	751
2nd i.f. coil L_9, L_{10}	752
Ratio detector transformer L_{11}, L_{12}, L_{13}	753
I.F. traps L_{14}, L_{15}	759

The escutcheon for the EM80 tuning indicator can be supplied by McMichael Radio Ltd.