Finally tested was the Portus and Haywood decoder (*WW* Sept 1970). Needing principally lower harmonic and beat tone distortion, I devised the following modifications, included in the circuit of Fig. 14.

- Change Tr11 and Tr12, formerly BC108 types, for 2N2369, ZTX313 or any high-speed switching transistor.
- Change Tr14 and Tr15 for high-gain audio types, BC109C, ZTX109C, etc.
- Convert the input amplifier to a compound emitter follower, now with a lower emitter resistor and a gain potentiometer at the input. This can be done neatly on the original Integrex p.c. board using only one link. This modification is only suitable if the input amplifier is not required to provide any gain.
- Operate the decoder with only 1.4V at TP2, the pilot level test point, not 1.5V.

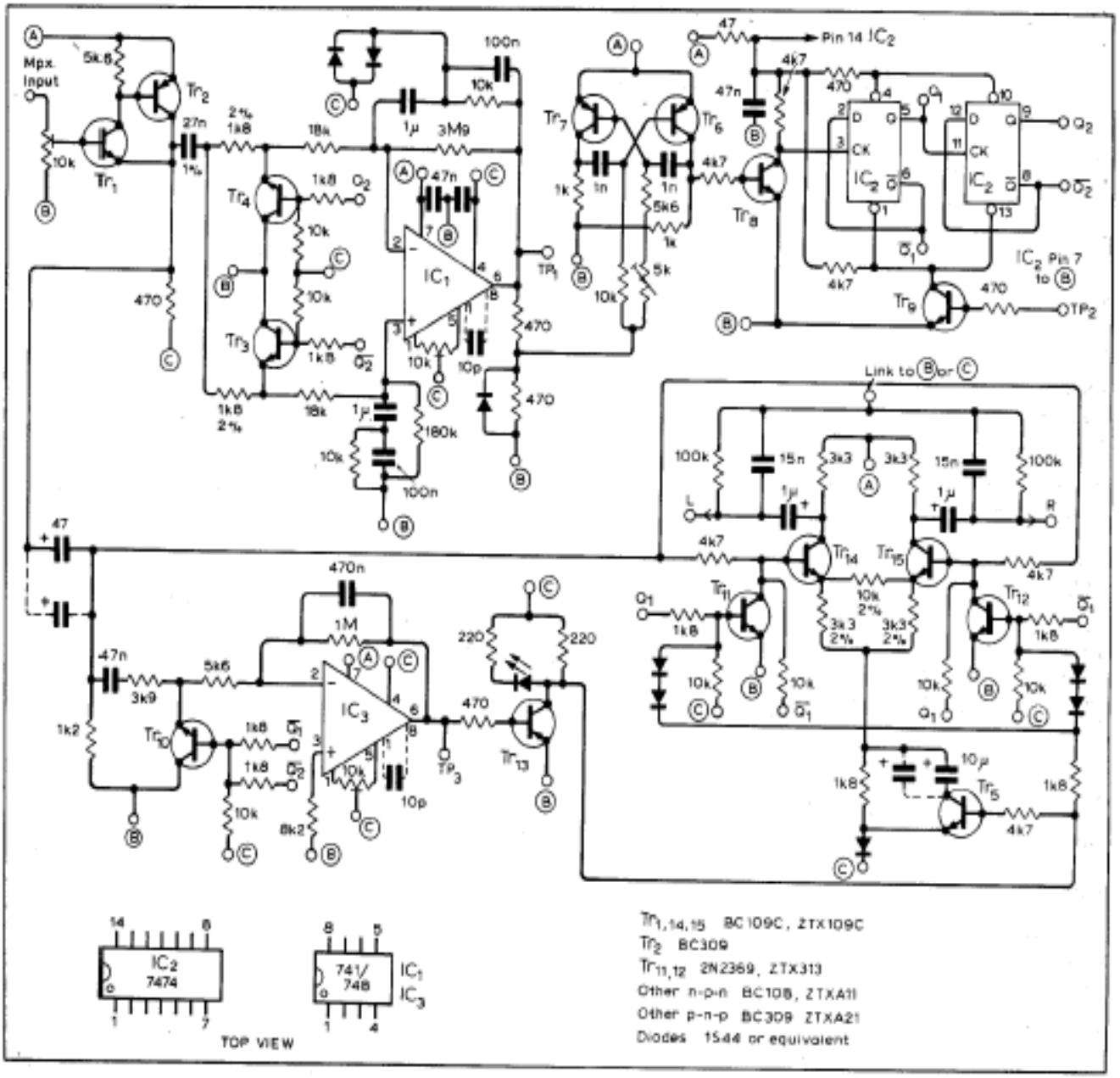
These modifications brought the 1kHz distortion in stereo to 0.06% and, with the further suggestion by Mr Portus of fitting pull-up resistors $R_{64}$, $R_{65}$ onto the bases of Tr14 and Tr15, gives the excellent figures in Table 3 with the only penalties a couple of dB lower audio output and higher switching waveform on the outputs. Low-frequency channel separation is easily improved by paralleling 1000µF 10V electrolytics across $C_5$ and $C_{18}$. Though irrelevant for normal listening, good separation is desirable when measuring the coder's noise level.

All decoders proved sensitive to supply hum and noise and filtering along the lines shown, Fig. 15, is needed to reduce the noise output from i.c. voltage regulators to allow signal-to-noise measurements beyond 64dB or so.

**Table 3. Stereo decoder comparison when fed with ideal multiplex signal.**

| | Input mV | Distortion (%) mono | Distortion (%) stereo 1kHz | Distortion (%) stereo 15kHz | Crosstalk dB 1kHz | Crosstalk dB 15kHz |
|---|---|---|---|---|---|---|
| MC1310 CA1310 | 300 | 0.09 | 0.09 | 0.87 | 40 | 37 |
| 1310 & filter | 300 | — | — | — | 40 | 20 |
| CA3090 | 180 | 0.17 | 0.18 | 1.7 L or R 3.5 at −10dB | 43 | 30 |
| Portus & Hayward | 600 | 0.05 | 0.38 | 1.3 | — | — |
| P&H modified | 600 | 0.04 | 0.04 | 0.35 | 30 | 31 |

Stereo distortion measured at full L, R, M or S level. Worst reading of two channels shown. By altering the pilot phase on the coder channel separation on the modified Portus and Haywood decoder will reach 54dB at 1kHz and 50dB at 15kHz. This has the same effect as adjusting the oscillator trimmers on the 1310 and CA3090 for best channel separation, not necessarily at a free-running frequency of exactly 76kHz.


Mpx. Input
Pin 14 IC2
IC2 Pin 7 to (B)
Link to (B) or (C)
TP1
TP2
TP3
IC2 7474
741/748 IC1 IC3
TOP VIEW
Tr1,14,15 BC109C, ZTX109C
Tr2 BC309
Tr11,12 2N2369, ZTX313
Other n-p-n BC108, ZTXA11
Other p-n-p BC309 ZTXA21
Diodes 1S44 or equivalent

▲ *Fig. 14. Modifications to the Portus and Haywood decoder to improve both distortion and channel separation. Faster switching times and high gain transistors in the matrix with a different input amplifier arrangement give 1kHz distortion better than 0.04%. Voltage levels of points A, B and C can be either +12, +6 and 0V or +6, 0 and −6V respectively.*

quieting on stereo while a further 6dB attenuation (685mV) will quieten a good tuner.

*Fig. 15. Stereo decoders proved susceptible to noise on the supply line and filtering is needed to measure signal-to-noise ratios much above 60dB. Regulator should be mounted out of the transformer's magnetic hum field. 2000μF capacitor should have low internal resistance.* ▼