Distribution Systems

RELAYING SOUND AND TELEVISION IN BLOCKS OF FLATS

By J. KASON*

SOME criticism has lately appeared in the press and technical journals of the ever increasing number of aerials adorning our towns and giving a distant community the appearance of a Picasso sketch. As new television programmes come into operation the multiplicity of aerials will become prohibitive. The owners of blocks of flats and/or local authorities object to the erection of individual aerials. The answer to that is relay distribution within the building. This is already very popular in the U.S.A.[1], and is growing in this country. Many suitable systems have been in existence for some time, and one, using channel amplifiers, has been specifically developed to provide programme relay services comprising television, f.m. sound and all-wave radio for blocks of flats.

There are three basic ways of distributing television signals, (*i*) low frequency carrier transmission, (*ii*) conversion of signals in Band III into available channels in Band I, and (*iii*) distribution of information at transmitted frequencies.

With the first mentioned system the carriers may have frequencies of say 5.4 Mc/s and 2.7 Mc/s with video and sound modulation by Band I and Band III signals. At the receiving end, 5-valve terminal units would receive the signals satisfactorily. The low-carrier distribution method can also be adapted for reception with ordinary television receivers. The advantage of such a system is the centralization of all equipment, the small number of repeaters required due to the low loss in the cable at this low carrier frequency and the higher power handling capabilities of the output valve or valves since better cross modulation figures are achievable at these frequencies.

The second system entails conversion of signals in Band III into available channels in Band I. Some distribution systems based on this type of conversion are in use to-day, and have the advantage that cable losses are halved, compared with what they would be at Band III frequencies. They have, however, some disadvantages *viz*:—a maximum of no more than two or three television channels can be accommodated because only four unused channels are available and receiver selectivity prevents the use of adjacent channels. It is difficult to design a cheap and efficient three-channel filter in Band I. Not all television receivers to-day, even those with turret tuners, have all the channels available for reception. The receivers would, in neighbouring flats in some cases, tend to interact with each other, and with f.m. receivers.

The third system of distribution of signals at transmitted frequencies can be accomplished in one of two ways, *i.e.*, by using distributed amplifiers or channel amplifiers.

In the first method of the third system a combination of channel amplifiers and distributed[2,3] amplifiers is used for the distribution of signals. The mixing of bands is done at low level to avoid cross modulation. Low gain channel amplifiers are used to equalize the levels of various programmes in such a way as to compensate for line losses (output $\propto \sqrt{f}$). The combined signals are then fed *via* distributed amplifiers and splitters into lines. This system has the following advantages:—

The added reliability of the distributed amplifiers, since a failure (but not a breakdown) in the operation of one valve due to ageing reduces the gain by only 1.6dB (6 valve stage using EF95). There is no appreciable response characteristic drift. Higher output is permissible for a given cross modulation figure, since the total power output is shared by several valves, and theoretically and closely in practice the relationship between power and the number of valves is linear, hence this is an economical system when high power is required.

The disadvantages are:—low gain for a given number of valves. Critical impedance matching is required. The possible cumulative build up in frequency errors when

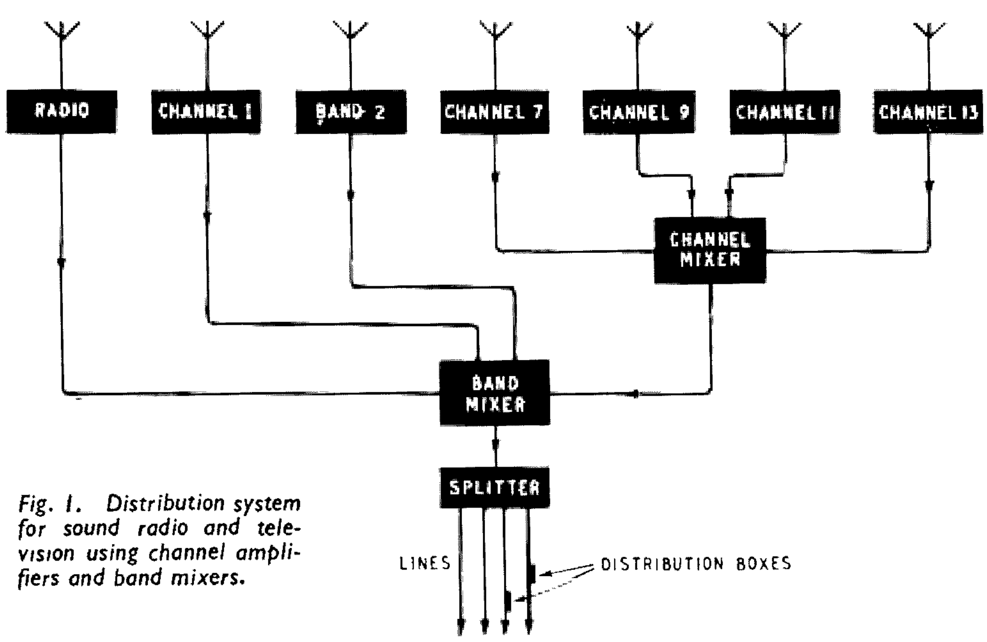

Fig. 1. Distribution system for sound radio and television using channel amplifiers and band mixers.

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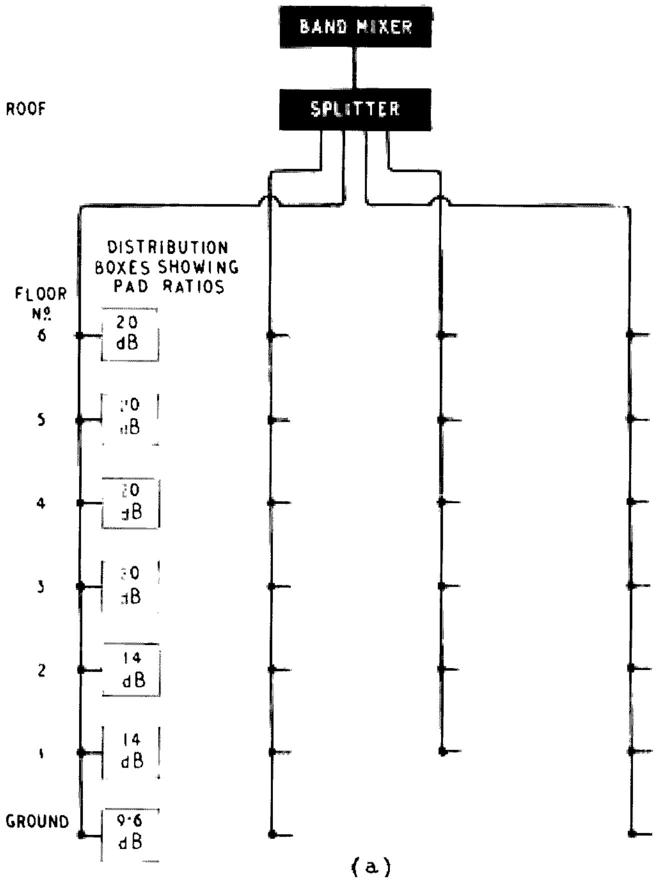

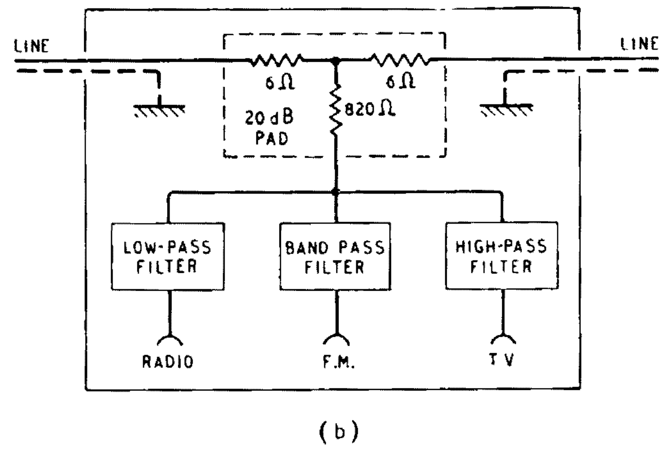

Fig. 2. (a) Schematic distribution system network for a small block of flats; (b) details of 20-dB pad.

amplifiers are cascaded. Valve failure, other than that due to ageing, puts all channels out of action.

In the second method channel amplifiers are employed for the distribution of signals. This system is easy to maintain and manufacture, shows a high gain per valve, low noise and low cost. Moreover, there is no need for channel equalizers, and on failure, only one channel is put out of service (Fig. 1). Although for a given cross modulation the output is relatively low, it is sufficient to feed television programmes throughout a block of flats. Examining the last two methods of distribution, it is evident that for installation in flats where the number of outlet points seldom exceeds one hundred, the channel transmission method is the most economical. The latter part of this article therefore deals with the channel method of distribution.

A schematic diagram of a block of flats is shown in Fig. 2. The network is planned on the basis of a maximum loss of 46 dB and the provision of 1 mV at the viewer's television outlet socket. This loss includes the insertion losses of the coaxial semi-air spaced 100-ohm lines, splitters, distribution boxes, band mixers and channel mixers. The planning of networks of various blocks of flats has shown that a 200-mV output into 100-ohm distribution lines is sufficient on Band III. A design of some equipment has been based on the above assumption and the following section of this article will deal with some aspects of this design.

One particular channel amplifier used for distribution of Band-III programmes employs Z152 valves with 210 volts supply for anodes and screens, and the maximum possible output with acceptable cross modulation is 250 mV fed into a 100-ohm coaxial cable. This amplifier has a gain of 52 dB in any channel in Band III with a bandwidth of 4 Mc/s (at $\pm$ 1 dB). Because of variation of signal strength in various localities, it has been found necessary to provide a gain control fitted in the cathode of the first Z152 valve with a maximum range of 20 dB. Over-coupled circuits are used for the inter-valve couplings and, with all trimmers tuned to the centre frequency of any channel in Band III, a bandwidth of 4 Mc/s is obtained.

Tests of this amplifier yielded very satisfactory results but only the noise and cross modulation tests need be discussed here, since these show the essential limitation in the performance of the amplifier. A signal of 300 μV fed into the Channel-9 amplifier showed a negligible increase of noise. However, for fringe areas, a cascode pre-amplifier is available. No noticeable cross modulation could be seen on a television receiver at the end of a 100-ohm line when the channel amplifier was providing 200 mV input. The cross modulation is 55 dB or better for the above output with the gain control in any position.

In order to find the isolation factor required for the band mixing unit (Fig. 1, 2, 3) a Band-III amplifier was tested for inter-modulation with an interfering Band-I signal, both amplifiers working at full output. The test showed that additional isolation of more than 10 dB had to be provided by the filters. Not more however than 1 dB of insertion loss can be permitted for Band III, as 200 mV output is only just sufficient to feed a 500-ft line satisfactorily.

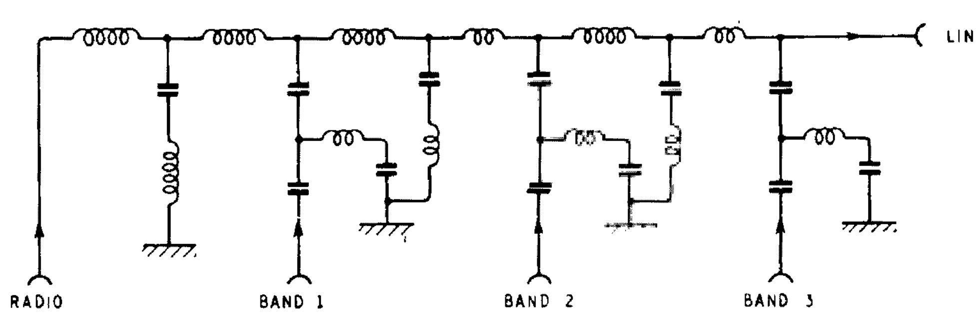

Fig. 3. Circuit arrangement of a band mixing unit.

Maximally flat, 4*th* order filters were chosen for the band mixing unit and proved to work satisfactorily. Some results obtained with these filters are given in the table.

For the purpose of combining several Band-III programmes, a two-channel mixing unit[4] based on resonant lines has been developed. Coaxial lines having an effective magnification, or " Q " factor, of approximately 30 were used and gave an insertion loss of under 0.8 dB on Channels 9 and 11 for negligible cross modulation at full output. A similar channel mixer has been developed for three or four channels in Band III. In the case of the three-channel mixing unit, Channels 7, 9 and 11 were used and Channel 13 was added for the four-channel mixer. Purely arbitrary channel frequencies were chosen to prove the design, and the insertion loss for any type of mixer remained under 0.85 dB.

Distribution boxes[5] providing for all-wave radio, Band I, Band II and Band III have been developed. Second order, lumped constant, filters were used as band acceptors and rejectors. Fig. 2 (b) shows a distribution box incorporating a 20-dB pad, which steps down the line voltage to a level of approximately 1 mV. The series arms (6 ohms) of the pad restore the cable impedance (Z_0). High-voltage-level signals are used in distribution because the effect of pick up by the cable is minimized and the high pad ratios prevent any appreciable interaction between the terminal units in flats. The filters isolate the receivers connected to the distribution box.

A splitter unit is a symmetrical resistive network giving, for n ways, $\frac{1}{n}$ th of the supplied voltage at the output terminals in such a way that the image and characteristic impedances are maintained. A four-way splitter is shown in Fig. 4.

The value of each resistance is given by

$$r = Z_0 \frac{n-1}{n+1}$$

where r = resistance
Z_0 = characteristic impedance
n = number of ways.

Conclusion:—The laboratory tests showed that the channel type of distribution is satisfactory for blocks of flats. The system is simple with regard to manufacture and maintenance, and very flexible. A further increase of one channel in Band III needs only the addition of one amplifier to the network. A Band-II amplifier of 15-Mc/s bandwidth and its auxiliary equipment have also been developed, but are only mentioned in passing (Fig. 1) in this article.

Field tests were carried out in a number of blocks of flats in London on lead type coaxial cables and braided paper insulated lines with favourable results.

Comparing the two methods of the third system, distribution by means of distributed amplifiers is advantageous where a high power is required, while the channel method is more economical for small installations.

FILTER TABLE

<table>
<tr><th>Frequency Mc/s</th><th>Insertion Loss dB</th><th>Atten in Bands dB</th><th colspan="2">Atten in Bands dB</th></tr>
<tr><td>200
94
55</td><td>0.9
1.8
0.9</td><td>B II 13.8
B I 25.1
B II 20.3</td><td colspan="2">B I 29.8
B III 25.1
B III 19.3</td></tr>
<tr><td></td><td></td><td colspan="3">Attenuation (dB) in Bands</td></tr>
<tr><td></td><td></td><td>I</td><td>II</td><td>III</td></tr>
<tr><td>25
5</td><td>0.5
1.0</td><td>22
25</td><td>23
31</td><td>25
33</td></tr>
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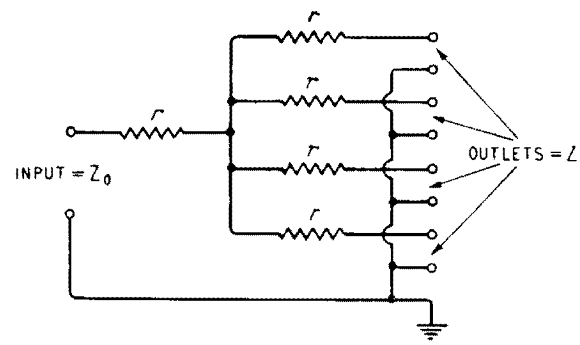

Fig. 4. Basic circuit for a splitter unit.

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5 J. Kason (E.M.I.) British Patent Application No. 27279/55.