THE MARK 10 DECCA RECEIVER

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1. Mark 10 Decca involves extra transmissions from the stations of the Decca System at present operational, but employs the same frequencies as are now in use with one additional frequency. For this price the new system, which can be added to these operational stations in a fashion which is compatible with their continued use in the present manner and without operationally significant disturbance of the services now provided, will provide primarily to air users the following advantages :

1) Overall service in use comparable with that of the present Mark 7 Decca receiver, but with

2) Automatic Lane identification of improved range at night

3) Zone Identification

4) Use of the same receiver on all Navigational Decca Chain frequencies envisaged instead of a selection of 9 such frequencies catered for by the Mark 7 Receiver.

The Mark 10 Decca System is therefore aimed primarily at providing a greatly simplified operational procedure in the air.

2. Figure I shows the normal C transmissions from Decca stations at present which provide present users with the fine patterns used for navigation. The Lane Identification System at present in use is carried out on each pattern in turn by switching off the transmissions of the two Slave Stations not involved in generating it and disposing their frequencies for a short burst of transmission at the Master and Slave Stations of the pattern being identified. This is executed once per minute for each pattern and the duration of the burst is about 1/2 second, after which the normal transmissions shown in the picture are resumed. For Red Pattern Lane Identification, therefore, the Green frequency 9f is brought up at the Red Slave Station while the Purple frequency 5f is used at the Master. The object of Lane Identification is to provide a 1f transmission from both stations and therefore involves an intermittent super-imposition of this coarse pattern on the Red baseline. It will be noted that a 1f signal is needed from Master and Slave to achieve Lane Identification and this signal is a beat-note between 8f and 9f from the Slave and between 5f and 6f from the Master, and only two frequencies are involved in its generation at source.

Figure 2 shows the extra transmissions required for Mark 10 Decca. For each station in turn the transmissions from all other stations are suppressed for a similarly short period of 1/2 second and all four frequencies are simultaneously transmitted

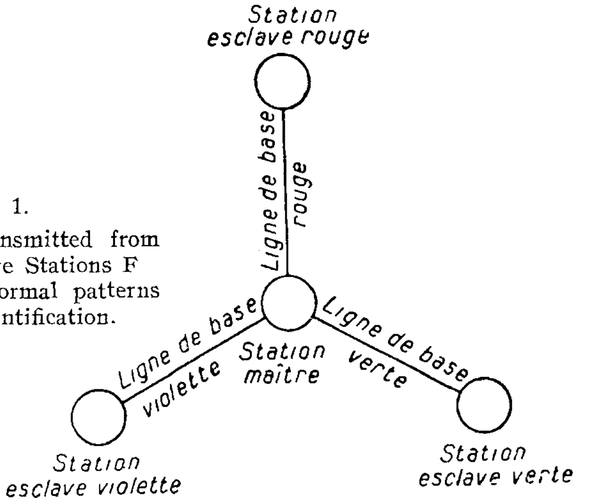

Fig. 1.

Frequencies transmitted from Master and Slave Stations F 14.2 kc/s for normal patterns and lane identification.

Fig. 1. — **Fréquences transmises par les stations maître et esclaves F = 14,2 kc/s, pour réseaux normaux et identification de chenaux**

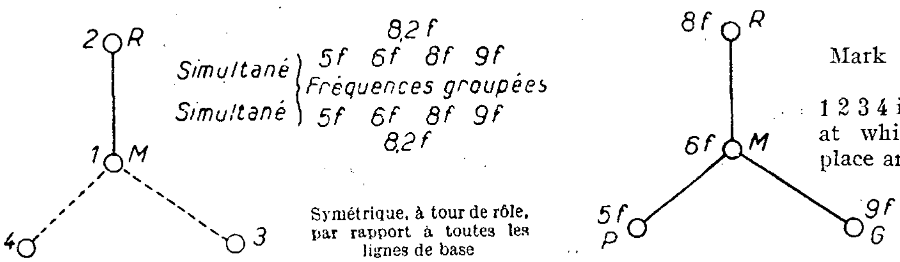

Fig. 2.

Mark 10 lane identification transmissions

1 2 3 4 indicate instants of time at which transmission takes place and at which relays close in receiver.

Fig. 2. — Les nos 1, 2, 3 et 4 indiquent les instants de la transmission et ceux de la fermeture des relais dans le récepteur

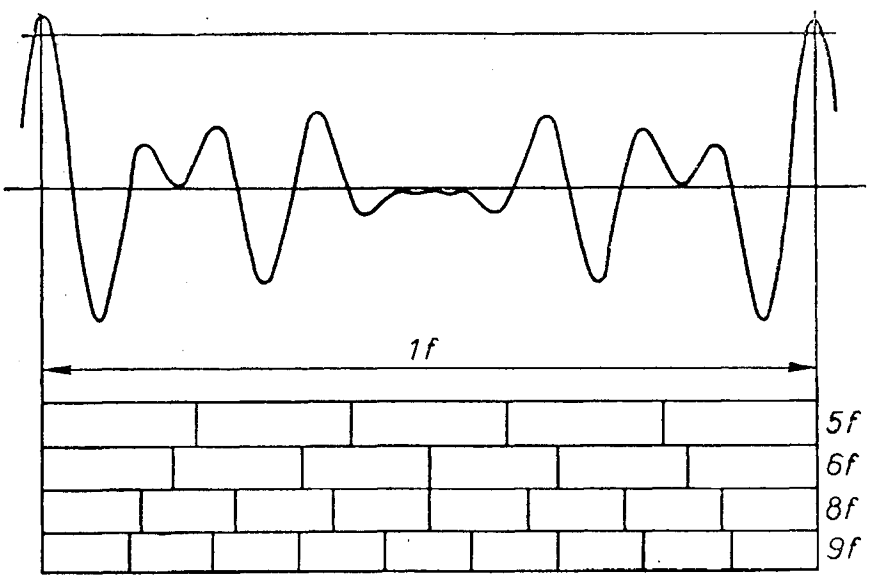

Fig. 3. — **Impulsion d'identification du chenal Decca Mark 10**

Fig. 3. — Mark 10 Decca lane identification pulse.

from the station in question with the addition of the 8.2f extra frequency used for Zone Identification.

Ignoring this last extra frequency which does not contribute to Lane Identification directly, figure 3 shows the commencement of each cycle of the CW transmissions on the four frequencies as they are electronically phase-controlled at the transmitting station against a horizontal time scale.

If we examine the lower section of the picture considering the 5f and 6f frequencies only, this shows the transmissions as generated from the Master Station for the present Lane Identification System. Now, remembering that the object of this combined transmission is to provide a 1f signal from this Station by means of a beat-note between the two signals, which 1f signal is to have a fixed and defined phase relationship to the 6f signal normally transmitted from Master, the two signals are electronically phase-locked at source so that their separate 1f subharmonics start a cycle at exactly the same instant represented by the left-hand end of our picture. If Lane Identification is to be achevied at the user's receiver, the phase relationship between 5f and 6f signals as shown must be preserved within certain limits. It will be seen, however, that a relatively small phase shift of the 5f signal relative to the 6f signal due to sky-wave phase disturbances can shift the coincidence of their cycle commencements to the commencement of the next 6f cycle and in these circumstances Lane Identification is incorrect. It can be shown that unless skywave is less than 28 % of groundwave in signal strength this can occur and over some terrains does occur at ranges as short as 150-180 miles from the station at night. The same considerations apply to the phase relationships between the 8f and 9f signals from the Slave Station used for the other 1f signal.

In the Mark 10 Receiver, however, all four frequencies are transmitted from the station and a pulse is generated from the received signals by addition of equal amplitude components of each frequency as shown at the top the picture. If this transmission is again being used to identify the appropriate commencement of the cycle of the 1f subharmonic of the 6f signal from the Master Station it will be seen that very considerable and fortuitous phase changes in the three other signals relative to the 6f signal must take place before the highest upward going pulse can appear in the wrong place. In fact, it can be shown that against a criterion of the highest peak being above a limited level defined either by a fixed fraction (say 90 %) of the maximum possible amplitude or by reference to the next highest peak, incorrect Lane Identification information cannot be derived until skywave field-stength exceeds 44 % of groundwave field-strenght. When this limit is exceeded the wanted peak falls below the defined limiter level and disappears. It is interesting to note that the Lane Identification pulse is produced by only the four widely separated harmonically-related frequencies used for other purposes in the Decca System anyway, and in consequence frequency spectrum economy is very marked compared with, for example, conventional pulse systems.

The presence of this pulse above the limiter level in the correct place unless skywave exceeds 44 % of groundwave, and its absence if this limit is exceeded, has two important results. Firstly, the range of Lane Identification is extended at night to that range at which the normal patterns of Decca are, for most air navigation purposes, found in practice to be reliable, and secondly, the Lane Identification function can now be made entirely automatic in the receiver. This has not been possible with the currently operational system employing only two signals from each station due to a gradual transition from good to bad Lane Identification information without a clearly defined transition point as is now defined by the disappearance of a pulse below a limiting level.

The Zone Identification indication is achieved by the phase-comparison of a 0.2f beat-note derived between the signals received at 8f and 8.2f from the Mark 10 transmission burst from the Master Station with a similar signal derived from that from the Slave Station.

3. The Mark 10 Receiver is designed on superheterodyne principles rather than the conventional « straight » receiver of earlier Marks known to users. It employs only 16 crystals employed in the Mark 7 Receiver for only 9 such frequencies, and incorporates some interesting techniques which there is no time in this lecture to describe, but those interested can obtain such descriptions from the Decca Company's brochures on the subject. It has no operational controls or indicators on it at all, these being transferred to Decometers and a Control Box in the cockpit, so in installation the receiver can be remotely stowed as with previous Decca receivers.

The Decometers (figure 4) are of interest, being of new design. The single pointer is under continual control of the normal transmissions from the ground stations and indicates the Lane against a scale divided into 24 Lane divisions for Red, 18 for Green and 30 for Purple conventionally numbered as in the Mark 7 Receiver display. This pointer is driven from a discriminator working at an effective comparison frequency of 1f and corresponds within the Zone to the fractional pointer of a normal Decometer, though in contrast to the latter it is not directly geared to an integrating lane counter. The function of integrating the revolutions of this pointer is performed by a combination of a Sector pointer driven from that same discriminator but via a 5 : 1 step down gear and a lettered disc (carrying 10 Zonal-letters round its face) further geared to the Sector pointer via a 2:1 step down gear, so that one of its letters is displayed in the small window on the face of the Decometer as for the Mark 7 Receiver. We therefore have that for each revolution of the Lane pointer on its dial the Sector pointer will move forward one-fifth of a revolution and the Zone disc will move one-tenth of a revolution to display the next letter in the window. Since the sector pointer and Lane pointer are driven from the same discriminator their movements are identically controlled and integration of the revolutions of the latter are displayed on the Zonal disc directly from the movements of the former. It will further be clear that for a given position of the Sector on the dial face there are two possible letters to be displayed in the window — A or F, B or G, etc. — and one can be changed to the other if desired by the Re-set knob.

In practice the operational procedure is very simple. The user must, knowing his position only sufficiently well to select the group of Zones A to E or F to G in which he is situated in each pattern, switch on his receiver at the Control Box and set the Re-set knobs on the Decometers to indicate a Zone letter in the appropriate group on each Decometer. The transmission from the Ground Stations will first automatically position the Lane pointer in the correct position and Sector pointer at one of six alternative positions on the dial within one minute of time at most. This is the Automatic Lane Identification function, but Zone Identification within the selected group has not yet been considered. However, after the bursts of transmission from Master and, say, Red Slave Stations, the receiver has all the information to display the correct Zone within the group and does this by flicking the Lane pointer to a certain position on the dial. If this displaced position of the Lane pointer is within the arms of the Sector pointer, the Zone displayed in the window is correct ; if not, then the Re-set knob is turned until that desired result is achieved, thereby correcting

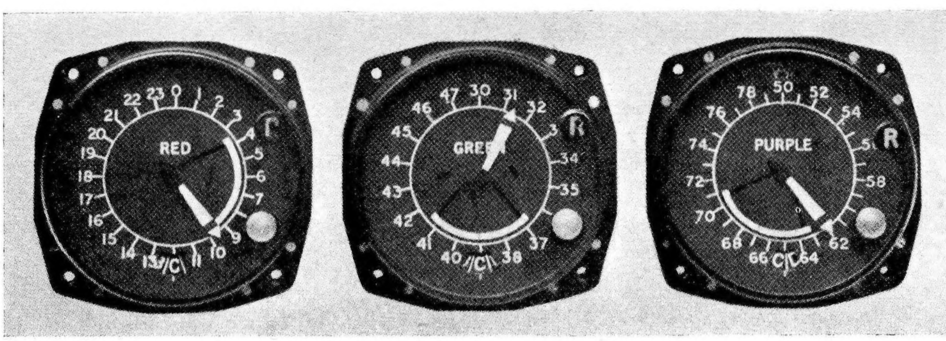

Fig. 4

the Letter so displayed. The receiver is now fully set up and as the aircraft moves the Decometer indications will integrate in the usual manner the movements of the aircraft across the patterns and at each minute the Lane pointers will flick to confirm the correct Zone indication. If by any chance integration is lost due to failure of the signals and the receiver has « slipped » a lane, the next Lane Identification sequence will automatically correct matters. Provided the group of 5 Zones can be identified for each pattern, all this setting-up procedure can very rapidly and easily be carried out in flight. The reduction by factor of 5 of the residual ambiguity of the Decca System and the extreme simplicity of operation willl be most welcome to air users in general.

4. Prototype Mark 10 Receivers are complete and provisions for extra transmissions from the Master and Green Slave Stations of the English Chain are nearly so, and immediate operational trials are expected to fulfill the promise of these new techniques.