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(54) Waveguide apparatus.

(57) Waveguide apparatus for transforming signals between the TE_{10} mode and a circular mode, shown in schematic exploded form, includes a Magic-T 10 in which the H-plane port 11 is terminated. A signal in the TE_{10} mode is applied to its E-plane port 8, resulting in signals in the TE_{10} mode being produced at its outputs 12 and 13, the field being in opposite senses. The outputs 12 and 13 are arranged adjacent one another so that the effective output of the Magic-T 10 is a signal in the TE_{20} mode. This is applied to a short taper 14 having an aperture therethrough, this being of rectangular section in the face adjacent the Magic-T output ports 12 and 13 and of cruciform section at the other face. The taper 14 is followed by a spacer 15 and iris 16 having a cruciform aperture therethrough. The application of the signal in the TE_{20} mode at the Magic-T outputs 12 and 13 results in an output signal in the TE_{01} mode being launched in the circular waveguide following the iris 16. The apparatus may also be used to transform a TE_{01} applied to the iris 16 into an output signal at the E-plane port 8 in the TE_{10} mode.

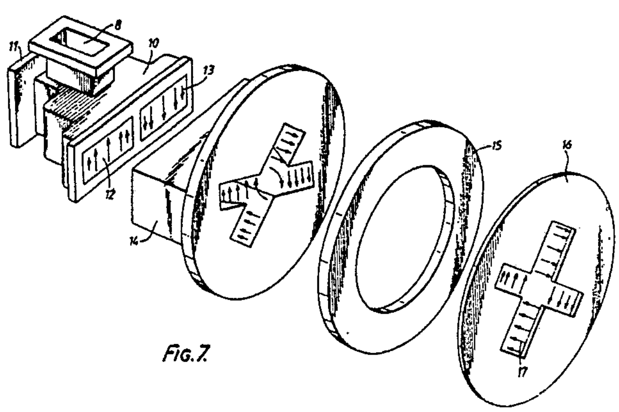

FIG. 7

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WAVEGUIDE APPARATUS

This invention relates to waveguide apparatus and more particularly, but not exclusively, to apparatus for transforming signals between the TE_{10} mode and the TE_{01} mode.

In arrangements in which it is desired to transmit microwave radiation over an appreciable distance, for example to a remote antenna, the energy is often transmitted along a circular waveguide in the TE_{01} mode. The TE_{01} mode, which is illustrated in Figure 1, is one in which the electric field lines are circumferential and thus power losses tend to be small because they do not intercept the walls of the waveguide. The energy to be transmitted along the waveguide is normally generated in the TE_{10} mode, as shown in Figure 2, which exists in rectangular waveguides and in which the electric field lines are generally parallel to the short sides of the waveguide. A transition section must be included to convert signals from the TE_{10} mode into the TE_{01} mode and consists of a tapered section in which the cross-section of the waveguide gradually changes from the rectangular shape to a circular section. The transition section must be relatively long in order to obtain a final signal having good mode purity, being typically of the order of one metre for signal frequencies of 6Ghz.

The present invention arose from an attempt to provide a more compact waveguide apparatus for transforming signals between the TE_{10} and TE_{01} modes.

Acccording to the invention there is provided waveguide apparatus for transforming signals between the TE_{10} mode and a circular waveguide mode comprising a Magic-T having its output ports arranged adjacent to one another and means for transmitting a signal via its E-plane port and signals via its output port, such that a signal in the TE_{10} mode applied to the E-plane port results in signals at the outputs which form a signal in the TE_{20} mode, and means for using the signal in the TE_{20} mode alone to produce the circular waveguide mode. By using apparatus in accordance with the invention, the circular mode can be produced from a signal in the TE_{10} mode using a relatively small transition section which may be, for example, of the order of five times shorter than a conventional transition section. Preferably, the circular mode is the TE_{01} mode. Normally, the input to a Magic-T is applied via its H-plane port and the E-plane port is connected to a load for matching purposes. By terminating the H-plane port and applying the input signal to the E-plane port, the signals at the two outputs of the Magic-T are in the TE_{10} mode in opposite senses. Thus, by arranging the outputs adjacent to one another, the two, opposite TE_{10} modes combine to form a TE_{20} mode, as shown in Figure 3, where the reference 1 indicates one of the Magic-T outputs and reference 2 the other. The production of the TE_{20} mode is an intermediate point in the eventual transformation of the signal into the TE_{01} mode or other circular mode. Apparatus in accordance with the invention may thus be made less bulky than conventional transition sections, which makes it particularly advantageous for arrangements in which the waveguide is required to move, for example in a rotating joint. Of course, the Magic-T is a symmetrical device such that in apparatus in accordance with the invention, when a signal in the TE_{20} mode is applied to the outputs of the Magic-T, a signal is derived from the E-plane port which is in the TE_{10} mode. Thus, the waveguide apparatus may act to transform signals from the TE_{10} mode into the TE_{01} mode and vice-versa. Although apparatus in accordance with the invention may tend to have reduced bandwidth capability and mode purity compared to a conventional transition section, it has good matching characteristics and offers sufficiently good performance for its use to be advantageous in a number of applications.

In one embodiment of the invention a taper section is included which has an aperture therethrough, the transverse section of which is substantially rectangular at one end and substantially cruciform at its other end, the taper section being arranged such that signals from the Magic-T outputs are applied to the rectangular section part of the aperture. By using a taper section, the mode purity of the resultant signal in the TE_{01} mode may be improved over what would otherwise be obtainable.

In another, particularly advantageous embodiment of the invention, a taper section is included having an aperture therethrough, the transverse section of the aperture being substantially rectangular at one end of the taper section and, at its other end, having two substantially concave sides which are joined by four substantially straight sides, the width of the aperture being larger at the concave sides than at its centre, the taper section being arranged such that signals from the Magic-T outputs are applied to the part of the aperture having rectangular section.

It is further preferred that an iris is included, the iris having a cruciform aperture therein via which signals from and to the Magic-T outputs are arranged to pass. The cruciform aperture is preferably arranged to overlap the non-rectangular end of the taper section. Again, the non-rectangular end of the taper section and the iris are also of use in transforming a signal in the TE_{01} mode to the TE_{10} mode.

It may be preferred that a waveguide rotating joint is included which is capable of transmitting two signals across the joint in respective different waveguide modes. Thus only one rotating joint is required for the transmission of two signals between relatively rotating members, whereas using previously known apparatus, a separate rotating joint would have been required for each signal. The size of waveguide apparatus can therefore be reduced which is particularly important for example, in applications such as satellite communication equipment and in radar apparatus. The waveguide modes chosen must be such that there is little or no coupling between them. It is preferred that the two signals are at respective different frequencies. These frequencies might be, for example, 4 GHz and 6 GHz which are typical frequency bands for satellite communication down and up paths. By using widely spaced frequency bands for the two signals, any coupling between them tends to be further reduced.

It is preferred that the waveguide at the joint is circular, and that one mode is the TM_{01} mode and the other is the TE_{01} mode. When a signal in one of these modes is imposed on another signal in the other mode, the electric field lines of the two modes are orthogonal and there is substantially no coupling between them. Another advantage in employing these two modes is that there is only a very small electric field along the longitudinal axis in the TE_{01} modes so that, for example, a cable may be positioned along it.

Some ways in which the invention may be performed is now described by way of example with reference to the accompanying drawings, in which:

Figure 4 is a schematic perspective view of a waveguide rotating joint which includes apparatus in accordance with the invention;

Figure 5 is a schematic sectional view of the apparatus shown in Figure 4;

Figure 6 is an explanatory diagram relating to the operation of the apparatus shown in Figure 4;

Figure 7 is an exploded view of part of the rotating joint shown in Figure 4:

Figure 8 shows part of another apparatus in accordance with the invention.

With reference to Figures 4 and 5, apparatus in accordance with the invention includes two circular waveguide sections 3 and 4 which are relatively rotatable at a rotating joint 5 about axis X-X. Two ports 6 and 7 are included for transmission of microwave energy across the rotating joint 5 in the TM_{01} waveguide mode, which has radial electrical field lines as shown in Figure 6. Power in the TE_{01} mode can also be transmitted across the rotating joint 5 via ports 8 and 9, between which the TM_{01} ports 6 and 7 are located. The frequency of the TE_{01} mode signal is different from that of the TM_{01} mode signal.

TE_{01} port 8 is the E-plane input port of a Magic-T 10, the H-plane input port having a termination 11. As is more clearly shown in Figure 7, the two output ports 12 and 13 of the Magic-T 10 are arranged adjacent one another. Microwave energy applied in the TE_{10} mode to the port 8 reaches one of the outputs 12 in the TE_{10} mode, as illustrated by the arrows, and the other output port 13 in the TE_{10} mode in the opposite sense. Thus, the output of the Magic-T is effectively in the TE_{20} mode.

The output of the Magic-T 10 is applied to a short taper 14 which has a rectangular section aperture on the side adjacent output ports 12 and 13 which opens out into a substantially cruciform section aperture at its other face. A mode is set up at the cruciform aperture face of the taper 14 as illustrated by the arrows. Signals passed via the Magic-T outputs 12 and 13 and the taper 14 are then applied via a spacer 15 to an iris 16 having a cruciform aperture 17 therein. This sets up a mode at the iris 16 as illustrated by the arrows. The iris 16 is the last stage in the transition section 18 which produces the TE_{01} mode in the circular waveguide at the joint 5. A similar transition section 19 is included on the other side of the rotating joint 5 and includes the port 9, which again is the E-plane port of a Magic-T.

The taper 14, or iris 16 where this is included, is arranged to present a short circuit at 20 (as shown in Figure 5) to energy passing through ports 6 and 7 so as to inhibit the undesirable TE_{11} mode.

Figure 8 shows another short taper 21 which may be used instead of the taper 14 shown in Figure 7. The taper 21 has a rectangular aperture 22 in one face which opens out into and aperture 23 having two curved sides and four straight side between them, as shown. This configuration give particularly good mode purity.

Claims

1. Waveguide apparatus for transforming signals between the TE_{10} mode and a circular waveguide mode comprising a Magic-T having its output ports arranged adjacent one another and means for transmitting a signal via its E-plane port and signals via its output ports, such that a signal in the TE_{10} mode applied to the E-plane port results in signals at the outputs which form a signal

in the TE_{20} mode, and means for using the signal in the TE_{20} mode alone to produce the circular waveguide mode.

2. Apparatus as claimed in claim 1 wherein the circular waveguide mode is the TE_{01} mode.

3. Apparatus as claimed in claim 1 or 2 and including a taper section having an aperture therethrough, the transverse section of the aperture being substantially rectangular at one end of the taper section and substantially cruciform at its other end, the taper section being arranged such that signals from the Magic-T outputs are applied to the part of the aperture having rectangular section.

4. Apparatus as claimed in claim 1 or 2 and including a taper section having an aperture therethrough, the transverse section of the aperture being substantially rectangular at one end of the taper section and, at its other end, having two substantially concave sides which are joined by four substantially straight sides, the width of the aperture be larger at the concave sides than at its centre, the taper section being arranged such that signals from the Magic-T outputs are applied to the part of the aperture having rectangular section.

5. Apparatus as claimed in claim any preceding and including an iris having a cruciform aperture therein via which signals from and/or to the Magic-T outputs are arranged to pass.

6. Apparatus as claimed in any preceding claim and including a waveguide rotating joint capable of transmitting two signals across the joint in respective different waveguide modes.

7. Waveguide apparatus as claimed in claim 6 wherein the two signals are at respective different frequencies.

8. Waveguide apparatus as claimed in claim 6 or 7 wherein the waveguide at the joint is circular and one mode is the TM_{01} mode and the other is the TE_{01} mode.

9. Apparatus as claimed in claim 8 wherein the rotating joint includes ports for the signal in the TM_{01} mode located between ports for the signal in the TE_{01} mode.

10. Waveguide apparatus as claimed in claim 9 wherein the signal in the TE_{01} mode is transmitted into a resonant cavity at a distance from a port for the signal in the TM_{01} mode such that it acts as a short circuit for the signal in the TM_{01} mode.

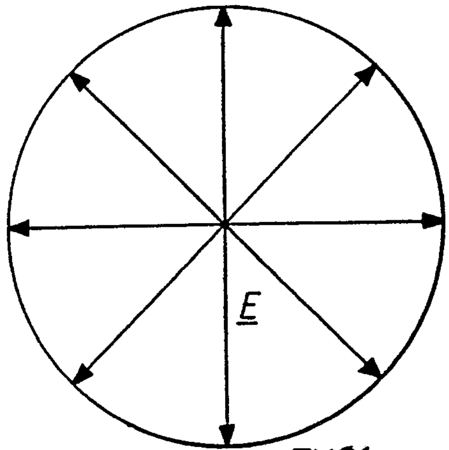

FIG.6.

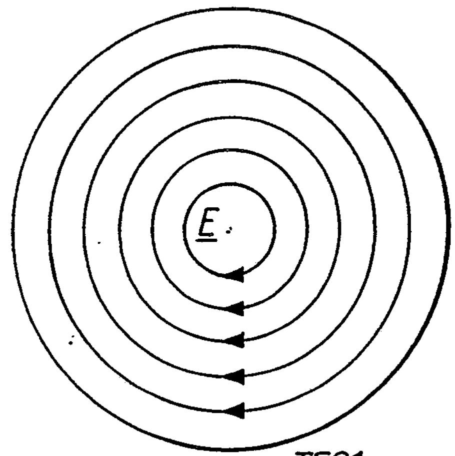

FIG.1.

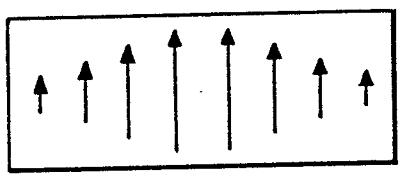

FIG.2.

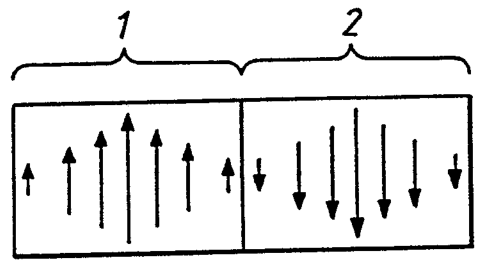

FIG.3.

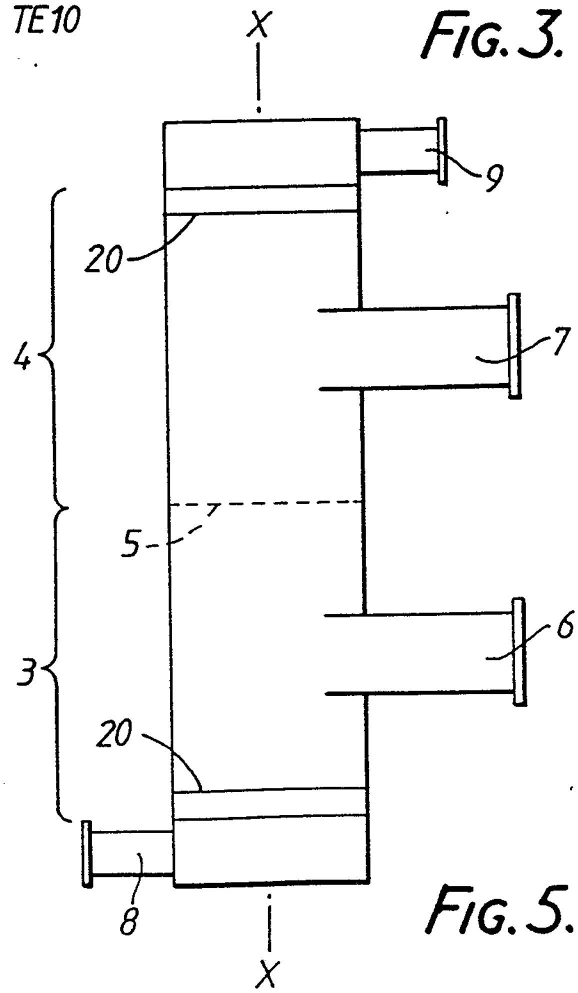

FIG.5.

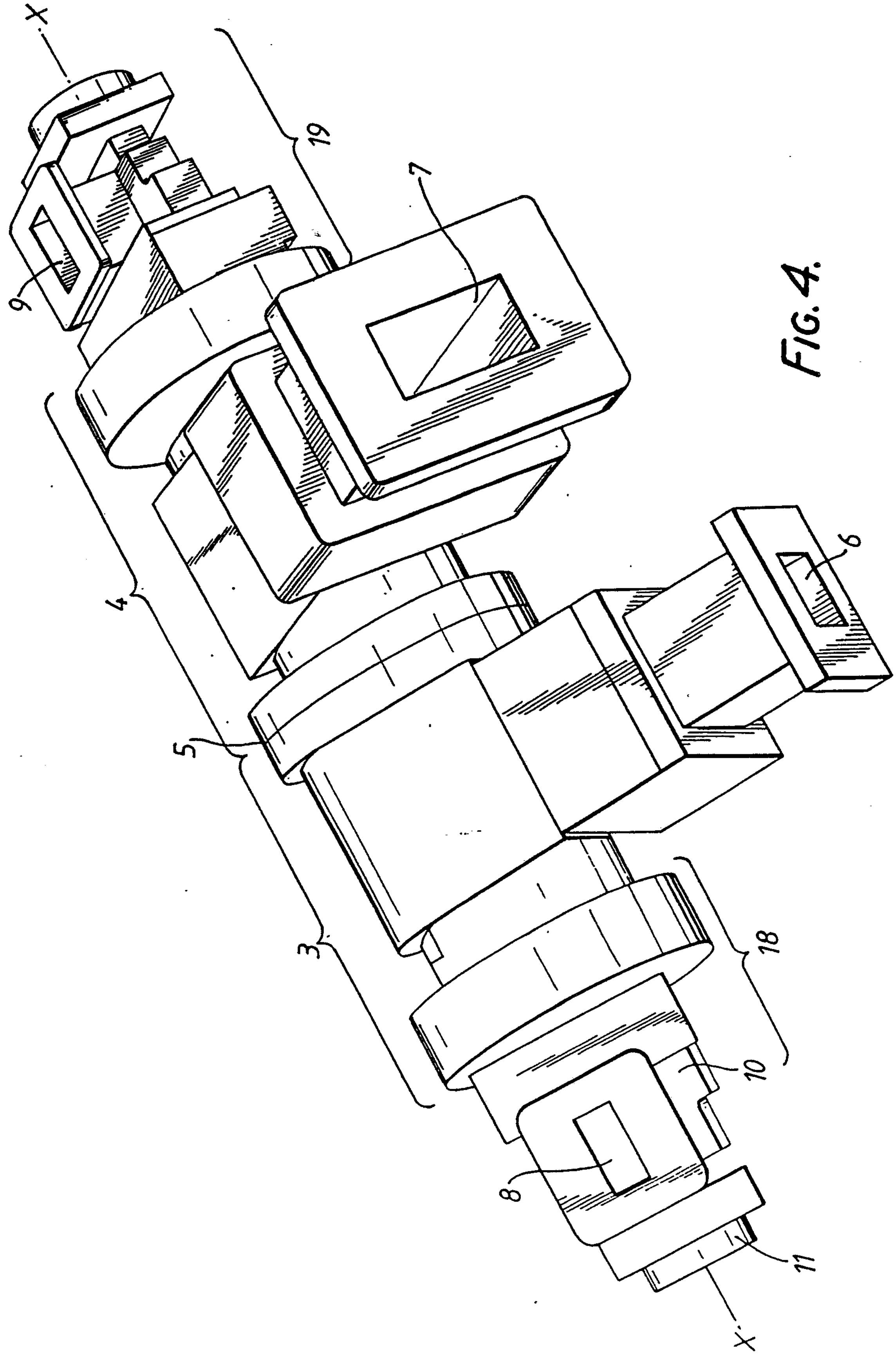

FIG. 4.

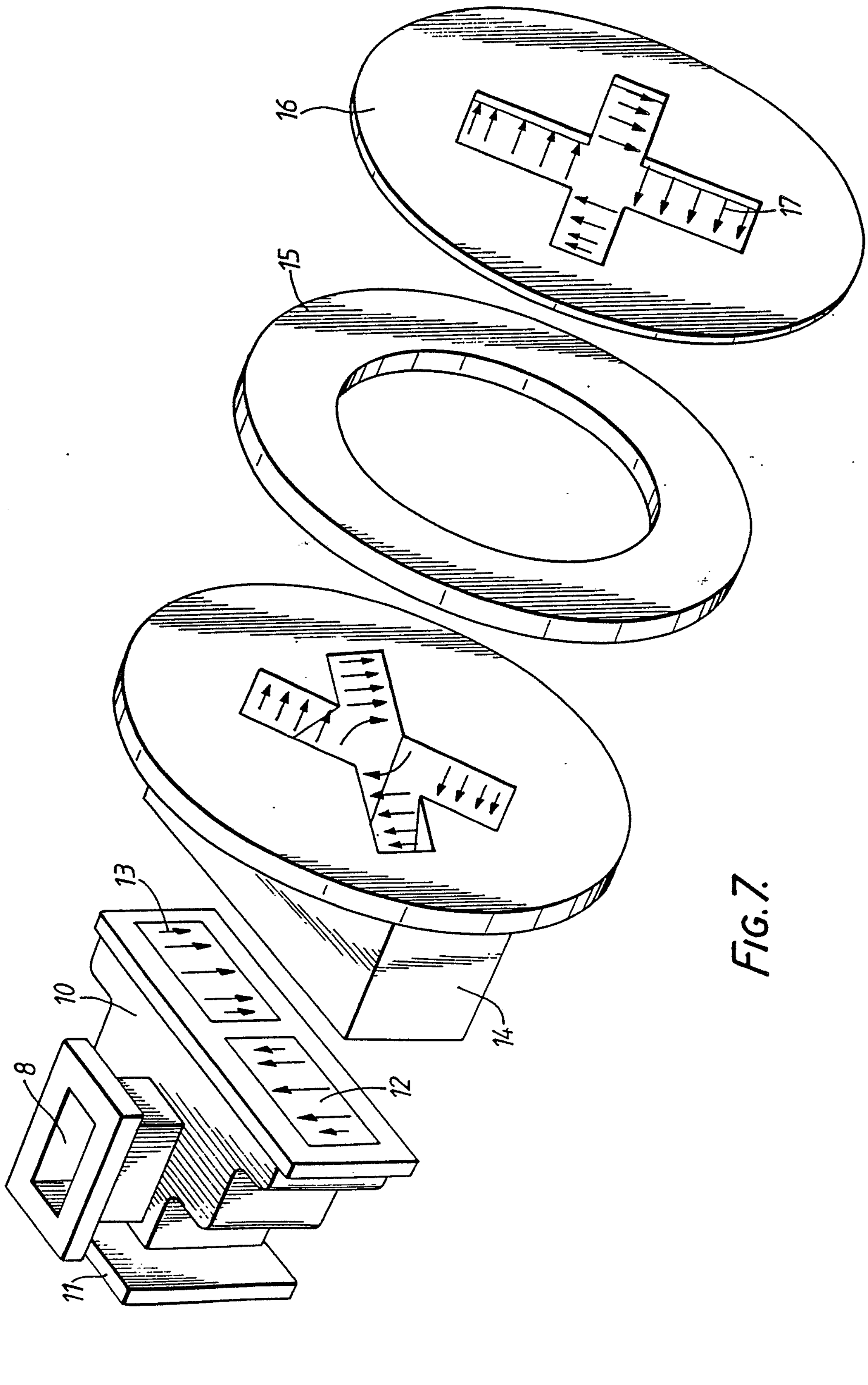

FIG.7.

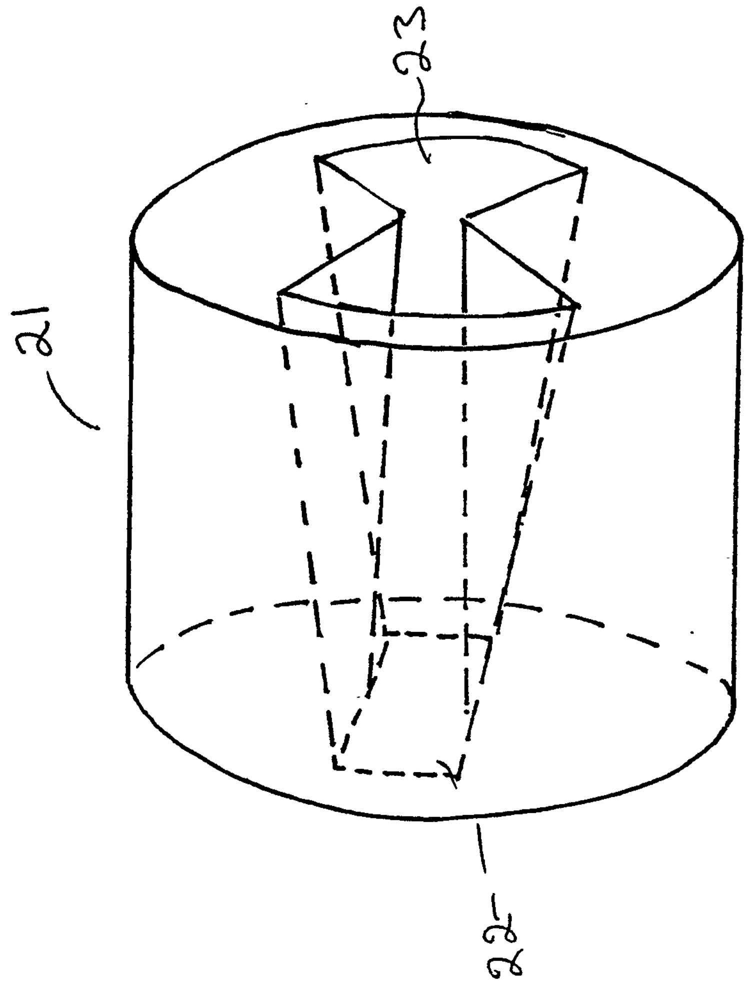

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 5128

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-2 656 513 (A.P. KING) * Column 3, line 71 - column 8, line 71; figures 1-3 *	1,2,4	H 01 P 1/163 H 01 P 1/06
Y		3,5-8	
A	DE-A-1 933 950 (THOMSON-CSF) * Page 3, last paragraph - page 4, line 7; figure 1 *	1	
Y	US-A-2 825 031 (F.E. PARISI) * Whole document *	3,5	
A		6,7	
Y	US-A-3 633 130 (J.S. AJIOKA) * Whole document *	6-8	
A	EP-A-0 243 888 (ALCATEL ESPACE) * Whole document *	6-10	
A	EP-A-0 210 543 (TEXAS INSTRUMENTS) * Abstract; figures *	6-10	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
X	FR-A-1 239 182 (CFTH) * Whole document *	1-3	H 01 P
A	US-A-2 455 158 (W.E. BRADLEY)		
A	US-A-3 100 881 (W.A. EDSON)		
A	US-A-3 230 484 (N. LIPETZ et al.)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-08-1989	LAUGEL R.M.L.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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