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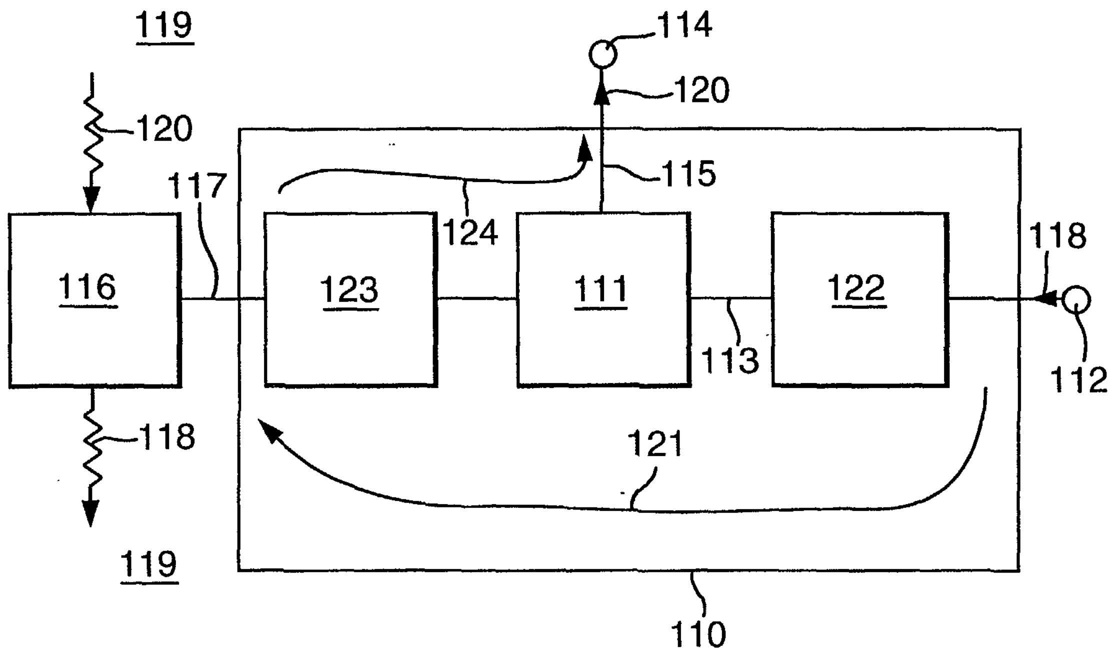
(54) **Improvements in or relating to diplexer apparatus**

(57) A diplexer apparatus comprises a diplexer 111 coupled to a transmit port 112, a receive port 114 and to a horn 116 which is arranged to substantially simultaneously transmit a transmit signal 118 or receive a receive signal 120, the transmit and receive signals 118 and 120 being co-linearly polarised signals. The diplexer 111 has one or more internal surface variations that are arranged to allow substantial all of the transmit signal 118 to pass from the transmit port 112 whilst prohibiting the receive signal 120 from passing. The receive signal 120 is reflected by the diplexer 111 and passes to the receive port 114. The diplexer 111 acts as a frequency discriminator of co-linearly polarised signals 118 and 120.

Fig.4.



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Description

[0001] The present invention relates to diplexer apparatus and to a method of separating signals of two different frequencies.

[0002] Figure 1, illustrates a classical configuration of an Ortho-Mode Transducer 10 having a through port 11 and a side port 12. The Ortho-Mode Transducer 10 includes a short circuit diametrical plane 13 which is used to separate two signals 14 and 15. It should be noted that the two signals 14 and 15 are orthogonal to one another in polarisation.

[0003] In operation the short circuit diametrical plane 13 produces a total reflection of signal 15, while the signal 14, perpendicular to the short circuit diametrical plane 13 is transmitted without significant perturbation, to the through port 11. If the side port 12 is located in a correct position, the reflected signal 15 is totally coupled inside port 12. This method allows the separation of two orthogonal polarised signals with the same frequency travelling in the same circular waveguide.

[0004] The Ortho-Mode Transducer cannot be used to discriminate between two co-polarised signals with different frequencies. A diplexer is usually used to accomplish this function.

[0005] Figure 2 illustrates a typical diplexer 20 used to separate two co-polarised signals 21 and 22 which have different frequencies. The diplexer 20 comprises a first port 23 which separates into second and third ports 24 and 25. The first port 23 is usually formed from a rectangular waveguide which is arranged to carry both signals 21 and 22 to a conducting plate 26 which is perpendicular to the electric field of the signals 21 and 22 and divides both signals 21 and 22 between the second and third ports 24 and 25. The ports 24 and 25 are usually formed from a rectangular waveguide and arranged to branch from the rectangular waveguide of first port 23. Ports 24 and 25 are arranged to house a frequency filter. In this example port 24 houses a high pass filter 27 and port 25 houses a low pass filter 28. In operation, the high pass filter 27 reflects the low frequency signal 22 and routes the high frequency signal 21 through to the second port 24. Similarly, the low pass filter 28 reflects the high frequency signal 21 whilst allowing the low frequency signal 22 to pass through to the third port 25. The diplexer 20 is arranged to provide impedance matching between the conducting plate 26 and filters 27 and 28 such that signals reflected by the filters 27 and 28 are recombined and are not reflected back through the first port 23.

[0006] An alternative diplexer 30 is illustrated in Figure 3 and is typically used in satellite communication operations and is commonly known as a branch guide coupler. The diplexer 30 comprises two parallel rectangular waveguides 31 and 32 coupled to one another by branch guides 33a to 33i. A first port 34 carries both a high frequency transmit signal and a low frequency receive signal. The branch guide 33a to 33i are designed to couple the high frequency transmit signal only from the waveguide 31 to waveguide 32. In this manner the high frequency transmit signal is totally coupled in waveguide 32 and arrives at a second port 35 whilst the low frequency receive signal is contained within waveguide 31 and is routed to a third port 36.

[0007] The diplexers 20 and 30 of Figures 2 and 3 suffer from a number of disadvantages when applied to systems having a considerable frequency separation between the two frequency signals to be discriminated. The diplexers 20 and 30 use the same waveguide to discriminate between both of the frequency signals and to route these to the output ports. A waveguide over cut-off for one of the signals will be a plus-mode waveguide for the other signal; in fact the cut-off frequency of the TE_{20} mode is lower than the high frequency transmit signal. This is a critical situation because the internal structure (the conductive plane and filter of diplexer 20 and the branch guides 33a to 33i of diplexer 30) can excite the TE_{20} mode, which is in turn very difficult to control.

[0008] Moreover, if one uses diplexers 20 and 30 the result is two signals in their respective rectangular waveguides and a transition is needed from a rectangular to a circular waveguide in order to connect a circular horn device to the rectangular waveguide. This transition is very critical and difficult for superior mode excitation control.

[0009] Furthermore, to improve the radiation performance of a horn in terms of pattern symmetry, a TM_{11} superior mode (Potter horn) needs to be introduced. In a dual mode Potter type horn, the TM_{11} is generated by a variation of the diameter in a circular waveguide in the throat of the horn before a flared section of the horn. This diameter variation must be arranged in a single-mode circular waveguide. However, arrangement of a transition from rectangular to circular waveguide results in a non single mode type waveguide for one of the signals and the TM_{11} mode cannot be correctly excited in the potter type horn.

[0010] It is an object of the present invention to obviate or mitigate the disadvantages associated with the prior art.

[0011] According to one aspect of the present invention a diplexer apparatus comprises a first arm arranged to carry a first signal of a first frequency, a second arm arranged to carry a second signal of a second frequency, and a discriminator coupled to both the first and second arms and having an internal surface variation arranged to allow the signal of only one of the arms to pass substantially unperturbed.

[0012] In this manner, the diplexer apparatus can be arranged to discriminate between two signals having different frequencies by only allowing one of the signals to pass.

[0013] The first and second signals may be co-linear polarised signals. In this manner, the diplexer apparatus can be arranged to discriminate between two signals having different frequencies, but substantially similar polarised states.

[0014] The internal surface variation may correspond to a change in the effective cross section through the discriminator. The internal surface variation may correspond to step structure. Preferably, the internal surface of the discriminator may have a substantially circular cross section and the internal surface variation may correspond to a change in the effective diameter of the discriminator.

[0015] The internal surface variation may be arranged to allow only the higher frequency of the first and second signals to pass. The discriminator may incorporate a third arm arranged to transmit and to receive the first and second signals. The third arm may act as an horn of an antenna. The first signal may correspond to a transmit signal and the second signal may correspond to a receive signal. The first signal may have a frequency value greater than or equal to the second signal. The first signal may have a frequency value greater than or equal to twice that of the second signal.

[0016] There may be at least one further arm arranged to carry a corresponding further signal having a different frequency to that of the first and second signals and the discriminator may be coupled to the further arm and may have at least one further internal surface variation arranged to allow only the further signal to pass.

[0017] Preferably, the higher frequency signal may be composed of two modes. For example, the first signal or the transmit signal may be carried by two modes, TE11 and TM11, in a proper amplitude ratio so as to correctly couple the diplexer apparatus to a Potter type horn in an efficient manner.

[0018] According to another aspect of the invention a method of separating signals of two different frequencies comprises arranging a first arm of a diplexer apparatus to carry a first signal having a first frequency, arranging a second arm of a diplexer apparatus to carry a second signal having a second frequency, and discriminating between the frequencies of the first and second signals using a discriminator coupled to the first and second arms and having an internal surface variation arranged to allow only one of the signals to pass substantially unperturbed.

[0019] According to a further aspect of the invention a communications system comprises at least one remote unit and at least one base station arranged to communicate with each remote unit over a communication channel, the remote unit and/or base station having a diplexer apparatus in accordance with the invention.

[0020] According to another aspect of the invention a method of operating a communications system which has at least one remote unit and at least one base station arranged to communicate with each remote unit over a communication channel, the remote unit and/or base station having a method of separating signals of two different frequencies in accordance with the invention.

[0021] The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates a prior art configuration of a Ortho-Mode Transducer;

Figure 2 illustrates a prior art diplexer used to discriminate between co-polarised signals with different frequencies;

Figure 3 illustrates an alternative prior art diplexer used to discriminate between two co-polarised signals with different frequencies;

Figure 4 illustrates a schematic block diagram of a diplexer apparatus according to the invention, and

Figure 5 illustrates a side elevation view of a diplexer apparatus according to the present invention.

[0022] Referring to Figure 4, a diplexer apparatus 110 is described in general terms and comprises a diplexer 111 coupled to a transmit port 112 via a first arm 113 and coupled to a receive port 114 via a second arm 115.

[0023] A horn 116 is coupled to the diplexer 111 via a third arm 117 and is arranged to either transmit a transmit signal 118 from transmission port 112 into free space 119 or to receive a receive signal 120 from free space 119 for onward transmission to the receive port 114.

[0024] The transmit signal 118 follows a transmit signal path 121 from the transmit port 112 through a transmit exciter 122 and the diplexer 111, and substantially undisturbed through a receive exciter 123 to arrive at the horn 116. Similarly, the receive signal 120 is collected by the horn 116 and follows receive signal path 124 which passes through the receive exciter 123 and via the diplexer 111 to arrive at receive port 114.

[0025] The diplexer 111 is arranged to allow either the reception, transmission or substantially coincidental transmission and reception of transmit and receive signals 118, 120. In this particular embodiment the diplexer apparatus 110 is arranged to operate in the extremely high frequency (EHF) frequency band which is typically characterised by millimetric waves having a frequency bandwidth 20 GHz and 60 GHz.

[0026] In the present invention the transmit and receive signals 118 and 120 are co-linearly polarised signals in the EHF band. This band is characterised by high frequency values and by what can be considered an unusually large separation between the receive signal 120, typically between 20.2 and 21.2 GHz and the transmit signal 118, typically between 43.5 and 44.5 GHz.

[0027] Referring to Figure 5, a diplexer apparatus 130 has a diplexer section 131 coupled to a transmit port 132 via a first arm 133 and to a receive port 134 via a second arm 135. Also coupled to the diplexer section 131 via a third arm 136 is a horn generally indicated by reference numeral 137. As previously described the horn 137 is arranged to either transmit a transmit signal 138 from the transmit port 132 into free space 139 or to receive a receive signal 140 from free space 139 for onward transmission to the receive port 134.

[0028] The horn 137, diplexer section 131 and first arm 133 form a circular waveguide, whereas the second arm 135 is formed from a rectangular waveguide. The diplexer section 131 comprises internal annular variations in the effective diameter of the diplexer section 131 as indicated by reference numerals 141, 142 and 143. These restrictions in diameter 141 to 143 are arranged so as to cut off lower frequency values i.e. those values corresponding to receive signals 140 whilst allowing higher frequency signals, i.e. transmit signals 138, to travel through the diplexer section 131 with minimum disturbance. In this manner, transmit and receive signals 140 and 138 which have the same linear polarisation, but have different frequencies, can be discriminated and guided to their respective port 132 and 134. Accordingly, the diplexer section 131 acts as a frequency discriminator of co-linearly polarised signals.

[0029] The operation of discrimination between a higher frequency transmit signal 138 and a relatively lower frequency receive signal 140 is described as follows. The third arm 136 is a circular waveguide and is arranged to carry both the higher and lower frequency signals 138 and 140. The third arm 136 is too large to support a single mode for the higher frequency transmit signal 138 and in this way the higher frequency transmit signal 138 travelling through the third arm 136 remains concentrated to an internal section of the waveguide and is routed from the transmit port 132 without substantial disturbance from a coupler hole 144 providing access to the second arm 135. The coupling level of the power for the higher frequency transmit signal 138 to the arm 135 is negligible. The annular variation of effective diameter at 142 acts as a cut off section for the lower frequency receive signal 140, i.e. substantially no low frequency receive signal 140 will propagate after annular variation 142 which produces a total reflection of the lower frequency receive signal 140. If the coupler hole 144 is located correctly, the reflected receive signal 140 is totally coupled in second arm 135. It should be noted that discrimination is on the basis of frequency rather than the polarisation of signals 138 and 140.

[0030] In this embodiment, the annular variation 142 is arranged to excite the TM_{11} mode correctly for the higher frequency transmit signal 138 for proper excitation of a Potter type horn 137. The circular waveguide annular variation between 142 and 143 acts as a single-mode waveguide for the higher frequency transmit signal 138 and the annular variation 143 acts as a matching section for the higher frequency transmit signal 138.

[0031] Furthermore, the third arm 136 which carries both transmit and receive signals 138 and 140 should be a plus-mode circular waveguide for the transmit signal 138. The TM_{11} mode arrangement has been described above and because of the dimensions of the third arm 136 it can propagate other higher modes, i.e. TE_{21} and TM_{01} odd modes. These modes are undesirable for the radiation characteristics of the horn 137 as they are not symmetrical. In fact the electromagnetic field generated by these modes are not symmetrical with the longitudinal plane of the circular waveguide and they produce an asymmetric illumination of an antenna dish. Generally, these modes are not excited in a circular waveguide, but the presence of an asymmetrical geometric structure such as coupler hole 144 which acts as an asymmetric structure inside the circular waveguide, can cause excitation. In order to provide a symmetry of the electromagnetic field and reduce the odd mode excitation a symmetric hole 145 is arranged opposite the coupler hole 144 for the second arm 135.

Claims

1. A diplexer apparatus , comprising

   a first arm arranged to carry a first signal of a first frequency,
   a second arm arranged to carry a second signal of a second frequency, and
   a discriminator coupled to both the first and second arms and having an internal surface variation arranged to allow the signal of only one of the arms to pass substantially unperturbed.

2. A diplexer apparatus, as in Claim 1, wherein the first and second signals are co-linear polarised signals.

3. A diplexer apparatus, as in Claims 1 or 2, wherein internal surface variation corresponds to a change in the effective cross section through the discriminator.

4. A diplexer apparatus, as in any preceding claim, wherein the internal surface variation corresponds to step structure.

5. A diplexer apparatus, as in any preceding claim, wherein the internal surface of the discriminator has a substantially circular cross section and the internal surface variation corresponds to a change in the effective diameter of the discriminator.

6. A diplexer apparatus, as in any preceding claim, wherein the internal surface variation is arranged to allow only the higher frequency of the first and second signals to pass.

7. A diplexer apparatus, as in any preceding claim, wherein the discriminator incorporates a third arm arranged to transmit and to receive the first and second signals.

8. A diplexer apparatus, as in any preceding claim, wherein the first signal corresponds to a transmit signal and the second signal corresponds to a receive signal.

9. A diplexer apparatus, as in any preceding claim, wherein the first signal has a frequency value greater than or equal to the second signal.

10. A diplexer apparatus, as in Claim 9, wherein the first signal has a frequency value greater than or equal to twice that of the second signal.

11. A diplexer apparatus, as in any preceding claim, wherein there is at least one further arm arranged to carry a corresponding further signal having a different frequency to that of the first and second signals and the discriminator is coupled to the further arm and has at least one further internal surface variation arranged to allow only the further signal to pass.

12. A diplexer apparatus, as in Claims 6 to 11, wherein the higher frequency signal is composed of two modes.

13. A diplexer apparatus substantially as illustrated in and/or described with reference to the accompanying drawings.

14. A method of separating signals of two different frequencies, comprising

arranging a first arm of a diplexer apparatus to carry a first signal having a first frequency,
arranging a second arm of a diplexer apparatus to carry a second signal having a second frequency, and
discriminating between the frequencies of the first and second signals using a discriminator coupled to the first and second arms and having an internal surface variation arranged to allow only one of the signals to pass substantially unperturbed.

15. A method of separating signals of two different frequencies substantially as illustrated in and/or described with reference to the accompanying drawings.

16. A communications system, comprising at least one remote unit and at least one base station arranged to communicate with each remote unit over a communication channel, the remote unit and/or base station having a diplexer apparatus according to Claims 1 to 13.

17. A method of operating a communications system having at least one remote unit and at least one base station arranged to communicate with each remote unit over a communication channel, the remote unit and/or base station having a method of separating signals of two different frequencies in accordance with Claims 14 or 15.

Fig.1.

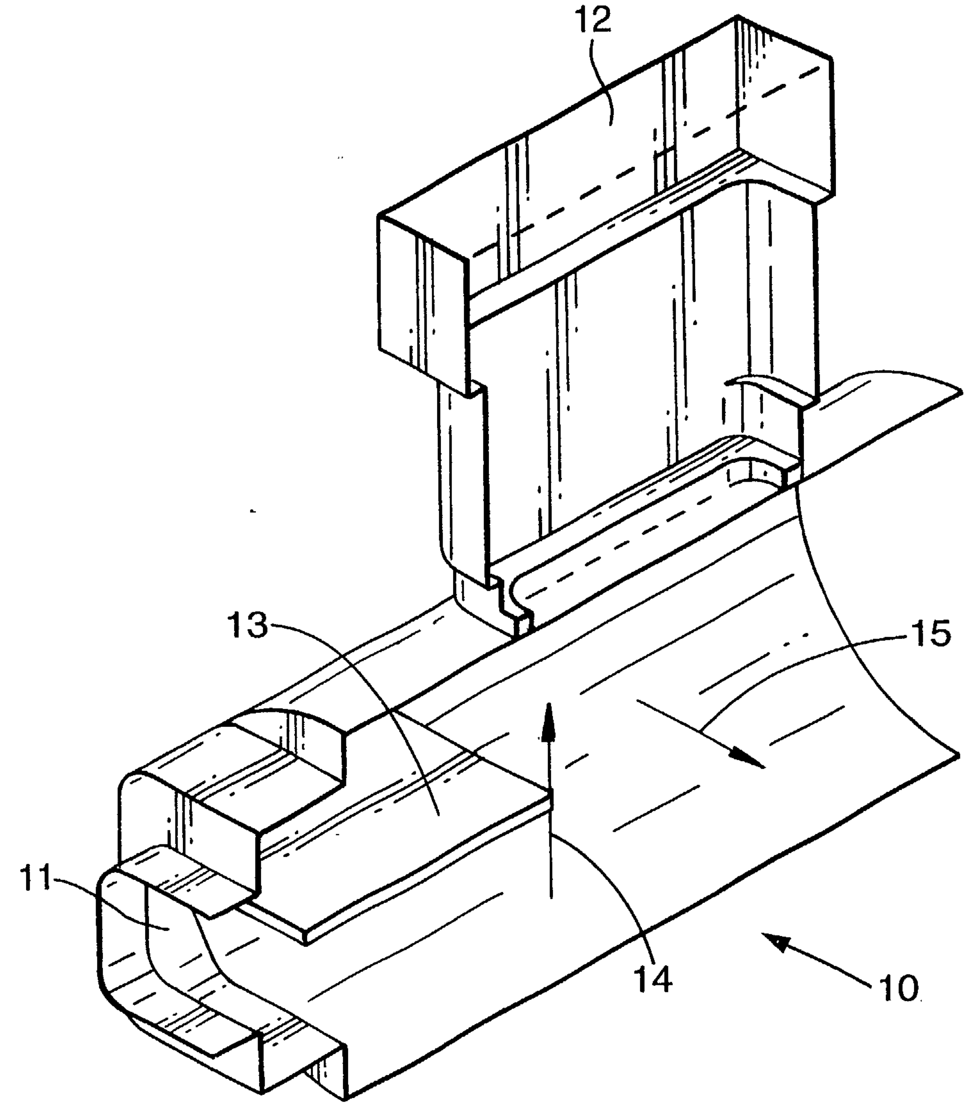

Fig.2.

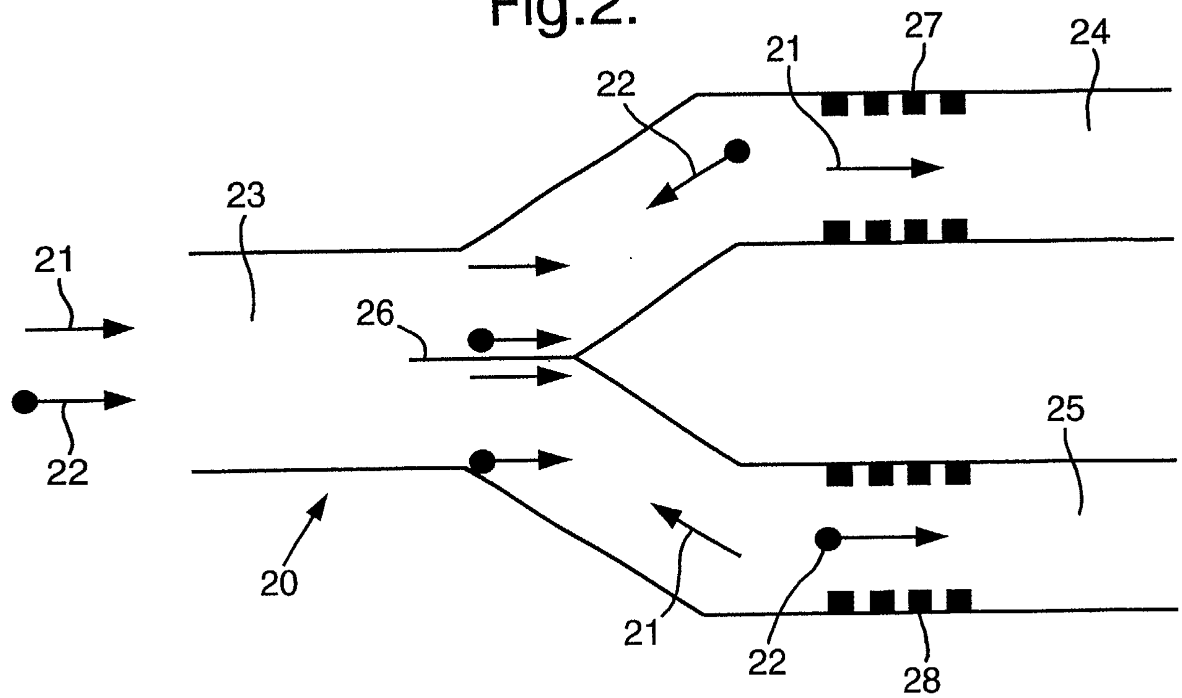
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Fig.3.

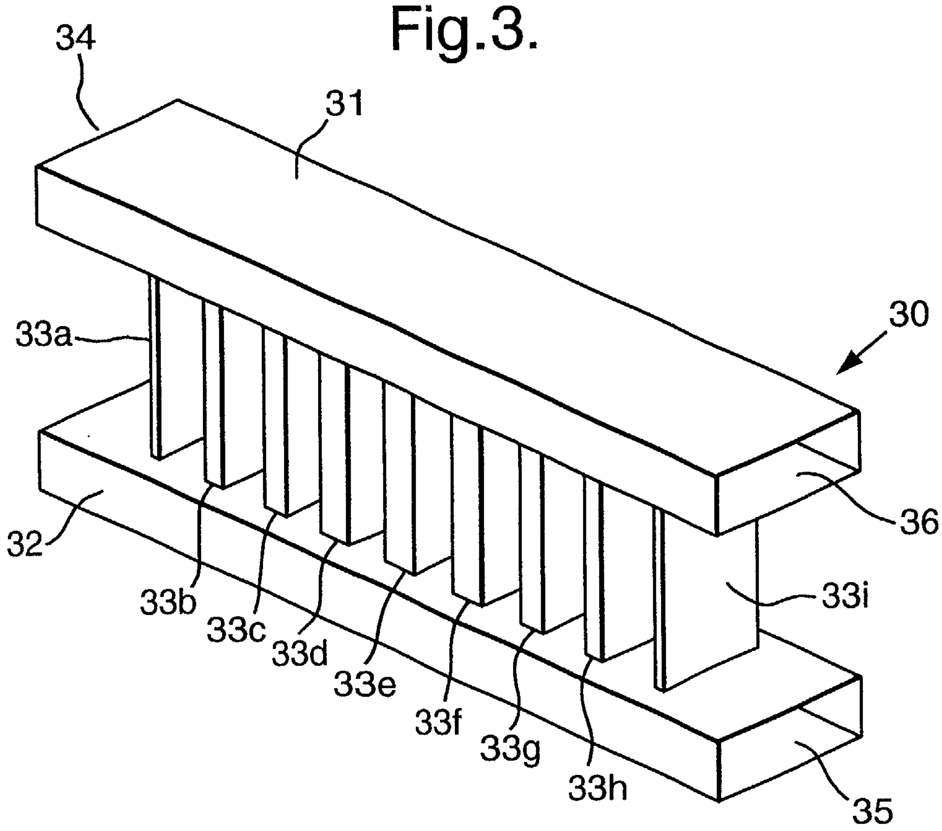
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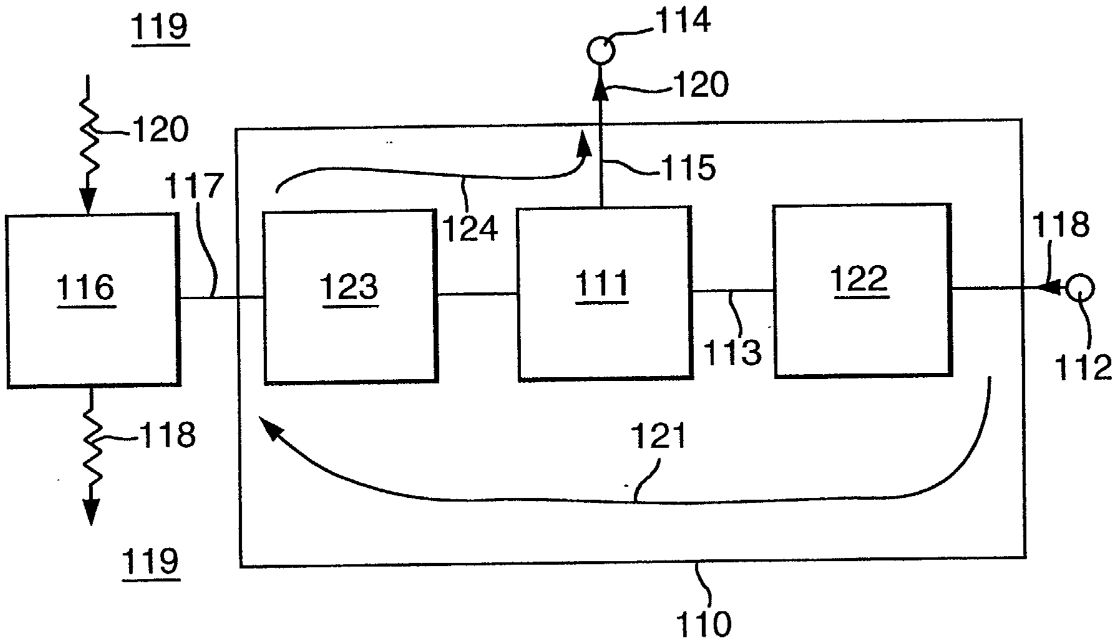
Fig.4.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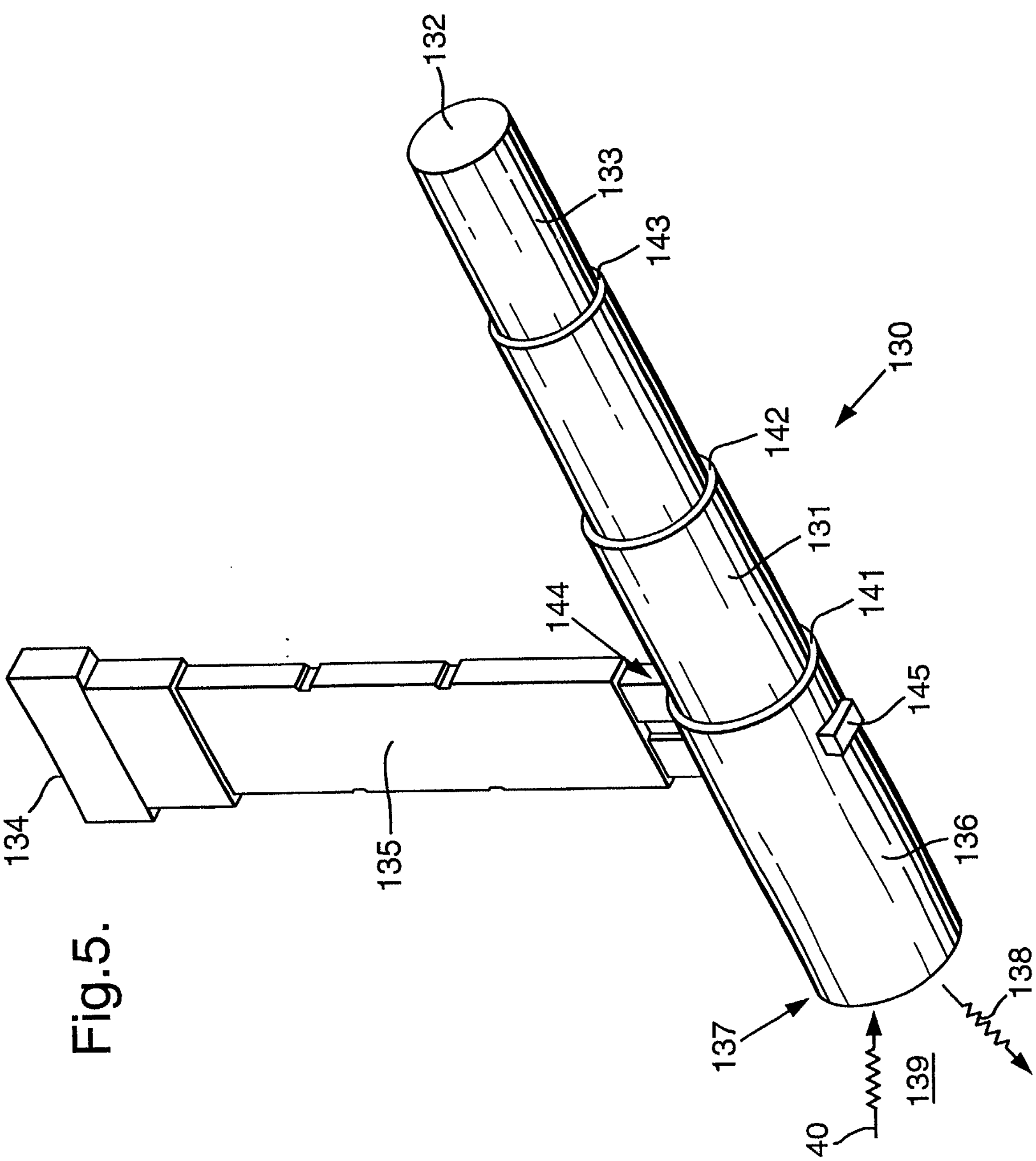

Fig.5.