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Description

This invention relates to a device for distributing and/or combining microwave electric power between a single waveguide and a plurality of microwave transmission paths.

5 In recent years, it has been attempted to use semiconductor amplifier elements such as gallium-arsenic (GaAs) field effect transistors (FETs) instead of conventional travelling-wave tubes, in order to amplify signals in the microwave band. However, the semiconductor amplifier element has an output power of several watts at the most. When it is necessary to amplify a high frequency signal of high electric power, such elements must be operated in parallel. For this reason, it is accepted practice to distribute input
10 signals in the microwave band into a plurality of channels by a microwave distributor, to amplify the signals of each channel by the above-mentioned semiconductor amplifier element, and to combine the amplified output signals of each of the channels into a signal of one channel by a microwave combiner, thereby obtaining a high power high frequency signal. However, electric power is lost when the phases of the microwave electric signals distributed by the microwave distributor are not in agreement, or when the
15 microwave signals are not combined in phase by the microwave combiner. It is, therefore, desired that phases of microwave signals be uniformly distributed in the microwave distributor and in the microwave combiner. It is also necessary that the distributor or combiner itself lose as little electric power as possible.

Figure 1A of the accompanying drawings shows a conventional microwave power amplifier, in which a high frequency input signal IN is divided into four 3-dB hybrid circuits, the divided input signals are
20 individually amplified by four solid state amplifier elements 2 to 5, and the amplified output signals are combined by hybrid circuits 6, thereby obtaining an amplified high-frequency output signal OUT. In the amplifier of Fig. 1A, when the microwave electric power is distributed from a single waveguide to a plurality of transmission paths or is combined in the opposite direction, branching points which branch at a ratio of 1:2 or combining points must be provided at each of the places as denoted by reference numeral 1
25 in Fig. 1B. The distribution of electric power from a single waveguide 7 directly into many transmission paths (such as waveguides) 8—1, 8—2, . . . , or vice versa, is not possible. In the conventional amplifier of Fig. 1A, each of the hybrid circuits 1 or 6 consists of a magic T as shown in Fig. 1C. Therefore, if magic T's are used at a plurality of branching points, the whole amplifier becomes very bulky and complex in construction. Furthermore, the amplifier element and the waveguide are usually connected via a structure
30 which consists of the following interconnected components: a waveguide — a ridge waveguide — an amplifier element with strip lines which serve as input and output terminals — a ridge waveguide — a waveguide. Therefore, the construction is complicated and, moreover, its reliability is not good, since the strip lines are connected to the ridge waveguides simply by a press fit.

An object of the present invention is to provide a device for distributing and/or combining microwave
35 electric power between a single waveguide and a plurality of microwave transmission paths which is capable of uniformizing the phase distribution of microwave electric power when it is to be distributed or combined.

US—A—4291278 discloses a microwave power amplifier comprising a first electromagnetic horn having a throat portion which is coupled to an input microwave path and which radially disperses a
40 microwave input signal; an oversized waveguide coupled at one end to the open end of the first electromagnetic horn; a second electromagnetic horn the open end of which is coupled to the other end of the oversized waveguide and which combines microwave signals from the oversized waveguide; a plurality of amplifier units which are arranged in the oversized waveguide, each of the amplifier units receiving and amplifying the microwave signal from the first electromagnetic horn after converting it into
45 an MIC mode signal, and the output signal of each of the amplifier units being transmitted into the second electromagnetic horn after it is converted into a waveguide mode signal; and phase compensating means for uniformizing the phases of the microwave signals distributed by the first electromagnetic horn or for adjusting the phases of the microwave signals fed out from the plurality of amplifier units, the phase compensating means being arranged between the first electromagnetic horn and the oversized waveguide
50 or between the oversized waveguide and the second electromagnetic horn, wherein the compensating means comprises for each of the plurality of amplifier units an MIC transmission line and a waveguide/MIC converting element which is coupled to the MIC transmission line and which is disposed within the oversized waveguide. This disclosure contains no detail on how phase compensation is achieved.

In accordance with one aspect of the present invention, a microwave power amplifier comprises a first
55 electromagnetic horn having a throat portion which is coupled to an input microwave path and which radially disperses a microwave input signal; an oversized waveguide coupled at one end to the open end of the first electromagnetic horn; a second electromagnetic horn the open end of which is coupled to the other end of the oversized waveguide and which combines microwave signals from the oversized waveguide; a plurality of amplifier units which are arranged in the oversized waveguide, each of the
60 amplifier units receiving and amplifying the microwave signal from the first electromagnetic horn after converting it into an MIC mode signal, and the output signal of each of the amplifier units being transmitted into the second electromagnetic horn after it is converted into a waveguide mode signal; and phase compensating means for uniformizing the phases of the microwave signals distributed by the first electromagnetic horn or for adjusting the phases of the microwave signals fed out from the plurality of
65 amplifier units, the phase compensating means being arranged between the first electromagnetic horn and

the oversized waveguide or between the oversized waveguide and the second electromagnetic horn, wherein the phase compensating means comprises for each of the plurality of amplifier units an MIC transmission line and a waveguide/MIC converting element which is coupled to the MIC transmission line and which is disposed within the oversized waveguide, and is characterised in that the length of the MIC transmission line corresponding to the waveguide/MIC converting element disposed at the central position along the direction of enlargement of the oversized waveguide is the largest, and the lengths become smaller as the distance from the central position increases; and in that the positions of the waveguide/MIC converting elements along the direction of propagation of the microwave signals vary in accordance with the position thereof along the direction of enlargement of the oversized waveguide, the lengths and positions of the MIC transmission lines being selected in accordance with the phase of microwave electric power at the position of the corresponding waveguide/MIC converting element relative to the direction of enlargement of the oversized waveguide.

In accordance with a second aspect of the present invention, a device for distributing and/or combining microwave electric power between a first microwave path and a plurality of second microwave paths, comprises an electromagnetic horn having a throat portion which is coupled to the first microwave path; an oversized waveguide coupled at one end to the open end of the horn and at the other end to the plurality of second microwave paths; and phase compensating means for uniformizing the phases of the microwave signals distributed by the horn or for adjusting the phases of the microwave signals fed out from the plurality of second microwave paths, the phase compensating means being provided by the plurality of second microwave paths each of which comprises an MIC transmission line and a waveguide/MIC converting element which is coupled to the MIC transmission line and disposed at the end portion of, or within, the oversized waveguide, and is characterised in that the length of the MIC transmission line corresponding to the waveguide/MIC converting element disposed at the central position along the direction of enlargement of the oversized waveguide is the largest, and the lengths become smaller as the distances from the central position become larger; and in that the positions of the waveguide/MIC converting elements along the direction of propagation of the microwave signals vary in accordance with the position thereof along the direction of enlargement of the oversized waveguide, the lengths and positions of the MIC transmission lines being selected in accordance with the phase of microwave electric power at the position of the corresponding waveguide/MIC converting element relative to the direction of enlargement (E) of the oversized waveguide.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1A is a block circuit diagram of a microwave amplifier which uses a conventional distributor and a conventional combiner of microwave electric power;

Figure 1B is a diagram of a conventional distributor or combiner used in the amplifier of Figure 1A;

Figure 1C is a perspective view of a magic T used in a conventional distributor or combiner of Figure 1B;

Figure 2 is a perspective view of a microwave amplifier which uses a distributor and a combiner according to the present invention;

Figure 3 is a perspective view of part of the microwave amplifier of Figure 2;

Figure 4 is a partial perspective view of another embodiment of the present invention;

Figure 5A is a perspective view of a microwave amplifier which uses a distributor and a combiner according to the present invention;

Figure 5B is an enlarged view of part of the microwave amplifier of Figure 5A;

Figure 6 is a schematic view of a distributor or combiner according to the present invention;

Figure 7 is a graph of the phase distribution characteristics of the device of Figure 6;

Figures 8 to 11 are perspective views of waveguide-MIC converters used in distributors or combiners according to the present invention;

Figure 12 is a schematic view of a conventional microwave power amplifier;

Figure 13 is a schematic partially cut-away view of a microwave power amplifier used in a distributor or a combiner according to the present invention;

Figure 14 shows partial plan and side views of the microwave power amplifier of Figure 13 in detail;

Figure 15 is a block circuit diagram of an equivalent circuit of the device of Figure 14;

Figure 16 is a perspective view of the structure of a microstrip line; and

Figure 17 is a graph of the frequency-gain characteristics of the circuit of Figure 15.

Figure 2 illustrates a microwave amplifier which uses a distributor and a combiner according to the present invention. The amplifier includes an input waveguide 20, a distributing electromagnetic horn (E-plane horn) 21, an oversized waveguide 22 which has a broad E-plane, a combining electromagnetic horn (E-plane horn) 23, and an output waveguide 24. In the oversized waveguide 22 a plurality of amplifiers 30 is arranged, each amplifier being made up of an input dipole antenna 25, a solid state amplifier 26 constructed in the form of a microwave integrated circuit (MIC) employing one or more stages of solid state amplifier elements, and a dipole antenna 27 on the output side.

Figure 3 illustrates a concrete example of an amplifier 30, comprising a dielectric substrate 31 with a metal block 32 on its back surface. The metal block is secured to the bottom of the waveguide 22. One side (segment) of the dipole antenna 25 having an overall length of $\lambda/2$, is formed by a pattern 25a on the front

surface, and the other side thereof is formed by a pattern 25b on the back surface. A matching circuit 33 is provided, wherein small squares represent electrically conductive patterns for adjusting the impedance, these patterns being wire-bonded to a base portion of the antenna according to need. Reference numeral 34 denotes an amplifier element (such as an FET) with its gate being connected to the pattern 25a. The source of the FET 34 is grounded, and its drain is connected to an amplifier element 35 of the next stage. Reference numerals 36, 37, --- denote amplifier elements of the subsequent stages, and the output of the final stage is connected to the antenna 27 of the output side. When the electromagnetic horn 21 is an E-plane horn, segments of the antennas 25 (the same holds true for the antennas 27) are arrayed along the direction of electric field E as shown in Fig. 2, and the antennas are all arrayed in series along the electric field. When the electromagnetic horn 21 is an H-plane horn, the antenna elements are turned by 90° toward the direction of electric field E as shown in Fig. 4, whereby the antennas are all arrayed in a direction at right angles to the direction of electric field E, i.e., parallel with the direction of electric field E.

Figure 5A illustrates a microwave amplifier using a distributor and a combiner as another embodiment of the present invention in which slot antennas are employed as small antennas. Namely, a unit amplifier 30 comprises slot antennas 41, 42 on the input and output sides, an amplifier 26, and slot/strip line converters 43, 44. Slot antennas 41a, 41b, 41c, --- and 42a, 42b, 42c, --- on the input side and output side are arrayed in series along the direction of electric field E. With this construction, electromagnetic waves emitted from an antenna 41b are not mixed into the electromagnetic waves emitted from the other antenna 41a as shown in Fig. 5B, so that an isolation effect between the antennas is attained. In Fig. 5B, reference numeral 45 denotes a dielectric substrate, and 46a, 46b, --- denote electrically conductive patterns which form horned slots for antennas 41a, 41b, ---. Converters 43, 44 of Fig. 5A comprise electrically conductive patterns formed on the opposite surface of the substrate. It should be noted that the above-mentioned isolation effect results from the fact that the electric lines of force 47 of the slot antenna 41b are evenly absorbed by the conductors 46a, 46b constituting the slot antenna 41a. Like the case of Fig. 4, the slot antennas may be arrayed in a direction at right angles to the direction of electric field, that is, parallel with the direction of the electric field. In this case, however, the isolation effect cannot be expected.

In the above-mentioned microwave amplifier, a high-frequency input is distributed into a plurality of input antennas by the distributing electromagnetic horn, and outputs amplified by amplifiers coupled to the input antennas are combined into one output by the output antennas and the combining electromagnetic horn. Therefore, the high power microwave amplifier can be realized in a compact and simplified construction without requiring hybrid devices such as magic T's. Furthermore, a reliable connection between the amplifiers and the waveguides is obtained.

Figure 6 illustrates a device for distributing microwave electric power according to an embodiment of the present invention. The distributor of Fig. 6 comprises an E-plane horn 102 coupled to a standard waveguide 101 through which microwave signals are introduced, an oversized waveguide 103 coupled to the E-plane horn 102, and an MIC device 104' coupled to transmission paths of the oversized waveguide 103. The MIC device 104' comprises waveguide-MIC converters 105a', 105b', --- 105e' arrayed in the direction of electric field vector, i.e. in the direction of vector E indicated by arrows E in the oversized waveguide 103, and formed on a dielectric substrate 108', MIC transmission paths 106a', 106b', --- 106e' connected to the waveguide-MIC converters, and microwave amplifiers 107a, 107b, ---, 107e connected to the MIC transmission paths. The waveguide-MIC converters 105a', 105b', ---, 105e' are composed of dipole antennas formed on a dielectric substrate 108' and linearly arrayed in the widthwise direction of the oversized waveguide, i.e., in the direction of vector E. Further, the MIC transmission paths 106a', 106b', ---, 106e' are composed of microstrip lines formed on the dielectric substrate 108'.

In the microwave distributor of Fig. 6, microwave signals introduced via the standard waveguide 101 are dispersed in the direction of vector E by the E-plane horn 102 and received by the waveguide-MIC converters 105a', 105b', ---, 105e' via oversized waveguide 103. Microwave signals received by the waveguide-MIC converters 105a', 105b', ---, 105e' are transmitted via MIC transmission paths 106a', 106b', ---, 106e' to amplifiers 107a, 107b, ---, 107e and amplified. In this case, the input microwave signals are distributed into a plurality of waveguide-MIC converters 105a', 105b', ---, 105d' by the E-plane horn 102 and the oversized waveguide 103.

Depending upon the positions in the widthwise direction of the oversized waveguide 103, the waveguide-MIC converters 105a', 105b', ---, 105e' are arrayed at different positions in the lengthwise direction of the oversized waveguide 103. Furthermore, MIC transmission paths 106a', 106b', ---, 106e' are formed straight to connect the waveguide-MIC converters 105a', 105b', ---, 105e' to the amplifiers 107a, 107b, ---, 107e. Due to this construction, the lengths of the MIC transmission paths 106a', 106b', ---, 106e' can be increased toward the center portion in the widthwise direction of the oversized waveguide and decreased toward the peripheral portions, in order to uniformize the phase distribution of microwave electric powers input to the amplifiers 107a, 107b, ---, 107e. In this case, differences in the signal transmission distances from the throat portion of the E-plane horn 102 to the waveguide-MIC converters via the oversized waveguide between the central portion and peripheral portions of the waveguide can become large. However, since microwave signals propagate in the space in the oversized waveguide 103 at a speed faster than when they propagate on the dielectric substrate 108', it is possible to adjust the lengths of the MIC transmission paths 106a', 106b', ---, 106e' so that the phase distribution can be perfectly uniformized.

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Below the phase distribution characteristics of the E-plane horn are described. As illustrated in Fig. 7, central axis of the E-plane horn is set on the x-axis so that the y-axis passes through the throat portion of the E-plane horn. In this case, the phase distribution on an opening plane of the E-plane horn, i.e., the phase distribution at a given point P on a line which passes through a point (r, o) in Fig. 7 which is perpendicular to the x-axis, is given by the following equation:

$$\varphi = \frac{2\pi r}{\lambda g} \left(\frac{1}{\cos \theta} - 1 \right) \quad (\text{rad}) \quad (1)$$

In the above equation, φ represents a phase distribution at a given point P when the phase at the point (r, o) is 0 rad., λg represents a guide wavelength in the E-plane horn, θ represents an angle between the x-axis and the line segment connecting the point P to the origin O.

Below, the case in which the phase difference generated by the E-plane horn is corrected by changing the lengths of strip lines as shown in Fig. 6 is discussed. In the device for distributing microwave electric power of Figure 6, if the plane which includes a connection portion between the E-plane horn and the oversized waveguide is denoted by AA', the plane which is closest to the E-plane horn 102 which includes the waveguide-MIC converters is denoted by BB', and the plane which is remotest from the E-plane horn 102 which includes the waveguide-MIC converters is denoted by CC', the phase difference on the plane AA' is found from the equation (1). In the portion between the plane AA' and the plane BB', the phase difference generated by the E-plane horn is almost maintained provided the distance is short between the plane AA' and the plane BB'. Therefore, it is the portion between the plane BB' and the plane CC' which contributes to correct the phase. Here, the wavelength λg_2 of a strip line is given by the following equation:

$$\lambda g_2 = \frac{\lambda}{\sqrt{\epsilon_{\text{eff}}}} \quad (2)$$

where λ denotes a free-space wavelength, and ϵ_{eff} denotes an effective dielectric constant of a dielectric material on which strip lines are formed.

Further, if a guide wavelength of the waveguide is denoted by λg , and the length of the waveguide by L, the quantity of phase shift φ_1 is given by:

$$\varphi_1 = \frac{2\pi L}{\lambda g} \quad (3)$$

In Fig. 11, therefore, if the distance between the waveguide-MIC converters and the plane BB' is denoted by l, the phase distribution φ_2 on the plane CC' is given by:

$$\varphi_2 = \frac{2\pi l}{\lambda g} - \frac{2\pi l}{\lambda g_2} = 2\pi l \left(\frac{1}{\lambda g} - \frac{\sqrt{\epsilon_{\text{eff}}}}{\lambda} \right) \quad (4)$$

with the quantity of the phase shift at an intersecting point of the central axis OO' and the plane CC' as a reference. Here, the sum of φ_2 of the equation (4) and φ of the equation (1) should be brought to zero.

Therefore, the phase distribution can be uniformalized by finding distances l which satisfy an equation:

$$\frac{r}{\lambda g} \left(\frac{1}{\cos \theta} - 1 \right) + l \left(\frac{1}{\lambda g} - \frac{\sqrt{\epsilon_{\text{eff}}}}{\lambda} \right) = 0 \quad (5)$$

with regard to various angles θ .

Although the above description has dealt with the device for distributing microwave electric power, it will be obvious that the phase distribution is uniformalized even for a device for combining microwave electric power by using the same construction. That is, in the device for combining microwave electric power having the same construction as that of Fig. 6, microwave signals of a plurality of channels are introduced from the side of strip lines, combined through the oversized waveguide 103 and the E-plane horn 102, and the combined signals are sent into the standard waveguide 101. In this case, the microwave signals can be combined maintaining a uniform phase by changing the lengths of the strip lines depending upon the positions in the widthwise direction of the oversized waveguide.

In the embodiments mentioned above, the phase distribution can be uniformalized in a device for distributing and combining microwave electric power relying upon a very simple construction. Moreover, since hybrid circuits are not employed, a device for distributing and combining microwave electric power can be realized featuring greatly reduced transmission losses.

Figure 8 illustrates the construction of a waveguide-MIC converter used in a device for distributing and combining microwave electric power according to the present invention. In an oversized rectangular

waveguide 131, the distance of a set of opposing walls is made greater than a distance between the walls of a standard waveguide. In this embodiment, the distance between the walls is increased in the direction of electric field vector indicated by arrow E, i.e., increased in the direction of vector E. On a dielectric substrate 132 a plurality of, e.g. four in the case of Fig. 8, MIC antennas 133—1, 133—2, 133—3, and 133—4 are formed. Each of the MIC antennas 133—1, 133—2, -- is a so-called slot antenna obtained by forming electrically conductive patterns on the dielectric substrate 132 as indicated by the hatched areas. Further, the MIC antennas 133—1, 133—2, -- are arrayed in the direction of electric field vector E of the oversized waveguide 131 and coupled to the transmission path of the oversized waveguide 131 at an end portion thereof.

In the waveguide-MIC converter of Fig. 8, microwave signals introduced from the side of the oversized waveguide 131, i.e., introduced from the direction of arrow A, are received by the array of MIC antennas 133—1, 133—2, -- at the end of oversized waveguide 131 and transmitted to a plurality of MIC channels. In this case, a standard waveguide is coupled to the input side of the oversized waveguide 131 via, for example, a horn element. Microwave power amplifiers comprising gallium-arsenic FET's are connected to the plurality of MIC antennas 133—1, 133—2, --. When the microwave electric power is combined by the waveguide-MIC converter of Fig. 8, microwave signals are input to the MIC antennas from the direction of arrow B. The microwave signals are emitted from the MIC antennas into the transmission path in the oversized waveguide 131 and combined into microwave electric power.

In the waveguide-MIC converter of Fig. 8, if microwave signal input from the side of arrow A is transmitted in a TE₁₀ mode through the oversized waveguide 131, the electric field is established by the microwave signal in a direction indicated by arrow E in Fig. 8, whereby potential differences develop among the conductors constituting the slot antennas 133—1, 133—2, --, and microwave electric power is transmitted. In this case, the magnetic field in the oversized waveguide 131 is established in a direction perpendicular to the arrow E, i.e., established in a direction perpendicular to slot planes of the MIC antennas or perpendicular to the plane of the dielectric substrate 132.

Figure 9 shows the construction of another waveguide-MIC converter. In the waveguide-MIC converter of Fig. 9, dipole antennas 145—1, 145—2, 145—3, and 145—4 are formed on a dielectric substrate 144 in place of the slot antennas 133—1, 133—2, -- employed in the converter of Fig. 8. The dipole antennas 145—1, 145—2, -- comprise conductive patterns formed on the front surface of the dielectric substrate 144 as indicated by solid lines and conductive patterns formed on the back surface as indicated by dotted lines. Conductors 146—1, 146—2, 146—3, and 146—4 forming MIC transmission paths are coupled to the dipole antenna elements formed on the front surface of the dielectric substrate 144. To the dipole antenna elements formed on the back surface of the dielectric substrate 144 are coupled balanced-to-unbalanced transformer portions 147—1, 147—2, 147—3, and 147—4 which have gradually increasing pattern widths. Patterns formed on the back surface of the dielectric substrate 144 stretching over the whole width are coupled to the subsequent stage of the balanced-to-unbalanced transformer portions.

Even in the waveguide-MIC converter of Fig. 9, microwave signal input from the side of the oversized waveguide 141 is received separately by the dipole antennas 145—1, 145—2, -- formed on the MIC substrate and taken out via transmission paths 146—1, 146—2, -- in a similar manner to the case of Fig. 8. Further, the microwave signals input from the side of transmission paths 146—1, 146—2, -- on the side of MIC substrate, are emitted from dipole antennas 145—1, 145—2, -- into the transmission path in the oversized waveguide 141 and transmitted being combined together. Even in this case, the oversized waveguide 141 is connected to the standard waveguide via, e.g., an E-plane horn. In the embodiment of Fig. 9, also, a microwave signal is transmitted in the TE₀₁ mode through the oversized waveguide 141 in a similar manner to the embodiment of Fig. 8. As indicated by arrow E in Fig. 9, therefore, the electric field vector is generated in a direction perpendicular to the direction in which the signal travels through the oversized waveguide 141.

Figure 10 illustrates still another waveguide-MIC converter. In the waveguide-MIC converter of Fig. 10, the oversized waveguide 158 has a larger width in the direction of the magnetic field vector as indicated by arrow H. Further, MIC antennas 159—1, 159—2, ---, 159—n coupled to the oversized waveguide 158, are so arrayed that their substrate surfaces are perpendicular to the magnetic field vector H. Therefore, the microwave signal in the oversized waveguide 158 assumes the form of, for example, TE waves of such as the TE₁₀ mode. In the waveguide-MIC converter of Fig. 10, therefore, TM waves in the oversized waveguide 158 are separately transmitted to the MIC antennas 159—1, 159—2, ---, 159—n, or microwave signals from the MIC antennas 159—1, 159—2, ---, 159—n are emitted into the oversized waveguide 158 and combined and transmitted in the form of TM waves.

Figure 11 shows still another waveguide-MIC converter. In the waveguide-MIC converter of Fig. 11, an MIC substrate 163 having a plurality of dipole antenna elements 162—1, 162—2, 162—3, 162—4 is coupled to an end of the oversized waveguide 161 which is the same as that of Fig. 8 or 9. Here, however, the MIC substrate 163 is disposed at right angles to the direction in which the electromagnetic waves travel through the oversized waveguide 161, unlike the device of Fig. 8 or 9. The dipole antenna elements 162—1, 162—2, 162—3, 162—4, however, are arrayed in the oversized waveguide 161 in a direction of electric field vector E of the microwaves. In the construction of Fig. 11, the microwaves in the oversized waveguide 161 are transmitted, for example, in the TE₁₀ mode, received by the dipole antenna elements 162—1, 162—2, ---, and distributed into MIC transmission paths 164—1, 164—2, 164—3, and 164—4. Conversely, microwave

signals input from the MIC transmission paths 164—1, 164—2, 164—3, and 164—4 are emitted into the oversized waveguide 161 through the MIC antennas, i.e., through the dipole antennas 162—1, 162—2, 162—3, and 162—4 and transmitted being combined into one signal. According to the construction of Fig. 11, the oversized waveguide 161 and the MIC transmission paths 164—1, 164—2, 164—3, and 164—4, can be set at right angles of each other or at any desired angle, thereby increasing the degree of freedom for arraying the transmission paths.

In the above-mentioned waveguide-MIC converters, the mode of electromagnetic field can be converted between the waveguide and the MIC transmission paths relying upon a very simply constructed device, thereby enabling distribution and combination of microwave electric power. In the above-mentioned converters, furthermore, microwave electric power can be distributed and combined without using hybrid circuits. In distributing and combining microwave electric power, therefore, transmission losses can be reduced strikingly.

According to the above-mentioned embodiments, phase characteristics of microwaves in the waveguides can be uniformized at predetermined distances from the opening plane of the oversized waveguide. Therefore, phase characteristics of the distributed microwave signals can be uniformized by providing waveguide-MIC converters or microwave amplifiers at the above-mentioned positions. In the case of the device for combining microwave electric power, the microwave signals can be efficiently combined maintaining the same phase by supplying microwave signals of the same phase from the above-mentioned positions.

Also in the embodiments mentioned above, the phase distribution can be uniformized in combining or distributing microwave signals relying upon a very simply constructed device. Moreover, since hybrid circuits are not employed, transmission losses can be greatly reduced at the time of distributing or combining microwave electric power.

Figure 12 illustrates a conventional power amplifier in which an amplifier 241 of a microwave integrated circuit (MIC) is inserted in waveguides 244, 245 of the transmission path via mode-converting ridge waveguides 242, 243 being interposed on the input and output sides of the amplifier 241. With this system, however, increased space is required for inserting the waveguides 242, 243, mode conversion losses are increased, and connection between the amplifier 241 and waveguides 242, 243 is not so reliable since the conductor pieces 241c of the input and output terminals of the amplifier are simply brought into contact with ridges 242a, 243a of the waveguides 242, 243. In Fig. 12, reference numeral 241b denotes an amplifier element such as an FET.

Figure 13 illustrates a power amplifier which can be adaptable to the device for distributing and combining microwave electric power according to the present invention. In Fig. 13, reference numeral 250 denotes a short waveguide that is inserted between waveguides 255 and 256 which constitute a signal transmission path, 251 denotes a metal block secured to the bottom surface 250a of the waveguide 250, 252 denotes a high-frequency power amplifier of the MIC construction secured onto the metal block 251, and 253 and 254 denote terminals for biasing the amplifier element.

Figure 14 illustrates in detail the amplifier 252, in which reference numeral 260 denotes an amplifier element such as a packaged-type FET, 261 and 262 denote dielectric substrates divided into two (the element 260 may be mounted on the center of a piece of substrate), 263 and 264 denote surface patterns, i.e., conductors, and 265 denote a back-surface pattern which stretches to the side of the conductor 264.

Base portions of the surface patterns 263, 264, i.e., the sides of the amplifier element 260, constitute a microstrip line together with the back-surface pattern 265 as shown in Fig. 16, whereby ends thereof serve as the transmitting antenna and a receiving antenna, respectively. Gate electrode G and drain electrode D of the FET 260 are soldered or wire-bonded to the base portions of the surface patterns 263 and 264. Matching adjusting elements 267 and 268 are provided in the base portions of the surface patterns 263 and 264 to properly match the impedance with regard to the FET 260. That is, the amplifier element have different S-parameters even when they have the same ratings, and the frequency f vs. gain G characteristics are often deviated from a predetermined curve C_1 , as shown by C_2 in Fig. 17. To correct the deviation, a plurality of thin conductive films represented by small squares in Fig. 14 are suitably wire-bonded onto the surface patterns 263 and 264 to adjust the electrostatic capacity with respect to the back-surface pattern. Figure 15 is a diagram of an equivalent circuit, in which $-V_g$ denotes a negative bias voltage applied to the gate electrode G, and $+V_d$ denotes a positive bias voltage applied to the drain electrode D. The source electrode S is grounded via the metal block 251. Choke coils 270 and 271 are established by branched patterns 269 of the surface patterns 263 and 264.

The tapered end of the back-surface pattern 265 works to adjust the impedance so that the surface pattern 263 will effectively serve as an antenna. In the ordinary MIC construction, the back surface has a uniform earth pattern. According to the present invention, however, the end of the pattern 265 is narrowed to adjust the capacity relative to the surface pattern 263, i.e., the width of the pattern gradually increases from the end to realize an optimum matching condition with the least amount of reflection.

The above-mentioned high-frequency power amplifier presents the following advantages:

- (1) Reduced space is required since two ridge waveguides are not needed to convert the mode.
- (2) The amplifier element features improved input and output efficiency due to the use of a microstrip matching circuit which is based upon a tapered back-surface pattern and surface patterns.

(3) Since the amplifier is coupled to the transmission path through antennas, high reliability is maintained in the connection portions.

(4) When the amplifiers are to be connected in a plurality of stages, a plurality of waveguides 250 containing amplifiers should be connected in cascade. In this case, the amplifiers are connected through antennas which have a function to cut off direct current. Therefore, there is no need to use capacitors for cutting off the direct current, i.e. for cutting off the bias voltage, unlike the case of connecting the transistors in a plurality of stages.

Claims

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1. A microwave power amplifier comprising a first electromagnetic horn (102) having a throat portion which is coupled to an input microwave path (101) and which radially disperses a microwave input signal; an oversized waveguide (103) coupled at one end to the open end of the first electromagnetic horn; a second electromagnetic horn the open end of which is coupled to the other end of the oversized waveguide (103) and which combines microwave signals from the oversized waveguide; a plurality of amplifier units (107a—107e) which are arranged in the oversized waveguide (103), each of the amplifier units receiving and amplifying the microwave signal from the first electromagnetic horn after converting it into an MIC mode signal, and the output signal of each of the amplifier units being transmitted into the second electromagnetic horn after it is converted into a waveguide mode signal; and phase compensating means for uniformizing the phases of the microwave signals distributed by the first electromagnetic horn or for adjusting the phases of the microwave signals fed out from the plurality of amplifier units, the phase compensating means being arranged between the first electromagnetic horn and the oversized waveguide or between the oversized waveguide and the second electromagnetic horn, wherein the phase compensating means comprises for each of the plurality of amplifier units (107a—107e) an MIC transmission line (106'a, . . . 106'e) and a waveguide/MIC converting element (105'a, . . . 105'e) which is coupled to the MIC transmission line and which is disposed within the oversized waveguide (103), characterised in that the length of the MIC transmission line (106'c) corresponding to the waveguide/MIC converting element (105'c) disposed at the central position along the direction of enlargement of the oversized waveguide (103) is the largest, and the lengths become smaller as the distance from the central position increases; and in that the positions of the waveguide/MIC converting elements along the direction of propagation of the microwave signals vary in accordance with the position thereof along the direction of enlargement of the oversized waveguide (103), the lengths and positions of the MIC transmission lines being selected in accordance with the phase of microwave electric power at the position of the corresponding waveguide/MIC converting element relative to the direction of enlargement of the oversized waveguide. (Figure 6)

2. An amplifier according to claim 1, characterised in that each of the amplifier units (26, 30) is equipped with a microwave power amplifier comprising a metal block (251) secured and disposed in a waveguide (250); dielectric substrates (261, 262) secured on the metal block; a pair of strip conductors (263, 264) formed on the surfaces of the substrates; at least one antenna element formed at the end of at least one of the pair of strip conductors; an amplifier element (260) having an input terminal (G) and an output terminal (D) connected to the pair of strip conductors, respectively; and back surface patterns (265) which are provided on the back surfaces of the substrates, each of which constitutes a microstrip line together with the strip conductor for impedance matching with the amplifier element, at least one of the back surface patterns having a narrowed end to obtain impedance matching with the antenna. (Figure 14)

3. An amplifier according to any of the preceding claims, characterised in that each of the amplifier units (26) comprises an MIC transmission line connected to a waveguide/MIC converting element which is disposed at the end portion of or within the oversized waveguide (22), each of the waveguide/MIC converting elements being an MIC dipole antenna (25) formed on the sides of a dielectric substrate.

4. An amplifier according to claim 1 or claim 2, characterised in that each of the amplifier units (30) comprises an MIC transmission line connected to a waveguide/MIC converting element (41a—41c; 42a—42c) which is disposed at the end portion of or within the oversized waveguide (22), each of the waveguide/MIC converting elements being an MIC slot antenna formed on one side of a dielectric substrate. (Figure 5A)

5. An amplifier according to claim 4, characterised in that each of the waveguide/MIC converting elements (43, 44) comprises a conductor line pattern formed on the side opposite to the side carrying the MIC slot antenna, the conductor line pattern being formed along the direction perpendicular to the direction of the slot line portion of the MIC slot antenna.

6. A device for distributing and/or combining microwave electric power between a first microwave path and a plurality of second microwave paths, the device comprising an electromagnetic horn having a throat portion which is coupled to the first microwave path; an oversized waveguide coupled at one end to the open end of the horn and at the other end to the plurality of second microwave paths; and phase compensating means for uniformizing the phases of the microwave signals distributed by the horn or for adjusting the phases of the microwave signals fed out from the plurality of second microwave paths, the phase compensating means being provided by the plurality of second microwave paths each of which comprises an MIC transmission line (106'a, . . . 106'e) and a waveguide/MIC converting element

(105'a, ... 105'e) which is coupled to the MIC transmission line and disposed at the end portion of, or within, the oversized waveguide (103), characterised in that the length of the MIC transmission line (106'c) corresponding to the waveguide/MIC converting element (105'c) disposed at the central position along the direction of enlargement (E) of the oversized waveguide (103) is the largest, and the lengths become
5 smaller as the distances from the central position become larger; and in that the positions of the waveguide/MIC converting elements (105a', ... 105e') along the direction of propagation of the microwave signals vary in accordance with the position thereof along the direction of enlargement (E) of the oversized waveguide (103), the lengths and positions of the MIC transmission lines being selected in accordance with the phase of microwave electric power at the position of the corresponding waveguide/MIC converting
10 element relative to the direction of enlargement (E) of the oversized waveguide. (Figure 6)

7. A device according to claim 6, characterised in that each of the second microwave paths comprises an MIC transmission line (106'a, ... 106'e) connected to a waveguide/MIC converting element (105'a, ... 105'e) which is disposed at the end portion of or within the oversized waveguide (103), each of the waveguide/MIC converting elements being an MIC dipole antenna formed on the sides of a dielectric
15 substrate (108').

8. A device according to claim 6, characterised in that each of the second microwave paths comprises an MIC transmission line connected to a waveguide/MIC converting element which is disposed at the end portion of or within the oversized waveguide (131), each of the waveguide/MIC converting elements (133—1, ... 133—4) being an MIC slot antenna formed on one side of a dielectric substrate (132). (Figure
20 5A)

9. A device according to claim 8, characterised in that each of the waveguide/MIC converting elements comprises a conductor line pattern (43) formed on the substrate on the opposite side to the MIC slot antenna, the conductor line pattern being formed along the direction perpendicular to the direction of the slot line portion of the MIC slot antenna (41a, ... 41c). (Figure 5A)

25 10. A device according to any of claims 6 to 9, arranged to distribute microwave electric power between a first microwave path (60) and a plurality of second microwave paths (65—1, ... 65—n), wherein each of the second microwave paths is equipped with a microwave power amplifier comprising a metal block (251) secured and disposed in a waveguide (250); dielectric substrates (261, 262) secured on the metal block; a pair of strip conductors (263, 264) formed on the surfaces of the substrates; at least one antenna element
30 formed at the end of at least one pair of strip conductors; an amplifier element (260) having an input terminal (G) and an output terminal (D) connected to the strip conductors, respectively; and back surface patterns (265) which are provided on the back surfaces of said substrates, each of which constitutes a microstrip line together with the strip conductor for impedance matching with the amplifier element, at least one of the back surface patterns having a narrowed end to obtain impedance matching with the
35 antenna.

11. A device according to any of claims 6 to 9, arranged to combine microwave electric power between a first microwave path (60) and a plurality of second microwave paths (65—1, ... 65—n), wherein each of the second microwave paths is equipped with a microwave power amplifier comprising a metal block (251) secured and disposed in a waveguide (250); dielectric substrates (261, 262) secured on the metal block; a
40 pair of strip conductors (263, 264) formed on the surfaces of the substrates; at least one antenna element formed at the end of at least one pair of strip conductors; an amplifier element (260) having an input terminal (G) and an output terminal (D) connected to the strip conductors, respectively; and back surface patterns (265) which are provided on the back surfaces of said substrates, each of which constitutes a microstrip line together with the strip conductor for impedance matching with the amplifier element, at
45 least one of the back surface patterns having a narrowed end to obtain impedance matching with the antenna.

Patentansprüche

50 1. Mikrowellenleistungsverstärker mit einem ersten elektromagnetischen Horn (102), das einen Halsabschnitt hat, der an einen Eingangs-Mikrowellenweg (101) gekoppelt ist, und das ein Mikrowelleneingangssignal radial dispergiert; einem übergroßen Wellenleiter (103), der an einem Ende mit dem offenen Ende des ersten elektromagnetischen Horns gekoppelt ist; einem zweiten elektromagnetischen Horn, dessen offenes Ende mit dem anderen Ende des übergroßen Wellenleiters
55 (103) gekoppelt ist und das Mikrowellensignal von dem übergroßen Wellenleiter kombiniert; einer Vielzahl von Verstärkereinheiten (107a—107e), welche in dem übergroßen Wellenleiter (103) angeordnet sind, wobei jede der Verstärkereinheiten das Mikrowellensignal von dem ersten elektromagnetischen Horn empfängt und es, nachdem es dieses in ein MIC-Modussignal umgewandelt hat, verstärkt, und das Ausgangssignal von jeder der Verstärkereinheiten in das zweite elektromagnetische Horn übertragen wird,
60 nachdem es in ein Wellenleitermodussignal umgewandelt worden ist; und phasenkompensationseinrichtungen zur Uniformierung der Phasen der Mikrowellensignale, die durch das erste elektromagnetische Horn verteilt worden sind, oder zum Justieren der Phasen der Mikrowellensignale, die aus der Vielzahl von Verstärkereinheiten ausgespeist werden, wobei die Phasenkompensationseinrichtungen zwischen dem ersten elektromagnetischen Horn und dem übergroßen Wellenleiter oder zwischen dem übergroßen
65 Wellenleiter und dem zweiten elektromagnetischen Horn angeordnet sind, wobei die

Phasenkompensationseinrichtungen für jede der Vielzahl von Verstärkereinheiten (107a—107e) eine MIC-Transmissionsleitung (106'a, . . . 106'e) und ein Wellenleiter/MIC-Umwandlungselement (105'a, . . . 105'e), welches mit der MIC-Transmissionsleitung verbunden ist und welches innerhalb des übergroßen Wellenleiters (103) angeordnet ist, umfassen, dadurch gekennzeichnet, daß die Länge der MIC-Transmissionsleitung (106'c), die dem Wellenleiter/MIC-Umwandlungselement (105'c) entspricht und die an der zentralen Position längs der Richtung der Vergrößerung des übergroßen Wellenleiters (103) angeordnet ist, die größte ist, und die Längen mit zunehmendem Abstand von der zentralen Position kleiner werden; und daß die Positionen der Wellenleiter/MIC-Umwandlungselemente längs der Fortpflanzungsrichtung der Mikrowellensignale in Übereinstimmung mit deren Position längs der Richtung der Vergrößerung des übergroßen Wellenleiters (103) variieren, wobei die Längen und Positionen der MIC-Transmissionsleitungen in Übereinstimmung mit der Phase der elektrischen Mikrowellenenergie bei der Position des entsprechenden Wellenleiter/MIC-Umwandlungselementes relativ zu der Richtung der Vergrößerung des übergroßen Wellenleiters ausgewählt werden (Figur 6).

2. Verstärker nach Anspruch 1, dadurch gekennzeichnet, daß jede der Verstärkereinheiten (26, 30) ausgestattet ist mit einem Mikrowellenleistungsverstärker, der einen Metallblock (251) umfaßt, welcher in einem Wellenleiter (250) angeordnet und befestigt ist; mit dielektrischen Substraten (261, 262), die auf dem Metallblock gesichert sind; einem Paar von Streifenleitern (263, 264), die auf den Oberflächen der Substrate gebildet sind; wenigstens einem Antennenelement, welches an dem Ende von wenigstens einem von dem Paar von Streifenleitern gebildet ist; einem Verstärkerelement (260), das einen Eingangsanschluß (G) und einen Ausgangsanschluß (D) hat, die jeweils mit dem Paar von Streifenleitern verbunden sind; und mit Rückseitenmustern (265), die auf den rückseitigen Oberflächen der Substrate vorgesehen sind, von denen jedes eine Mikrostreifenleitung zusammen mit dem Streifenleiter zur Impedanzanpassung mit dem Verstärkerelement bildet, wobei wenigstens eines der Rückseitenmuster ein schmaleres Ende hat, um eine Impedanzanpassung mit der Antenne zu erzielen (Figur 14).

3. Verstärker nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß jede der Verstärkereinheiten (26) eine MIC-Transmissionsleitung umfaßt, die mit einem Wellenleiter/MIC-Umwandlungselement verbunden ist, das an dem Endabschnitt von oder innerhalb des übergroßen Wellenleiters (22) angeordnet ist, wobei jedes der Wellenleiter/MIC-Umwandlungselemente eine MIC-Dipolantenne (25) ist, die auf den Seiten eines dielektrischen Substrates gebildet ist.

4. Verstärker nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß jede der Verstärkereinheiten (30) eine MIC-Transmissionsleitung umfaßt, die mit einem Wellenleiter/MIC-Umwandlungselement (41a—41c; 42a—42c) verbunden ist, das an dem Endabschnitt von oder innerhalb des übergroßen Wellenleiters (22) angeordnet ist, wobei jedes der Wellenleiter/MIC-Umwandlungselemente eine MIC-Schlitzantenne ist, die auf einer Seite eines dielektrischen Substrates angeordnet ist (Figur 5A).

5. Verstärker nach Anspruch 4, dadurch gekennzeichnet, daß jedes der Wellenleiter/MIC-Umwandlungselemente (43, 44) ein Leiterleitungsmuster umfaßt, das auf der Seite gegenüber derjenigen Seite gebildet ist, welche die MIC-Schlitzantenne trägt, wobei das Leiterleitungsmuster längs der Richtung senkrecht zu der Richtung des Schlitzleitungsabschnitts der MIC-Schlitzantenne gebildet ist.

6. Vorrichtung zur Verteilung und/oder Kombination von elektrischer Mikrowellenenergie zwischen einem ersten Mikrowellenweg und einer Vielzahl von zweiten Mikrowellenwegen, welche Vorrichtung ein elektromagnetisches Horn umfaßt, das einen Halsabschnitt hat, der an den ersten Mikrowellenweg angekoppelt ist; einen übergroßen Wellenleiter, der an einem Ende mit dem offenen Ende des Horns und an dem anderen Ende mit der Vielzahl von zweiten Mikrowellenwegen gekoppelt ist; und Phasenkompensationseinrichtungen zur Uniformierung der Phasen der Mikrowellensignale, die durch das Horn verteilt werden oder zur Justierung der Phasen der Mikrowellensignale, die von der Vielzahl von zweiten Mikrowellenwegen ausgespeist werden, welche Phasenkompensationseinrichtungen durch eine Vielzahl von zweiten Mikrowellenwegen gebildet sind, von denen jeder eine MIC-Transmissionsleitung (106'a, . . . 106'e) und ein Wellenleiter/MIC-Umwandlungselement (105'a, . . . 105'e) umfaßt, welches mit der MIC-Transmissionsleitung gekoppelt und an dem Endabschnitt von, oder innerhalb des, übergroßen Wellenleiters (103) angeordnet ist, dadurch gekennzeichnet, daß die Länge der MIC-Transmissionsleitung (106'c), die dem Wellenleiter/MIC-Umwandlungselement (105'c) entspricht und die an der zentralen Position längs der Richtung der Vergrößerung (E) des übergroßen Wellenleiters (103) angeordnet ist, die größte ist, und die Längen mit zunehmenden Abständen von der zentralen Position kleiner werden; und daß die Positionen der Wellenleiter/MIC-Umwandlungselemente (105a', . . . 105e') längs der Fortpflanzungsrichtung der Mikrowellensignale in Übereinstimmung mit deren Position längs der Richtung der Vergrößerung (E) des übergroßen Wellenleiters (103) variieren, wobei die Längen und Positionen der MIC-Transmissionsleitungen in Übereinstimmung mit den Phasen der elektrischen Mikrowellenenergie bei der Position des entsprechenden Wellenleiter/MIC-Umwandlungselementes relativ zu der Richtung der Vergrößerung (E) des übergroßen Wellenleiters ausgewählt werden (Figur 6).

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß jede der zweiten Mikrowellenwege eine MIC-Transmissionsleitung (106'a, . . . 106'e) umfaßt, die mit einem Wellenleiter/MIC-Umwandlungselement (105'a, . . . 105'e) verbunden ist, das an dem Endabschnitt oder innerhalb des übergroßen Wellenleiters (103) angeordnet ist, jedes der Wellenleiter/MIC-Umwandlungselemente eine MIC-Dipolantenne ist, die auf den Seiten des dielektrischen Substrats (108') gebildet ist.

8. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß jeder der zweiten Mikrowellenwege

eine MIC-Transmissionsleitung umfaßt, die mit einem Wellenleiter/MIC-Umwandlungselement verbunden ist, das an dem Endabschnitt von oder innerhalb des übergroßen Wellenleiters (131) angeordnet ist, jedes der Wellenleiter/MIC-Umwandlungselemente (133—1, ... 133—4) eine MIC-Schlitzantenne ist, die auf einer Seite eines dielektrischen Substrats (132) gebildet ist (Figur 5A).

5 9. Vorrichtung nach Anspruch 8, dadurch gekennzeichnet, daß jedes der Wellenleiter/MIC-Umwandlungselemente ein Leiterleitungsmuster (43) umfaßt, welches auf dem Substrat auf der gegenüberliegenden Seite der MIC-Schlitzantenne gebildet ist, das Leiterleitungsmuster längs der Richtung senkrecht zu der Richtung des Schlitzleitungsabschnitts der MIC-Schlitzantenne (41a, ... 41c) gebildet ist (Figur 5A).

10 10. Vorrichtung nach einem der Ansprüche 6 bis 9, angeordnet zur Verteilung von elektrischer Mikrowellenenergie zwischen einem ersten Mikrowellenweg (60) und einer Vielzahl von zweiten Mikrowellenwegen (65—1, ... 65—n), bei der jeder der zweiten Mikrowellenwege mit einem Mikrowellenleistungsverstärker ausgestattet ist, der einen Metallblock (251) umfaßt, der in einem Wellenleiter (250) angeordnet und gesichert ist; mit dielektrischen Substraten (261, 262), die an dem
15 Metallblock gesichert sind; einem Paar von Streifenleitern (263, 264), die auf den Oberflächen der Substrate gebildet sind, wenigstens einem Antennenelement, das an dem Ende von wenigstens einem Paar von Streifenleitern gebildet ist; einem Verstärkerelement (260), das einen Eingangsanschluß (G) und einen Ausgangsanschluß (D) hat, die jeweils mit den Streifenleitern verbunden sind; und Rückseitenmustern (265), welche auf den rückseitigen Oberflächen der genannten Substrate vorgesehen sind, von denen jedes
20 eine Mikrostreifenleitung zusammen mit dem Streifenleiter zur Impedanzanpassung mit dem Verstärkerelement bildet, wobei wenigstens eines der Rückseitenmuster ein schmaleres Ende hat, um eine Impedanzanpassung mit der Antenne zu erhalten.

11. Vorrichtung nach einem der Ansprüche 6 bis 9, angeordnet zum Kombinieren von elektrischer Mikrowellenenergie zwischen einem ersten Mikrowellenweg (60) und einer Vielzahl von zweiten
25 Mikrowellenwegen (65—1, ... 65—n), bei der jeder der zweiten Mikrowellenwege mit einem Mikrowellenleistungsverstärker ausgestattet ist, der einen Metallblock (251) umfaßt, der in einem Wellenleiter (250) angeordnet und gesichert ist; mit dielektrischen Substraten (261, 262), die an dem Metallblock gesichert sind; einem Paar von Streifenleitern (263, 264), die auf den Oberflächen der Substrate gebildet sind; wenigstens einem Antennenelement, das an dem Ende von wenigstens einem Paar von
30 Streifenleitern gebildet ist; einem Verstärkerelement (260), das einen Eingangsanschluß (G) und einen Ausgangsanschluß (D) hat, die jeweils mit den Streifenleitern verbunden sind; und rückseitigen Oberflächenmustern (265), die auf den rückseitigen Oberflächen der genannten Substrate vorgesehen sind, von denen jedes zusammen mit dem Streifenleiter eine Mikrostreifenleitung zur Impedanzanpassung mit dem Verstärkerelement bildet, und wenigstens eines der rückseitigen Oberflächenmuster ein schmaleres
35 Ende zur Erzielung einer Impedanzanpassung mit der Antenne hat.

Revendications

40 1. Amplificateur de puissance micro-onde comprenant un premier cornet électromagnétique (102) possédant une partie d'étranglement qui est couplée à un trajet micro-onde d'entrée (101) et qui disperse radialement un signal d'entrée micro-onde; un guide d'ondes surdimensionné (103) couplé, par une première extrémité, à l'extrémité ouverte du premier cornet électromagnétique; un deuxième cornet électromagnétique dont l'extrémité ouverte est couplée à l'autre extrémité du guide d'ondes
45 surdimensionné (103) et qui combine les signaux micro-onde venant du guide d'ondes surdimensionné; plusieurs unités amplificatrices (107a—107e) qui sont disposées dans le guide d'ondes surdimensionné (103), chacune des unités amplificatrices recevant et amplifiant le signal micro-onde qui vient du premier cornet électromagnétique après l'avoir converti en un signal de mode MIC (circuit intégré micro-onde), le signal de sortie de chacune des unités amplificatrices étant transmis dans le deuxième cornet
50 électromagnétique après avoir été converti en un signal de mode guide d'ondes; et un moyen de compensation de phase servant à uniformiser les phases des signaux micro-onde distribués par le premier cornet électromagnétique ou à ajuster les phases des signaux microonde délivrés par les différentes unités amplificatrices, le moyen de compensation de phase étant disposé entre le premier cornet électromagnétique et le guide d'ondes surdimensionné ou entre le guide d'ondes surdimensionné et le
55 deuxième cornet électromagnétique, où le moyen de compensation de phase comprend, pour chacune des différentes unités amplificatrices (107a—107e), une ligne de transmission MIC (106'a, ... 106'e) et un élément de conversion guide d'ondes/MIC (105'a, ... 105'e) qui est couplé à la ligne de transmission MIC et qui est disposé à l'intérieur du guide d'ondes surdimensionné (103), caractérisé en ce que la longueur de la ligne de transmission MIC (106'c) correspondant à l'élément de conversion guide d'ondes/MIC (105'c)
60 disposé à la position centrale suivant la direction d'élargissement du guide d'ondes surdimensionné (103) est la plus grande, et les longueurs deviennent plus petites au fur et à mesure que la distance à la position centrale augmente; et en ce que les positions des éléments de conversion guide d'ondes/MIC suivant la direction de propagation des signaux micro-onde varie en fonction de leur position suivant la direction d'élargissement du guide d'ondes surdimensionné (103), les longueurs et les positions des lignes de
65 transmission MIC étant choisies en fonction de la phase de la puissance électrique micro-onde à la position

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de l'élément correspondant de conversion guide d'ondes/MIC par rapport à la direction d'élargissement du guide d'ondes surdimensionné. (figure 6)

2. Amplificateur selon la revendication 1, caractérisé en ce que chacune des unités amplificatrices (26, 30) est équipée d'un amplificateur de puissance micro-onde comprenant un bloc de métal (251) fixé et disposé dans un guide d'ondes (250); des substrats diélectriques (261, 262) fixés sur le bloc de métal; une paire de conducteurs en bandes (263, 264) formés sur les surfaces des substrats; au moins un élément d'antenne formé à l'extrémité d'au moins un conducteur de la paire de conducteurs en bandes; un élément amplificateur (260) possédant une borne d'entrée (G) et une borne de sortie (D) respectivement connectées à la paire de conducteurs en bandes; et des configurations de surfaces dorsales (265) qui sont disposées sur les surfaces dorsales des substrats, chacune d'elles constituant une ligne à microbande avec le conducteur en bande servant à l'adaptation d'impédance vis-à-vis de l'élément amplificateur, au moins une des configurations de surfaces dorsales ayant une extrémité rétrécie de manière à réaliser l'adaptation d'impédance vis-à-vis de l'antenne. (figure 14)

3. Amplificateur selon l'une quelconque des revendications précédentes, caractérisé en ce que chacune des unités amplificatrices (26) comprend une ligne de transmission MIC connectée à un élément de conversion guide d'ondes/MIC qui est disposé à la partie terminale du guide d'ondes surdimensionné (22) ou à l'intérieur de celui-ci, chacun des éléments de conversion guide d'ondes/MIC étant une antenne dipolaire MIC (25) formée sur les côtés d'un substrat diélectrique.

4. Amplificateur selon la revendication 1 ou 2, caractérisé en ce que chacune des unités amplificatrices (30) comprend une ligne de transmission MIC connectée à un élément de conversion guide d'ondes/MIC (41a—41c; 42a—42c) qui est disposé à la partie terminale du guide d'ondes surdimensionné (22) ou à l'intérieur de celui-ci, chacun des éléments de conversion guide d'ondes/MIC étant une antenne fendue MIC formée sur un côté d'un substrat diélectrique. (figure 5A)

5. Amplificateur selon la revendication 4, caractérisé en ce que chacun des éléments de conversion guide d'ondes/MIC (43, 44) comprend une configuration de ligne conductrice formée sur le côté opposé au côté portant l'antenne fendue MIC, la configuration de ligne conductrice étant formée suivant la direction perpendiculaire à la direction de la partie de ligne fendue de l'antenne fendue MIC.

6. Dispositif permettant de distribuer et, ou bien, de combiner une puissance électrique micro-onde entre un premier trajet micro-onde et une pluralité de deuxième trajets micro-onde, le dispositif comprenant un cornet électromagnétique possédant une partie d'étranglement qui est couplé au premier trajet micro-onde; un guide d'ondes surdimensionné couplé par une première extrémité à l'extrémité ouverte du cornet et, par l'autre extrémité, à la pluralité de deuxième trajets micro-onde; et un moyen de compensation de phase servant à uniformiser les phases des signaux micro-onde distribués par le cornet ou à ajuster les phases des signaux micro-onde délivrés par la pluralité de deuxième trajets micro-onde, le moyen de compensation de phase étant produit par la pluralité de deuxième trajets micro-onde, lesquels comprennent chacun une ligne de transmission MIC (106'a, . . . 106'e) et un élément de conversion guide d'ondes/MIC (105'a, . . . 105'e) qui est couplé à la ligne de transmission MIC et disposé à la partie terminale du guide d'ondes surdimensionné (103) ou à l'intérieur de celui-ci, caractérisé en ce que la longueur de la ligne de transmission MIC (106'c) correspondant à l'élément de conversion guide d'ondes/MIC (105'c) disposé à la position centrale suivant la direction d'élargissement (E) du guide d'ondes surdimensionné (103) est la plus grande, et les longueurs deviennent plus petites au fur et à mesure que les distances à la position centrale deviennent plus grandes; et en ce que les positions des éléments de conversion guide d'ondes/MIC (105'a', . . . 105'e') suivant la direction de propagation des signaux micro-onde varie en fonction de leur position suivant la direction d'élargissement (E) du guide d'ondes surdimensionné (103), les longueurs et les positions des lignes de transmission MIC étant choisies en fonction de la phase de la puissance électrique micro-onde à la position de l'élément correspondant de conversion guide d'ondes/MIC par rapport à la direction d'élargissement (E) du guide d'ondes surdimensionné. (figure 6)

7. Dispositif selon la revendication 6, caractérisé en ce que chacun des deuxième trajets micro-onde comprend une ligne de transmission MIC (106'a, . . . 106'e) connectée à un élément de conversion guide d'ondes/MIC (105'a, . . . 105'e) qui est disposé à la partie terminale du guide d'ondes surdimensionné (103) ou à l'intérieur de celui-ci, chacun des éléments de conversion guide d'ondes/MIC étant une antenne bipolaire MIC formée sur les côtés d'un substrat diélectrique (108).

8. Dispositif selon la revendication 6, caractérisé en ce que chacun des deuxième trajets micro-onde comprend une ligne de transmission MIC connectée à un élément de conversion guide d'ondes/MIC qui est disposé à la partie terminale du guide d'ondes surdimensionné (131) ou à l'intérieur de celui-ci, chacun des éléments de conversion guide d'ondes/MIC (133—1, . . . 133—4) étant une antenne fendue MIC formée sur un côté d'un substrat diélectrique (132). (figure 5A)

9. Dispositif selon la revendication 8, caractérisé en ce que chacun des éléments de conversion guide d'ondes/MIC comprend une configuration de ligne conductrice (43) formée sur le substrat du côté opposé à l'antenne fendue MIC, la configuration de ligne conductrice étant formée suivant la direction perpendiculaire à la direction de la partie de ligne fendue de l'antenne fendue MIC (41a, . . . 41c) (figure 5A)

10. Dispositif selon l'une quelconque des revendications 6 à 9, conçu pour distribuer une puissance électrique micro-onde entre un premier trajet micro-onde (60) et une pluralité de deuxième trajets micro-onde (65—1, . . . 65-n), où chacun des deuxième trajets micro-onde est équipé d'un amplificateur de puissance micro-onde comprenant un bloc de métal (251) fixé et disposé dans un guide d'ondes (250); des

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substrats diélectriques (261, 262) fixés sur le bloc de métal; une paire de conducteurs en bandes (263, 264) formés sur les surfaces des substrats; au moins un élément d'antenne formé à l'extrémité d'au moins une paire de conducteurs en bandes; un élément amplificateur (260) possédant une borne d'entrée (G) et une borne de sortie (D) respectivement connectées aux connecteurs en bandes; et des configurations de surfaces dorsales (265) qui sont disposées sur les surfaces dorsales desdits substrats, chacune d'elles constituant une ligne à microbande avec le conducteur en bande pour l'adaptation d'impédance vis-à-vis de l'élément amplificateur, au moins une des configurations de surfaces dorsales ayant une extrémité rétrécie afin de réaliser une adaptation d'impédance vis-à-vis de l'antenne.

11. Dispositif selon l'une quelconque des revendications 6 à 9, conçu pour combiner une puissance électrique micro-onde entre un premier trajet micro-onde (60) et une pluralité de deuxièmes trajets micro-onde (65—1, . . . 65—n), où chacun des deuxièmes trajets micro-onde est équipé d'un amplificateur de puissance micro-onde comprenant un bloc métallique (251) fixé et disposé dans un guide d'ondes (250); des substrats diélectriques (261, 262) fixés sur le bloc métallique; une paire de conducteurs en bandes (263, 264) formés sur les surfaces des substrats; au moins un élément d'antenne formé à l'extrémité d'au moins une paire de conducteurs en bandes; un élément amplificateur (260) possédant une borne d'entrée (G) et une borne de sortie (D) respectivement connectées aux conducteurs en bandes; et des configurations de surfaces dorsales (265) qui sont disposées sur les surfaces dorsales desdits substrats, chacune d'elles constituant une ligne à microbande avec le conducteur en bande pour l'adaptation d'impédance vis-à-vis de l'élément amplificateur, au moins une des configurations de surfaces dorsales ayant une extrémité rétrécie afin de réaliser une adaptation d'impédance vis-à-vis de l'antenne.

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Fig. 1A

PRIOR ART

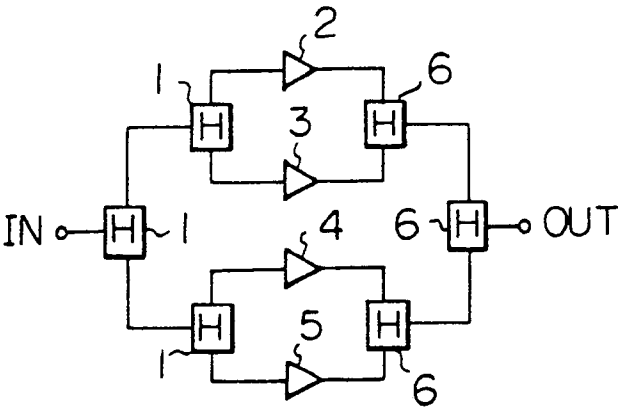


Fig. 1B

PRIOR ART

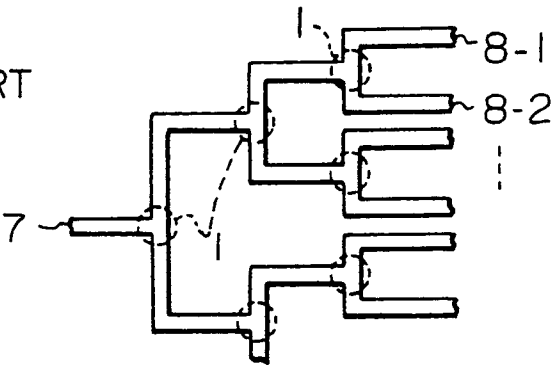


Fig. 1C

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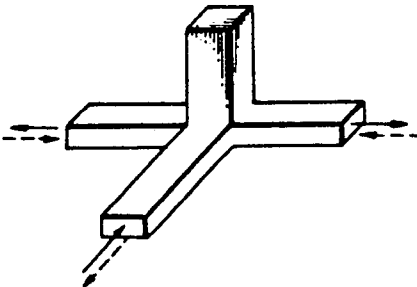


Fig. 3

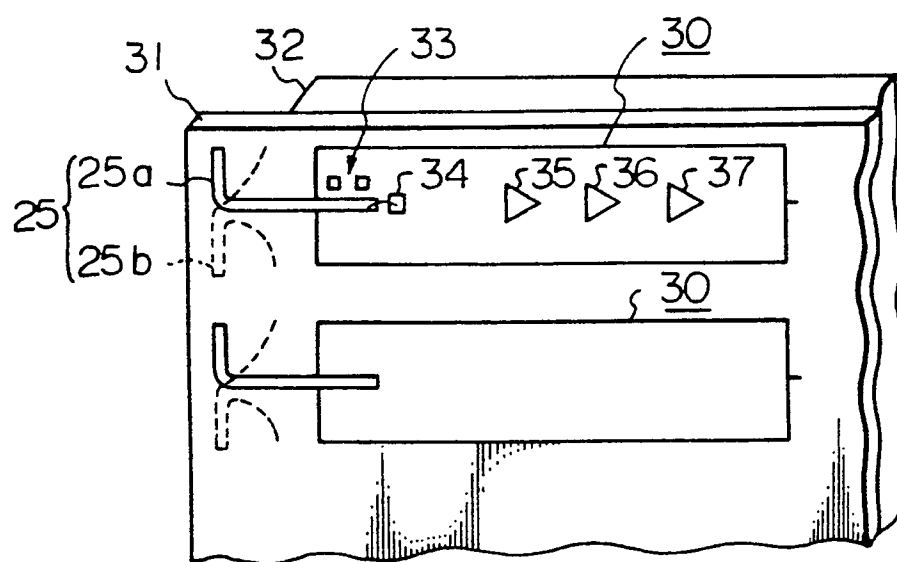
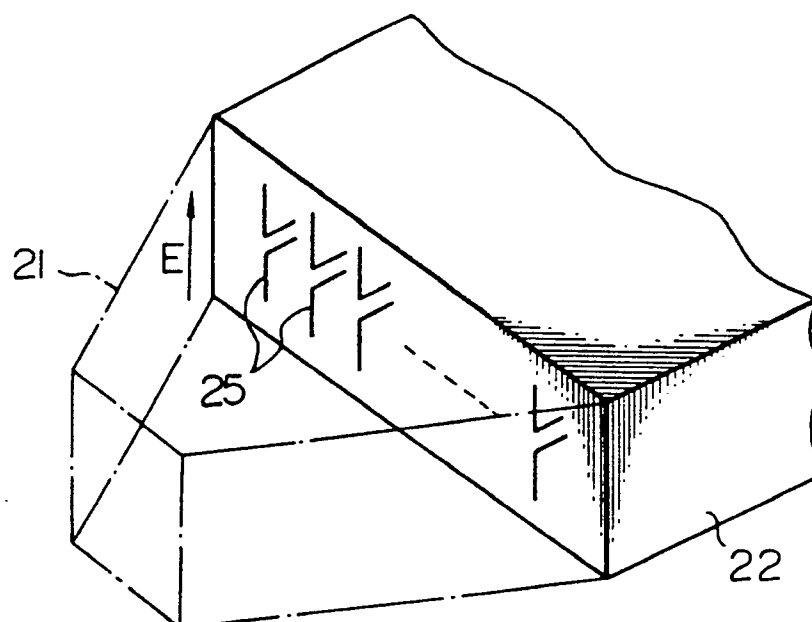


Fig. 4



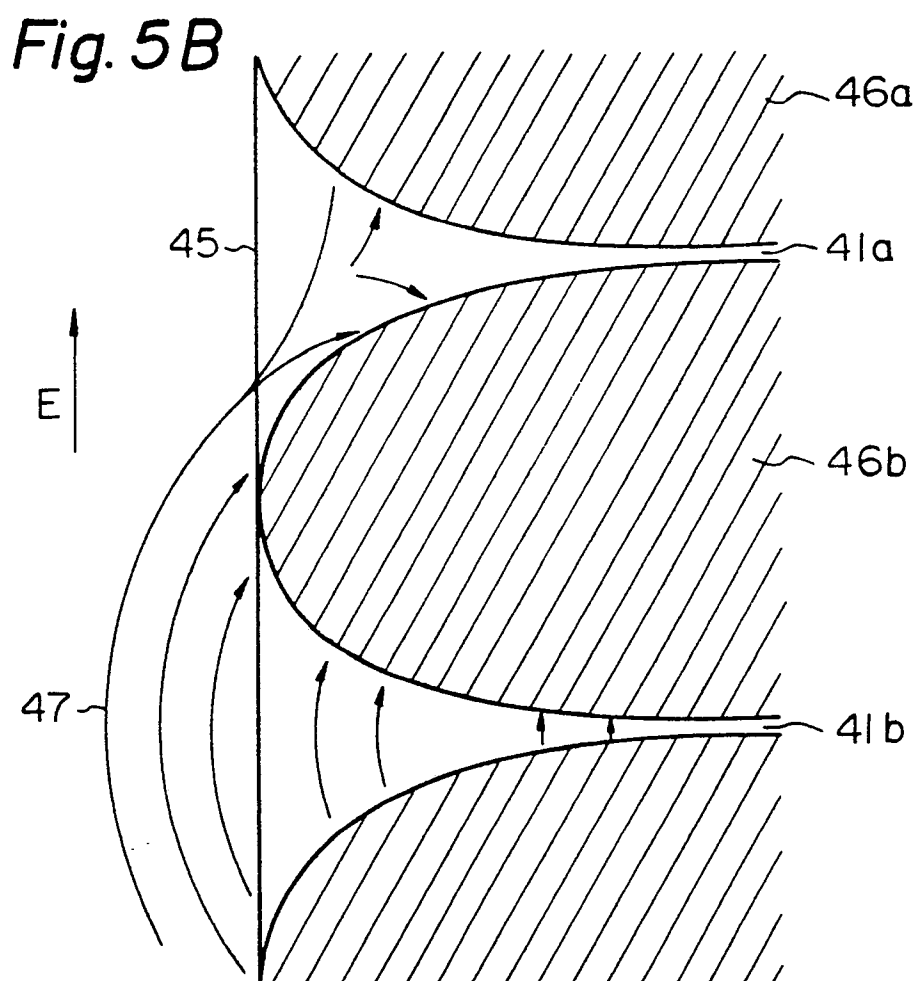
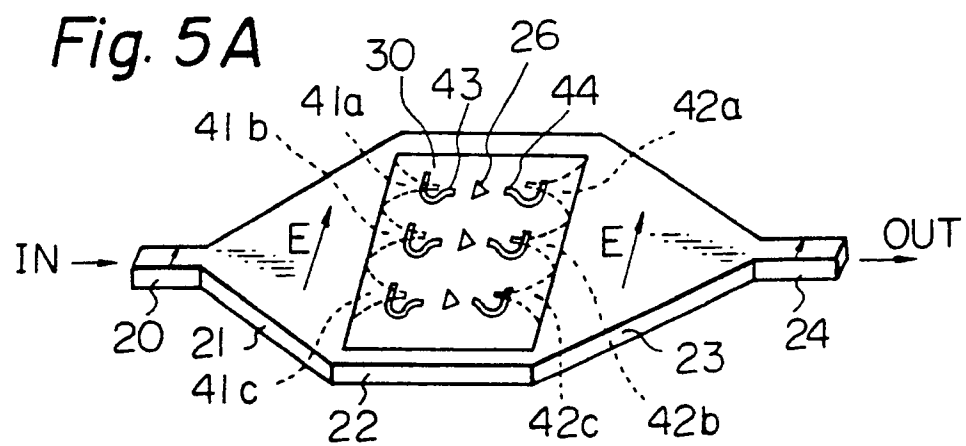


Fig. 2

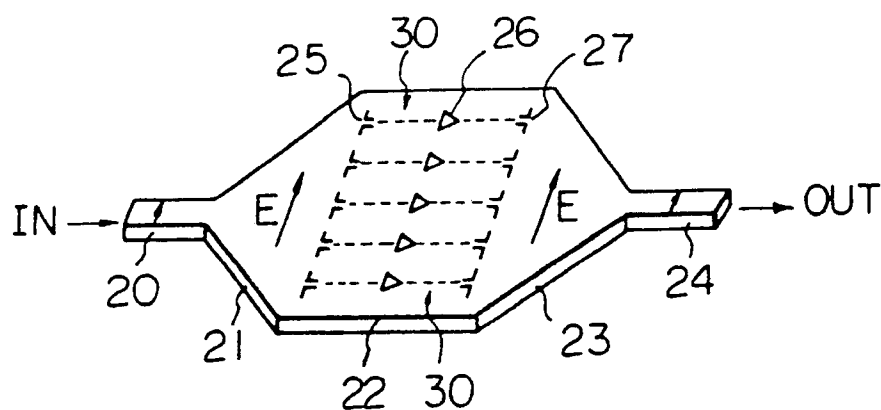


Fig. 6

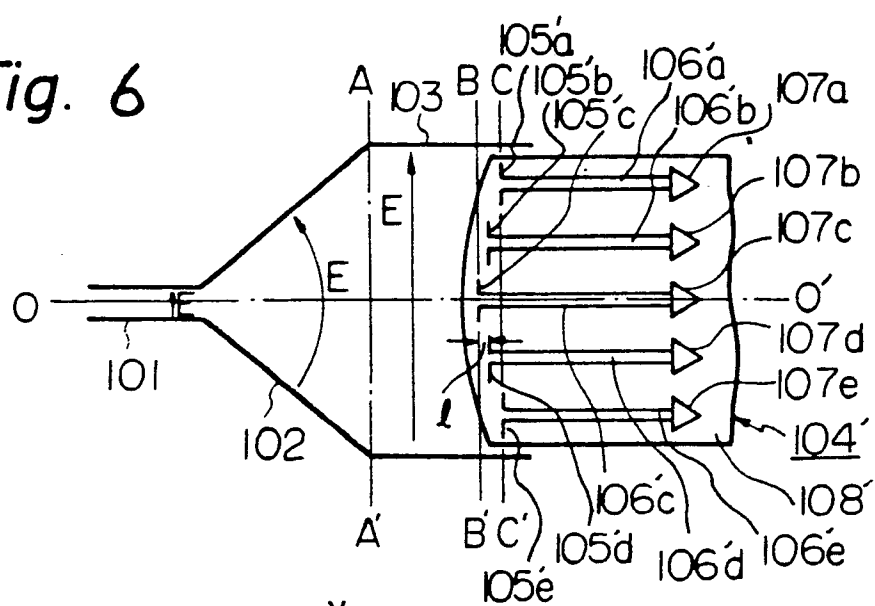


Fig.7

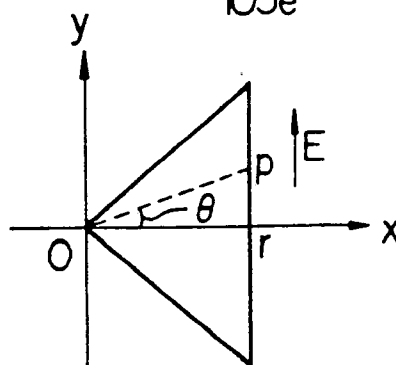


Fig. 8

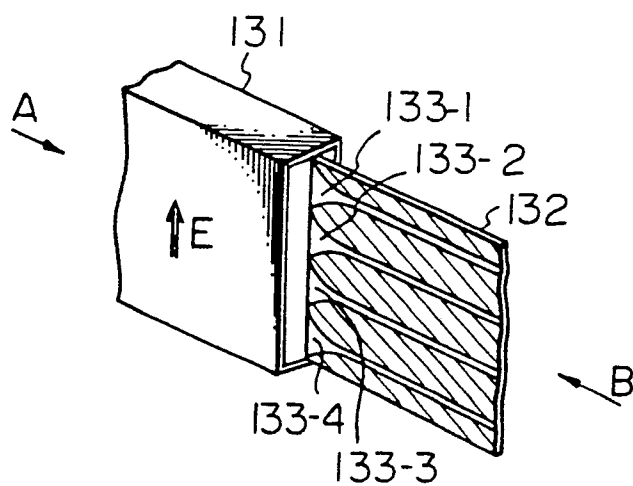


Fig. 9

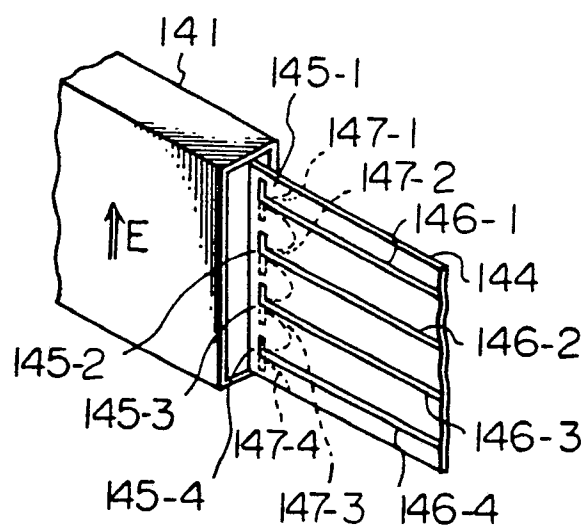


Fig. 10

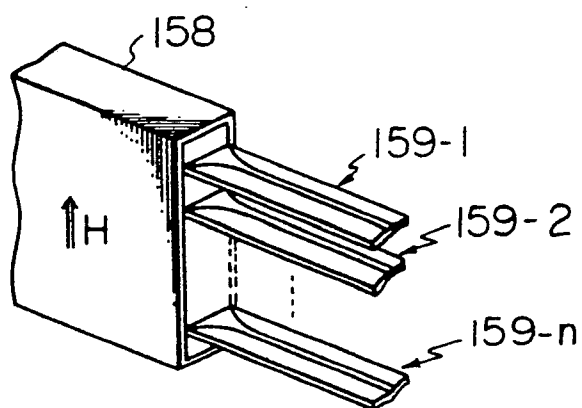


Fig. 11

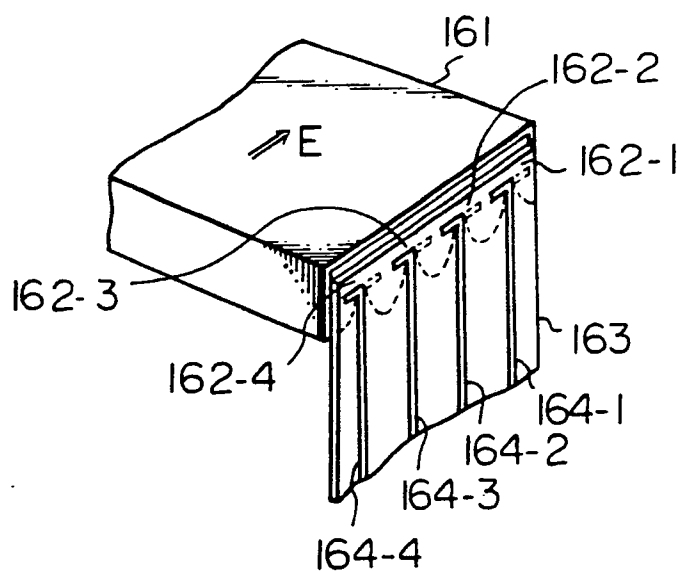


Fig. 12

PRIOR ART

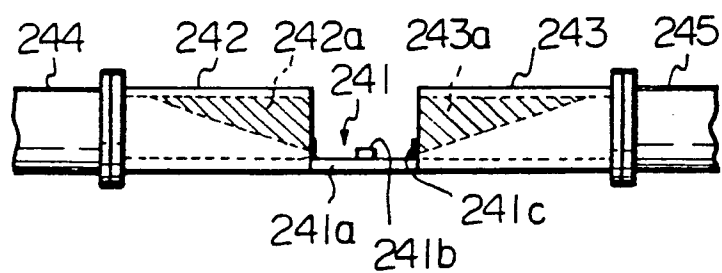


Fig. 13

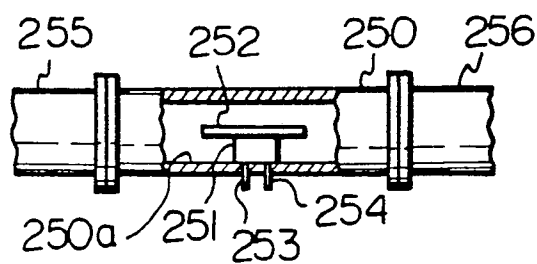


Fig. 14

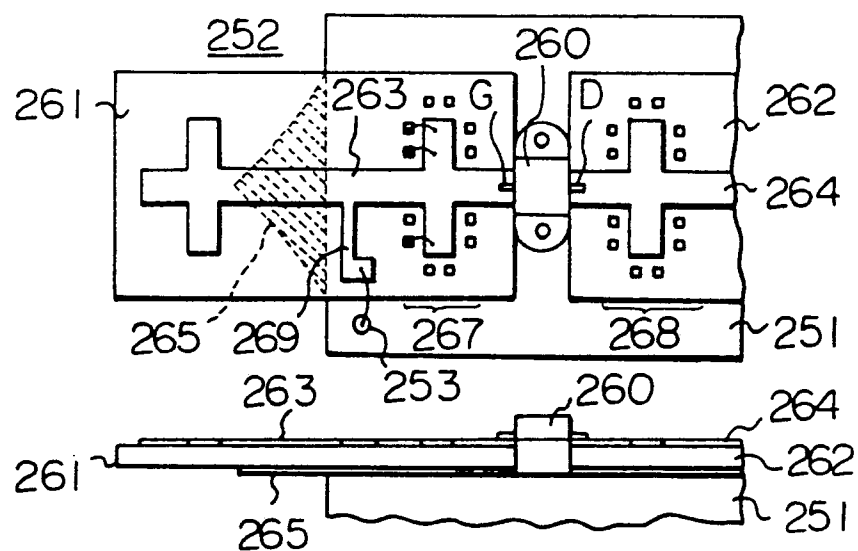


Fig. 15

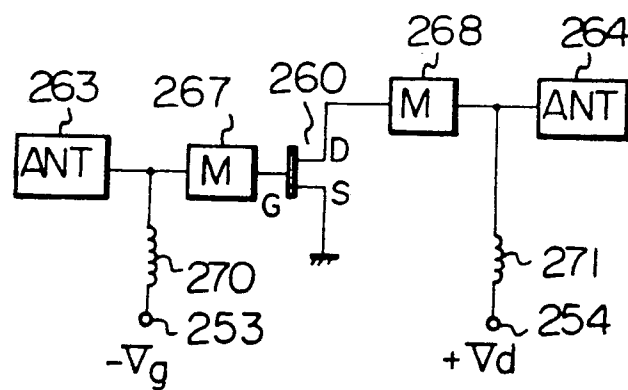


Fig. 16

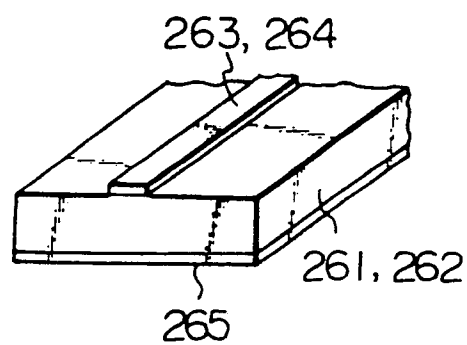


Fig. 17

