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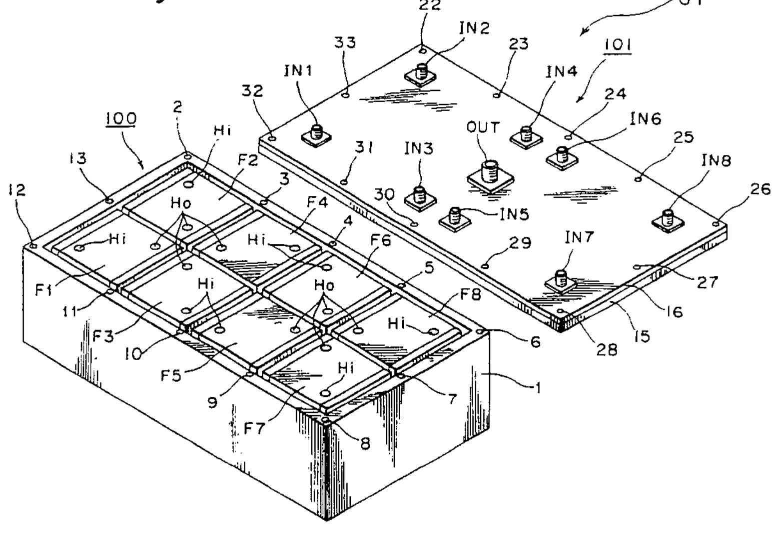
(54) **Radio frequency signal combining/sorting apparatus.**

(57) A radio frequency signal combining/sorting apparatus which includes a plurality of channel filters (F1, --- and F64) which allow band regions of respective transmission channels to pass through them, isolators (IN1, --- and IN64) connected to respective inputs of the channel filters, a plurality of sets of power composing circuits (JU1,JU2,JU3,JU4) each including branch lines for composing outputs of the channel filters as one output, and hybrid circuits (H1 to H3) arranged to compose outputs per two sets of the power composing circuits (JU1,JU2,JU3,JU4). The band regions of the respective channel filters are selected in such relation that the band regions of the respective channel filters of the same power composing circuit are spaced from each other to a largest extent.

Fig. 3



EP 0 432 729 A2

RADIO FREQUENCY SIGNAL COMBINING/SORTING APPARATUS

BACKGROUND OF THE INVENTION

The present invention generally relates to communication equipment and more particularly, to a radio frequency signal combining/sorting apparatus which composes a plurality of transmission signals for transmission to a common output line or antenna.

It has been recent trend that, in a mobile unit communication system such as an automobile telephone, etc. utilizing a frequency band region of 800 MHz, a so-called cellular system is widely employed, in which radio frequency channels correspond in number to the traffic of the cells (wireless zones) are provided in one base station.

By way of example, in the mobile unit communication system for the automobile telephone or the like recently showing a rapid increase in the number of users, a large number of channels as many as, e.g. 32 to 64 channels are required in one base station.

In the case where so many radio frequency channels are to be provided in one base station, the antenna sharing technique at the base station is essential from the economical point of view, and development of an efficient radio frequency signal combining/sorting apparatus for composing many input signals into one output signal has been strongly demanded.

The radio frequency signal combining/sorting apparatus is not limited in its application, only to the antenna sharing device as referred to above, by may also be applied generally to a power composing device having a construction as shown in Fig. 15 or 16.

In Fig. 15, the known power composing device PA includes so-called 3dB hybrid circuits H1,H2 and H3 connected to each other and respectively grounded through resistors R1,R2 and R3 for dummy loads, input terminals IN1 and IN2 for the 3dB hybrid circuit H1, input terminals IN3 and IN4 for the 3dB hybrid circuit H2, and an output terminal OUT led out from the 3dB hybrid circuit H3.

In the above arrangement PA, the 3dB hybrid circuit H1 composes the power of the signals inputted from the input terminals IN1 and IN2 for application to one input of the 3dB hybrid circuit H3, while the 3dB hybrid circuit H2 composes the power of the signals inputted from the input terminals IN3 and IN4 so as to be applied to the other input of said 3dB hybrid circuit H3. Thus, the 3dB hybrid circuit H3 subjects the both signals thus inputted to power composition for output thereof.

Meanwhile, the known power composing device PB in Fig. 16 includes input terminals IN1,IN2, --- and INn respectively coupled to channel filters F1,F2, --- and Fn each constituted by a band-pass filter, through isolators I1,I2,--- and In, a power composing circuit (or junction unit) JU coupled with said channel filters F1,F2,--- and Fn, and an output terminal OUT led out from the circuit JU.

In the power composition circuit PB as described above, respective signals inputted from the input terminals IN1,IN2, --- and INn are prevented from mixing into other inputs by the isolators I1,I2, --- and In, and the signals passing through channel filters F1,F2, --- and Fn are subjected to the power composition by the junction unit JU for output therefrom through the output terminal OUT.

Although the so-called 3dB hybrid composing system shown in Fig. 15 is of a simplified system without frequency characteristics in principle, since half of the power is absorbed by dummy loads each time the power passes through the 3dB hybrid circuit, it is not generally used as the signal combining/sorting apparatus for effecting power transmission.

On the other hand, in the so-called junction unit composing system shown in Fig. 16, through employment of the channel filters for passing band region of the predetermined channels, by inputting signals of the corresponding channels, the power composition may be effected at a small sharing loss, and therefore, the system is generally employed as the radio frequency signal combining/sorting apparatus.

Relation between the respective channels and transmission characteristics of the respective channels is shown in a graphical diagram of Fig. 17, in which center frequencies of the respective channels and channel filters are represented by f1,f2,f3, --- and fn. As is seen from Fig. 17, in order to reduce interference with respect to neighboring channels, Q value above a predetermined constant value is necessary, while a high frequency temperature stability is required for suppressing an increase of an insertion loss due to displacement of the central frequency by the temperature. However, in the case where the arrangement is applied to such a system as having a channel interval of 100KHz, for example, in a band region of 800MHz to 1.5 GHz, it is difficult to construct a channel filter having a stable frequency characteristic, with a high Q value, maintained even in a cavity resonator, semi-coaxial cavity resonator or dielectric resonator, etc., and thus, an increase in the insertion loss can not be avoided.

SUMMARY OF THE INVENTION

Accordingly, an essential object of the present invention is to provide a radio frequency signal combining/sorting apparatus which is so arranged to employ channel filters not provided with very high Q value and frequency temperature stability, and yet, to be applicable to a system having many channels, with small channel intervals.

Another object of the present invention is to provide a radio frequency signal combining/sorting apparatus of the above described type in which resonators used therein as channel filters are further reduced in size so as to achieve compact size, low loss and cost reduction of the apparatus on the whole including composite parts.

In accomplishing these and other objects, according to one preferred embodiment of the present invention, there is provided a radio frequency signal combining/sorting apparatus which includes a plurality of channel filters which allow band regions of respective transmission channels to pass therethrough, isolators connected to respective inputs of said channel filters, a plurality of sets of power comparing circuits including branch lines for composing outputs of said channel filters as one output, and hybrid circuits arranged to compose outputs per two sets of said power composing circuits. The band regions of said respective channel filters are selected in such relation as the band regions of the respective channel filters of the same power composing circuit being spaced from each other to a largest extent.

By the arrangement of the present invention as described above, the band regions of the respective channel filters connected to one power composing circuit are allocated in every other channel alternately. Therefore, the channel interval of the respective signals inputted to the one power composing circuit is doubled for enlarging, thereby to reduce interference with respect to the neighboring channels. Therefore, requirements for the Q value and frequency temperature stability to the respective channel filters are alleviated. On the contrary, even in the case where channel filters provided with the same Q value and frequency temperature stability are employed, it becomes possible to apply the apparatus to a system in which a larger number of channels are set at small channel intervals.

In another embodiment of the present invention, there is also provided a radio frequency signal combining/sorting apparatus which includes a channel filter unit formed with signal input coupling means receiving holes and signal output coupling means receiving holes, and provided with a plurality of TM mode dielectric resonators respectively adapted to allow band regions of specific channels to pass therethrough. The dielectric resonators are arranged on the same plane at least as said signal output coupling means receiving holes, and a junction unit having a circuit board in which the signal output coupling means project from the surface thereof, and on which branched lines including transmission lines for composing outputs of said signal output coupling means are provided. The junction unit is combined with said channel filter unit to constitute said radio frequency signal combining/sorting apparatus.

The radio frequency signal combining/sorting apparatus in the above embodiment of the present invention, is broadly divided into the channel filter unit and the junction unit each having constructions as described above, which are combined with each other to provide one radio frequency signal combining/sorting apparatus.

In the case where radio frequency signal combining/sorting apparatus is used for a cellular base station, since the power required for transmission is comparatively lowered following reduction of the cell radius in recent years, compact dielectric resonators with a small power capacity may be employed therefor. Generally, in the TM mode dielectric resonators such as TM_{010} and TM_{110} modes, etc., although the Q value is slightly low as compared with that of the dielectric resonator of $TE_{01\delta}$ mode, when the dielectric resonator is to be reduced in size, the TM mode dielectric resonator is capable of maintaining the Q value high as compared with the TE mode dielectric resonator. Accordingly, the channel filter unit may be compact in size and low in the insertion loss.

Moreover, since the signal output coupling means to be coupled with the outputs of the respective dielectric resonators of the channel filter unit is integrally formed with the junction unit, by combining the junction unit into one unit with the channel filter unit, a radio frequency signal combining/sorting apparatus still more reduced in size on the whole may be constituted.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic circuit diagram showing construction in principle of a radio frequency signal combining/sorting apparatus according to the present invention,

Fig. 2 is a diagram showing transmission characteristics of the respective channel filters shown in Fig. 1,

Fig. 3 is a perspective exploded view of a radio frequency signal combining/sorting apparatus according to one preferred embodiment of the present invention, with its channel filter unit and junction unit shown as separated from each other,

Fig. 4 is also a perspective view of the combining/sorting apparatus of Fig. 3, with its channel filter unit and junction unit combined with each other to constitute said apparatus,

Fig. 5 is a schematic exploded perspective view showing construction of a dielectric resonator representing one of channel filters employed in the arrangement of Figs. 3 and 4,

Fig. 6 is a cross sectional view of the channel filter of Fig. 5 as assembled,

Fig. 7 is a schematic top plan view for explaining construction of the junction unit,

Figs. 8(A) to 8(C) are fragmentary cross sections on an enlarged scale, taken along the lines 8A-8A, 8B-8B, and 8(C)-8(C) in the junction unit of Fig. 7,

Fig. 9(A) is a perspective view of a radio frequency signal combining/sorting apparatus according to a second embodiment of the present invention as observed from its side of signal input connectors,

Fig. 9(B) is a similar view thereof as observed from its side of a signal output connector,

Fig. 10 is a schematic top plan view of the apparatus of Figs. 9(A) and 9(B),

Fig. 11 is a schematic side sectional view of the apparatus of Figs. 9(A) and 9(B),

Fig. 12 is a schematic circuit diagram showing general construction of the combining/sorting apparatus according to the second embodiment of the present invention,

Fig. 13 is a circuit diagram similar to Fig. 12, which particularly shows another embodiment thereof,

Figs. 14(1) to 14(4) are characteristics of the respective channel filters of the apparatus of Fig. 13,

Fig. 15 is a circuit diagram showing a conventional power composing system (already referred to),

Fig. 16 is a circuit diagram similar to Fig. 15, which particularly shows another conventional power composing system (already referred to), and

Fig. 17 is a diagram showing transmission characteristics of the respective channel filters of the system in Fig. 15 (already referred to).

DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Principle of the present invention

Referring now to the drawings, there is shown in Fig. 1 a schematic circuit diagram representing general construction in principle, of a radio frequency signal combining/sorting apparatus G1 according to the present invention, which generally includes channel filters F1,F3, --- and Fn-1, and F2,F4, --- and Fn which respectively allow band regions of allocated transmission channels to pass therethrough, isolators I1,I3, --- and In-1, and I2,I4, --- and In connected to inputs of the respective channel filters, a power composing circuit JU1 (Junction unit) connected to outputs of the channel filters F1,F3, --- and Fn-1 and constituted by branch lines for composing the respective outputs as one output, another power composing circuit JU2 (Junction unit) connected to outputs of the channel filters F2,F4, --- and Fn and constituted by other branch lines, a 3dB hybrid circuit H connected to outputs of said power composing circuits JU1 and JU2 and grounded through a resistor or dummy load R.

In the above arrangement according to the present invention, the signals inputted from the input terminals IN1,IN3, --- and INn-1 are filtered by the channel filters F1,F3, --- and Fn-1 independently of the signals inputted from the input terminals IN2,IN4, --- and In so as to be composed as one output by the power composing circuit JU1. Meanwhile, the signals inputted from the input terminals In2,In4, --- and INn are filtered by the channel filters F2,F4, --- and Fn independently of the signals inputted from the input terminals In1, IN3, --- and INn-1, so as to be composed as one output by the power composing circuit JU2. Thus, these two outputs are composed as one output by the 3dB hybrid circuit H.

Fig. 2 shows transmission characteristics of the channel filters F1 to F6 in the channel filters F1 to Fn. Here, f1 to f6 correspond to resonance frequencies of the channel filters F1 to F6, and the transmission characteristics of the channel filters at the side connected to the power composing circuit JU1 are shown in the upper stage, with those of the filters at the side connected to the power composing circuits JU2 are given in the lower stage. Thus, the band regions of the respective channel filters connected to one power composing circuit are alternately allocated to every other channel. Therefore, the interval between the respective signals inputted to one power composing circuit is doubled for enlarging, thereby to reduce interference with respect to the neighboring channels. Accordingly, requirements of Q value and frequency temperature stability for the respective channel filters may be alleviated. Conversely, even in the case where channel filters provided with the same Q value and frequency temperature stability are employed, they can be applied to a system in which more channels are set through a narrow channel interval.

It is to be noted here that, in the foregoing arrangement, by the function of the hybrid circuit H and the dummy load R, although the power to be outputted becomes half the ccmposite power to be outputted from the two power composing circuits JU1 and JU2, since the insertion loss in the respective filters is reduced as compared with the case where only the conventional simple junction unit composing system is employed, it becomes possible to effect the composition at a low insertion loss on the whole.

First embodiment

Figs. 3 to 8(C) show constructions of a radio frequency signal combining/sorting apparatus according to one preferred embodiment of the present invention,

Fig. 3 is a perspective exploded view of the radio frequency signal combining/sorting apparatus G1, with its channel filter unit and junction unit shown as separated from each other, and Fig. 4 is a perspective view of the combining/sorting apparatus G1 of Fig. 3, with its channel filter unit and junction unit combined with each other to constitute apparatus.

In Fig. 3, the radio frequency signal combining/sorting apparatus G1 generally includes a channel filter unit 100 and a junction unit 101 shown as separated from each other for clarity. The channel filter unit 10a further includes a metallic case 1 of a rectangular cubic box-like configuration open as its upper portion and eight TM mode dielectric resonators F1 to F8 accommodated in said case 1. Each of these dielectric resonators F1 to F8 is constituted by a cavity of a metallized ceramic material of a hexahedron configuration and a dielectric member in a square pillar shape provided in said cavity as will be described in more detail later. On the upper surfaces of the respective dielectric resonators F1 to F8 in Fig. 3, there are formed signal input coupler inserting holes Hi and signal output coupler inserting holes Ho. Moreover, on peripheral edges around the upper opening of the case 1, threaded holes 2 to 13 are formed to receive screws for fixing the junction unit 101.

Meanwhile, the junction unit 101 shown in Fig. 3 is mainly constituted by two substrates 15 and 16 of ceramic material, branch lines formed between said two substrates, signal input coupling means, signal output coupling means, and input and output connectors to be mentioned hereinbelow. In Fig. 3, the ceramic substrates 15 and 16 are mounted with eight signal input connectors IN1 to IN8 and one signal output connector indicated by OUT on the upper surface thereto. On the peripheral edge of the substrates 15 and 16, holes 22 to 33 are formed in positions corresponding to the threaded holes 2 to 13 for fixing the junction unit 101 onto the channel filter unit 100 by screws (not shown).

When assembled, the channel filter unit 100 and the junction unit 101 are combined as shown in Fig. 4, thereby to constitute the eight channel radio frequency signal combining sorting apparatus G1.

Subsequently, the construction of one of the dielectric resonators to be employed in the channel filter unit 100 will be explained with reference to Figs. 5 and 6.

In the schematic exploded perspective view of Fig. 5, the dielectric resonator represented as F includes a square ceramic member 50 in a square box-like configuration open at opposite sides, and metallized on the outer sides thereof, with a square piller-like inner dielectric member 51 being integrally formed with a bottom 50a of the ceramic member 50, and ceramic side plates 53 and 55 metallized in inner faces thereof facing the open sides of the ceramic member 50. When the ceramic member 50 and the side plates 53 and 55 are combined, the dielectric resonator having a ceramic cavity is constituted. Moreover, on the upper surface of the ceramic member 50, the holes Hi and Ho for receiving the signal input coupling means and signal output coupling means are formed.

As is seen from Fig. 6 showing the cross section of the one dielectric resonator F of Fig. 5 after assembly, there is formed the shielded cavity by an electrode layer 52 formed on the outer side of the ceramic member 50, and electrodes 54 and 56 formed in the inner faces of the ceramic side plates 53 and 55, and by the functions of said cavity and the inner dielectric member 51, the resonator functions as a TM_{110} mode dielectric resonator.

Subsequently, construction of the junction unit 101 will be described with reference to Figs. 7 to 8-(C).

Fig. 7 represents the branch lines formed over the upper surface of the ceramic substrate 15 and particularly made of transmission lines. In Fig. 7, a so-called tri-plate type transmission line is indicated by Numeral 45.

Figs. 8(A), 8(B) and 8(C) respectively show fragmentary cross sections taken along the lines 8A-8A, 8B-8B, and 8(C) and 8(C) in Fig. 7.

In Fig. 8(A) showing the cross section along the line 8(A)-8(A) at the transmission line portion, the ceramic substrate 15 is constituted by forming electrode layers 41 over upper and under surfaces of a ceramic plate 40, while the other ceramic substrate 16 is also composed by forming electrode layers 43 over upper and under surfaces of a ceramic plate 42. In a predetermined portion of the ceramic substrate 15, a groove g is formed, along which groove, a dielectric member 44 is provided, with an electrode 45 further formed on the dielectric member 44 as shown. This electrode 45 constitutes the tri-plate type transmission line together with the electrode 41 of the ceramic substrate 15, and the electrode 43 of the ceramic substrate 16. Fig. 8(B) shows the cross section at the portion where the signal output coupling means is provided (the cross section along the line 8B-8B in Fig. 7). As shown in Fig. 8(B), a through-hole 15a is formed at a predetermined portion of the ceramic substrate 15, and a coupling probe (i.e. signal output coupling means) 17 is extended through the dielectric member 44 and the electrode layer 45, with the end portion of the probe 17 projecting from the undersurface of the ceramic substrate 15 via the through-hole 15a.

Fig. 8(C) shows the cross section at the portion of the output connector (taken along the line 8C-8C in Fig. 7). At this portion, an opening is formed in the ceramic substrate 16, and the output connector OUT is mounted on the upper surface of the ceramic substrate 16, with a central conductor 18 of said connector being connected to the electrode 45 as illustrated.

Moreover, at the mounting portions of the respective input connectors, through-holes are formed in the ceramic substrates 15 and 16, and central conductors of the respective input connectors extend through the under surface of the substrate 15 as the signal input coupling means such as the coupling probes, coupling loops, etc.

By applying and fixing the junction unit 101 having the construction as described above onto the channel filter unit 100, the coupling probes 17 projecting from the undersurface of the junction unit 101 are inserted into the signal output coupling means insertion holes of the respective dielectric resonators, while the central conductors of the respective signal input connectors are to be inserted into the signal input coupling means insertion holes of the respective dielectric resonators. Accordingly, the signals for the respective channels inputted from the signal input connectors are inputted to the respective corresponding dielectric resonators, and the signals produced in the signal output coupling means are subjected to the power composition by the branch lines 45 constituted by the transmission lines for output through the output connector OUT.

It is to be noted here that the branch line shown in Fig. 7 is so set that the electrical length from each output of the dielectric resonator (i.e. equivalent short-circuit face of the resonator) to the first branch point a or b becomes an odd multiple of 1/4 wavelength respectively, while the electrical length from the branch point a or b to another branch point at the second stage (i.e. the point where the central conductor of the output connector OUT is to be connected) becomes a integer multiple of 1/2 wavelength. By setting the branch lines as described above, at the frequency for the design wavelength, impedance obtained by viewing the other dielectric resonator from the respective branch points is excessively increased, and thus, power feeding may be effected from the output connector with almost no loss in the transmission power of its own channel.

Second embodiment

Figs. 9(A) to Fig. 11 show the radio frequency signal combining/sorting apparatus according to a second embodiment of the present invention.

Figs. 9(A) and 9(B) represent an external appearance of a 32 channel radio frequency signal combining/sorting apparatus G2, in which Fig. 9(A) is a view as observed from the signal input connector side, and Fig. 9(B) is a view as observed from the signal output connector side of said apparatus. In Figs. 9(A) and 9(B), on one surface of the main body B of the apparatus G2 (Fig. 9(A)), 32 input connectors IN1 to IN32 corresponding to the number of channels are arranged on the same plane, while on the opposite other surface thereof (Fig. 9 (B)), one output connector OUT is provided. Moreover, on the four side faces of the main body B of the apparatus G2 other than the opposite surfaces provided with the signal input connectors IN1 to IN32 and the signal output OUT, a plurality of air cooling fans represented by Numerals 60,61,62,63,64,65,66,67 etc. are mounted.

Fig. 10 is a schematic top plan view showing general construction in the interior of the combining/sorting apparatus G2, while Fig. 11 is a schematic side sectional view on an enlarged scale, taken along the line 11-11 in Fig. 10.

In Fig. 10, symbols F1 to F32 denote channel filters respectively composed of TM_{010} mode dielectric resonators which allow band regions of the allocated channels to pass therethrough. The outputs of the odd numbered channel filters represented by F1 to F31 are composed as one output by the power composing circuit (referred to as a junction unit hereinafter) JU1 composed of the branch lines. On the other hand, the respective outputs of the even numbered channel filters indicated by symbols F2 to F32 are composed as one output by the junction unit JU2. There are provided circulators C1 and C2 respectively connected with dummy loads R1 and R2. The circulator C1 is adapted to lead the output of the junction unit JU1 to the output connector OUT, while the circulator C2 leads the output of the junction unit JU2 to the output connector OUT.

Meanwhile, each of symbols JUa to JUh represents a junction unit in which the branch lines composed of the transmission lines are formed on the substrate, so as to compose four resonator outputs respectively. For example, the junction unit JUa composes the respective outputs of the resonators F1,F3,F9 and F11 at a point a. Meanwhile, for example, the junction unit Juh composes the respective outputs of the resonators F22, F24,F30 and F32 at a point h. The outputs of these junction units are composed by the branch lines JU1 and JU2 constituted by coaxial cables or the like and supplied to the circulators C1 and C2 respectively.

It is to be noted here that the branch lines of the junction units JUa to JUh are so set that the electrical length thereof from each resonator to the branch point is an odd multiple of 1/4 wavelength. Meanwhile, in the branch lines JU1 and JU2 for composing outputs of the respective junction units, the electrical length from the junction unit to the branch point i or j is set to be an integer multiple of 1/2 wavelength.

In the junction unit JU1, the electrical length from the respective outputs of the channel filters F1,F3,F9 and F11 (equivalent short-circuiting faces of the respective resonators) to the first branch point a, the electrical length from the respective outputs of the channel filters F5,F7,F13 and F15 to the first branch point c, the electrical length from the respective outputs of the channel filters F17,F19,F25 and F27 to the first branch point c, and the electrical length from the respective outputs of the channel filters F21,F23,F29 and F31 to the first branch point g are respectively set to be odd multiples of 1/4 wavelength. Similarly, in the junction filer unit JU2, the electrical length from the respective outputs of the channel filters F2,F4,F10 and F12 to the first branch point b, the electrical length from the respective outputs of the channel filters F6,F8,F14 and F16 to the first branch point d, the electrical length from the respective outputs of the channel filters F18,F20,F26 and F28 to the first branch point f, and the electrical length from the respective outputs of the channel filters F22,F24,F30 and F32 to the first branch point h are respectively set to be odd multiples of 1/4 wavelength. Meanwhile, the electrical length from the branch points a,c,e and g to the branch point i at the second stage is set to be integer multiples of 1/2 wavelength. Similarly, the electrical length from the branch point b,d,f, and h to the branch point j at the second stage is set to be integer multiples of 1/2 wavelength. By constructing the junction unit as described above, in the frequency for the design wavelength, the impedance when the other channels are viewed from the respective branch points is increased to a large extent, and the transmission power of the own channel is fed to the circulators C1 and C2 with almost no loss. Similarly, coupling attenuation amount with respect to other transmitters (i.e. circuitry for supplying transmission power to the channel filter through the isolator) is also increased for consequent reduction of interference between the transmitters. In the cross sectional view of Fig. 11, the internal construction is shown with respect to the channel filter F4. In Fig. 11, a ceramic cavity 70 has a pillar-like inner dielectric member integrally formed between a bottom wall and a top wall of the cavity, whereby the TM_{010} mode dielectric resonator is constituted. Signal input coupling loop 72 and signal output coupling loop 73 with respect to this resonator are provided on the bottom wall and top wall of said ceramic cavity 70. 32 channel filters having the construction as described above are accommodated in the metallic case. In Fig. 11, there are provided input connectors IN2,IN4,IN6 and IN8, and isolators I2,I4,I6 and I8 for supplying signals from the respective input connectors to the coupling loops of the respective resonators (channel filters). There are also provided the branch line as the junction unit JUb for coupling the respective outputs of the channel filters F2,F4,F10 and F12 (the outputs of the above coupling loops) as shown in Fig. 10, with the point b by the electrical length in the odd multiple of 1/4 wavelength, and the branch line as the junction unit JUd for coupling the respective outputs of the channel filters F6,F8,F14 and F16 as shown in Fig. 10, with the point d by the electrical length in the odd multiple of 1/4 wavelength. The branch line at the first stage thereof, is constituted by the pattern on the board, four example, as a strip line or transmission line, while the branch line at the second stage is constituted by a coaxial cable and the like.

By the foregoing arrangement, the signals inputted from the signal input connectors in the odd numbers represented by the respective input connectors IN1 to IN31, are subjected to the power composition by the four junction units and coaxial cable, etc. so as to be supplied to the circulator C1, and the signals inputted from the signal input connectors in the even numbers represented by the respective input connectors IN2 to IN32, are subjected to the power composition by the four junction units and coaxial cable etc. so as to be supplied to the circulator C2. Half of the input power to the circulators C1 and C2 is respectively absorbed by the dummy loads R2 and R1, and the composition signal is outputted from the output terminal OUT.

On the other hand, the air cooling fans 60 to 67 are adapted to suppress temperature rise of the dielectric resonators by directly cooling the cavities of the 32 dielectric resonators. Particularly, the air cooling fans 63 and 64 suppress heat generation of the dummy loads R1 and R2. Since the respective dielectric resonators are each of TM mode, with the inner dielectric member being directly in contact with the two faces of the cavity (i.e. by integral molding), the heat of the inner dielectric member is efficiently radiated from its surface through the cavity for reduction of the temperature rise in the inner dielectric member.

Accordingly, the frequency variation is stabilized, with a reduction of the insertion loss.

It should be noted here that, in the foregoing embodiments, although the dielectric resonators of single mode are employed as the channel filters, the arrangement may, for example, be so modified as to use one multi-TM mode dielectric resonator as a multi-stage channel filter, or a channel filter for a plurality of channels.

Fig. 12 is a circuit diagram showing general construction of the combining/sorting apparatus G2 according to the second embodiment as described so far.

In Fig. 12, the channels allocated to the channel filters F1 to F32 are equal to the numbers of said filters. More specifically, the junction unit JU1 composes the outputs of the channel filters F1 to F31 which allow the odd-numbered channels, to pass therethrough, while the junction unit JU2 composes the outputs of the channel filters F2 to F32 which cause the even-numbered channels to pass therethrough. The output of the junction unit jU1 passes through the circulator C1 so as to output 1/2 of its power from the output terminal OUT, and the 1/2 of the power passes through the circulator C2 and is consumed by the dummy load R2. Meanwhile, the output of the junction unit JU2 passes through the circulator C2 so as to output 1/2 of its power from the output terminal OUT, and the 1/2 of the power passes through the circulator C1 and is consumed by the dummy load R1.

Although the foregoing embodiments are related to the 32 channel radio frequency signal combining/sorting apparatus, in order to constitute a radio frequency signal combining/sorting apparatus with more channels, it may be so arranged to provide a plurality of sets of the combining/sorting apparatus having the circuit construction as described above, and to subject the outputs thereof to power composition by hybrid circuits.

Fig. 13 shows one example of such circuit construction G3 as referred to above. In Fig. 13, channel filters F1 to F64 allow band regions of the channels equal to the filter numbers to pass therethrough. Input terminals IN1 to IN64 respectively apply input signals to the respective channel filters through isolators. The junction unit JU1 is arranged to compose the output of the channel filters F1,F5, --- and F61 into one output, the junction unit JU2 is adapted to compose the outputs of the channel filters F3,F7, --- and F63, the junction unit JU3 is intended to compose the outputs of the channel filters F2,F6, --- and F62, and the junction unit JU4 is to compose the outputs of the channel filters F4,F8, --- and F64. H1,H2 and H3 represent 3dB hybrid circuits respectively having resistors R1,R2 and R3 as dummy loads. The 3dB hybrid circuit H1 composes the outputs of the two junction units JU1 and JU2, and the 3dB hybrid circuit H2 composes the outputs of other two junction units JU3 and JU4. Further, the 3dB hybrid circuit H3 composes the output of the hybrid circuits H1 and H2.

Figs. 14(1) to 14(4) are diagrams showing channels allocated to the respective channel filters shown in Fig. 13, and the transmission characteristics. In Figs. 14(1) to 14(4), the transmission characteristics of the respective channel filters for applying signals to the junction units JU1 to JU4 are shown. By setting so that the band regions of the channel filters connected to the respective junction units are most spaced from each other, influence due to interference between the respective channel filters and the respective transmitters connected thereto is reduced to the minimum.

As is clear from the foregoing description, according to one aspect of the present invention, the pass-band region of the channel filter to be connected to one power composing circuit consisted of the branch line becomes wider than the channel interval to be transmitted on the whole, and therefore, the apparatus is less affected by the state of Q value and frequency temperature stability, and thus, it becomes possible to achieve the low insertion loss composition. Moreover, even in the case where channel filters provided with the same Q value and frequency temperature stability are employed, a large number of channels set at a narrow channel interval may be transmitted, without increasing the insertion loss.

Furthermore, in another aspect of the present invention, since the TM mode dielectric resonator is employed for the channel filter, it is possible to achieve the compact size, with a comparatively high Q value provided, and moreover, by forming the junction unit provided with the branch line of the transmission line and the signal output coupling means, into one unit with the channel filter unit, a further compact size may be achieved on the whole. Another advantage of the apparatus of the present invention is such that, since each channel filter is constituted by the TM mode dielectric resonator, a high heat radiating efficiency is achieved, with the temperature rise being suppressed to be low. Accordingly, the combining/sorting apparatus compact in size, and low in insertion loss and cost, can be advantageously employed for the base stations of the cellular system having a reduced cell radius.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.

Claims

1. A radio frequency signal combining/sorting apparatus which comprises:

a plurality of channel filters (F1, --- and F64) which allow band regions of respective transmission channels to pass therethrough isolators (IN1, --- and IN64) connected to respective inputs of said channel filters,

a plurality of sets of power composing circuits (JU1,JU2,JU3,JU4) each including branch lines for composing outputs of said channel filters as one output, and

hybrid circuits (H1 to H3) arranged to compose outputs per two sets of said power composing circuits (JU1,JU2,JU3,JU4), the band regions of said respective channel filters being selected in such relation as the band regions of the respective channel filters of the same power composing circuit being spaced from each other to a largest extent.

2. A radio frequency signal combining/sorting apparatus which comprises:

a channel filter unit (100) formed with signal input coupling means receiving holes (Hi) and signal output coupling means receiving holes (Ho), and provided with a plurality of TM mode dielectric resonators (F1 to F8) respectively adapted to allow band regions of specific channels to pass therethrough, said dielectric resonators (F1 to F8) being arranged on the same plane at least as said signal output coupling means receiving holes (Ho), and

a junction unit (101) having a circuit board in which the signal output coupling means project from the surface thereof, and on which branched lines including transmission lines for composing outputs of said signal output coupling means provided, said junction unit (101) being combined with said channel filter unit (100) to constitute said radio frequency signal combining/sorting apparatus.

Fig. 1

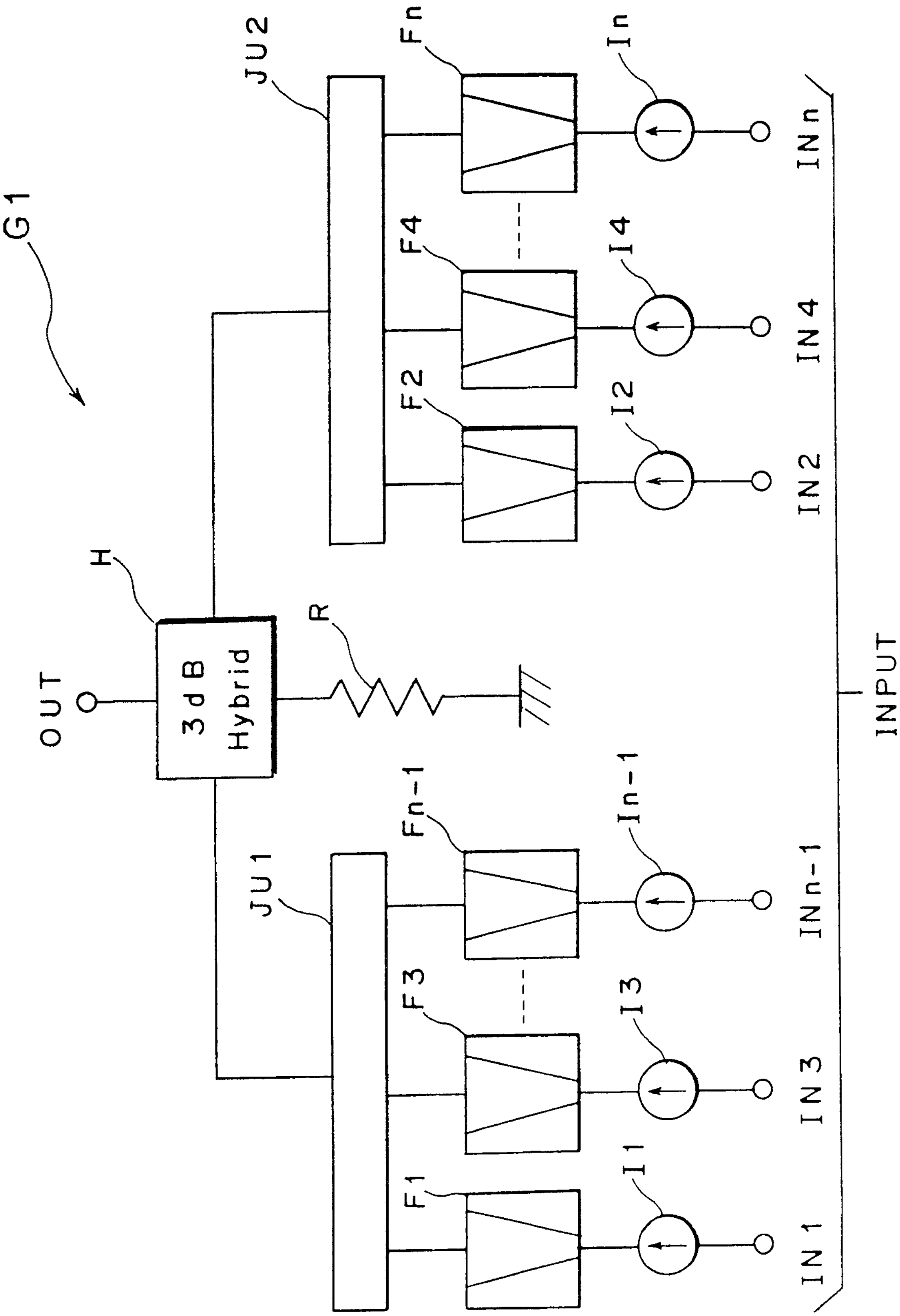

G1
OUT
3dB
Hybrid
H
R
JU1
JU2
F1
F3
Fn-1
F2
F4
Fn
I1
I3
In-1
I2
I4
In
IN1
IN3
INn-1
IN2
IN4
INn
INPUT

Fig. 2

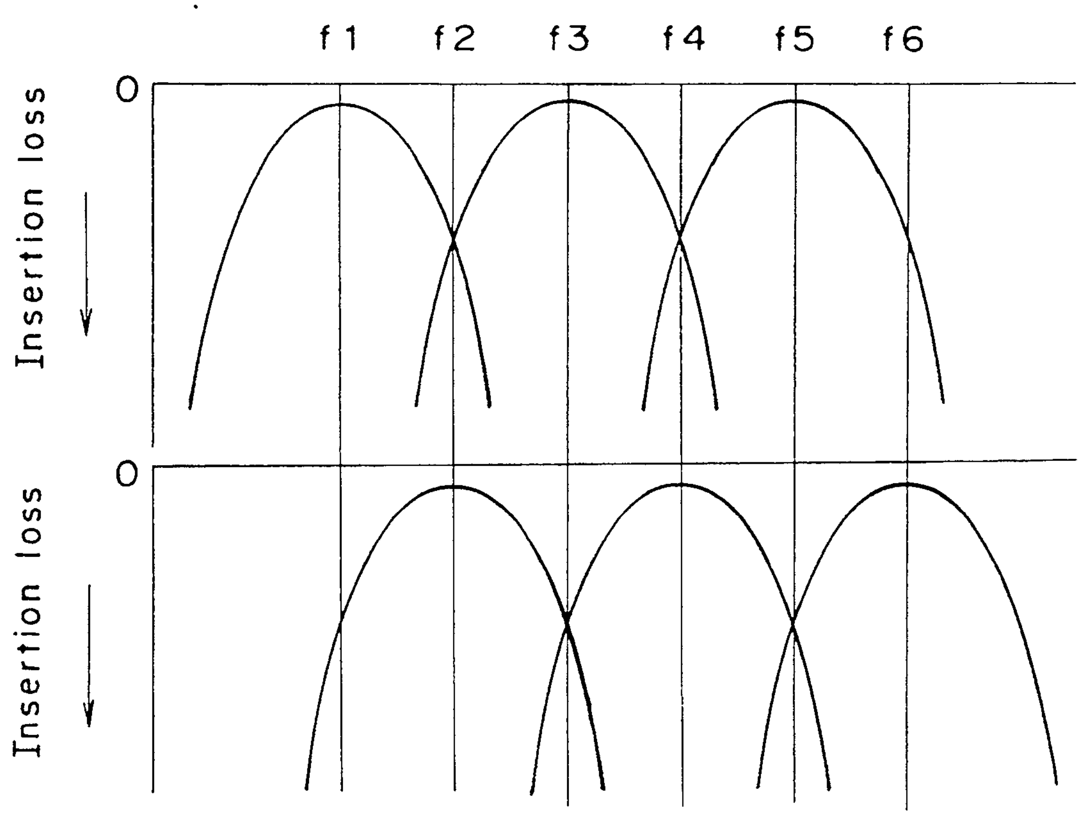


Fig. 3

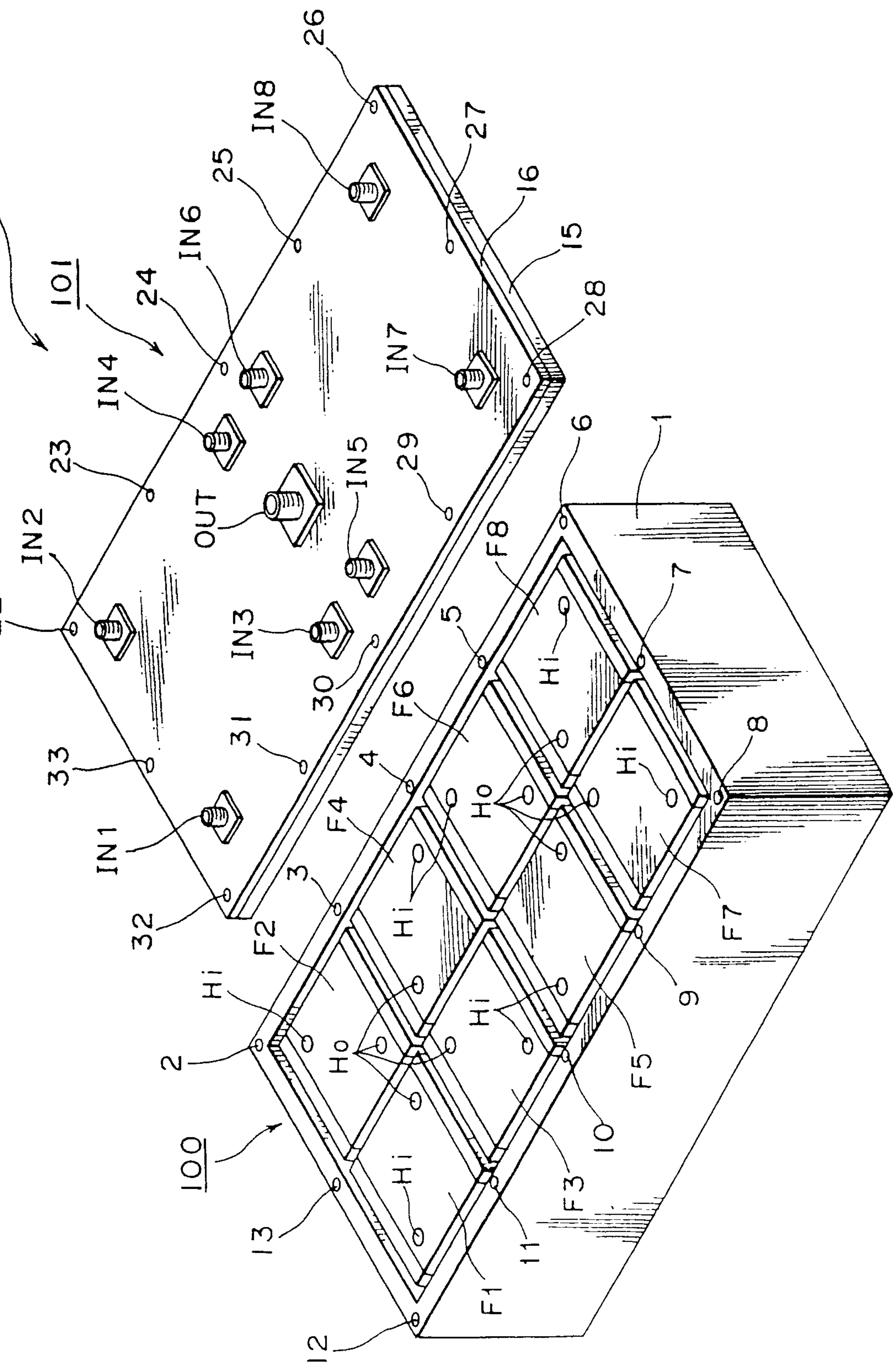

G1
101
100
IN1
IN2
IN3
IN4
IN5
IN6
IN7
IN8
OUT
F1
F2
F3
F4
F5
F6
F7
F8
Hi
Ho
1
2
3
4
5
6
7
8
9
10
11
12
13
15
16
22
23
24
25
26
27
28
29
30
31
32
33

Fig. 4

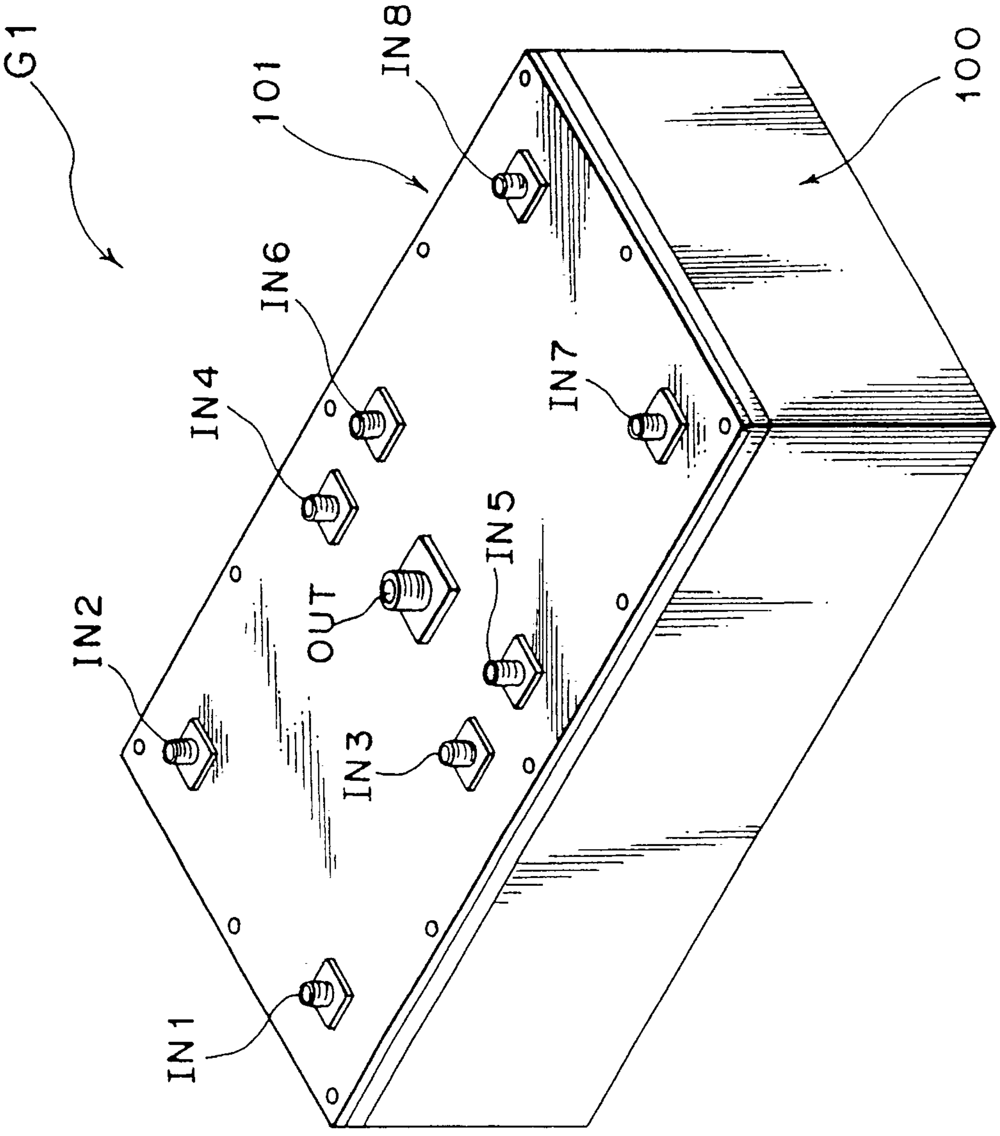


Fig. 5

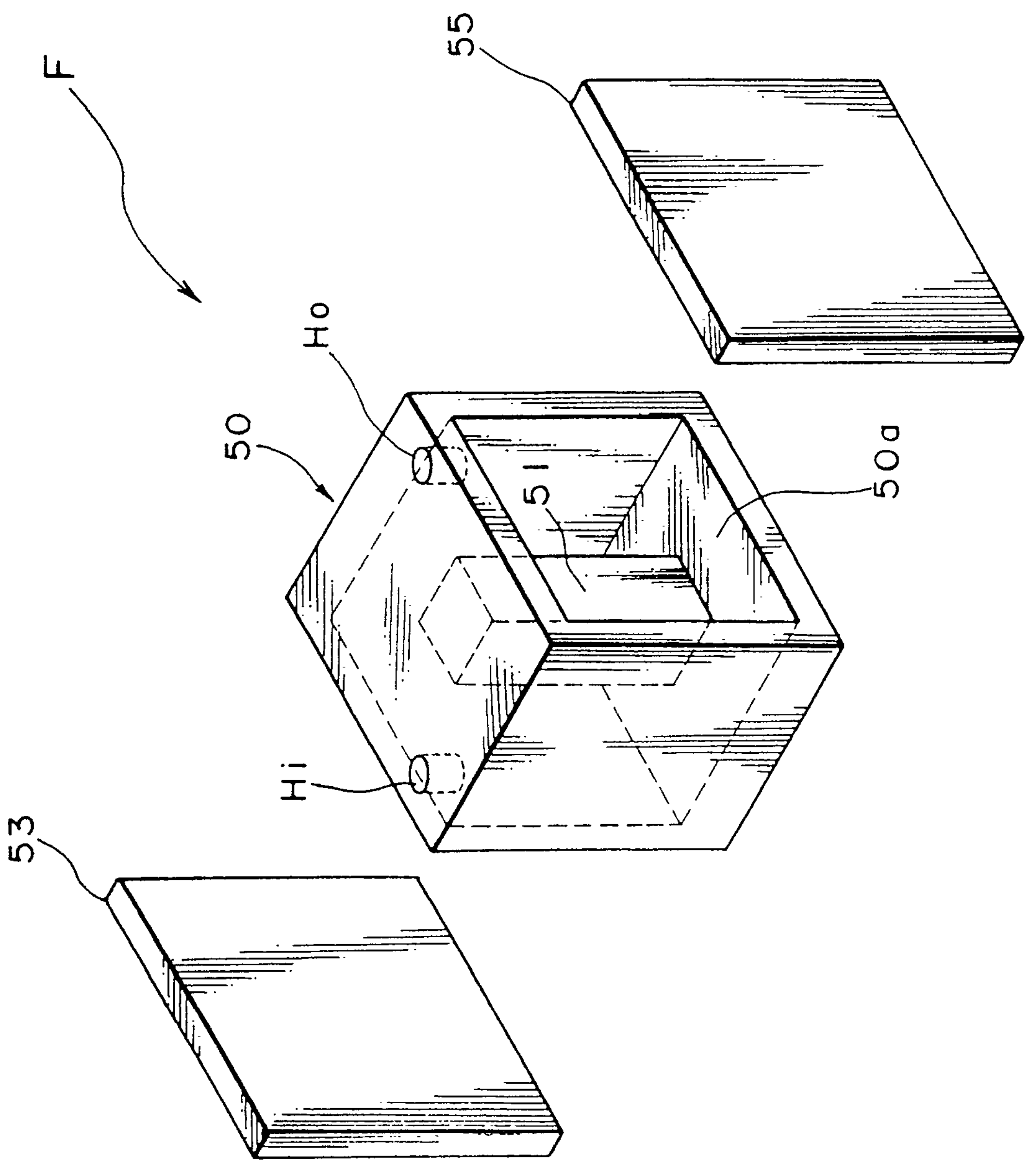


Fig. 6

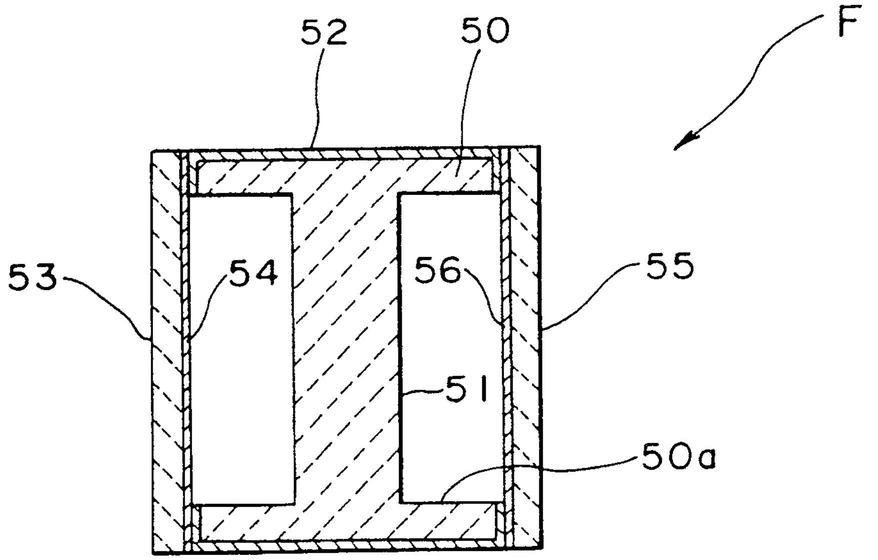
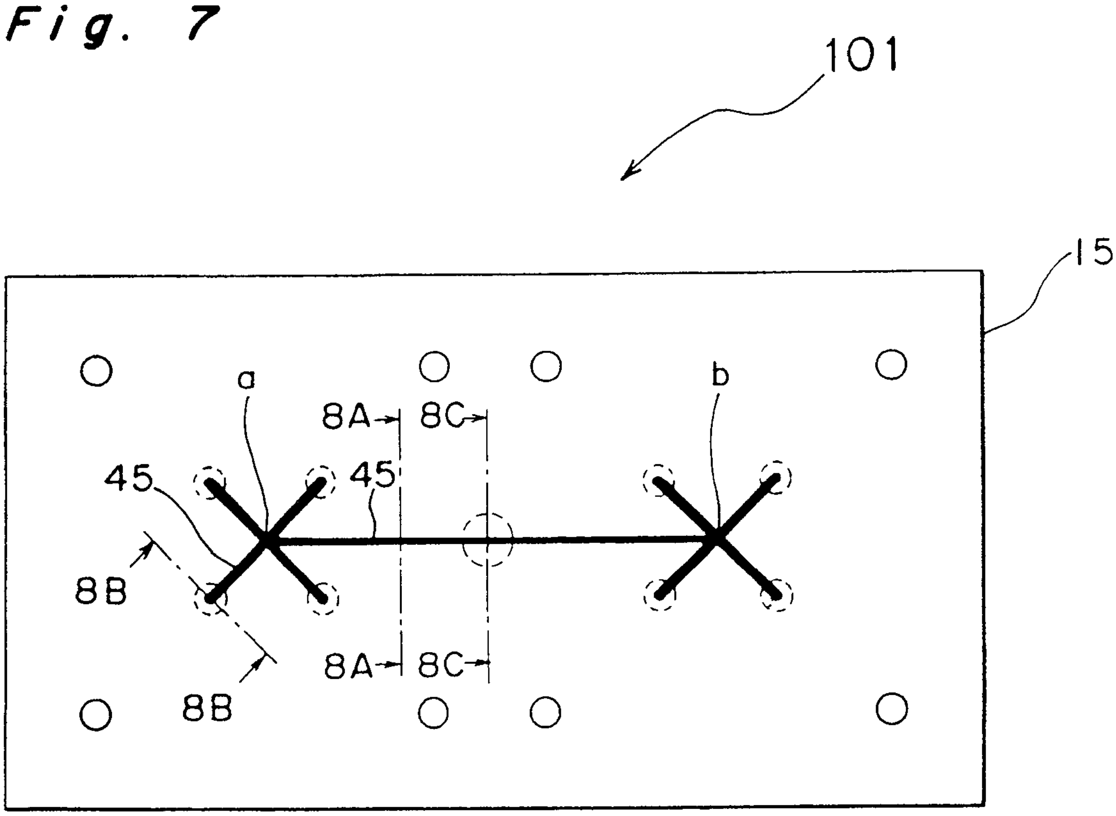


Fig. 7



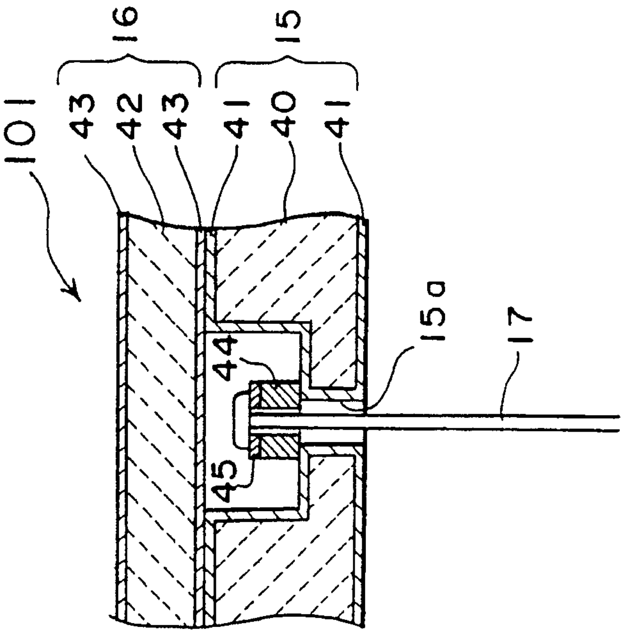


Fig. 8(B)

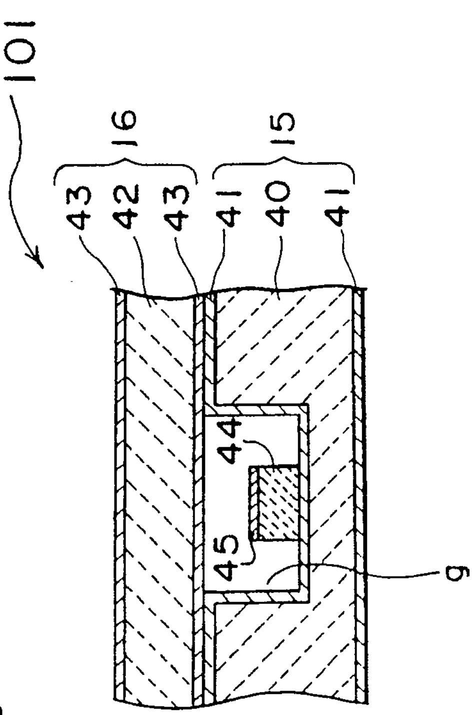


Fig. 8(A)

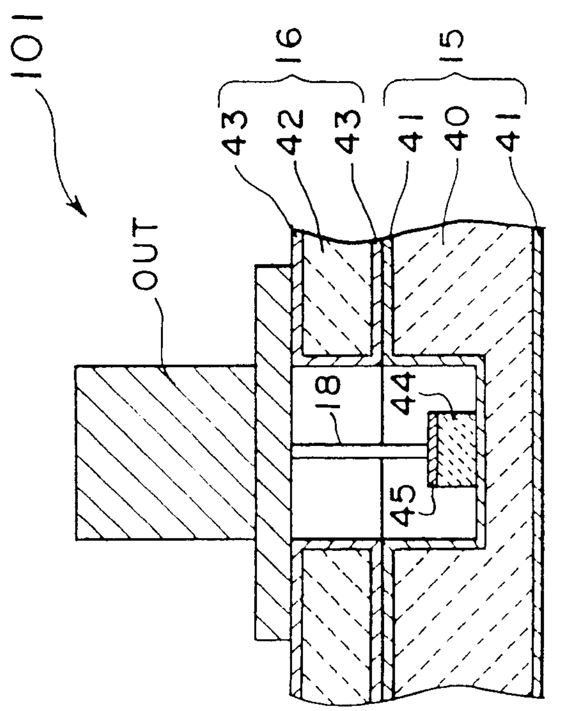


Fig. 8(C)

Fig. 9(A)

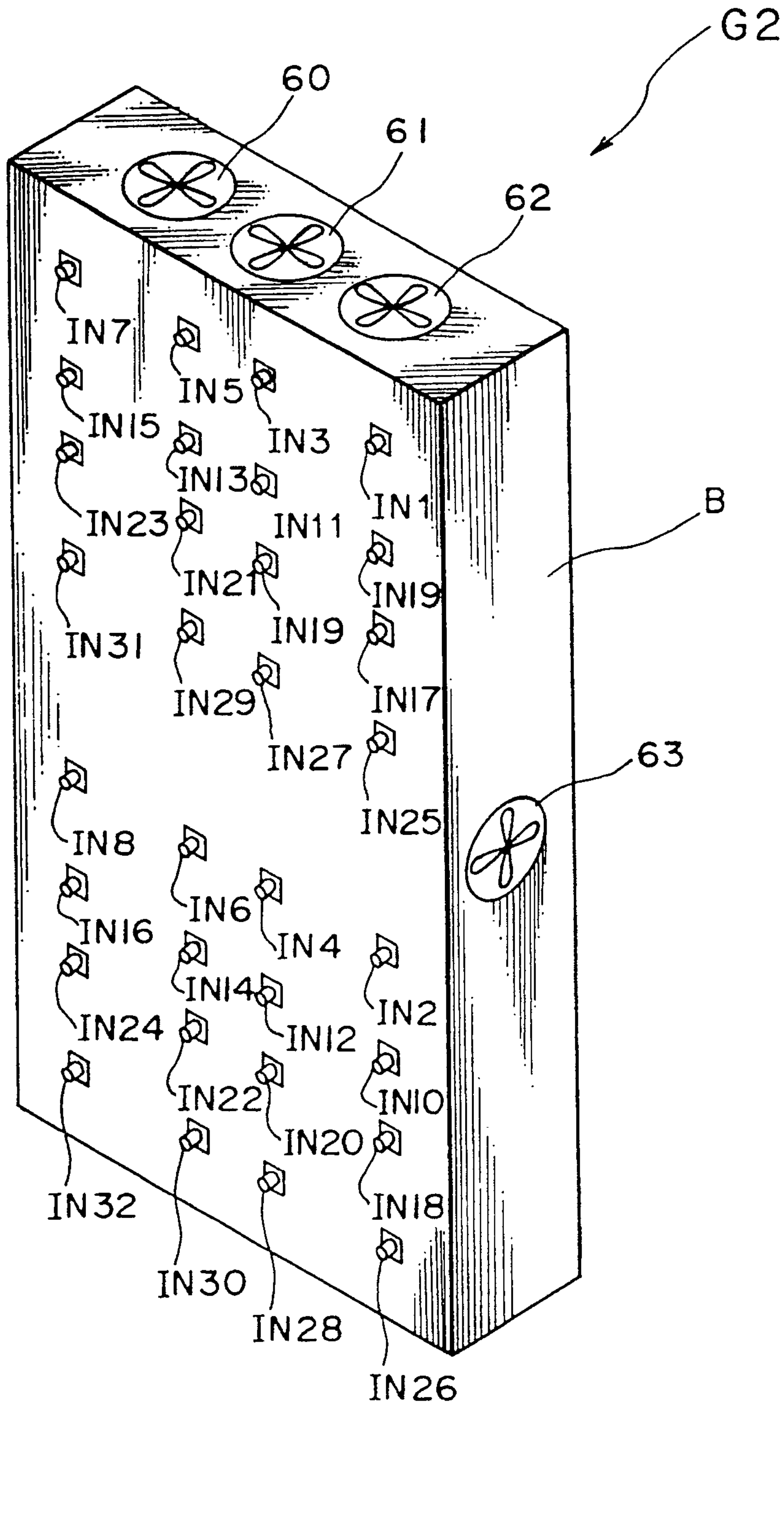

G2
60
61
62
B
63
IN7
IN5
IN15
IN3
IN13
IN1
IN23
IN11
IN21
IN19
IN19
IN31
IN29
IN17
IN27
IN25
IN8
IN6
IN4
IN16
IN14
IN2
IN24
IN12
IN22
IN10
IN20
IN18
IN32
IN30
IN28
IN26

Fig. 9(B)

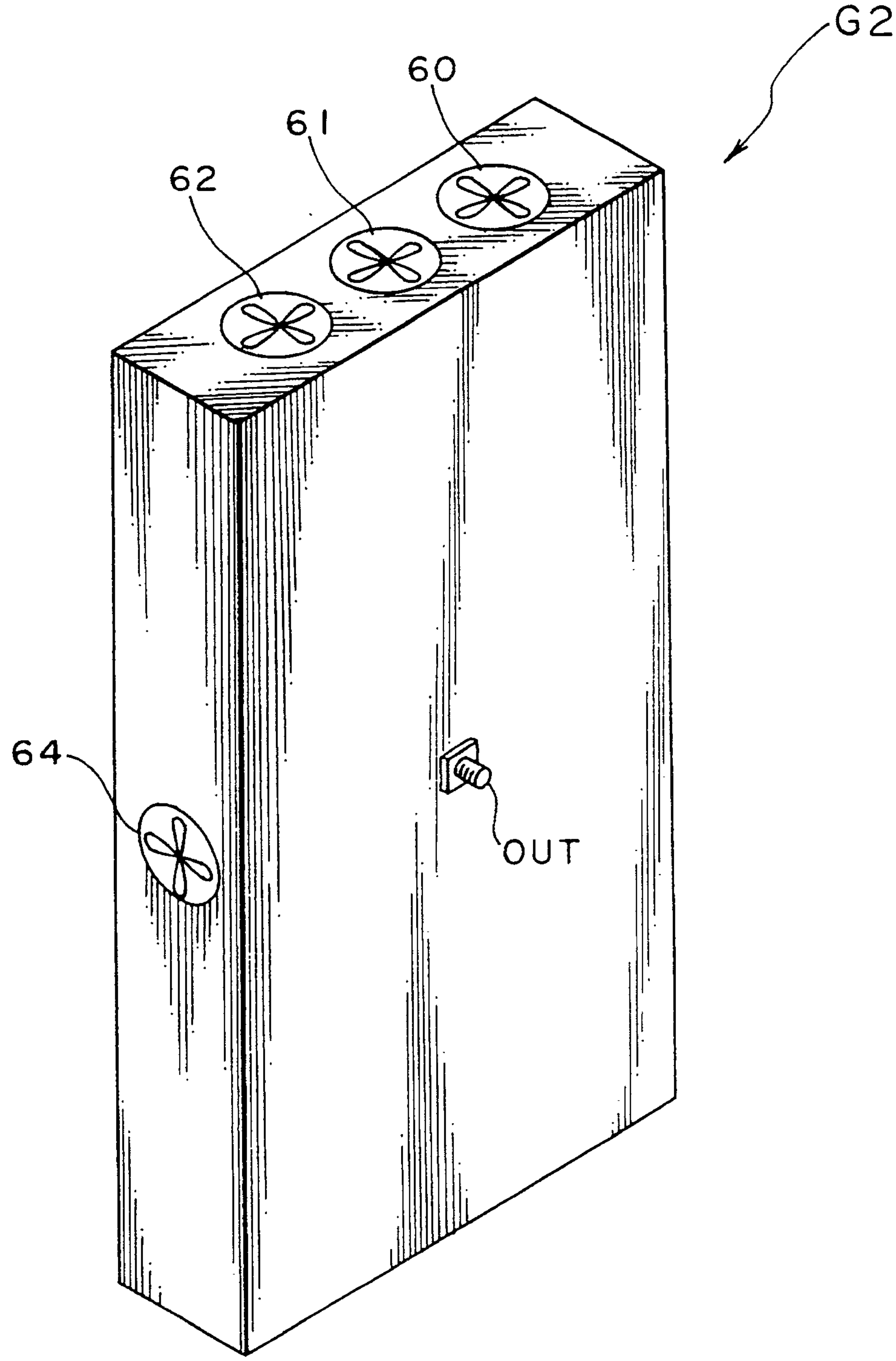
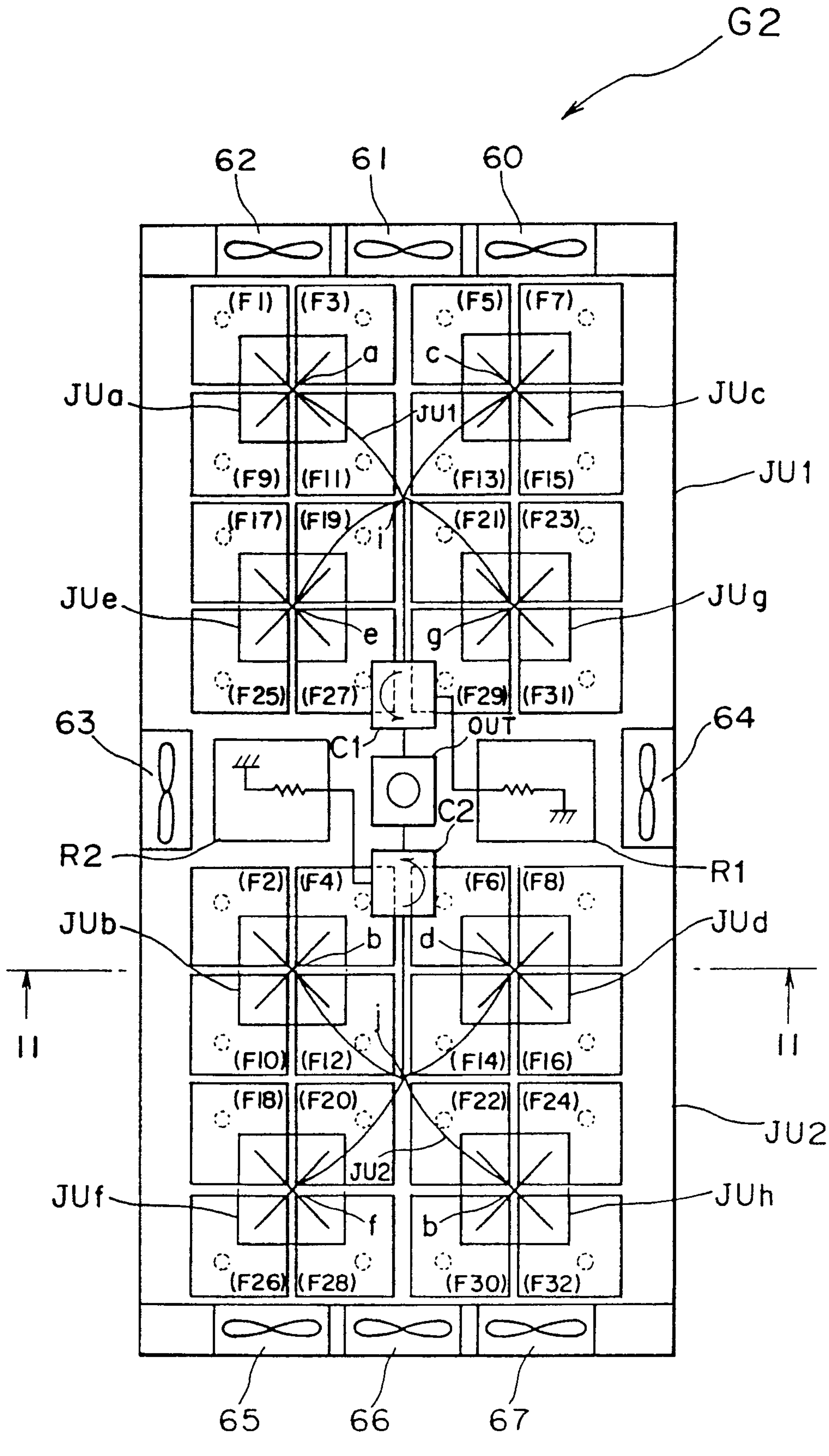


Fig. 10


G2
62
61
60
(F1)
(F3)
(F5)
(F7)
a
c
JUa
JU1
JUc
(F9)
(F11)
(F13)
(F15)
JU1
(F17)
(F19)
i
(F21)
(F23)
JUe
JUg
e
g
(F25)
(F27)
(F29)
(F31)
63
C1
OUT
64
C2
R2
R1
(F2)
(F4)
(F6)
(F8)
JUb
JUd
b
d
II
II
j
(F10)
(F12)
(F14)
(F16)
(F18)
(F20)
(F22)
(F24)
JU2
JU2
JUf
JUh
f
b
(F26)
(F28)
(F30)
(F32)
65
66
67

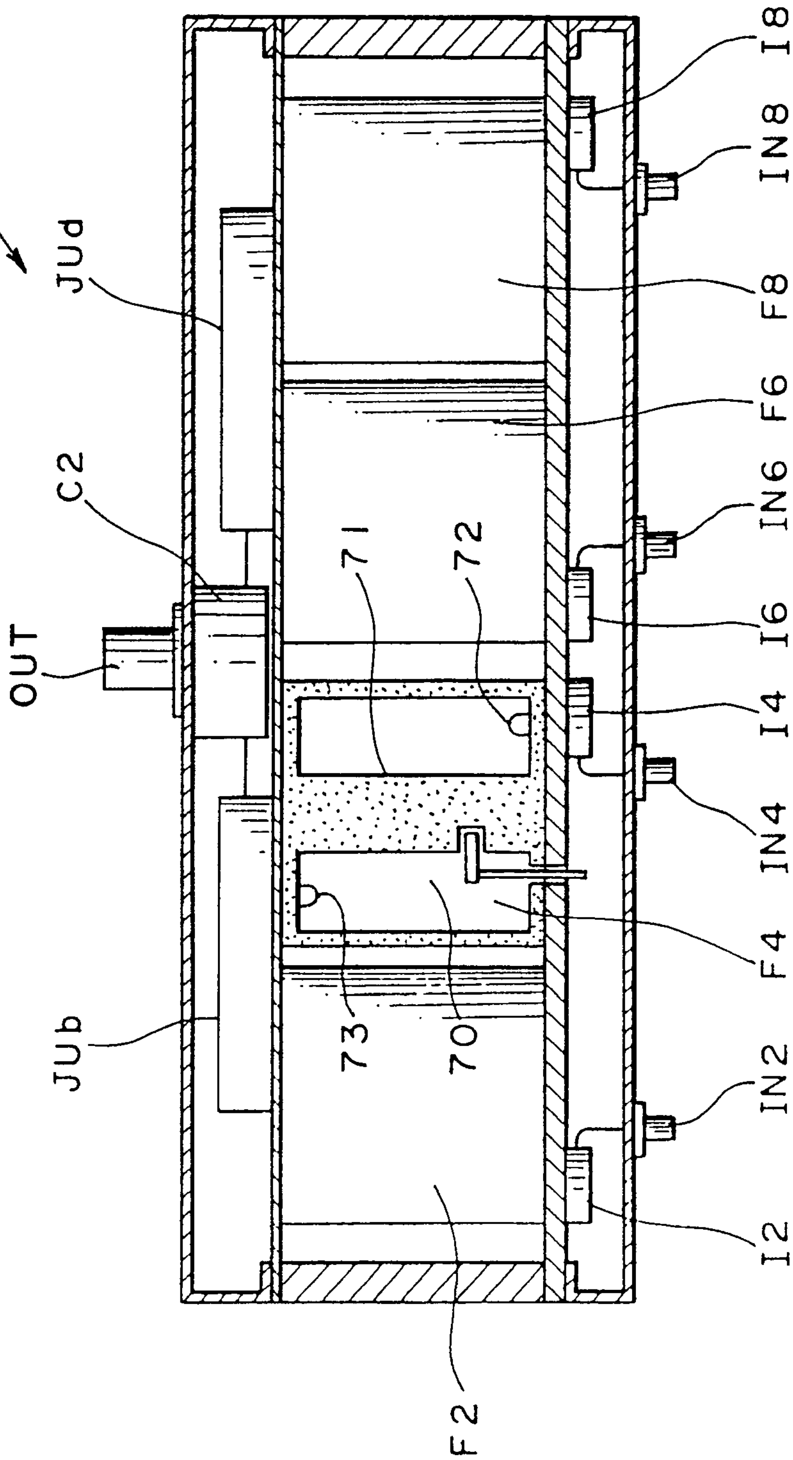


Fig. 11

Fig. 12

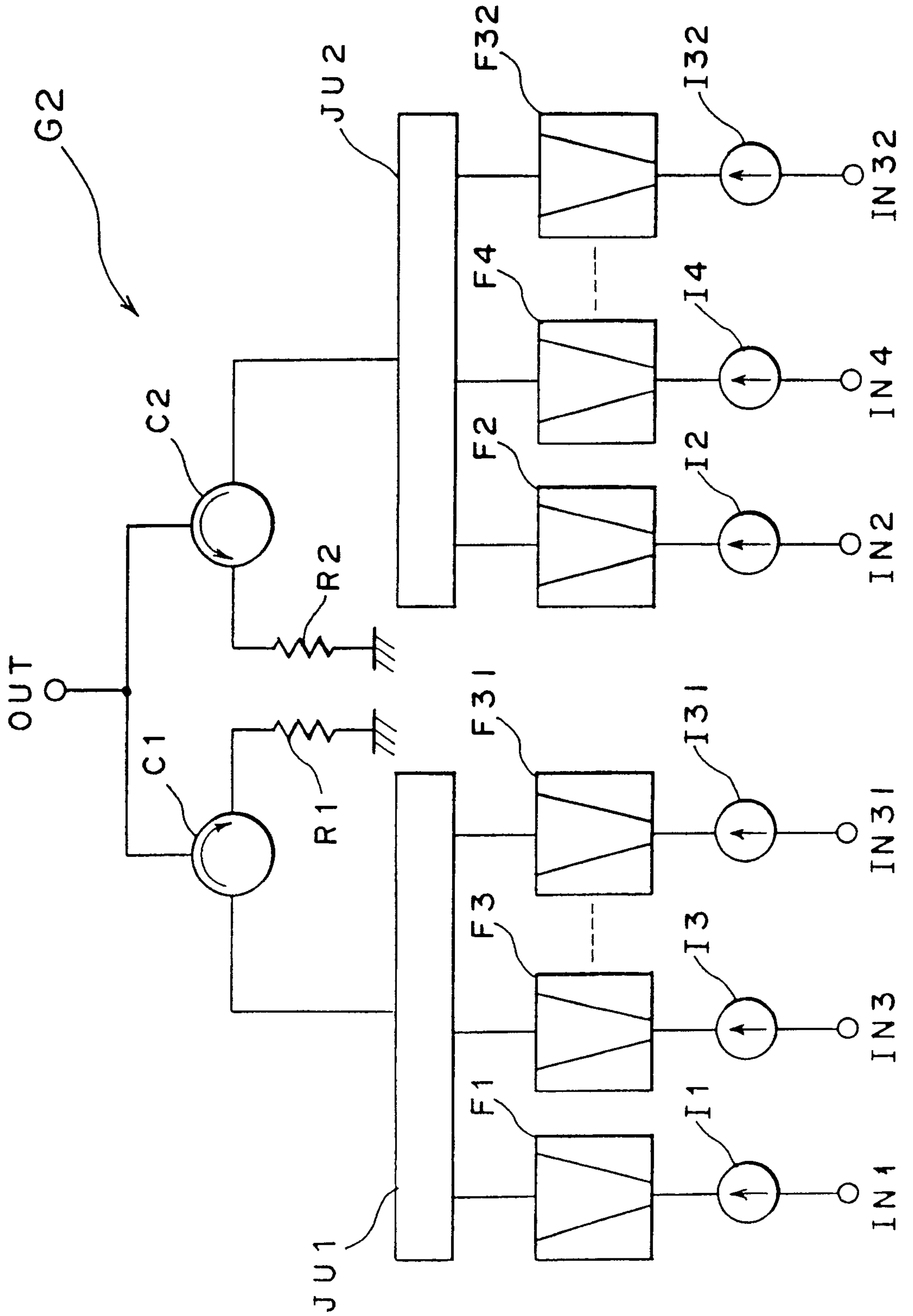
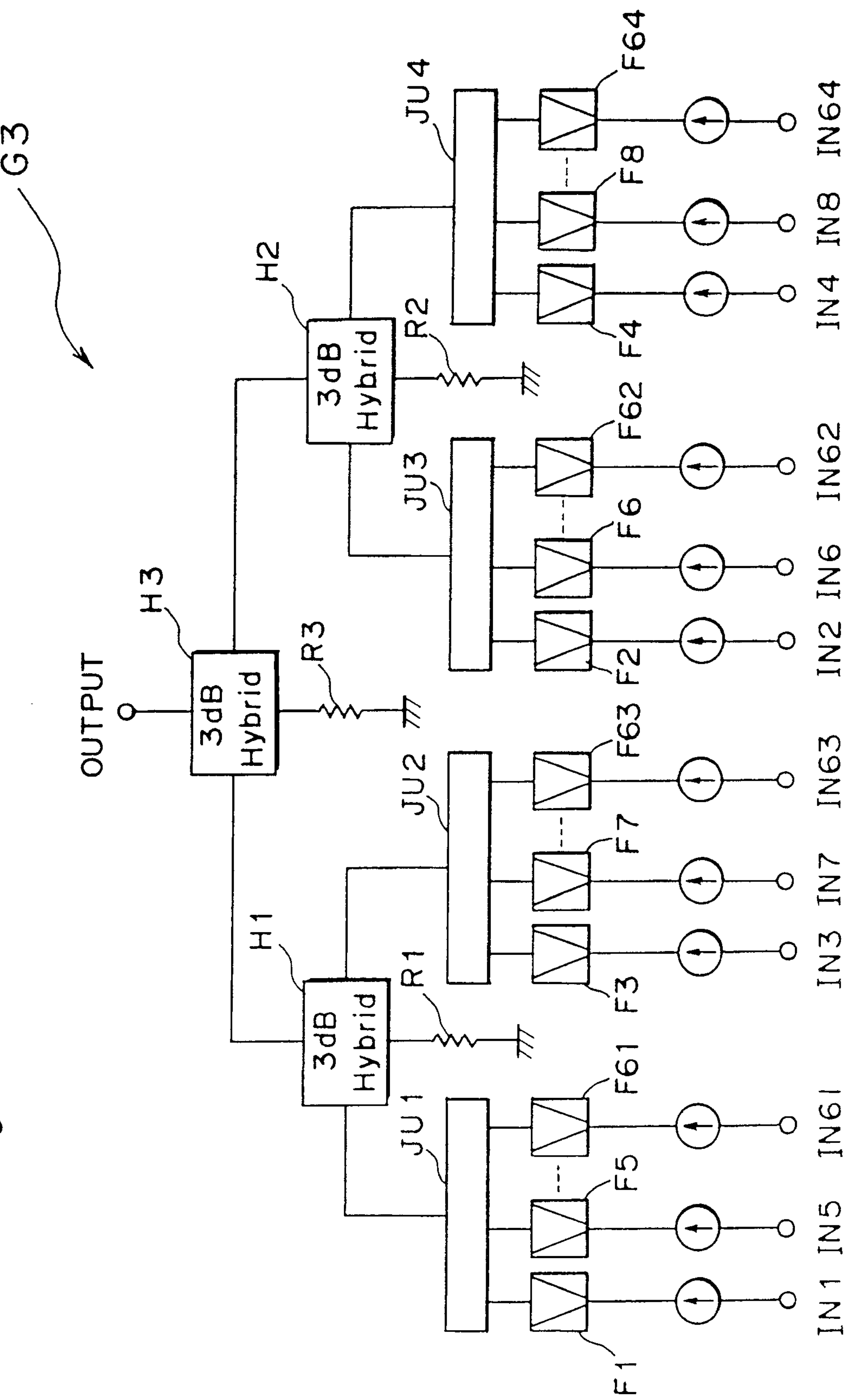

G2
OUT
C1
C2
R1
R2
JU1
JU2
F1
F3
F31
F2
F4
F32
I1
I3
I31
I2
I4
I32
IN1
IN3
IN31
IN2
IN4
IN32

Fig. 13


G3
OUTPUT
H3
3dB Hybrid
R3
H1
3dB Hybrid
R1
H2
3dB Hybrid
R2
JU1
JU2
JU3
JU4
F1
F5
F61
F3
F7
F63
F2
F6
F62
F4
F8
F64
IN1
IN5
IN61
IN3
IN7
IN63
IN2
IN6
IN62
IN4
IN8
IN64

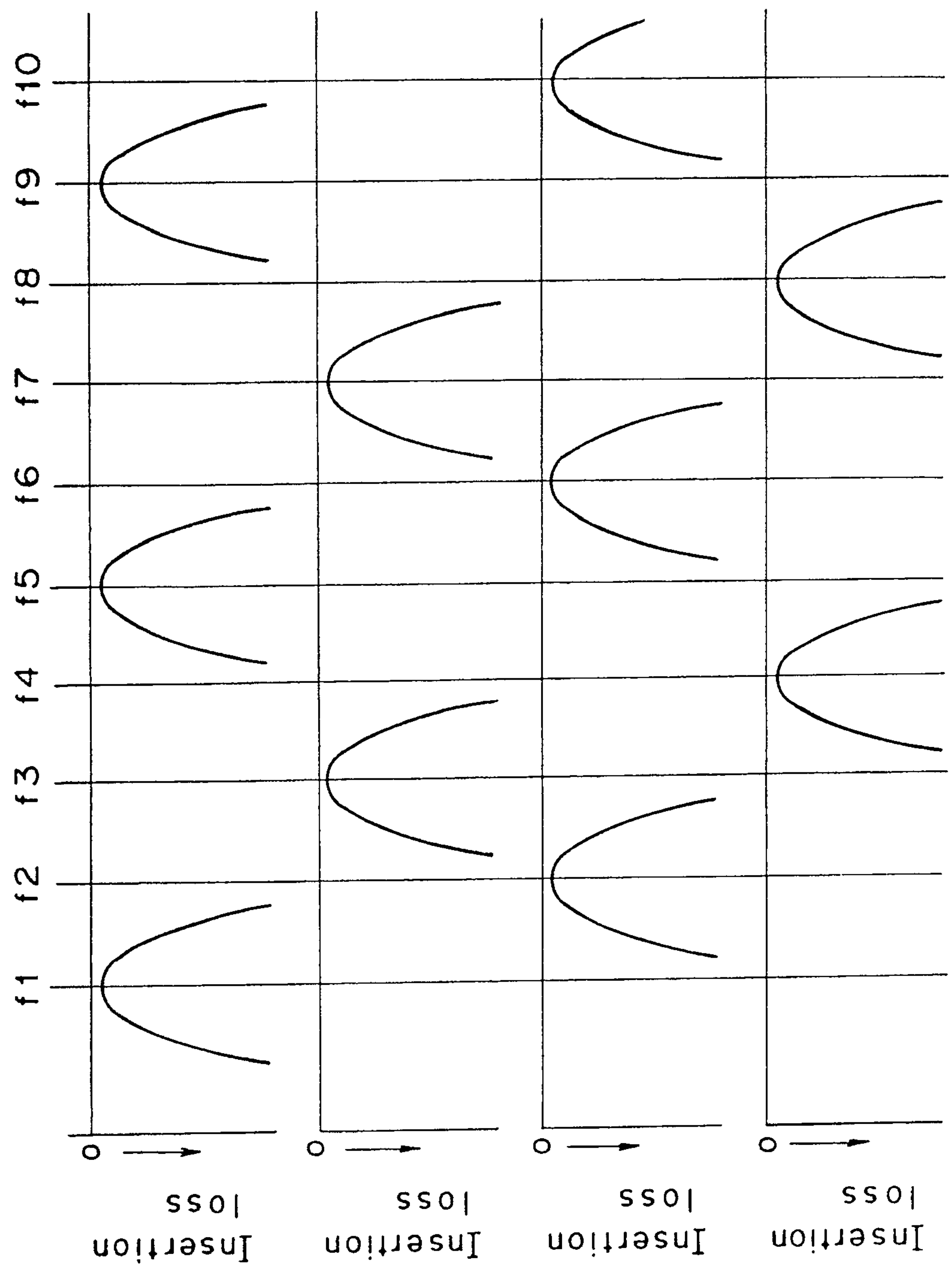


Fig. 14(1)

Fig. 14(2)

Fig. 14(3)

Fig. 14(4)

Fig. 15 PRIOR ART

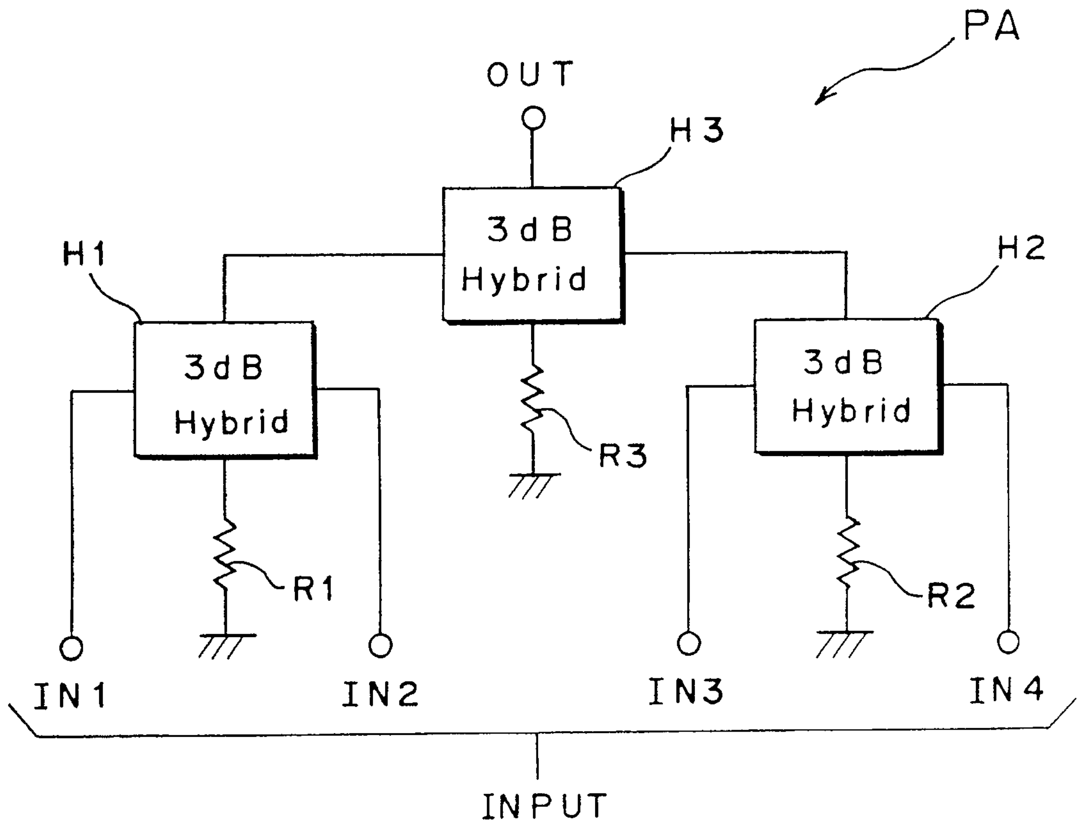


Fig. 16 PRIOR ART

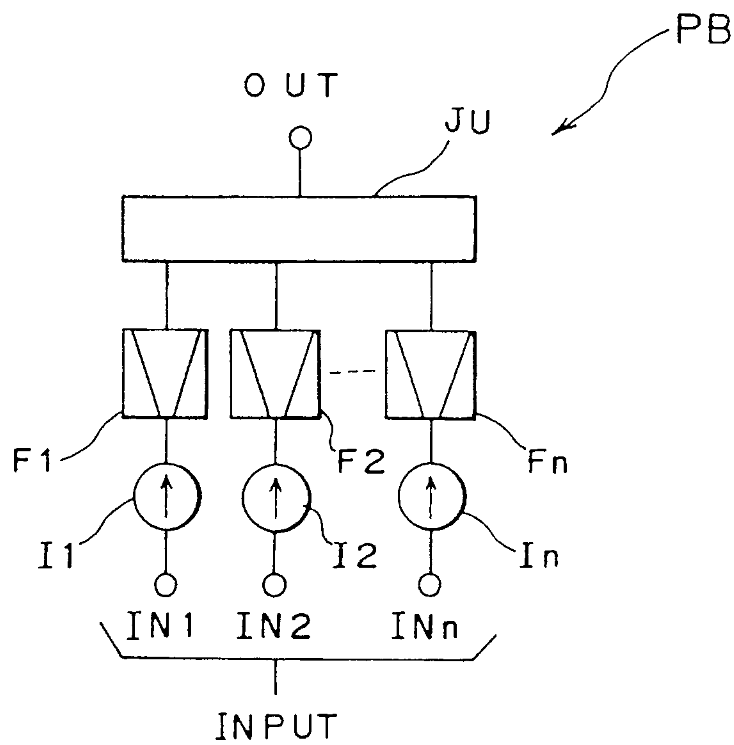


Fig. 17 PRIOR ART