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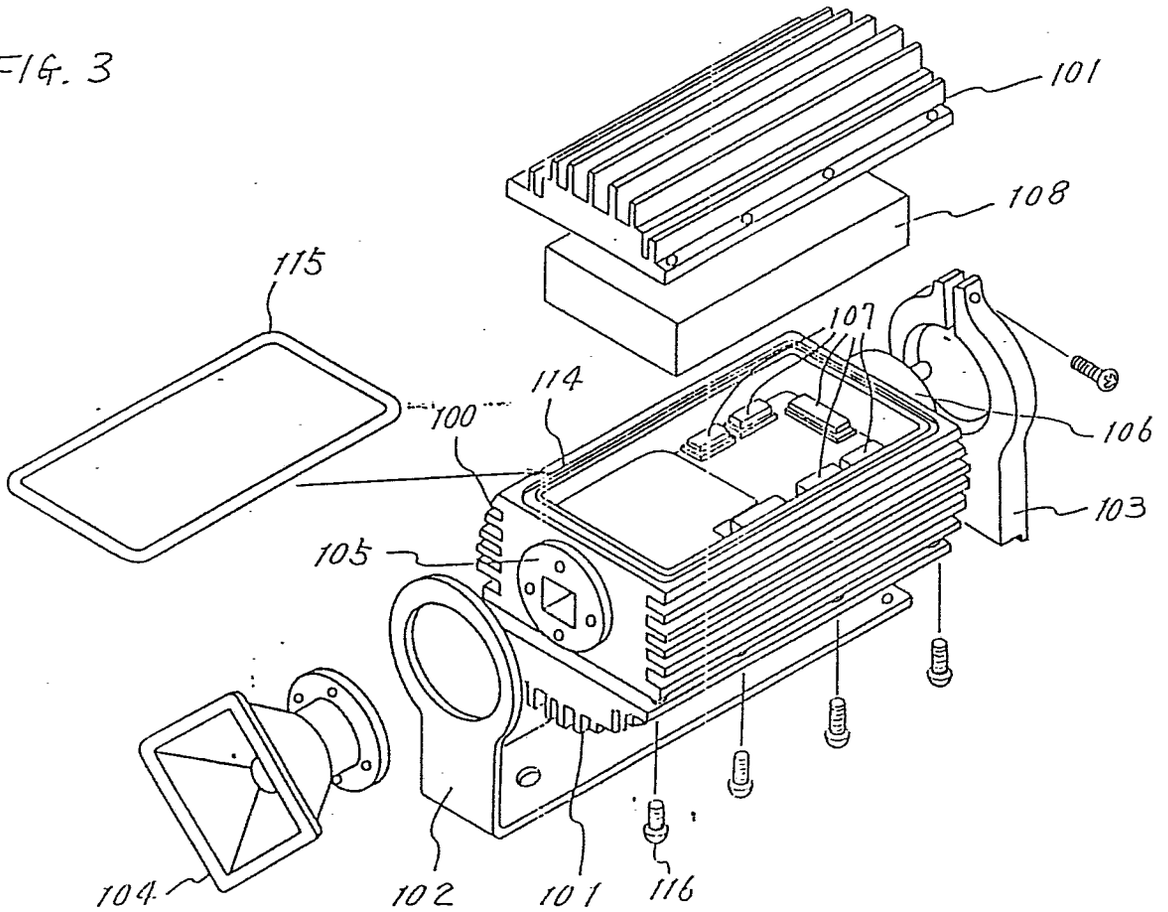
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(54) **Microwave transmitter/receiver apparatus.**

(57) The invention relates to a miniaturized microwave transmitter/receiver apparatus which allows the polarization angle of a primary reflector to be readily matched to the polarization plane of a polarized wave. The apparatus comprises a housing (100), a primary radiator (104), a transmit/receive multiplexer for multiplexing a transmit signal and a receive signal, a transmit filter and a receive filter, transmit means connected to the transmit filter for outputting the transmit signal by receiving a predetermined transmit intermediate frequency signal, and receive means connected to the receive filter for outputting a predetermined intermediate frequency signal, the multiplexer, the transmit and the receive filters, the transmit means and the receive means being accomodated in the housing (100).

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FIG. 3



MICROWAVE TRANSMITTER/RECEIVER APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a microwave transmitter/receiver apparatus applicable to terrestrial communication, satellite communication and others and, more particularly, to a transmitter/receiver apparatus which is small in size and allows the polarization plane of a polarized wave to be adjusted.

In a microwave communication system whose capacity is relatively small, a communication apparatus is usually made up of an antenna, a primary radiator, a transmit/receive multiplexer, a transmitter, a receiver, and other units. The transmitter and the receiver, which are discrete units, are connected to the transmit/receive multiplexer by a waveguide. The multiplexer in turn is connected to the primary radiator, or horn, by a feeder waveguide. The transmitter and the receiver are sometimes accommodated in a single housing.

In such a construction, the prerequisite is that the polarization plane of a polarized wave be aligned with that of the horn in order to increase the signal-to-noise (SN) ratio of transmit and receive signals. One of the approaches for fulfilling this requirement known in the art is designing all of the horn, transmit/receive multiplexer, transmitter, receiver and feeder waveguide rotatable. The problem with this approach is that, as discussed later in detail, a polarization adjusting mechanism becomes complicated and expensive and, since the loss of the feeder waveguide is increased, the transmit output has to be made greater increasing both the power consumption and the dimensions of the apparatus. Another prior art approach is inserting a polarizer between the transmit/receive multiplexer and the horn. The polarizer scheme, however, adds to the cost due to the use of a polarizer and brings about feed loss due to the use of the feeder waveguide, the latter inviting the same disadvantages as discussed in relation to the first-mentioned approach. Further, since both of the prior art approaches interconnect the circuits using a feeder waveguide, they cannot be implemented without increasing the overall apparatus scale and furnishing each junction with an air-and liquid-tight structure. Such results in prohibitively long assembling and adjusting time.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a miniaturized microwave transmitter/receiver apparatus.

It is another object of the present invention to provide a microwave transmitter/receiver apparatus which allows the polarization angle of a primary reflector to be readily matched to the polarization plane of a polarized wave.

A microwave transmitter/receiver apparatus of the present invention comprises a housing, a primary radiator, a transmit/receive multiplexer for multiplexing a transmit signal and a receive signal, a transmit filter and a receive filter connected respectively to a transmit input and a receive input of the transmit/receive multiplexer, transmit means connected to the transmit filter for outputting the transmit signal by receiving a predetermined transmit intermediate frequency (IF) signal, and receive means connected to the receive filter for outputting a predetermined IF signal by receiving the receive signal, the multiplexer, the transmit and the receive filters, the transmit means and the receive means being accomrnodated in the housing. The primary radiator may be mounted in an opening of the housing adapted for wave radiation. At least the multiplexer may be provided as a waveguide circuit in the housing. The apparatus may further comprise support means for supporting the housing rotatably about a wave radiation axis of the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects, features and advantages of the present invention will become more apparent from the following detailed description taken with reference to the accompanying drawings in which:

Fig. 1 is a side elevation showing a typical example of prior art transmitter and receiver having an antenna;

Fig. 2 is a view similar to Fig. 1 but showing another typical example of the prior art transmitter/receiver having an antenna;

Fig. 3 is an exploded perspective view of the overall structure of a microwave transmitter/receiver apparatus embodying the present invention;

Figs. 4A and 4B respectively are a front view and a side elevation of the transmitter/receiver apparatus in accordance with the present invention which is combined with an antenna;

Figs. 5A, 5B and 5C respectively are a side view, a front view and a rear view of the apparatus;

Fig. 6 is a block diagram of the apparatus in accordance with the present invention;

Fig. 7 is a section of the apparatus taken along a plane which is parallel to a central partition plate, or heat sink, of the apparatus and contains the center axis of the apparatus;

Fig. 8 is a section of the transceiver perpendicular to the heat sink and containing the center axis of the apparatus (taken along line A-A of Fig. 7); and

Fig. 9 is a section perpendicular to the wave radiation axis (taken along line B-B of Fig. 7).

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1 of the drawings, a prior art transmitter and receiver of the kind to which the present invention pertains is shown and includes a transmitter 10 and a receiver 11. As shown, the transmitter 10 and the receiver 11 are situated at the back of a parabolic reflector 2A in order not to block receive and transmit waves. The transmitter 10 and the receiver 11 are connected to a transmit/receive multiplexer 14 by elongate feeder waveguides 12 and 13, respectively, and further to a primary radiator, or horn, 15. Antenna-mount structural elements 16, 17, 18 and 19 serve to support the transmitter 10 and receiver 11 as illustrated. In this construction, the polarization plane of a polarized wave cannot be aligned with the angle of polarization of the horn 15 unless all of the transmitter 10, receiver, 11, waveguides 12 and 13, multiplexer 14 and horn 15 are rotated about the wave radiation axis over an adequate angle. This gives rise to a problem that a complicated and expensive polarization adjusting mechanism is required, in addition to the critical problem that waveguide loss is significant.

Referring to Fig. 2, there is shown another prior art transmitter/receiver which uses an offset type parabolic reflector 2B. An outstanding feature of this type of transmitter/receiver is that it can be situated in the vicinity of a primary radiator 15 to reduce feeder loss to a significant degree. In Fig. 2, designated by the reference numeral 21 is a transmit filter, 22 a receive filter, 12 a transmit feeder, 13 a receive feeder, 14 a transmit/receive multiplexer, and 15 the primary radiator, all of which are interconnected as illustrated. Support members 23 are adapted to mount the transmitter/receiver 10′ thereon and, to fulfill this role, provided with substantial mechanical strength. The support members 23 also serve to support the primary reflector, or horn, 15. This prior art system successfully reduces feeder loss but not to a negligible degree. A polarizer 20 is and has to be inserted between the multiplexer 14 and the horn 15 so that the plane of polarization may be rotatable. This type of construction is expensive due to the complicated structure, the considerable dimensions and weight, and the need for a polarizer. Further, the antenna mount structure 24, 25 and 26 which are stiff and heavy add to the overall weight and cost of the transmitter/receiver.

As described above, any of the prior art transmitter/receiverwith an antenna is intricate in construction and expensive and needs time-consuming assembly and adjustment in the event of installation. The construction of Fig. 1, which uses long feeders, suffers from a serious drawback that the substantial feed loss further increases the required transmitter output and aggravates receiver noise.

Hereinafter will be described a small-size and low-cost transmitter/receiver apparatus in accordance with the present invention which is free from the above-discussed drawbacks and suited for use in a medium to small capacity communication system.

Referring to Fig. 3, a transmitter/receiver apparatus embodying the present invention is shown in an exploded perspective view to best show its characteristic features. The apparatus includes a housing 100 in which a transmit/receive multiplexer, a transmit filter, a receive filter, a transmit circuit, a receive circuit and others are installed. Covers 101 are fastened to the housing 100 by screws 116 to cover, respectively, the top and the bottom of the housing 100. To make the apparatus air-and liquid-tight, O-rings 115 are received each in a groove 114 which is formed in the housing 100 as illustrated. The housing 100 is provided at opposite sides thereof with portions which serve as shafts for rotatably supporting the apparatus, i.e., a front shaft portion 105 and a rear shaft portion 106. The front shaft portion 105 bifunctions as a horn mounting flange. The rear shaft portions 106 has a connector thereinside which dictates input to and output from the apparatus. A front shaft support member 102 and a rear shaft support member 103 each being made of metal are rotatably coupled over the shaft portions 105 and 106, respectively. The rear shaft support member 103 also serves as a mechanism for clamping the rear shaft portion 106 and, thereby, preventing the apparatus from rotating. A primary radiator, or horn, 104 is mounted on the flange 105. The reference numeral 107 designates microwave circuit modules which constitute a transmit circuit, a receive circuit and others and are suitably separated on a function basis. Such circuit modules are produced by hybrid IC technology or monolithic IC technology. Any of these technology is effective to significantly cut down the dimensions of the transmit and receive

circuits. Designated by the reference numeral 108 is another circuit in which a local oscillator, an intermediate frequency (IF) amplifier and others are built in.

Before entering into a description of a more specific construction of the apparatus of the present invention, how the apparatus may be used in practice will be shown. Figs. 4A and 4B show an exemplary manner of use of the apparatus of the present invention, generally designated by the reference numeral 1. Also shown in Figs. 4A and 4B are a primary reflector 2 of an antenna, support members 3 for supporting the apparatus 1, a framework 4 for mounting the whole antenna with the apparatus 1, a mechanism 5 for adjusting the elevation of the antenna, and an antenna support post 6. Basically, the illustrative configuration constitutes an offset parabolic antenna. To align the antenna pointing to a direction of wave arrival, the azimuth is adjusted by the post 6 and the elevation by the elevation adjusting mechanism 5. Meanwhile, the plane of polarization of the horn 104 can be matched to that of the wave merely by rotating the whole apparatus 1 which carries the horn 104 integrally therewith. After the horn 104 has reached an adequate angular position, the previously stated clamp mechanism is operated to fix the whole apparatus in place. This completes the adjustment.

As described above, the apparatus of the present invention is characterized in that a horn, a transmit/receive multiplexer, a transmit and a receive circuits and others are provided in an integral and, therefore, smallsize configuration, and in that the whole apparatus is rotatably supported. This remarkably simplifies the entire apparatus structure inclusive of an antenna. The miniature construction makes it needless to use massive and heavy members for the members 3 which serve to support the apparatus in a predetermined positional relationship to the antenna. It also eliminates the need for a polarizer which is an expensive functional part otherwise required for a polarization matching purpose. Weather protection may be considerably enhanced by integrating the horn and the multiplexer and integrating components other than the horn with the apparatus. Since no waveguide shows itself out of the apparatus, only the previously mentioned two O-rings 115 suffice for the whole apparatus to attain an air-and liquid-tight struacture. Due to the decrease in the dimensions of the apparatus, undesirable wave blocking is remarkably reduced to allow the apparatus to be positioned adjacent to a reflector, with the result that a majority of feeder loss is substantially eliminated. Such leads to a decrease in the required output of the transmit amplifier which in turn contributes a great deal to the decrease in the power consumption of the apparatus. Since the efficiency of the transmit amplifier is as low as 10%, the decrease in the feeder loss has a significant desirable effect on the power consumption of the apparatus. Further, as a result of the decrease in the power consumption, the necessary dimensions of heat-radiating fins and, therefore, those of the whole apparatus are reduced.

The decrease in the feeder loss is reflected by a remarkable decrease in the receiver noise which in turn leads to a small-size antenna.

It will be seen from the foregoing that the apparatus of the present invention totally solves the various problems particular to the prior art apparatuses.

A more specific construction of the apparatus of the present invention will be described. Figs. 5A -5C show characteristic features of the external appearance of the apparatus. Specifically, Fig. 5A is a side elevation, Fig. 5B a front view as seen from the horn side, and Fig. 5C a rear view.

The housing 100 and the cover 101 are each formed with fins 117 which function mainly to radiate heat generated by the transmit amplifier and, thereby, suppress temperature elevation of the apparatus. At one side of the housing 100, the horn 104 is mounted to the flange portion 105 inwardly of the shaft portion for the housing 100. Also provided on the back of the housing 100 is the shaft portion 106 for the rotation of the housing 100. A single connector 109 is provided inwardly of the shaft portion 106. This is because, in this particular embodiment, both the transmit and receive IF signals are accommodated by a single coaxial cable and because the power source feeder for the apparatus, too, is implemented by that cable. The fins 117 on the housing 100 and cover 101 are distributed over the entire periphery of the apparatus so that the heat radiation ability is not effected even if the apparatus is rotated together with the horn 104. As shown in Fig. 5C, graduations 110 indicative of angles are provided between the rear shaft 106 and the rear metal support, or bearing 103 in order to facilitate adjustment of the polarization angle. Specifically, after the inclination of the whole antenna has been checked, the polarization angle can be readily adjusted with the aid of the graduations 110.

Next, the internal construction of the apparatus will be described.

Referring first to Fig. 6, there is shown a circuit arrangement which is built in the apparatus. All the circuit elements are accommodated in the apparatus except for the horn 104 and the input/output connector 109 which protrude to the outside. The transmit/receive multiplexer 50 is implemented by an othogonal mode transducer which uses a waveguide having a rectangular cross-section. A transmit filter 51 and a receive filter 51' each hav-

ing a waveguide structure are provided integrally with the multiplexer 50. The transmit side includes a detector 52 adapted to detect levels of transmit signals, a power amplifier 53, a filter 55 for selecting only transmit RF signals, and a transmit mixer, or transmit frequency converter, 56. The receive side, on the other hand, includes a low noise amplifier 54, a receive signal selection filter 57, and a receive mixer, or receive frequency converter, 58. The elements described so far constitute a transmit and receive RF circuit in combination. The power amplifier 53, low noise amplifier 54, transmit and receive mixers 56 and 58 and others are constructed by hybrid IC technology, while the others are implemented with waveguide circuit technology.

An output of a local oscillator 62 is routed via a splitter 61 to each of the transmit mixer 56 and the receive mixer 58.

The IF circuit includes IF filters 59 and 60 which respectively are associated with the mixers 56 and 58, a transmit IF amplifier 63, and a variable attenuator 64. The variable attenuator 64 is adapted to control the transmit power to a predetermined value in combination with the previously mentioned detector 52 and under the control of a control circuit 71. Designated by the reference numeral 65 is a receive IF amplifier. A control circuit 69 functions to monitor transmit and receive levels, output power of the local oscillator 62 and others and deliver alarm signals to the outside when any of them becomes unusual. A voltage regulator 70 is adapted to maintain voltage applied to the various sections of the circuit constant. To multiplex the transmit IF signals, receive IF signals, alarm signals, DC power and others on a single coaxial cable, the circuitry includes three multiplexers: a multiplexer (MPX3) 68 for separating an alarm signal ALM and a DC current DC from each other, a multiplexer (MPX2) 67 for separating the receive IF signal and the alarm signal including DC and a multiplexer (MPX1) 66 for separating receive IF signal, the transmit IF signal and the alarm signal including DC. These signals are delivered to and from the apparatus via the connector 109.

How the circuitry shown and described is miniaturized and compactly installed in the apparatus will be described hereinafter. The overall dimensions of a apparatus are chiefly determined by two factors, i.e., a heat radiation structure necessary for effectively radiating heat and a size of an RF circuit.

For effective radiation of heat, the apparatus of the present invention uses the following structure. Approximately 70% of heat generated by the apparatus is attributable to the transmit power amplifier 53 (Fig. 6). In accordance with the present invention, the power amplifier 53 is implemented by six to eight consecutive stages of transistor amplification circuits and configured as several discrete modules 107 (Fig. 3 or 7). As shown in Fig. 8, the modules are rigidly mounted on heat sink members 112, 113, 116, 118 of the apparatus housing 100. Heat transferred to the heat sink 118 is propagated to the housing 100 and cover 101 and, thereby, directly released to the outside via the fins 117 by conduction, while being partly released by radiation to adjacent spaces. Fig. 9 is a section along a plane which is perpendicular to the wave radiation axis of the apparatus, and shows a section along line B -B of Fig. 7. The heat reaching the heat sink 118 is directly propagated to the fins 117 on the outer periphery of the housing 100 and those on the cover 101. In this manner, the heat radiation structure effectively utilizes the combination of direct conduction and fins, thereby reducing the overall dimensions of the transceiver.

How the RF circuit is reduced in size will be described next. Fig. 7 shows the apparatus of the present invention in a section taken along a plane which contains the wave radiation axis (Fig. 5A, 119) and parallel to the heat sink member 116 or 118 (Fig. 8), on which the circuit modules are mounted. Fig. 8 is a section along line A-A of Fig. 7. As previously stated, the RF circuit is made up of a waveguide circuit 111 and the modules 107. The waveguide circuit 111 is formed by a combination of the members 112 and 113. The modules 107 are implemented with hybrid IC technology. The waveguide circuit 111 comprises the transmit/receive multiplexer 50, and the transmit filter 51 and receive filter 51' of Fig. 6 which are assembled integrally in the housing 100 as indicated by the reference numerals 201, 202 and 203, respectively. The incorporation of the waveguide circuit in the housing 100 leads to a miniature apparatus design. The members 113, 116 and 118 constitute the central partition plate of the housing 100. The central partition plate may be formed as an RF circuit plate independently of the housing 100.

Reducing the dimensions of the functional parts of the RF circuit by means of hybrid IC technology is another major factor which cuts down the size of the apparatus. Specifically, what contributes a great deal to the miniature apparatus configuration is the fact that the transmit power amplifier 53, low noise amplifier 54, transmit mixer 56, receive mixer 58 and others shown in Fig. 6 are miniaturized and, as shown in Fig. 7, installed as function modules 107.

In summary, it will be seen that a microwave transmitter/receiver apparatus of the present invention achieves various advantages as enumerated below.

(1) The size and, therefore, the cost is cut down. In addition, the need for a polarizer is eliminated to simplify the construction and reduce the weight of an antenna, thereby further promoting the cut-down of cost.

(2) The assembly, the adjustment of direction and that of the plane of polarization are facilitated to reduce the installation costs.

(3) The feed loss which is reduced to substantially zero by the miniaturization allows the output of a transmit power amplifier to be lowered, still further promoting the miniaturization. The receiver noise is suppressed and this contributes a great deal to the miniaturization of a parabolic reflector, which is turn makes considerable contribution to the reduction of the cost.

Claims

1. A microwave transmitter/receiver apparatus comprising:
a housing;
a primary radiator;
a transmit/receive multiplexer for multiplexing a transmit signal and a receive signal;
a transmit filter and a receive filter connected respectively to a transmit input and a receive input of said transmit/receive multiplexer;
transmit means connected to said transmit filter for outputting the transmit signal by receiving a predetermined transmit intermediate frequency (IF) signal; and
receive means connected to the receive filter for outputttting a predetermined receive IF signal by receiving the receive signal;
the transmit/receive multiplexer, the transmit and the receive filters, the transmit means and the receive means being accommodated in the housing;
the primary radiator being mounted in an opening of the housing adapted for wave radiation.

2. A microwave transmitter/receiver apparatus comprising:
a housing;
a primary radiator;
a transmit/receive multiplexer for multiplexing a transmit signal and a receive signal;
a transmit filter and a receive filter connected respectively to a transmit input and a receive input of said transmit/receive multiplexer;
transmit means connected to said transmit filter for outputting the transmit signal by receiving a predetermined transmit intermediate frequency (IF) signal; and
receive means connected to the receive filter for outputting a predetermined receive IF signal by receiving the receive signal;
the transmit/receive multiplexer, the transmit and the receive filters, the transmit means and the receive means being accommodated in the housing;
at least the multiplexer being provided as a waveguide circuit in the housing.

3. A microwave transmitter/receiver apparatus as claimed in claim 2, wherein the transmit and the receive filters are provided as a waveguide circuit in the housing.

4. A microwave transmitter/receiver apparatus as claimed in any of claims 1 to 3, further comprising support means for supporting the housing rotatably about a wave radiation axis of the housing.

5. A microwave transmitter/receiver apparatus as claimed in any of claims 2 to 4, wherein the primary radiator is mounted in a front end portion of the housing such that a center axis of the primary radiator is aligned with a wave radiation axis of the housing.

6. A microwave transmitter/receiver apparatus as claimed in claim 5, wherein an input/output connector which is connected to the transmit means and the receive means is mounted in a rear end portion of the housing.

7. A microwave transmitter/receiver apparatus as claimed in any of claims 2 to 6, wherein a plurality of fins for heat radiation are provided in a substantially uniform distribution on an outer periphery of the housing.

8. A.microwave transmitter/receiver apparatus comprising:
à housing;
a primary radiator;
a transmit/receive multiplexer for multiplexing a transmit signal and a receive signal;
a transmit filter and a receive filter connected respectively to a transmit input and a receive input of said transmit/receive multiplexer;
transmit means connected to said transmit filter for outputting the transmit signal by receiving a predetermined transmit intermediate frequency (IF) signal; receive means connected to the receive filter for outputting a predetermined receive IF signal by receiving the receive signal; and
support means for supporting the housing rotatably about a wave radiation axis of the housing;
the multiplexer, the transmit and the receive filters, the transmit means and the receive means being accommodated in the housing.

9. A microwave transmitter/receiver apparatus as claimed in any of claims 4 to 8, wherein said support means includes means for locking the housing in an angular position.

10. A microwave transmitter/receiver apparatus as claimed in any of claims 1, 8 and 9, wherein the multiplexer and the transmit and the receive filters are provided as a waveguide circuit in the housing.

11. A microwave transmitter/receiver apparatus as claimed in any of claims 1, 8 and 9, wherein at least the multiplexer is provided as a waveguide circuit in the central partition plate of the housing.

12. A microwave transmitter/receiver apparatus as claimed in claim 8 or 9, wherein the multiplexer and the transmit and the receive filters are provided as a waveguide circuit in the central partition plate of the housing.

13. A microwave transmitter/receiver apparatus as claimed in claim 8, wherein the multiplexer comprises an orthogonal mode transducer.

FIG. 1

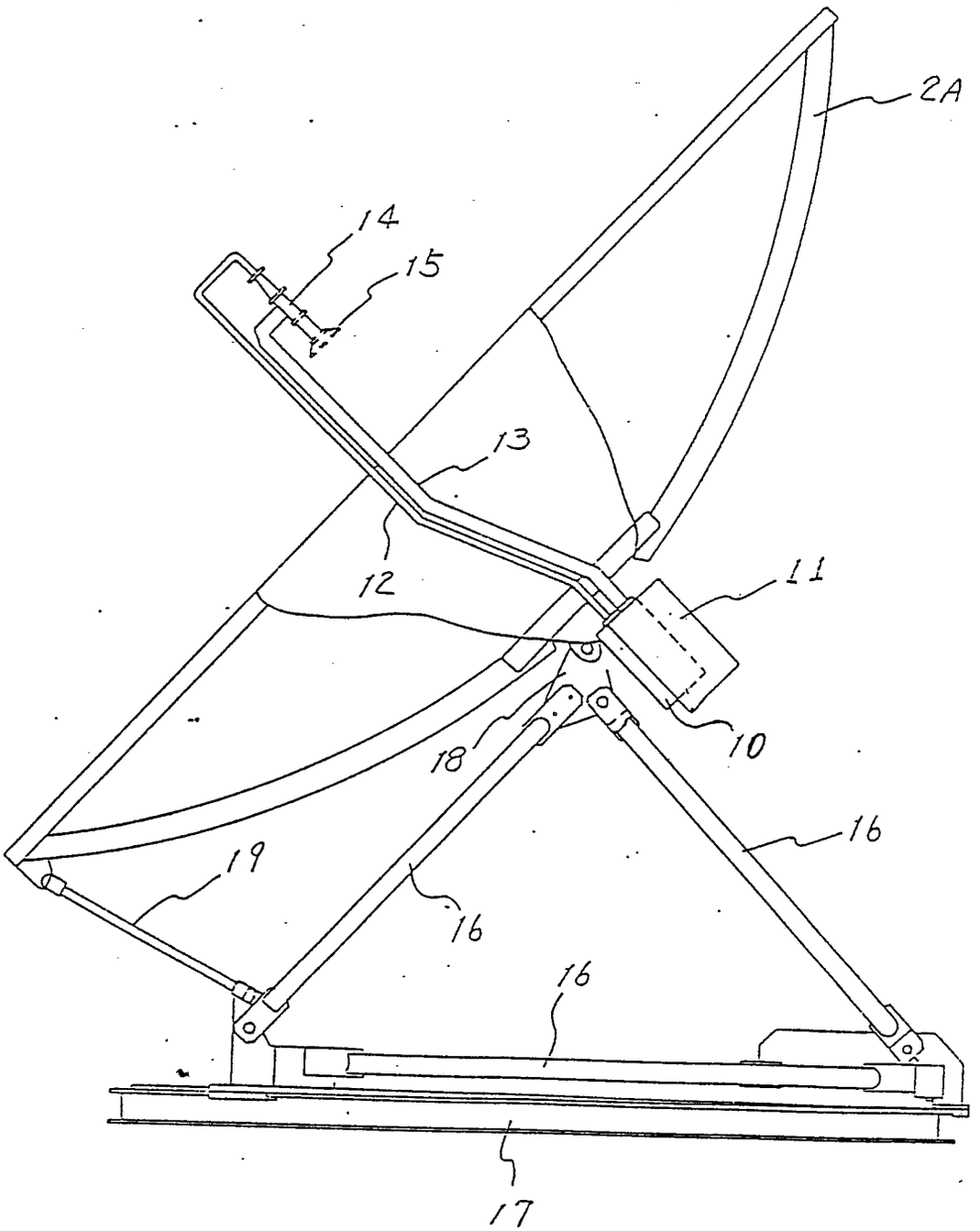
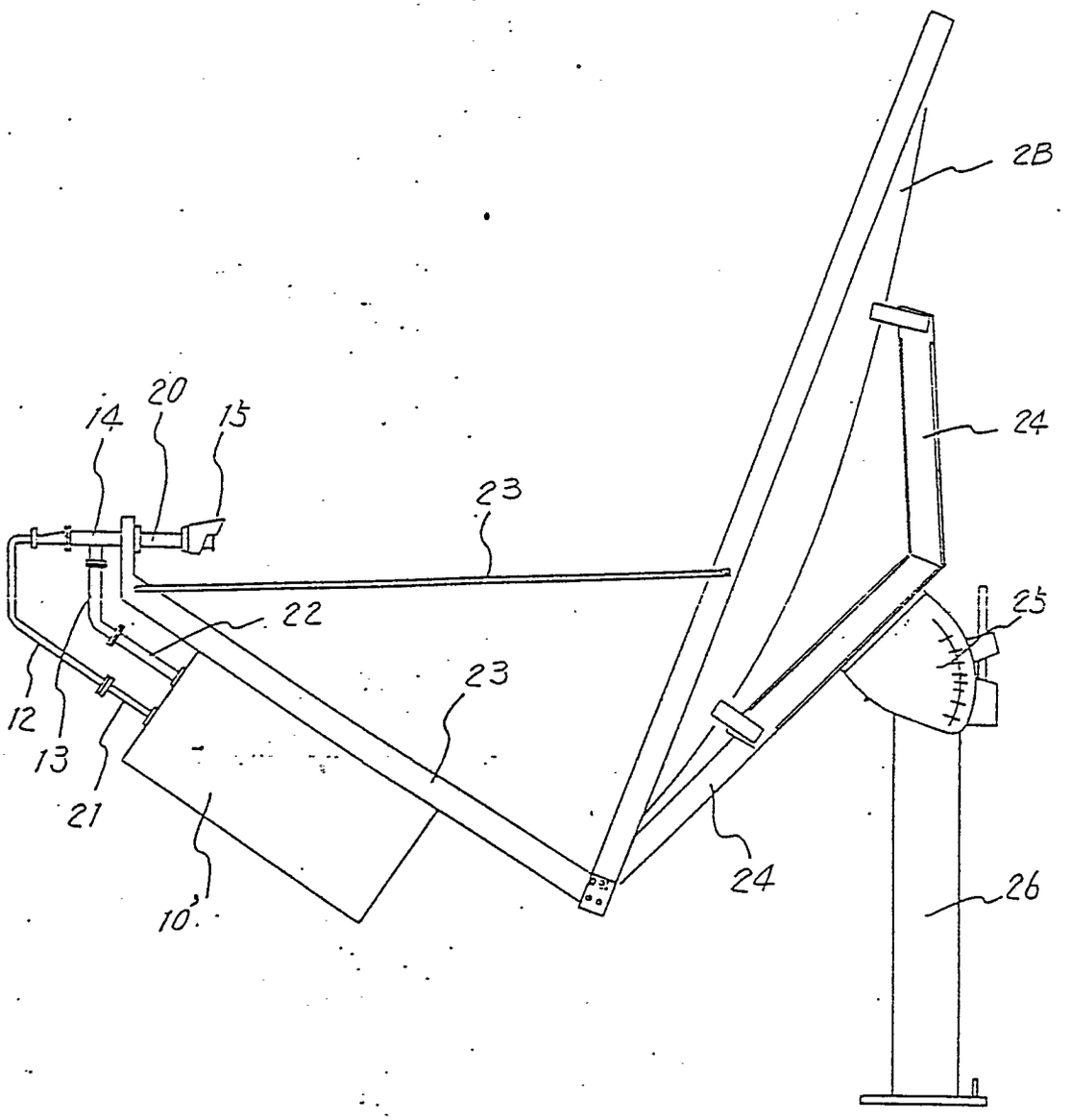


FIG. 2



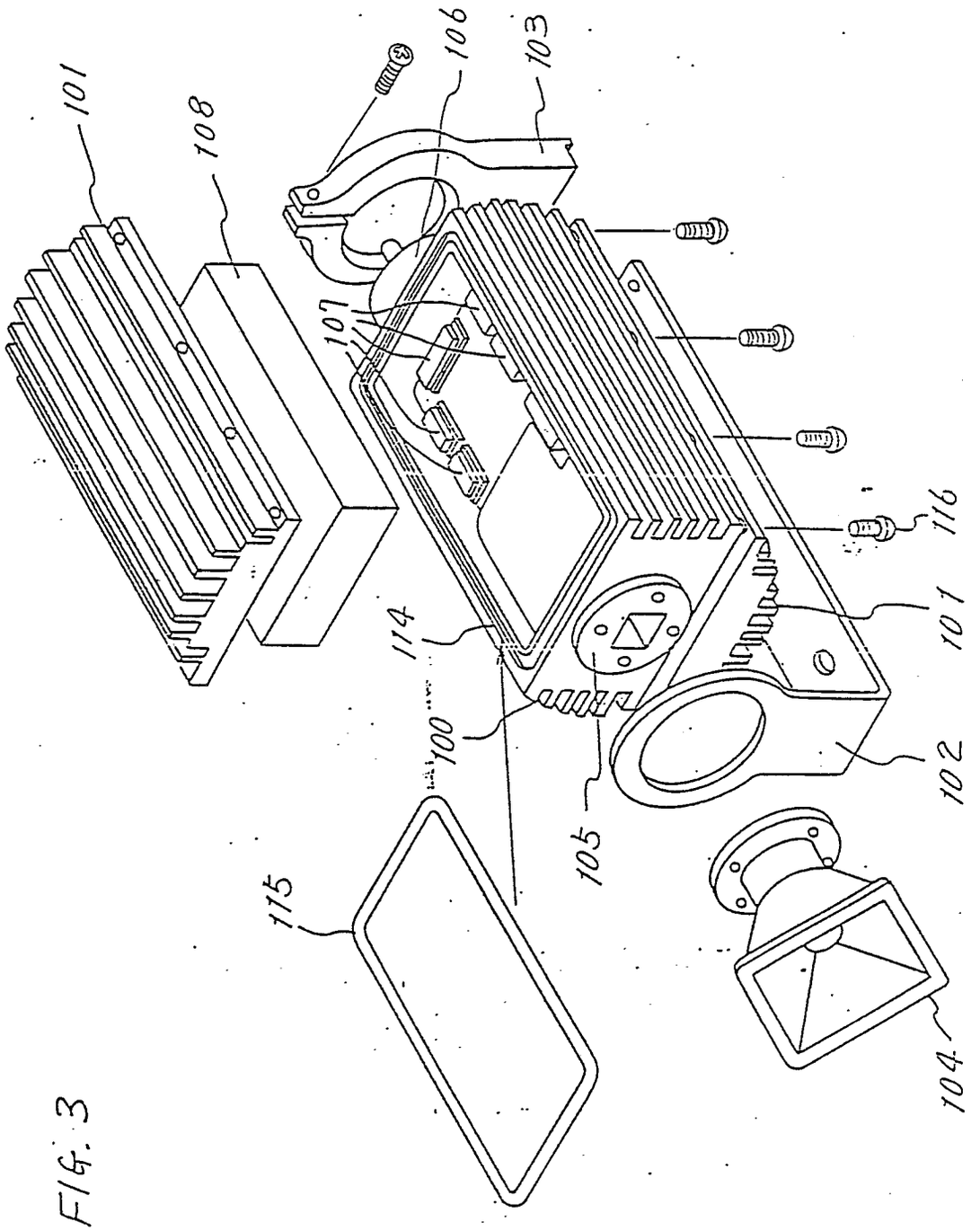


FIG. 3

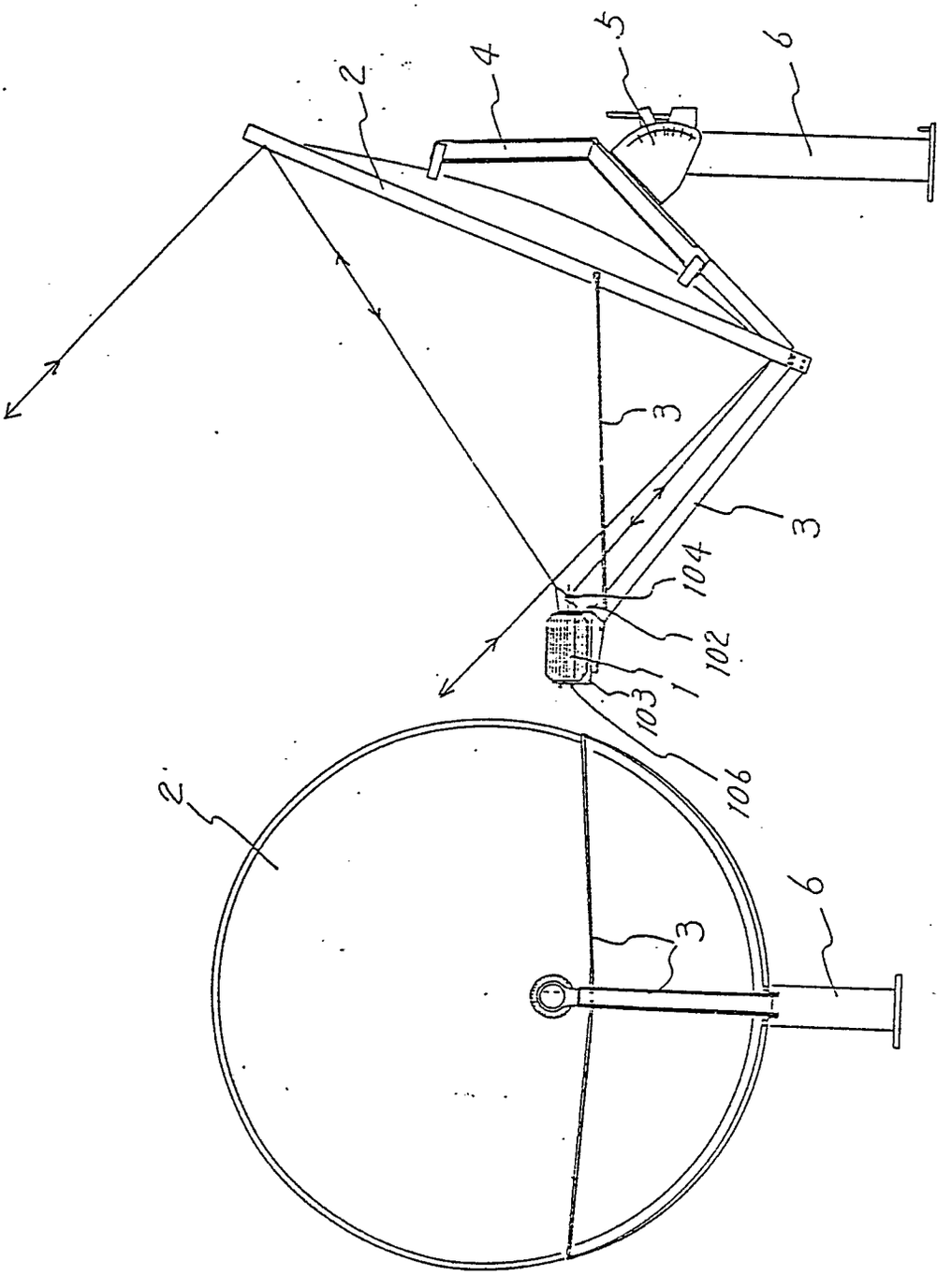


FIG. 4B

FIG. 4A

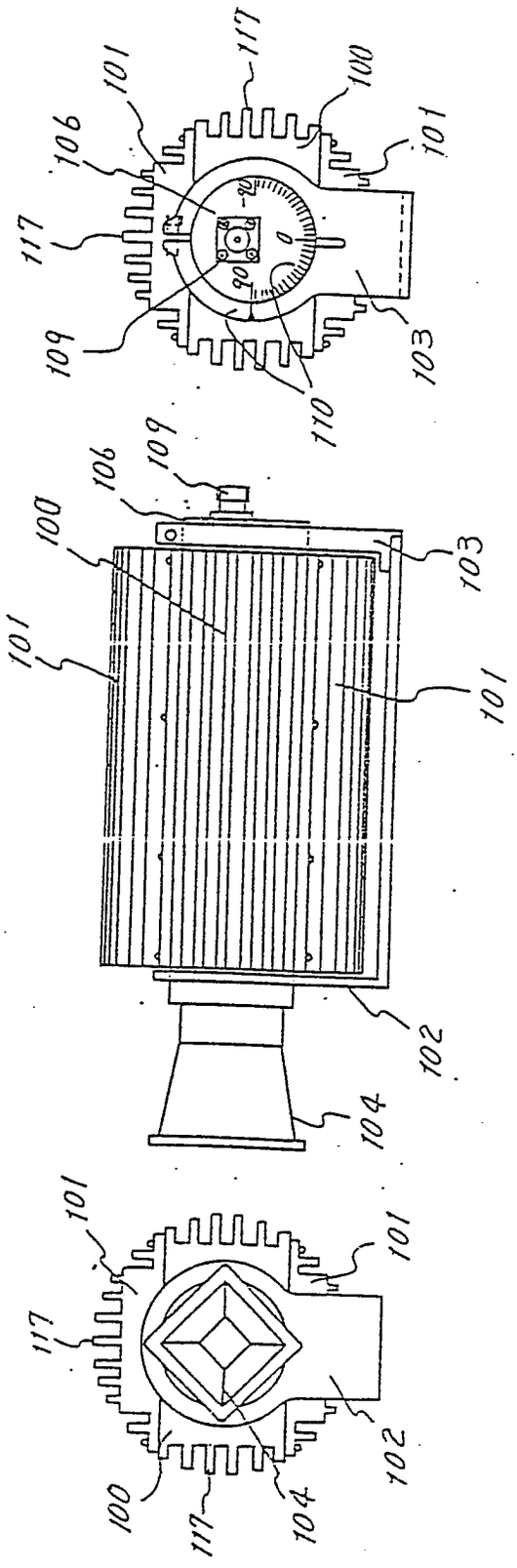


FIG. 5C

FIG. 5A

FIG. 5B

FIG. 6

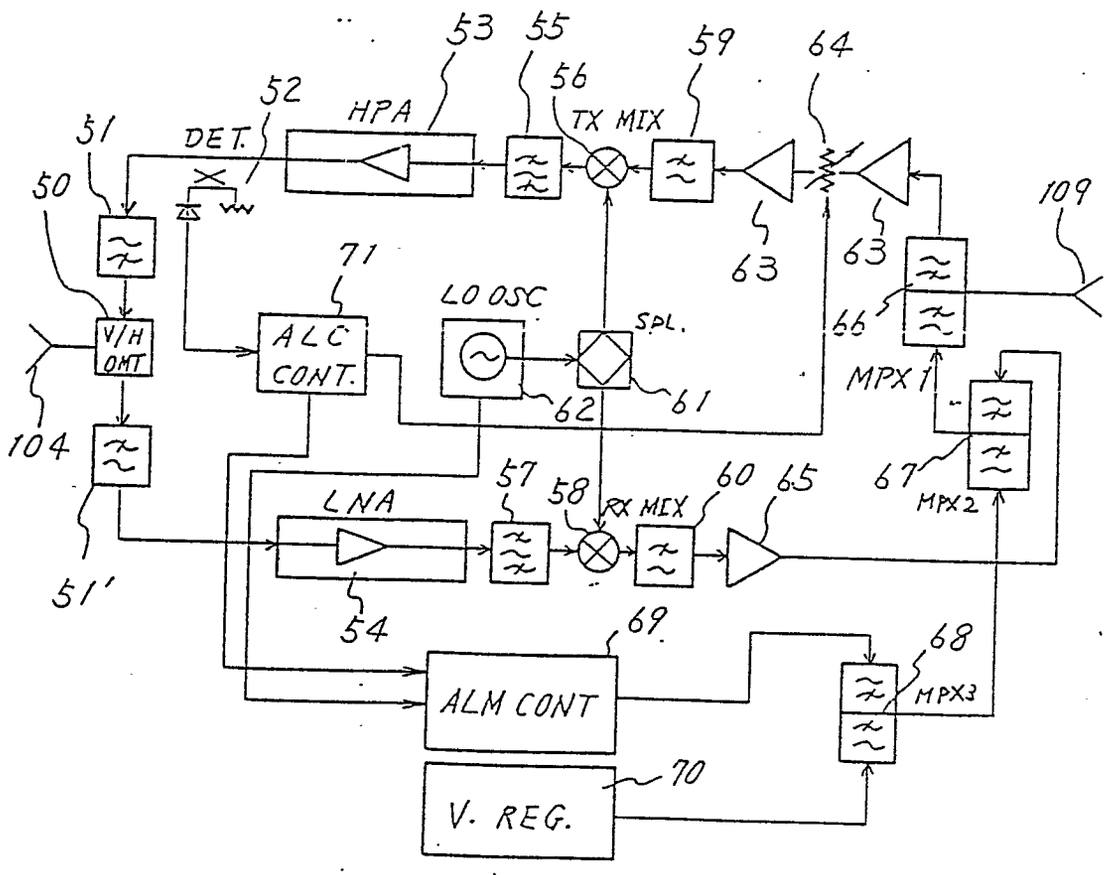
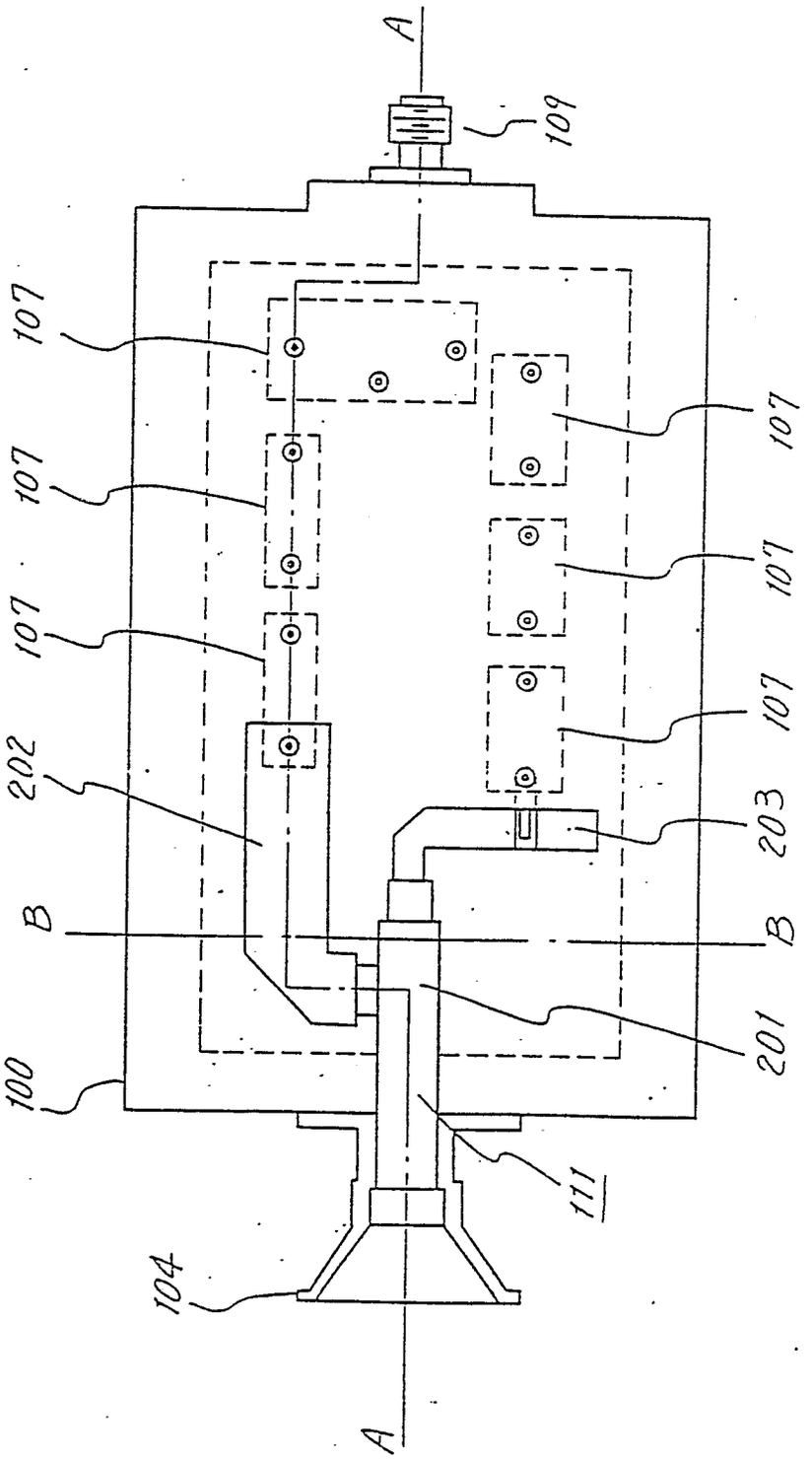

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ALM CONT
MPX3
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V. REG.

FIG. 7



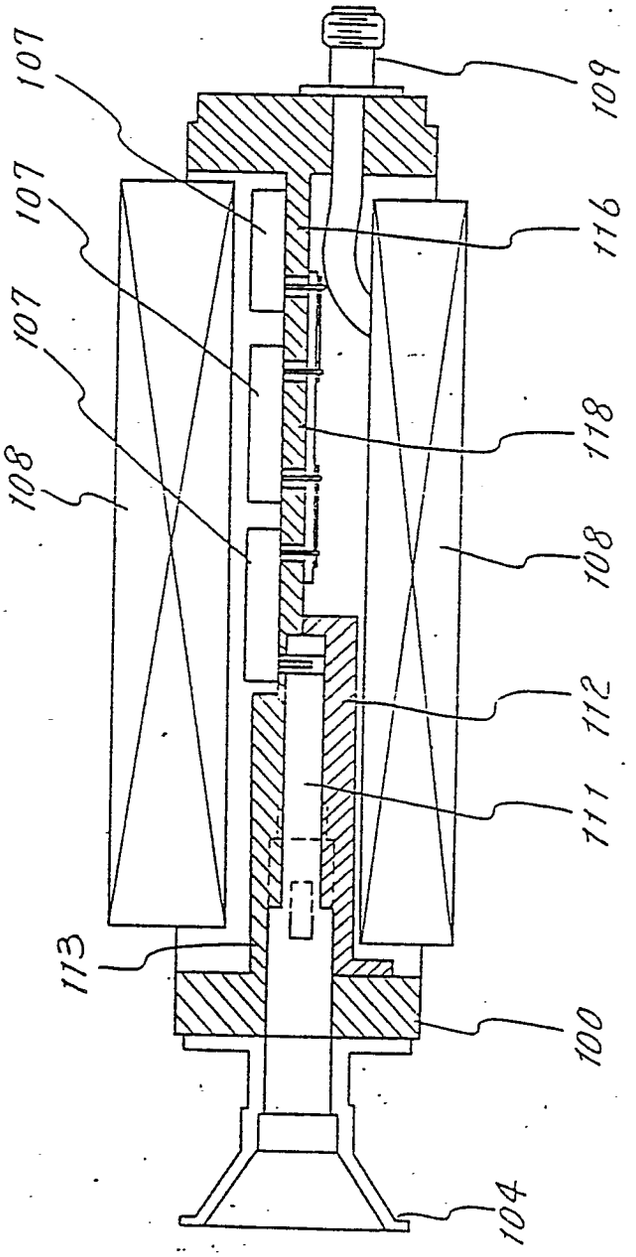


FIG. 8

FIG. 9

