

PATENT ASSIGNMENT

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SUBMISSION TYPE:	NEW ASSIGNMENT														
NATURE OF CONVEYANCE:	ASSIGNMENT														
CONVEYING PARTY DATA															
<table border="1"><thead><tr><th>Name</th><th>Execution Date</th></tr></thead><tbody><tr><td>Andrew Reino Anderson</td><td>12/06/1996</td></tr><tr><td>Glen Brian Backes</td><td>12/06/1996</td></tr><tr><td>Richard Thomas Demulling</td><td>12/06/1996</td></tr><tr><td>Dominic Louwagie</td><td>12/06/1996</td></tr><tr><td>Todd Charles Ortberg</td><td>12/06/1996</td></tr><tr><td>Edward F. Sansone</td><td>12/06/1996</td></tr></tbody></table>		Name	Execution Date	Andrew Reino Anderson	12/06/1996	Glen Brian Backes	12/06/1996	Richard Thomas Demulling	12/06/1996	Dominic Louwagie	12/06/1996	Todd Charles Ortberg	12/06/1996	Edward F. Sansone	12/06/1996
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RECEIVING PARTY DATA															
<table border="1"><tr><td>Name:</td><td>ADC Telecommunications, Inc.</td></tr><tr><td>Street Address:</td><td>13625 Technology Drive</td></tr><tr><td>City:</td><td>Eden Prairie</td></tr><tr><td>State/Country:</td><td>MINNESOTA</td></tr><tr><td>Postal Code:</td><td>55344</td></tr></table>		Name:	ADC Telecommunications, Inc.	Street Address:	13625 Technology Drive	City:	Eden Prairie	State/Country:	MINNESOTA	Postal Code:	55344				
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CORRESPONDENCE DATA															
Fax Number: (312)321-4299 <i>Correspondence will be sent via US Mail when the fax attempt is unsuccessful.</i>															
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PATENT
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NAME OF SUBMITTER:

Justin B. Rand

Total Attachments: 65

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ASSIGNMENT

WHEREAS, we, Andrew Reino Anderson, residing at 600 North Lilac Drive, No. 205, Golden Valley, MN 55422, Glen Brian Backes, residing at 8662 North Old Highway Road, St. Cloud, MN 56301, Richard Thomas Demulling, residing at 3460 92nd Court, Circle Pines, MN 55014, Dominic Louwagie, residing at 15980 North Hillcrest Court, Eden Prairie, MN 55346, Todd Charles Ortberg, residing at 2221 Lukewood Drive, Chanhassen, MN 55317, and Edward F. Sansone, residing at 2672 106th Lane N.W., Coon Rapids, MN 55433, made certain new and useful inventions and improvements for which we filed an application for Letters Patent of the United States on even date herewith, which is entitled RF CIRCUIT MODULE.

AND WHEREAS, ADC Telecommunications, Inc., a corporation organized and existing under and by virtue of the laws of the State of Minnesota, and having an office and place of business at 4900 West 78th Street, Minneapolis, MN 55435 (hereinafter "Assignee") is desirous of acquiring the entire right, title and interest in and to said inventions, improvements and application and in and to the Letters Patent to be obtained therefor;

NOW THEREFORE, to all whom it may concern, be it known that for and in consideration of the sum of One Dollar and other good and valuable considerations, the receipt and sufficiency whereof is hereby acknowledged, we have sold, assigned, and transferred, and by these presents do sell, assign and transfer unto said Assignee, its successors or assigns, the entire right, title and interest for all countries in and to all inventions and improvements disclosed in the aforesaid application, and in and to the application, all divisions, continuations, or renewals thereof, all Letters Patent which may be granted therefrom, and all reissues or extensions of such patents, and in and to any and all applications which have been or shall be filed in any foreign countries for Letters Patent on the inventions and improvements, including an assignment of all rights under the provisions of the International Convention, and all Letters Patent of foreign countries which may be granted therefrom; and we do hereby authorize and request the Commissioner of Patents and Trademarks to issue any and all United States Letters Patent for the aforesaid inventions and improvements to the Assignee as the assignee of the entire right, title and interest in and to the same, for the use of the Assignee, its successors and assigns.

AND, for the consideration aforesaid, we do hereby agree that we and our executors and legal representatives will make, execute and deliver any and all other instruments in writing including any and all further application papers, affidavits, assignments and other documents, and will communicate to said Assignee, its successors and representatives all facts known to us relating to said improvements and the history thereof and will testify in all legal proceedings and generally do all things which may be necessary or desirable more effectually to secure to and vest in said Assignee, its

successors or assigns the entire right, title and interest in and to the improvements, inventions, applications, Letters Patent, rights, titles, benefits, privileges and advantages hereby sold, assigned and conveyed, or intended so to be.

AND, furthermore we covenant and agree with said Assignee, its successors and assigns, that no assignment, grant, mortgage, license or other agreement affecting the rights and property herein conveyed has been made to others by us and that full right to convey the same as herein expressed is possessed by us.

IN TESTIMONY WHEREOF, I have hereunto set my hand this 6th day of December, 19 96.

Andrew Reino Anderson
Andrew Reino Anderson

STATE OF Minnesota)
COUNTY OF Dakota) ss.

On this 6th day of December, 19 96, before me personally appeared Andrew Reino Anderson to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.

[SEAL]

Gloria Carver
Notary Public



IN TESTIMONY WHEREOF, I have hereunto set my hand this 6th day of December, 1996.

Glen B Backes
Glen Brian Backes

STATE OF Minnesota)
COUNTY OF Dakota) ss.

On this 6th day of December, 1996, before me personally appeared Glen Brian Backes to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.



Gloria Carver
Notary Public

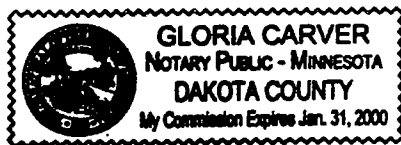
IN TESTIMONY WHEREOF, I have hereunto set my hand this 6th day of December, 1996.

Richard T. Demulling
Richard Thomas Demulling

STATE OF Minnesota)
COUNTY OF Dakota) ss.

On this 6th day of December, 1996, before me personally appeared Richard Thomas Demulling to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.

[SEAL]



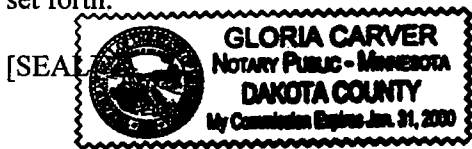
Gloria Carver
Notary Public

IN TESTIMONY WHEREOF, I have hereunto set my hand this 6th day of December, 1996.

Dominic Louwagie
Dominic Louwagie

STATE OF Minnesota)
COUNTY OF Dakota) ss.

On this 6th day of December, 1996, before me personally appeared Dominic Louwagie to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.



Gloria Carver
Notary Public

IN TESTIMONY WHEREOF, I have hereunto set my hand this 6th day of December, 1996.

Todd C. Ortberg
Todd Charles Ortberg

STATE OF Minnesota)
COUNTY OF Dakota) ss.

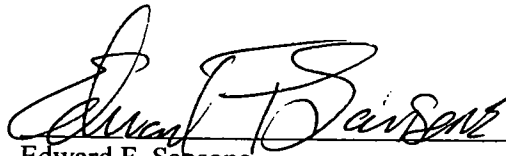
On this 6th day of December, 1996, before me personally appeared Todd Charles Ortberg to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.

[SEAL]



Gloria Carver
Notary Public

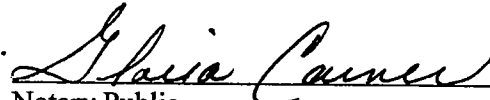
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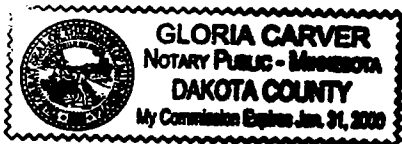

Edward F. Sansone

STATE OF Minnesota)
COUNTY OF Dakota) ss.

On this 6th day of December, 19 96, before me personally appeared Edward F. Sansone to me known and known to me to be the person described in and who executed the foregoing instrument, and he duly acknowledged to me that he executed the same for the uses and purposes therein set forth.

[SEAL]


Notary Public



RF CIRCUIT MODULE

I. BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

5 This invention pertains to circuits for broad-band RF systems. More particularly, this invention pertains to modular RF (radio frequency) circuit components.

2. DESCRIPTION OF THE PRIOR ART

10 In the telecommunications industry and more particularly in the video transmission industry, broad-band radio frequency (RF) signals (i.e., 5 MHz to 1 GHz) are carried over coax conductors from a headend to consumers. At the headend of the system, numerous signals are
15 manipulated to achieve a wide variety of functions and objectives. For example, signals carried on numerous coax cables may be combined onto a single coax conductor. Similarly, a signal on a main coax conductor may be divided into a plurality of signals carried on branch coax
20 conductors. Additionally, signals may be added or removed from a main conductor through directional couplers or the like.

 In addition to combining, splitting, diverting or adding signals, the headend will also include apparatus for
25 modifying signals. For example, in order to adequately tune the system, it may be desirable to provide attenuators

or the like to attenuate a signal to a desired level.
Further, as a broadband RF signal is carried over a length
of cable, the high frequency range of the signal may be
attenuated more than a low frequency range of the signal.

5 As a result, equalizers are utilized to modify the signal
to have a level intensity throughout its frequency range.

Throughout the system, performance
characteristics are critical. For example, a common
performance criteria is to maintain the flatness of a
10 signal. Flatness refers to maintaining a level intensity
of a signal throughout its frequency range. For example,
if the signal is attenuated by 2 dB at 1 Ghz, then it is
desirable that the signal be attenuated at 2 dB at the 5
Mhz frequency. Further, the system needs to be tuned for
15 impedance matching.

Prior art headends include a wide variety of
devices to accommodate and accomplish the functions
described above. It is desirable to provide an apparatus
to accommodate the various functions required at the
20 headend through a modular construction to permit ease of
maintenance and cable management in a headend. Such a
device must accommodate the performance characteristics of
the headend while permitting the modular construction to
enhance the cable management and organization of a headend.

25 II. SUMMARY OF THE INVENTION

According to a preferred embodiment of the
present invention, a module is provided for containing a
circuit for performing discrete functions on a radio

frequency signal. The module comprises a housing of electrically conductive material. The housing has a front face and an opposite rear face. The front face and rear face are separated by opposite sidewalls and opposite end walls. A plurality of coax connectors are secured to the rear face with an outer shield of the connectors electrically connected to the housing. A circuit board is contained within the interior. The circuit board is generally parallel to and spaced between the sidewalls.

10 The circuit board has a component side and a ground side. The ground side includes a layer of electrically conductive material which is electrically connected to the housing. A plurality of coax cable connection locations are provided on the ground side of the circuit board. Each of the coax

15 cable connections includes a ground connection for connecting ground shields of coax cables to the layer of electrically conductive material. The component side of the circuit board includes a plurality of circuit components interconnected with one another and with the

20 coax cable connection locations through a plurality of circuit paths. A plurality of coax cables are disposed within the interior and connected to individual ones of the coax connectors and the coax cable connection locations. Each of the coax cables has a ground shield connected to

25 the outer shields of the connectors and to the ground connections of the coax cable connection locations. A plurality of cables are routed for the cables to be disposed between the ground side of the circuit board and the opposing sidewall of the housing.

III. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a bottom end, front face and right
sidewall perspective view of one embodiment of a module
according to the present invention shown in exploded view
5 (with internal cables omitted);

Fig. 2 is a left side plan view of the module of
Fig. 1;

Fig. 3 is a right side plan view of the module of
Fig. 1;

10 Fig. 4 is a front elevation view of the module of
Fig. 1;

Fig. 5 is a rear elevation view of the module of
Fig. 1;

15 Fig. 6 is a bottom end view of the module of Fig.
1;

Fig. 7 is a top end view of the module of Fig. 1;

Fig. 8 is a rear, right side and top end exploded
view of the module of Fig. 1 with a cover removed;

20 Fig. 9 is a perspective view of internal
components of the module of Fig. 1;

Fig. 9A is a top plan view of a printed circuit
board and attached components;

Fig. 10 is an opposite side plan view of the
components of Fig. 9;

25 Fig. 11 is a side cross-sectional view of the
module of Fig. 1;

Fig. 12 is a view similar to that of Fig. 1
showing in exploded format an alternative embodiment of the
present invention;

Fig. 13 is a right side plan view of the module of Fig. 12;

Fig. 14 is a left side plan view of the module of Fig. 12;

5 Fig. 15 is a front elevation view of the module of Fig. 12;

Fig. 16 is a rear elevation view of the module of Fig. 12;

10 Fig. 17 is a bottom end view of the module of Fig. 12;

Fig. 18 is a top end view of the module of Fig. 12;

Fig. 19 is a bottom end, front face and right sidewall perspective view of a third embodiment of a module according to the present invention shown in exploded view (with internal cables omitted);

Fig. 20 is a right side plan view of the module of Fig. 19;

20 Fig. 21 is a left side plan view of the module of Fig. 19;

Fig. 22 is a front elevation view of the module of Fig. 19;

Fig. 23 is a rear elevation view of the module of Fig. 19;

25 Fig. 24 is a bottom end view of the module of Fig. 19;

Fig. 25 is a top end view of the module of Fig. 19;

Fig. 26 is a perspective view of a first embodiment of a chassis for holding modules according to the present invention;

Fig. 27 is a perspective view of a second embodiment of a chassis for holding modules of the present invention; and

Fig. 28 is a perspective view of a third embodiment of a chassis for holding modules of the present invention.

10 IV. DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the several drawing figures in which identical elements are numbered identically throughout, a description of the preferred embodiment of the present invention will now be provided.

15 With initial reference to Figs. 1 through 11, a module 10 according to the present invention will be described for use as a splitter/combiner module for splitting a main signal into a plurality of branch signals or, alternatively, combining a plurality of branch signals
20 into a common main signal. The module 10 includes a housing having a front face 14, a rear face 16. The front face and rear face 14, 16 are separated by opposing sidewalls 18, 20 and opposite end walls 22, 24. The housing 12 is formed of electrically conductive material.
25 Preferably, the material is nickel-plated aluminum.

Sidewall 18 and end walls 22, 24 are integrally formed as a box configuration with walls 22, 24 having inwardly protruding peripheral ledge 26. Rear wall 16 is

secured to walls 18, 22, 24 by screws 28. The sidewall 20 is fastened to the ledge 26 by a plurality of screws 28 received in aligned bolt holes 30 of sidewall 20 and threaded bolt holes 32 on the peripheral ledge.

5 The sidewall 20 is sized to have a length greater than the longitudinal dimension between walls 22, 24 such that ends 20a, 20b extend beyond ends 22, 24 as flanges for purposes that will be described.

 The front cover 14 includes extending edges 14a, 10 14b which extend beyond ends 22, 24. The front cover further has an internal ledge 34 (shown in Figs. 1, 8 and 11) on an interior surface of the cover 14. The ledge 34 is sized to extend into the interior of the housing when the front cover 14 is attached to the housing.

15 The front cover 14 and sidewall 20 are secured to the housing by the screws 28 received within aligned bolt holes. The screws 28 are preferably positioned at one-half inch on-center spacings to prevent EMI leakage as is conventional.

20 The front cover 14 includes a plurality of openings 36 the function of which will be described with the openings 36 arranged linearly along the face 14. Similarly, the front cover 14 includes an opening 38 sized to pass a coax connector 41 for purposes that will become 25 apparent.

 A plurality of coax connectors 40-0 through 40-8 are secured to the rear face 16. Each of the coax connectors is identical. Such connectors are conventional and include a central conductor surrounded by a grounded

shield. The grounded shields of the coax conductors are in direct physical and electrical contact with the electrically conductive material of the rear face 16.

Contained within the interior of the housing 12 is a printed circuit board 44. The printed circuit board 44 is supported on posts 42 by screws 43. The posts 42 are electrically conductive and connected to wall 18. The printed circuit board 44 includes a component side 44a and a ground side 44b (see Fig. 9). The ground side 44b opposes the wall 18 and the component side 44a opposes wall 20. The printed circuit board 44 is maintained in parallel, spaced relation between the walls 18, 20 by supports 42.

A layer 44c (Fig. 9) of electrically conductive material (such as a sheet layer of copper) is provided on the exterior surface of surface 44b.

A plurality of coax cable connection locations 48-0 through 48-8 are provided on the ground side 44b of the printed circuit board 44. Each of the coax cable connection locations 48-0 through 48-8 include a ground connection for connecting the ground shields of a coax cable to the conductive layer 44c.

A plurality of circuit components are disposed on the component side 44a of the printed circuit board 44. In the embodiment shown, the components include a solid state directional coupler 50 and three solid state splitter/combiners 52-1, 52-2 and 52-3.

It will be appreciated that a solid state directional coupler 50 is a commercially available item,

and an example of such is a 20dB coupler Product
No. CPL/20BE-08A3 sold by TRAK Microwave, 4726 Eisenhower
Blvd., Tampa, FL 33634-6391. Similarly, solid state
splitter/combiners 52-2 through 52-3 are commercially
5 available one-by-four splitters and examples of such are
Product No. SPL/4BE-53D sold by TRAK Microwave.
Splitter/combiner 52-1 is a one-by-two splitter such as
Product No. SPL/2BE-53D of TRAK Microwave.

The splitter/combiners each receive a signal and
10 divide an RF signal into two signals of equal strength.
Splitter/combiners 52-2 and 52-1 are electrically connected
in series. Similarly, splitter 52-3 is connected in series
with splitter 52-1 such that splitter 52-3 is connected in
parallel to splitter 52-2.

15 The electrical connection of the components 50
and 52-1 through 52-3 is provided through a plurality of
circuit paths 53 (Fig. 9A) contained on the surface 44a
where the circuit paths connect the components 50, 52-1 and
52-3 with the coax connection locations 48-0 through 48-8.
20 The circuit paths connect the components and the connection
locations such that connectors/ 40-0 is connected to the
directional coupler 50 with a portion of the signal
diverted from the directional coupler 50 to the coax
monitor connector 41 through cable 41-1. Preferably,
25 coupler 50 provides a -20dB monitor signal.

The main signal from the directional coupler 50
is passed to the splitter/combiner 52-1 which divides the
main signal into two signals with one passed along the
circuit paths to splitter/combiner 52-2 and the other

passed to splitter/combiner 52-3. Each of splitters 52-2 and 52-3 split a signal into four signals resulting in a total of eight branch signals passed to connection locations 48-1 through 48-8.

5 In the preceding paragraph, a signal is described as coming into the directional coupler from connector 40-0 and then eventually split and passed to connectors 40-1 through 40-8. With the directional coupler 50 arranged in the schematic shown of Fig. 3, such a signal flow path
10 would result in losing a monitor function at monitor port 41. With this schematic shown in Fig. 3, signals passed into connectors 40-1 through 40-8 are attenuated and combined to a main signal which is then passed through directional coupler 50 to OUT port 40-0. A portion of the
15 main signal is then passed from the directional coupler 50 to the monitor port 41 so that the signal may be monitored. If it is desirable to pass a signal into connector 40-1 for division into branch signals distributed to connectors 40-1 through 40-8, a different directional coupler 50 can be
20 provided such that a signal from connector 40-0 can be monitored at port 41.

Before the branch signals are passed to the connection locations, they are passed through attenuator components. Each of the attenuator components is identical
25 and includes a base member 60-1 through 60-8 which is secured to the component side 44a of the printed circuit board 44 along a leading edge 44d of the printed circuit board and with the base members 60-1 through 60-8 arranged in a linear array.

A plurality of the attenuator plugs 64-1 through 64-8 are provided to be releasably connected to individual ones of the base member 60-1 through 60-8. The attenuator plugs 64-1 through 64-8 provide an attenuation to a signal
5 to each of the branch ^{signal} ~~circuits~~ being sent to connectors 40-1 through connectors 40-8.

Attenuator plugs and base members are commercially available items such as those sold as Product No. F-7520-A (for a 20dB attenuator) through Communication
10 Associates 1750 T-'Coleman Road, Anniston, AL 36207. The plugs 64-1 - 64-8 can be individually selected to provide a discrete amount of attenuation to a signal. For example, a "zero" plug can be inserted into a base member to provide 0 dB attenuation. Alternatively, at an option of a
15 technician, the 0 dB plug may be replaced with a 15 dB plug to provide 15 dB attenuation to a signal. As a result, each of the branch circuits can be individually provided with a unique attenuation selected at an option of a
20 technician. The holes 36 on the front face 14 are arranged and sized such that each of the attenuator plugs extends through individual ones of the holes 36 to be grasped by an operator. As a result, an operator can remove and replace an attenuator plug without needing access to the interior of the housing 12.

25 To provide EMI leakage protection, the front face 14 is provided with a removable cover 100 surrounding the array of holes 36. A deformable, conductive seal 102 (silicon gasket impregnated with silver particles) is provided between the cover 100 and face 14. Threaded

connections 104 on the cover 100 are aligned with threaded holes on the standoff posts 106 such that the cover 100 can be secured to the face 14 by turning the threaded connectors 104 into the standoff posts 106. As the
5 threaded connection 104 is tightened, the edge of the cover 100 compresses into the seal 102 to thereby compress the seal 102 against the face 14 to provide an effective EMI seal.

The device thus described performs
10 splitter/combiner functions with connector 40-0 being a main connector and with connectors 40-1 through 40-8 being branch connectors. In other words, a signal admitted to connector 40-0 is split into eight equal signals passed to connectors 40-1 through 40-8. Further, the main signal may
15 be monitored through forward connector 41.

As shown in the drawings, all of the connectors 40-0 - 40-8 are connected to the connection locations 48-0 - 48-8 via coaxial cables 70-0 through 70-8 such that the ground shield of the coaxial cable is electrically
20 connected to the ground shield of the connectors 40-0 through 40-8, respectively, as well as connected to the conductive layer 44c.

In RF circuits, impedance matching is critical. The parallel relation of the electrically conductive layer
25 44c to the sidewall 18 of the housing 12 presents a small capacitance. Further, the spaced relation of the circuit paths 53 to the opposite sidewall 20 presents a minute capacitance. Capacitance between the housing and the circuit components are referred to as "parasitic

reactances^{cl}". Further, there is natural capacitance or reactance of components on the circuit board 44. The pathways 53 are tuned to balance the capacitance. The pathways 53 are tuned by adjusting the size of the circuit pathways 53 such that they present an inductance selected to balance the parasitic reactances and the circuit board reactances. It will be appreciated that sizing circuit pathways to present a desired impedance is well known in the art. Also, the cables 70-0 through 70-8 are routed between the ground surface 44c of the circuit board 44 and its opposing sidewall 18 of the housing 12. By routing the cables 70-8, 70-8 on this side of the circuit board 44 and avoiding placing the cables adjacent any of the circuit components or circuit pathways, undesirable reactances are avoided.

With the structure thus described, the desired circuit function is attained in a modular format. Further, in addition to impedance matching circuit components, the selection and arrangement of components permits a high performance module with impedance matching throughout and with desired flatness of a signal across the broad band frequency range.

As shown in the drawings, the forward ledge 34 includes a plurality of resilient spring contacts 35 mounted on the ledge 34 and positioned to swipe against the electrically conductive layer 44c as the cover 14 is placed on to the housing to insure enhanced electrical contact between the conductive layer 44c and the cover 14 so that

all elements are grounded when coaxial cables are connected to the rear connectors.

To further protect the signal, the front cover 100 is provided on front end 14 to cover and enclosed all
5 attenuator plugs 64-1 - 64-8 extending through holes 36. The cover 100 prevents EMI interference which would otherwise occur by uncovered plugs 64 extending through holes 36.

The foregoing discussion with respect to
10 Figs. 1-11 described an embodiment of the present invention for an RF module having splitter functions and monitor functions. Figs. 12-18 illustrate the invention in a different embodiment for an equalizer circuit. In an equalizer circuit, an equalizer component is used to
15 provide the same degree of attenuation at the extremes of the RF bandwidth. Elements similarly numbered with respect to the previously described embodiment are numbered similar in Figs. 12-18 with the addition of an apostrophe to distinguish between the embodiments.

20 In Fig. 12, a module 10' includes a housing having a base 18' and ^{end}sidewalls 22', 24'. The module 10' further includes a front face 14' and a rear face 16'. A side cover 20' closes the module 10'.

As in the previously described embodiment, the
25 present invention incorporates a printed circuit board 44' containing circuit components. The circuit board 44' is maintained in parallel spaced relation between the sidewall 20' and the lower sidewall 18' by support posts 42' and associated screws 43'.

For the equalizer circuit, the circuit components include a directional coupler 50' and an equalizer component 64' removably secured to a base member 60'. The equalizer 64' may be removed or replaced through an opening
5 36' in the forward wall 14'.

The rear wall 16' contains coax connectors 40-0', 40-1' and 40-2'. Coaxial cables (not shown) extend from the coax connectors 40-0' through 40-2' and beneath the printed circuit board 44' in a manner identical with that
10 previously described. Further, as in the previous embodiment, the circuit board 44' contains an electrically conductive layer opposing and electrically connected to surface 18'. Also, the circuit paths on the upper surface of the board 44' are provided to balance impedances as
15 previously described.

The coaxial cables will extend between the board 44' and the surface 18' for reasons previously discussed. The circuit paths on the board 44' are disposed such that an ~~incoming circuit~~ from incoming signal from 40-0' is
20 passed to the equalizer and then to the directional coupler 50'. Further, the separate incoming signal can be passed from connector 40-1' to directional coupler 50' encoupled with the signal from the equalizer 64' with the coupled signal passed to the output connector 40-2'. A support 51'
25 is mounted within the interior of the housing to guide equalizer 64' toward base member 60' in required alignment. As with the previous embodiment, a cover 100' covers the front face 14' together with a gasket 102' to prevent EMI.

All other features of the module 10' are similar to the module 10 including the external dimensions and tabs of the module such that a module 10' may be interchangeable in a chassis with a module 10. Further, the module 10' has
5 the same impedance matching and parasitic reactance compensation previously mentioned with respect to module 10. As a result, the invention of module 10 is incorporated into module 10' with module 10' showing a specific embodiment of the invention for use with an
10 equalizer component. It will be appreciated that equalizer components 64' are commercially available items. An example of such is product number G75-000 of ADC Broadband Communications Division, 999 Research Parkway, Meridan, CT 06450.

15 Figs. 19-25 illustrate a third embodiment of the present invention for use in a 6-port directional coupler. The directional couplers are used to split or add multiple signals. Elements similarly numbered with respect to the previously described embodiments are numbered similarly in
20 Figs. 19-25 with the addition of a double apostrophe to distinguish between the embodiments.

In Figs. 19-25, a module 10'' includes a housing 12'' having a base 18'' and ^{end}sidewalls 22'', 24''. The module 10'' further includes a front face 14'' and a rear
25 face 16''. A side cover 20'' closes the module 10''.

As in the previously described embodiments, the present invention incorporates a printed circuit board 44'' containing circuit components. The printed circuit board 44'' is maintained in parallel spaced relation between the

sidewalls 20'' and the lower sidewall 18'' by support post 42'' and associated screws 43''.

The circuit components include six directional couplers 50-1'' through 50-6'', each with individually associated attenuator plugs 64-1'' through 64-6'' which are removably secured to individual base members 60-1'' through 60-6''. Each of the attenuator plugs 64-1'' through 64-6'' may be removed or replaced through openings 36'' in the forward wall 14''.

The rear wall 16'' contains coax connectors 40-0'' through 40-6''. Coaxial cables (not shown in Figs.) extend from each of the coax connectors 40-0'' through 40-6'' and beneath the printed circuit board 44'' in a manner identical with that described with reference to the first preferred embodiment of Fig. 1. Further, as in the previous embodiment, circuit board 44'' contains an electrically conductive layer opposing and electrically connected to surface 18''. Also, the circuit paths on the upper surface of the board 44'' are provided to balance impedances as previously described.

The coaxial cables will extend between the board 44'' and the surface 18'' for reasons previously discussed. The circuit paths on the board 44'' are disposed such that six incoming signals may be separately connected to each of connectors 40-1'' through 40-6'' and passed through the individual attenuators 64-1'' through 64-6'' into the directional couplers 50-1'' through 50-6'' where the six signals will be joined into a common output signal passed to connector 40-0''. As with the previous embodiment, a

cover 100'' covers the front face 14'' together with a gasket 102'' to prevent EMI.

All of the features of the module 10'' are similar to the modules 10, 10' including the external dimensions and tabs of the modules such that the modules 10'', 10' and 10 may be interchangeable in a common chassis. Further, the module 10'' has the same impedance matching and parasitic reactants¹⁰ compensation previously mentioned with respect to module 10. As a result, the invention of modules 10 and 10' is incorporated into module 10'' with module 10'' showing a specific embodiment of the invention for use with a 6-port directional coupler circuit.

Fig. 26 shows a first chassis 200 for housing a plurality of modules 10. The chassis 200 includes horizontally spaced apart sidewalls 202,204 and vertically spaced apart top and bottom walls 206,208. The top and bottom walls 206,208 are spaced apart by a distance substantially equal to a distance between the end walls 22,24 of the module 10.

Each of the top and bottom walls 206,208 includes a plurality of vertically aligned grooves 210. The grooves 210 are sized to slidably receive the projecting flanges 20a,20b of the module 10 such that a module may be slidably inserted into the frame 200 with the modules 10 vertically positioned. In the embodiment shown, there are 12 pairs of vertically aligned grooves 210 such that 12 modules may be inserted into the frame 200. Since the flanges 20a,20b of the modules 10 are offset from a longitudinal plane of the

module 10, the grooves 210 are offset from module receiving spaces so that the entire open space between the sidewalls of the frame may be filled with modules. Also, the grooves 210 are spaced apart a distance selected such that as
5 modules are slidably inserted into the frame, adjacent modules are positioned with a small spacing between opposing sidewalls of adjacent modules 10.

Locking screws 214 are provided on the projecting tabs 14a,14b of the front walls 14 of the modules 10.
10 Corresponding threaded locking holes 216 are provided on both the top and bottom walls 206,208 of the frame 200. The screws 214 are not centrally positioned on the tabs 14a,14b. Instead, they are laterally offset from a central longitudinal axis of the front wall 14. The holes 216 are
15 similarly offset to require that a module 10 be placed in the frame 200 in a desired orientation and cannot be flipped 180° to be inserted in an undesired orientation. The frame 200 also includes a hinged cover 218 which preferably is transparent to permit an operator to inspect
20 the interior. Cable management brackets 220 are provided on the rear of the chassis 200.

From time to time, a customer or purchaser of the modules 10 may desire to hold the modules 10 in a horizontal alignment rather than the vertical alignment of
25 Fig. 26. An alternative chassis 200' is shown in Fig. 27 for holding the modules 10 in a horizontal alignment. In Fig. 27, the chassis 200' includes horizontally spaced apart sidewalls 202',204' and vertically spaced apart top and bottom walls 206',208'. An intermediate wall 209' is

provided midway and parallel to side walls 202',204'. The distance between either of side walls 202',204' and midwall 209' is equal to a distance between the end walls 22,24 of the module 10.

5 Each of the sidewalls 202',204' and the midwall 209' include a plurality of horizontally aligned grooves 210'. The grooves 210' are sized to slidably receive the projecting flanges 20a,20b of the module 10 such that a module may be slidably inserted into the frame 200' with
10 the module 10 horizontally positioned.

 In the embodiment shown in Fig. 27, there are six pairs of horizontally aligned grooves 210' on both sides of the center wall 209' such that the frame 200' can contain a total of 12 modules. As a result, chassis 200 and 200'
15 give an operator the opportunity to contain the exact same number of modules 10 in either a horizontal or a vertical alignment as the operator may select.

 Also, the locking screws 214 of the modules are aligned with locking holes 216' on the side walls 202',204' and mid wall 209'. Since the screws 214 are not centrally
20 positioned on tabs 14a,14b, and the holes 216' are not centrally positioned in modules receiving spaces, a module 10 must be placed in the frame 200 in a desired orientation and cannot be flipped 180° to an undesired orientation. As
25 in the embodiment of Fig. 26, the frame 200' of Fig. 27 includes a hinged cover 218' and cable management brackets 220'.

 Finally, Fig. 28 shows a chassis 200'' which may be used in the event that an operator does not wish to have

a combined total of 12 modules but instead only wishes to have a fewer number of modules. Chassis 200' retains two modules 10 in side-by-side horizontal alignment and includes mounting brackets 201 for mounting to a frame structure so that an operator can elect to mount pairs of modules at a time rather than twelve modules 10. Frame 200'' is similar to frame 200' in that it has an intermediate wall 209'' between side walls 202'' and 204'' with the locking screws 214 received within holes (not shown) of walls 202'', 204'' and 209''.

WHAT IS CLAIMED IS:

1. A module for containing a circuit for performing discrete circuit functions on a radio frequency signal, said module comprising:

a housing of electrically conductive material defining an enclosed interior;

said housing having a front face and an opposite rear face separated by opposite sidewalls and opposite end walls;

a plurality of coax connectors secured to said rear face with an outer shield of said connectors electrically coupled to said housing;

a circuit board contained within said interior and positioned generally parallel to and spaced between said sidewalls;

said circuit board having a component side opposing a first of said sidewalls and a ground side opposing a second of said sidewalls;

said ground side including a layer of electrically conductive material electrically connected to said housing;

a plurality of coax cable connection locations on said ground side of said circuit board, each of said coax cable connections including a ground connection for connecting ground shields of coax cables to said layer of electrically conductive material;

said component side of said circuit board including a plurality of circuit components interconnected

with one another and with said coax cable connection locations through a plurality of circuit paths;

a plurality of coax cables disposed within said interior and connected to individual ones of said coax connectors and said coax cable connection locations, each of said coax cables having ground shields connected to said outer shields of said connectors and to said ground connections of said coax cable connection locations; and

said plurality of cables routed for said cables to be disposed between said ground side of said circuit board and said second of said sidewalls.

2. A module according to claim 1 wherein said circuit paths are sized to have an impedance selected to balance a parasitic reactance between said circuit board and said housing.

3. A module according to claim 1 wherein said plurality of components includes splitter components for receiving a main signal from one of said coax connection locations and dividing said main signal into a plurality of branch signals delivered along said circuit paths to individual remaining ones of said coax connection locations.

4. A module according to claim 1 wherein said splitters components are adapted to act as combiner components for receiving said plurality of branch signals from said individual ones of said coax connection locations and combining said branch signals into said main signal

delivered along one of said circuit paths to said one of said coax connection locations.

5. A module according to claim 3 wherein said splitter components includes at least a first splitter and a second splitter connected in series.

6. A module according to claim 5 wherein said splitter components includes a third splitter connected in series with said first splitter and in parallel with said second splitter.

7. A module according to claim 3 wherein said circuit components include a plurality of attenuators associated with individual ones of said branch circuits.

8. A module according to claim 7 wherein said attenuators include a variable attenuator component for varying an amount of attenuation of said attenuators.

9. A module according to claim 8 wherein said attenuators includes a first attenuator component mounted on said component side of said circuit board and said variable attenuator component removably secured to said first component with said variable attenuator component selected for a fixed desired attenuation.

10. A module according to claim 9 wherein:

said attenuators are positioned adjacent said front face;

said front face having an opening sized to pass said second variable attenuator component through said front face;

an electrically conductive cover releasably secured to said front face and sized to cover said opening.

11. A module according to claim 10 wherein said cover and said front face include an electrically conductive, mechanically deformable seal.

12. A module according to claim 1 wherein said front face is removable from a remainder of said housing and includes electrically conductive, mechanically resilient conductors extending between said front face and said layer of conductive material.

13. A module according to claim 12 wherein said front face includes a protruding ledge disposed to support a leading edge of said circuit card.

14. A module according to claim 3 wherein said circuit components include a directional coupler for diverting a portion of said main signal to a connector location connected to a monitor coax connector.

15. A module according to claim 14 wherein said monitor coax connector is exposed on said front face.

16. A module according to claim 1 wherein said circuit components include a directional coupler.

17. A module according to claim 16 wherein said components include an equalizer for equalizing a radio frequency signal along a frequency range.

18. A module according to claim 17 wherein said equalizer includes a first equalizer component mounted on said component side of said circuit board and a variable equalizer component removably secured to said first component with said variable equalizer component selected for a fixed desired radio frequency equalization.

19. A module according to claim 18 wherein:

said equalizer is positioned adjacent said front face;

said front face having an opening sized to pass said second variable equalizer component through said front face;

an electrically conductive cover releasably secured to said front face and sized to cover said opening.

20. A chassis and module combination for permitting selective housing of a plurality of modules containing radio frequency circuits, said combination comprising:

A. a plurality of modules each having:

a housing of electrically conductive material defining an enclosed interior;

said housing having a front face and an opposite rear face separated by opposite sidewalls and opposite end walls, with each of said faces and sidewalls being of predetermined dimension and

with said sidewalls being parallel to one another;

a plurality of coax connectors secured to said rear face with an outer shield of said connectors electrically coupled to said housing;

a circuit board contained within said interior and positioned generally parallel to and spaced between said sidewalls;

said circuit board having a component side opposing a first of said sidewalls and a ground side opposing a second of said sidewalls;

said ground side including a layer of electrically conductive material electrically connected to said housing;

a plurality of coax cable connection locations on said circuit board, each of said coax cable connections including a ground connection for connecting ground shields of coax cables to said layer of electrically conductive material;

said component side of said circuit board including a plurality of circuit components interconnected with one another and with said coax cable connection locations through a plurality of circuit paths;

said circuit components selected to perform a circuit function on a radio frequency signal supplied to one of said connectors and to provide an output radio frequency signal to a remainder of said connectors;

a plurality of coax cables disposed within said interior and connected to individual ones of said coax connectors and said coax cable connection locations, each of said coax cables having ground shields connected to said outer shields of said connectors and to said ground connections of said coax cable connection locations;

each of said end walls having a projecting flange extending in a common plane generally parallel to said sidewalls and with said common plane offset from a central longitudinal axis of said housing; said front face including end portions extending beyond each of said end walls;

a locking member secured to each of said end portions and having a locking end extending through a rear surface of said end portions; at least one of said locking members positioned offset from a longitudinal axis of said front face;

B. a first chassis having:

a first chassis frame including horizontally spaced apart first sidewalls and vertically spaced apart first top and bottom walls with said first top and bottom walls spaced apart by a distance substantially equal to a distance between said end walls of said modules;

each of said first top and bottom walls including a plurality of vertically aligned first grooves sized to slidably receive said projecting flanges;

said first grooves spaced along said first top and bottom walls for a predetermined number of said modules to be slidably received within said first frame in a vertical orientation with said longitudinal axis of said front face vertically disposed and with opposing sidewalls of adjacent modules narrowly spaced apart;

a plurality of first mating lock members on each of said first top and bottom walls and positioned to mate with said locking members of said modules when said modules are received within said first frame in a predetermined orientation and with said flanges received within said first grooves;

C. a second chassis having:

a second chassis frame including horizontally spaced apart second sidewalls and vertically spaced apart second top and bottom walls;

an intermediate wall extending vertically between said second top and bottom walls and centrally positioned between said second sidewalls with said intermediate wall dividing said second frame into a left column and a right column;

said second sidewalls spaced from said intermediate wall by a distance substantially equal to a distance between said end walls of said modules;

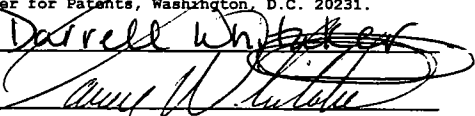
each of said second sidewalls and intermediate wall including a plurality of horizontally aligned second grooves sized to slidably receive said projecting flanges;

said second grooves spaced along said second sidewalls and said intermediate wall for half of said predetermined number of said modules to be slidably received within said left column of said second frame in a horizontal orientation with said longitudinal axis of said front face horizontally disposed and with opposing sidewalls of adjacent modules narrowly spaced apart; said second grooves further spaced along said second sidewalls and said intermediate wall for half of said predetermined number of said modules to be slidably received within said right column of said second frame in a horizontal orientation with said longitudinal axis of said front face horizontally disposed and with opposing sidewalls of adjacent modules narrowly spaced apart; and a plurality of second mating lock members on each of said second sidewalls and intermediate wall and positioned to mate with said locking members of said modules when said modules are received within said second frame in a predetermined orientation and with said flanges received within said second grooves.

RF CIRCUIT MODULE

ABSTRACT OF THE DISCLOSURE

A module for radio frequency signal circuits includes an electrically conductive housing. Coax
5 connectors are secured to the rear face of the housing. A circuit board is contained within the interior spaced between sidewalls of the housing. A ground side of the circuit board includes a layer of electrically conductive material which is electrically connected to the housing.
10 Coax cables extend within the interior of the housing from the coax connectors and between the ground side of the circuit board and an opposing sidewall. An opposite side of the circuit board contains circuit components inter-connected with one another through a plurality of circuit
15 paths.

CERTIFICATE UNDER 37 CFR 1.10:	
"Express Mail" mailing label number:	<u>TB762806077US</u>
Date of Deposit:	<u>December 6, 1996</u>
I hereby certify that this paper or fee is being deposited with the U.S. Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to BOX PATENT APPLICATION, Assistant Commissioner for Patents, Washington, D.C. 20231.	
By:	<u></u>
Name:	<u>Darrell W. Whitaker</u>

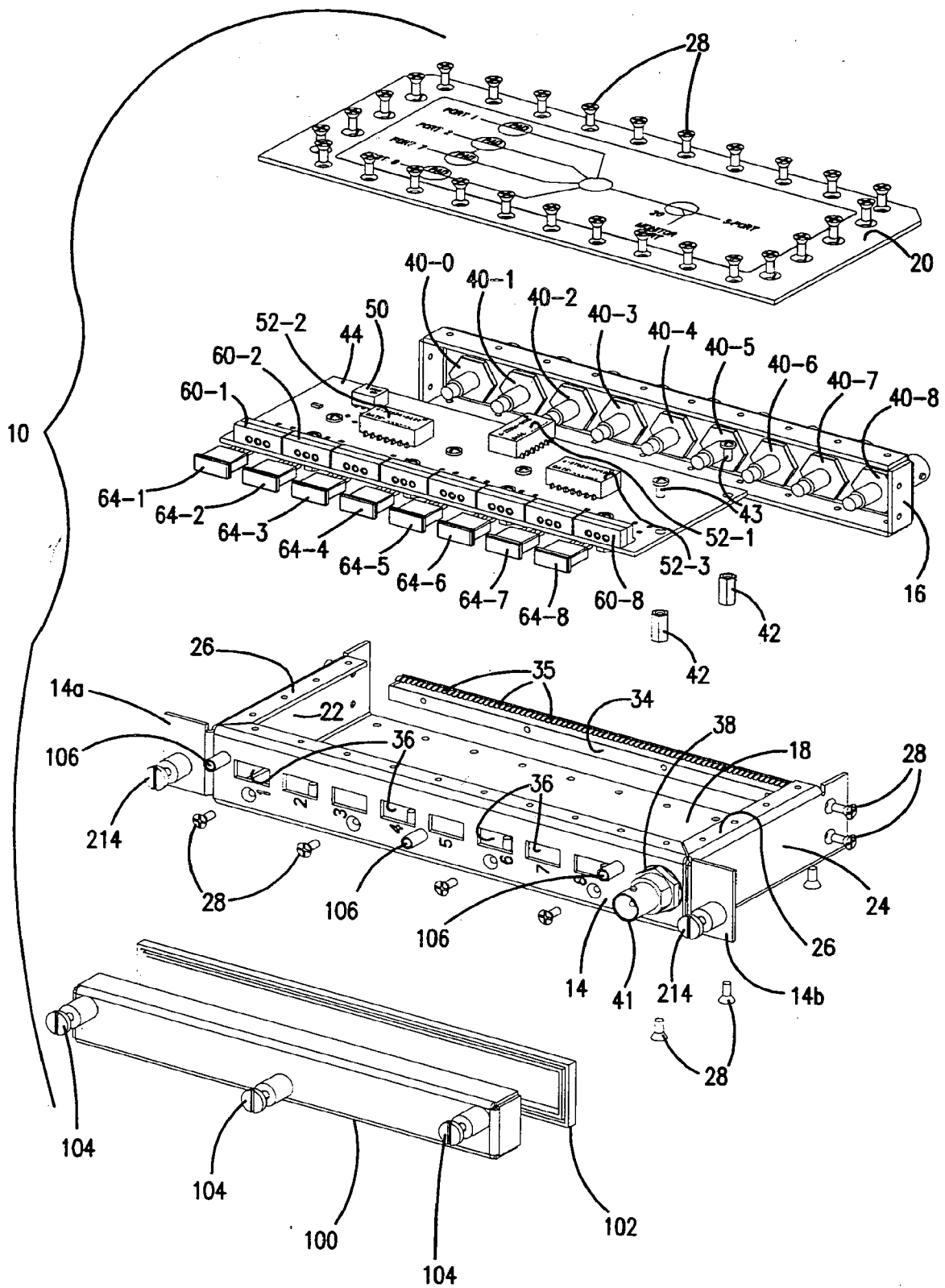


FIG. 1

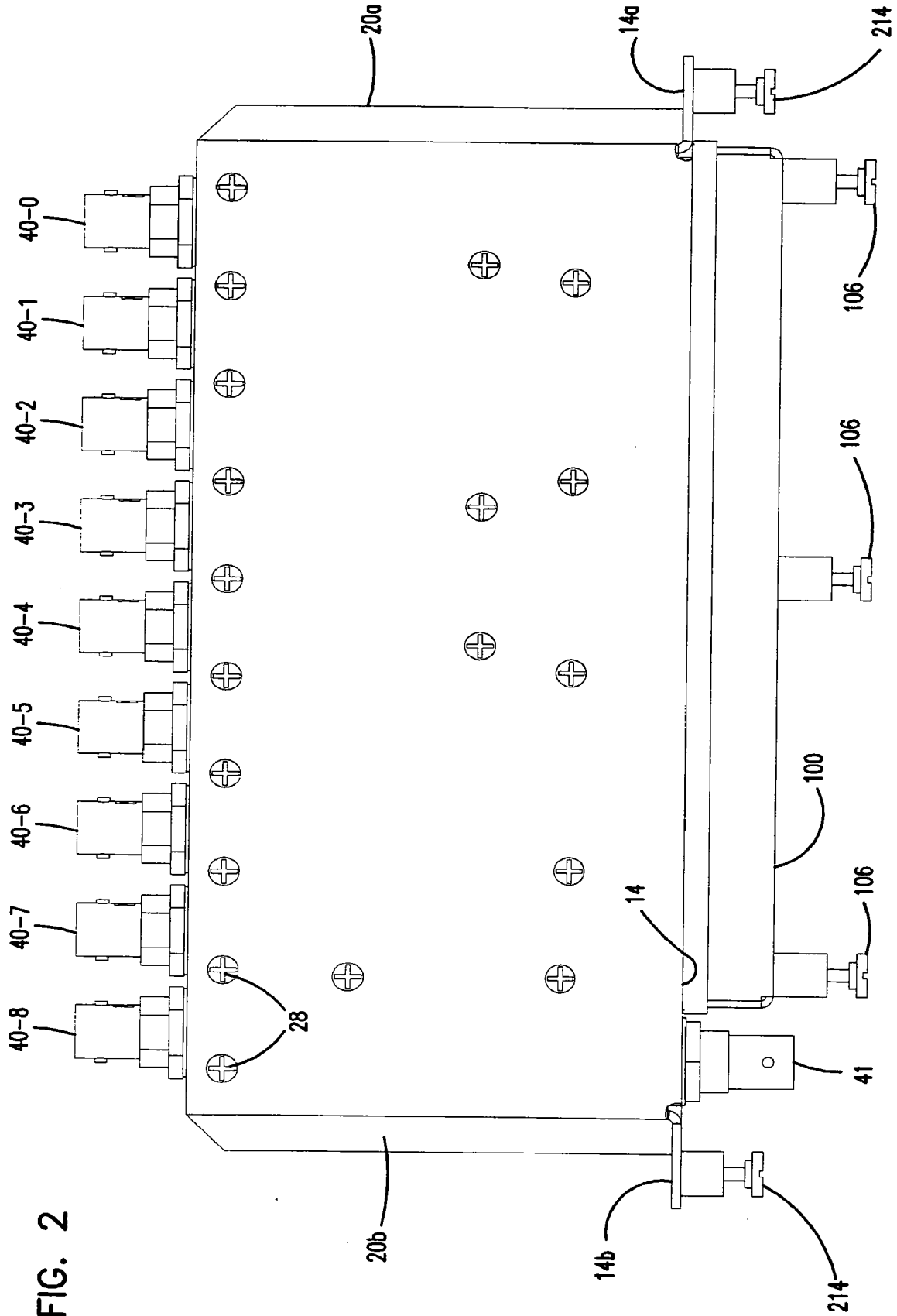


FIG. 2

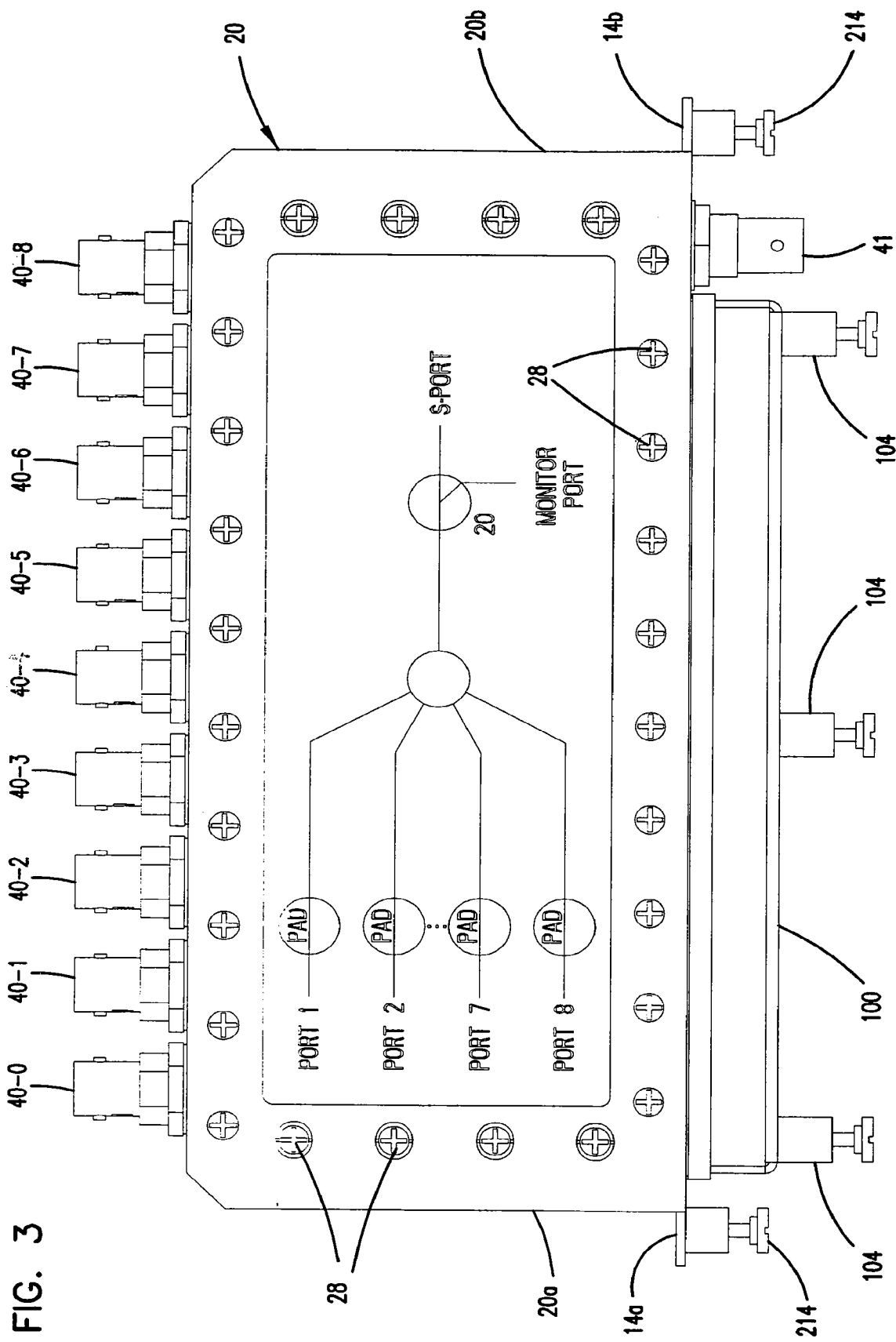


FIG. 3

FIG. 4

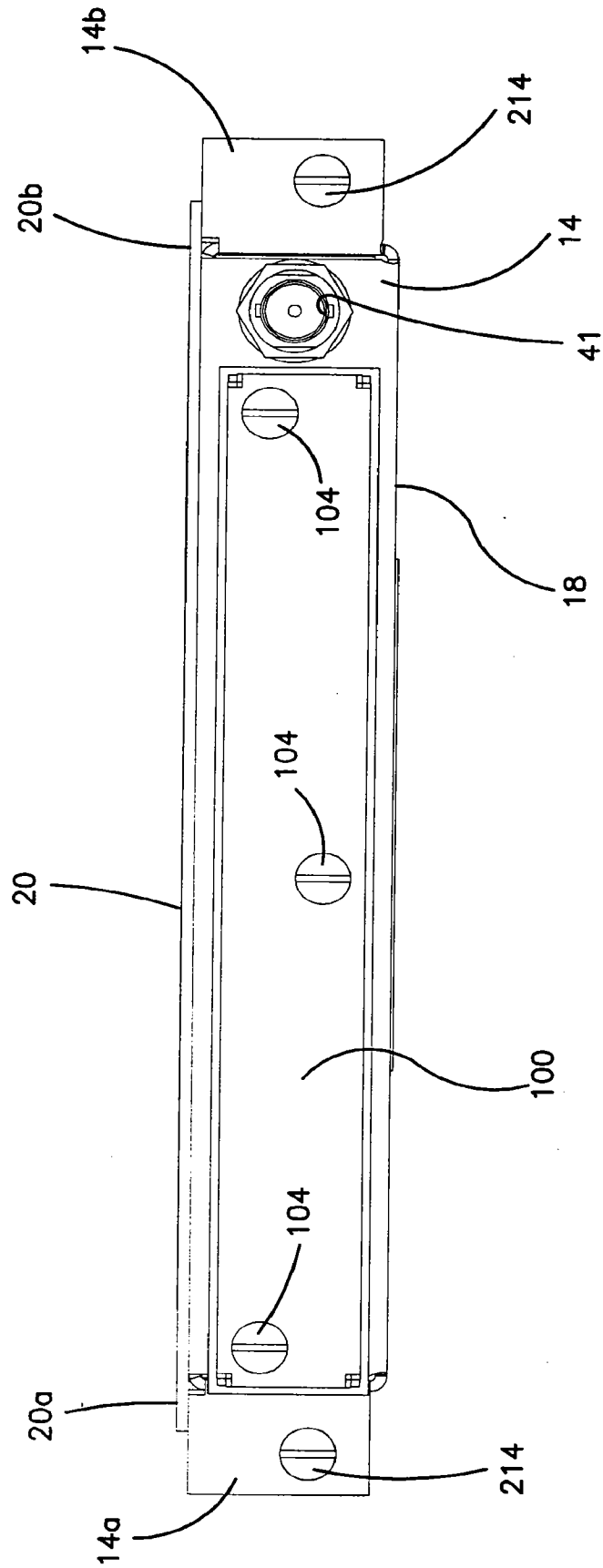


FIG. 5

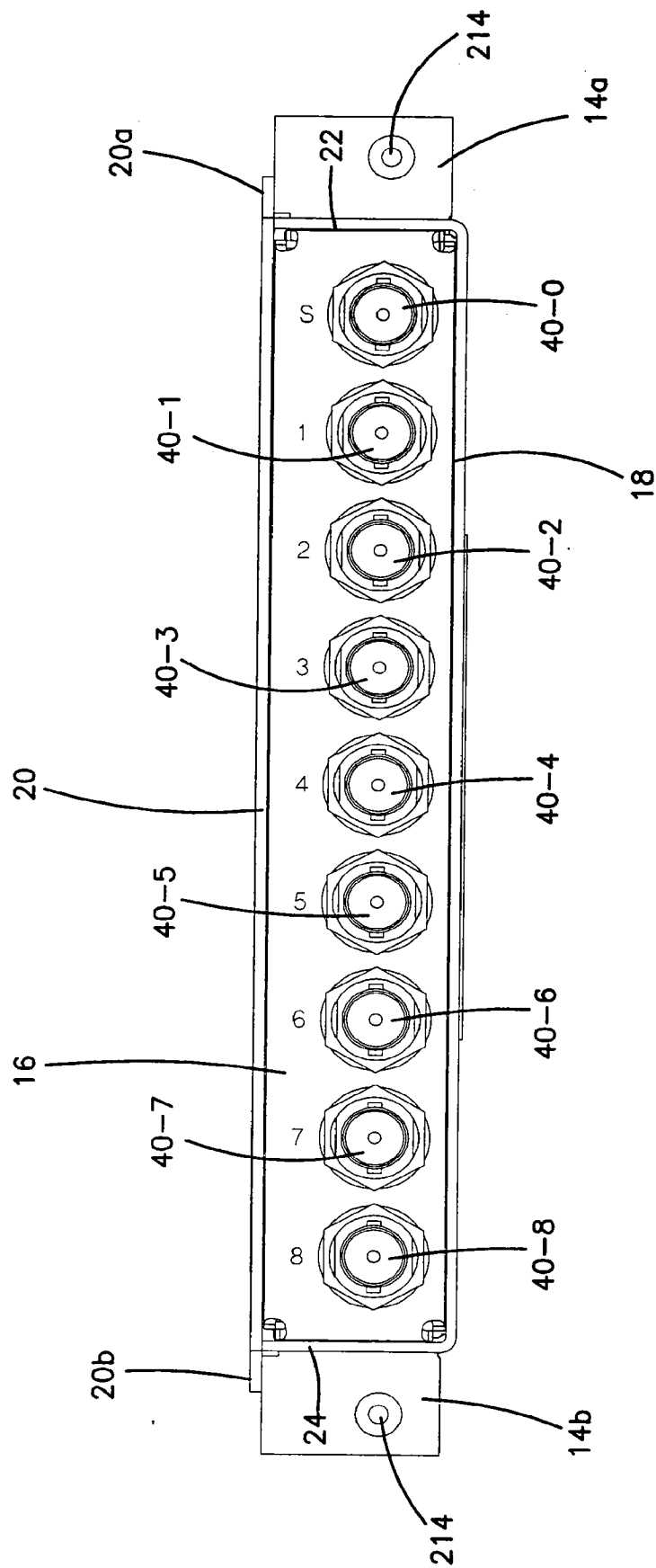


FIG. 6

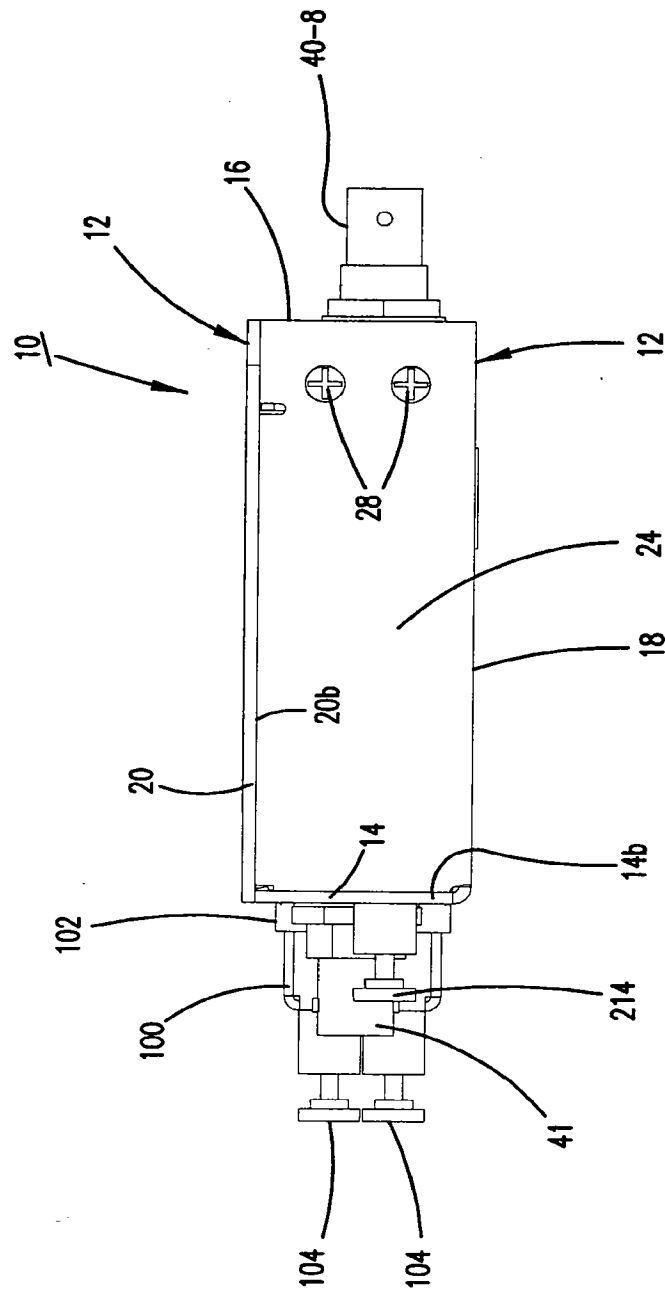


FIG. 7

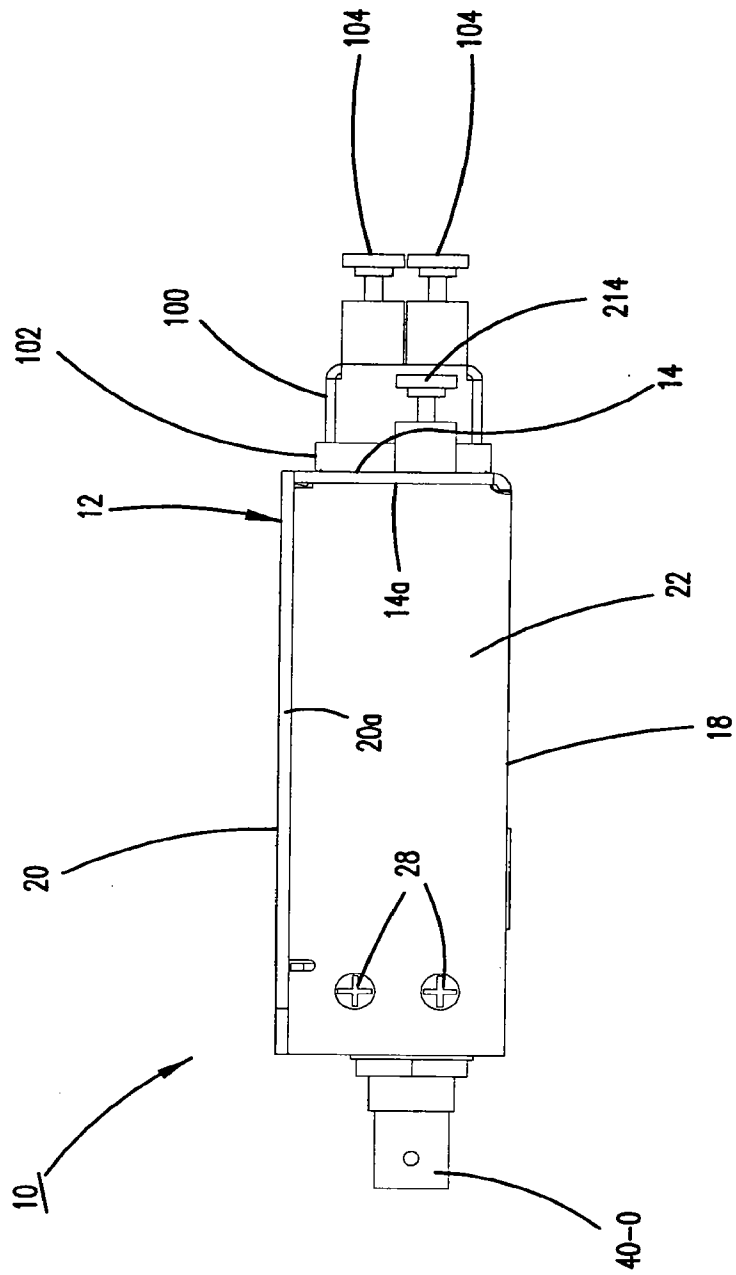


FIG. 8

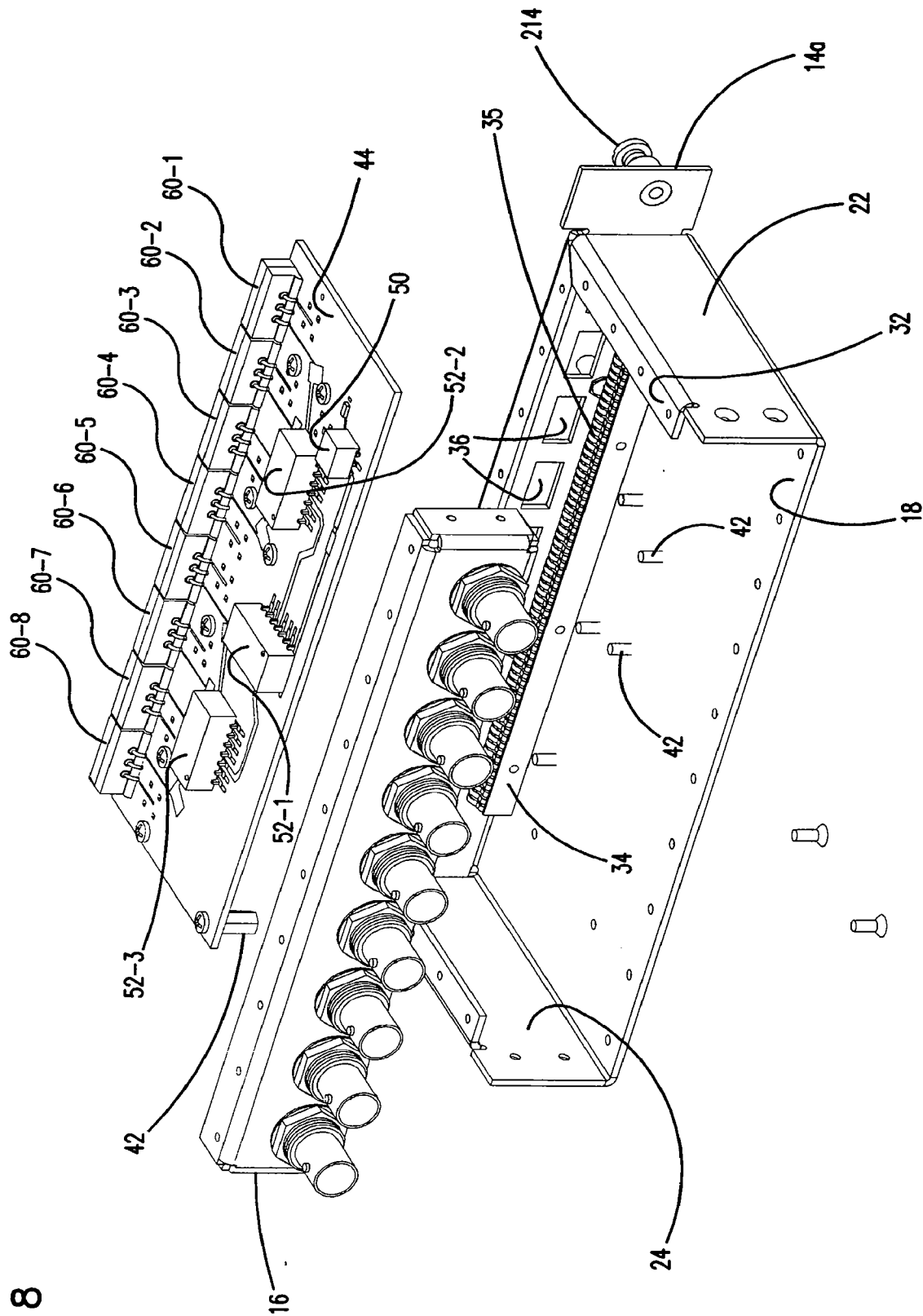


FIG. 9

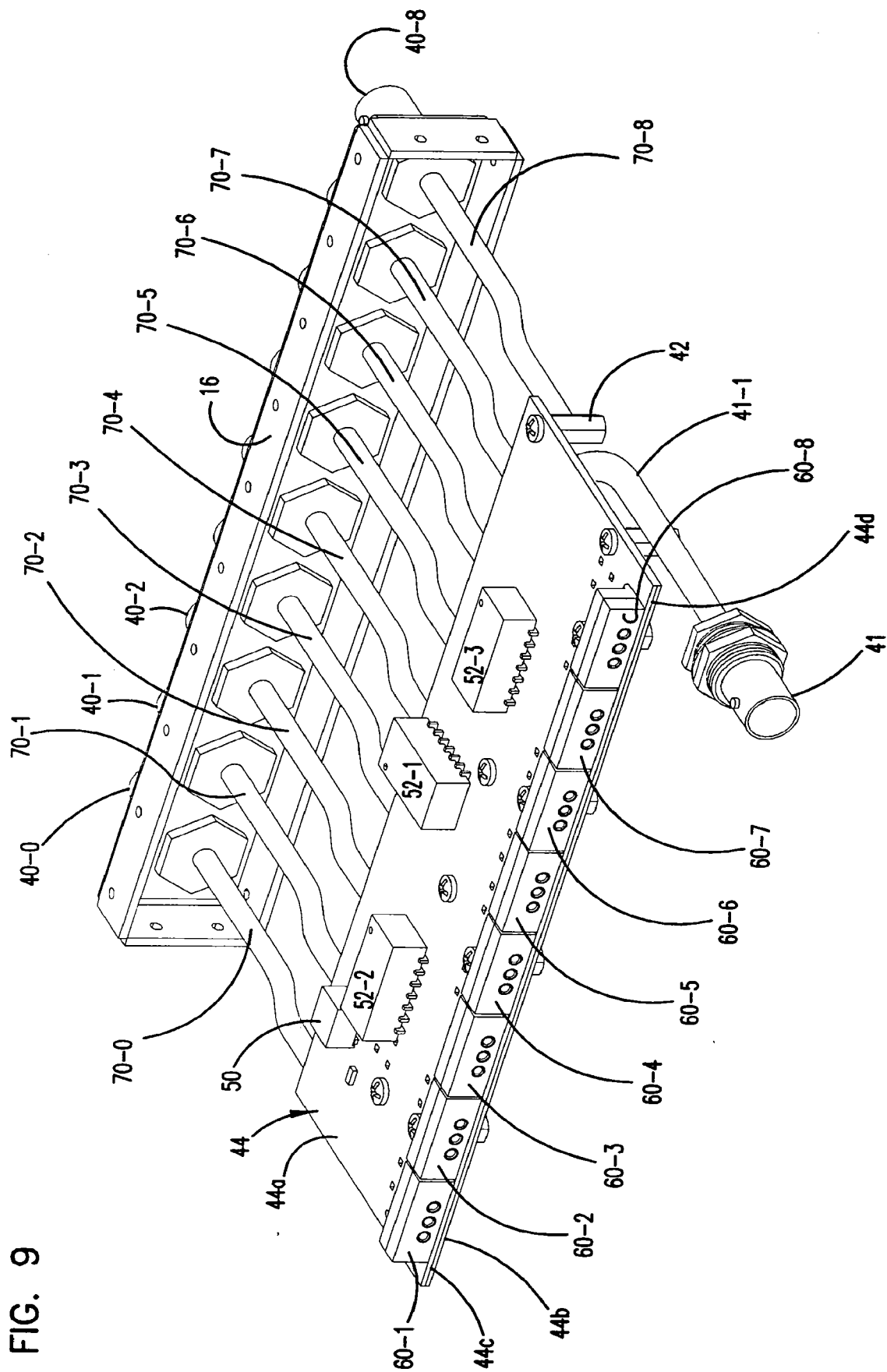


FIG. 9A

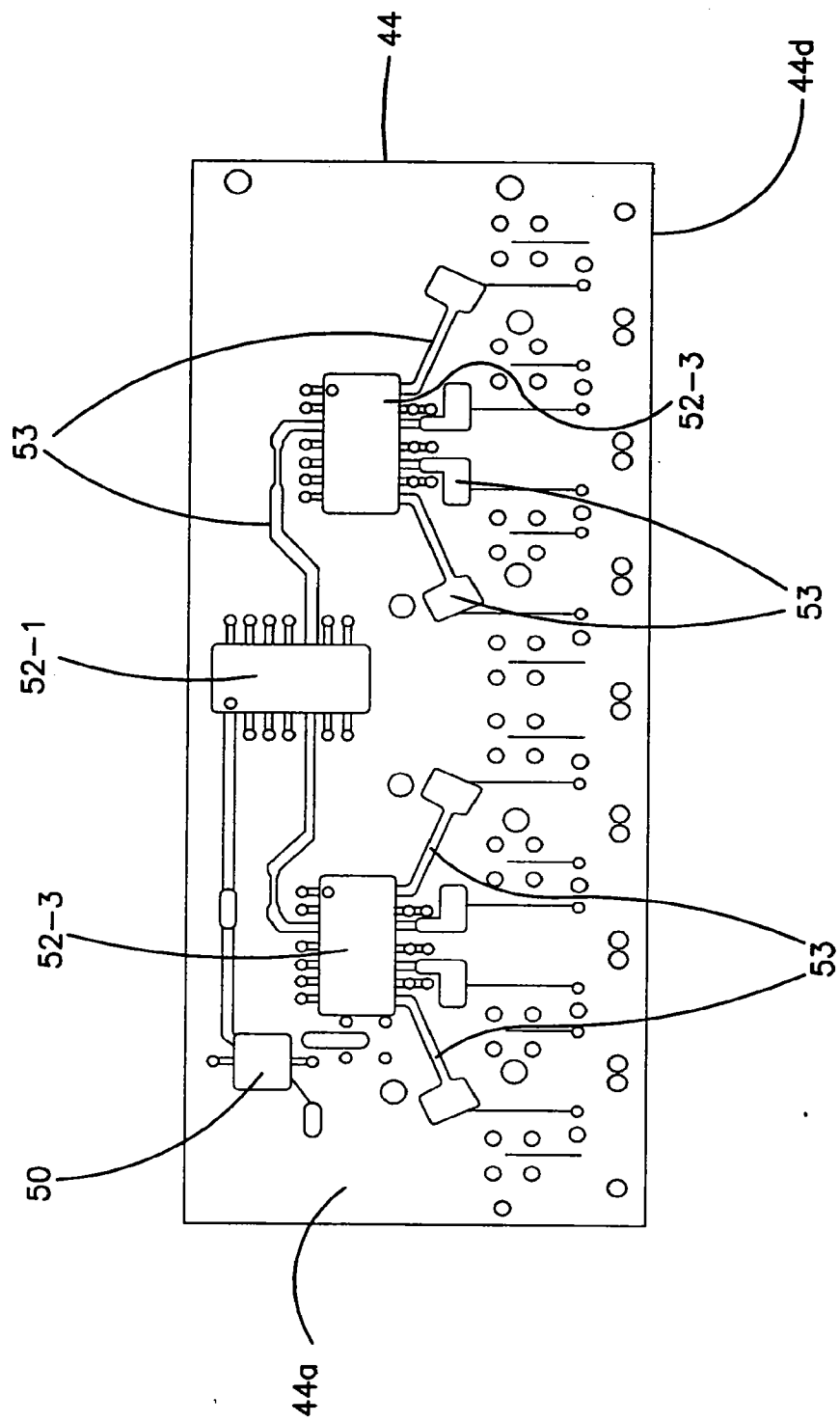
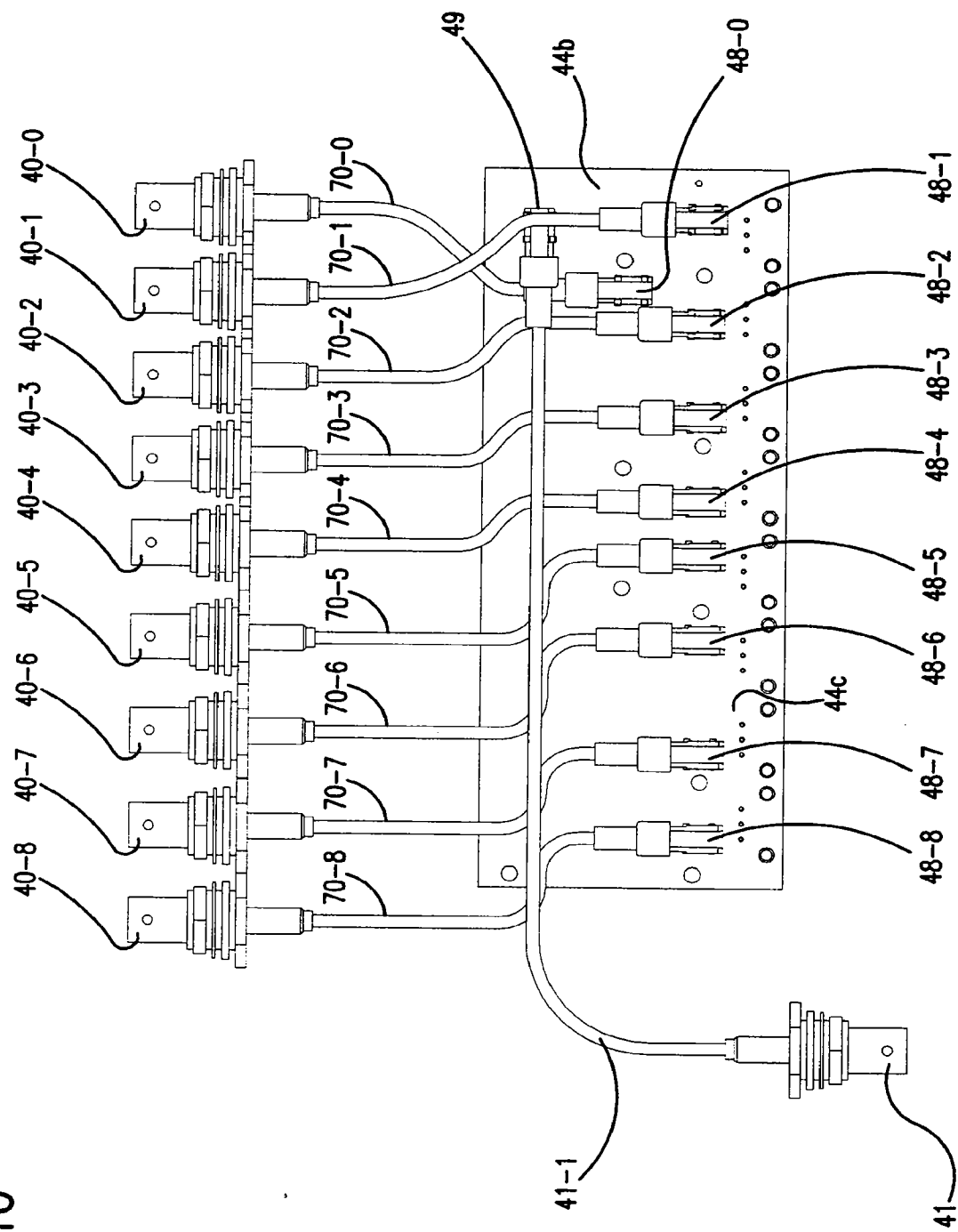


FIG. 10



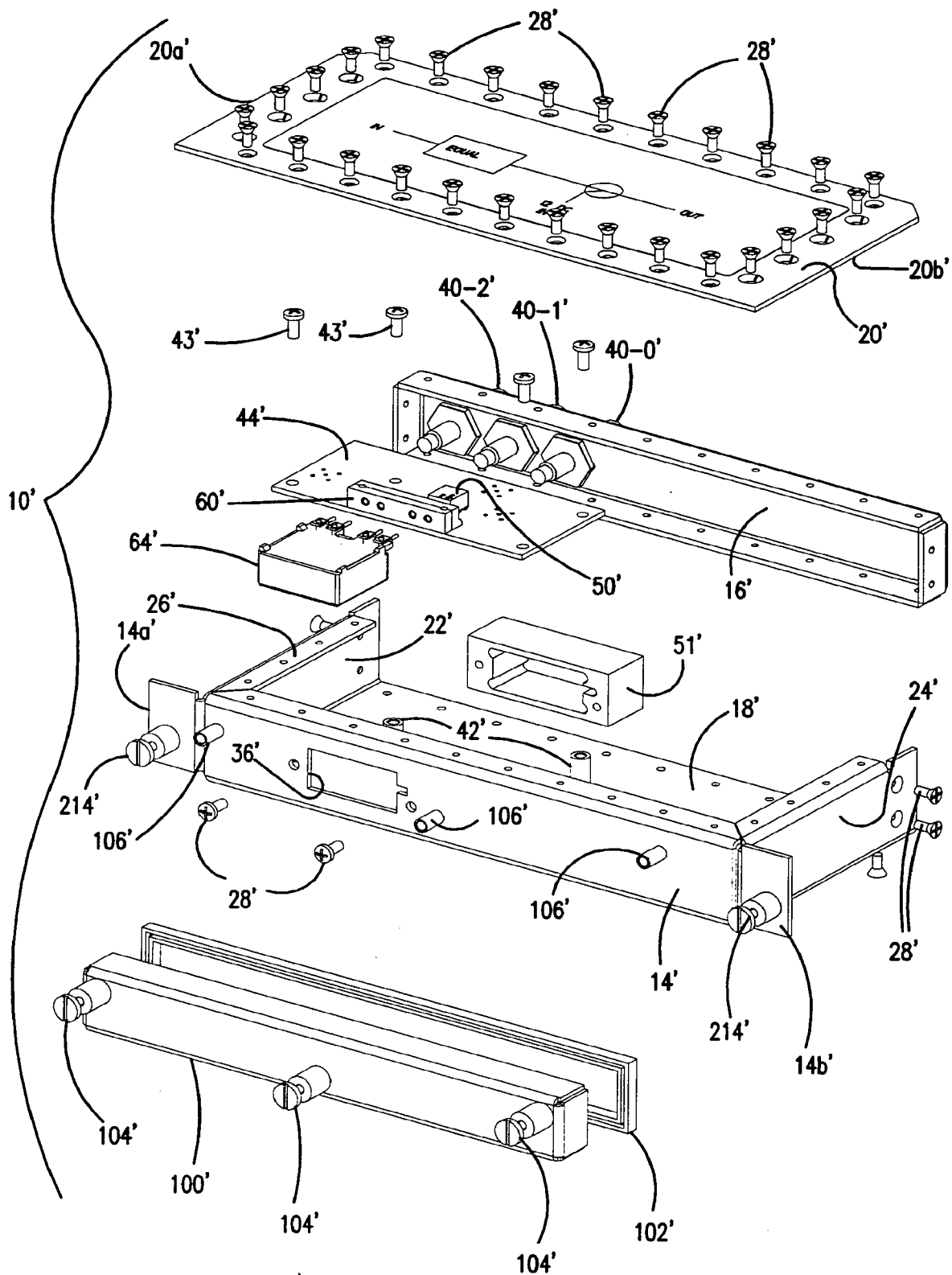


FIG. 12

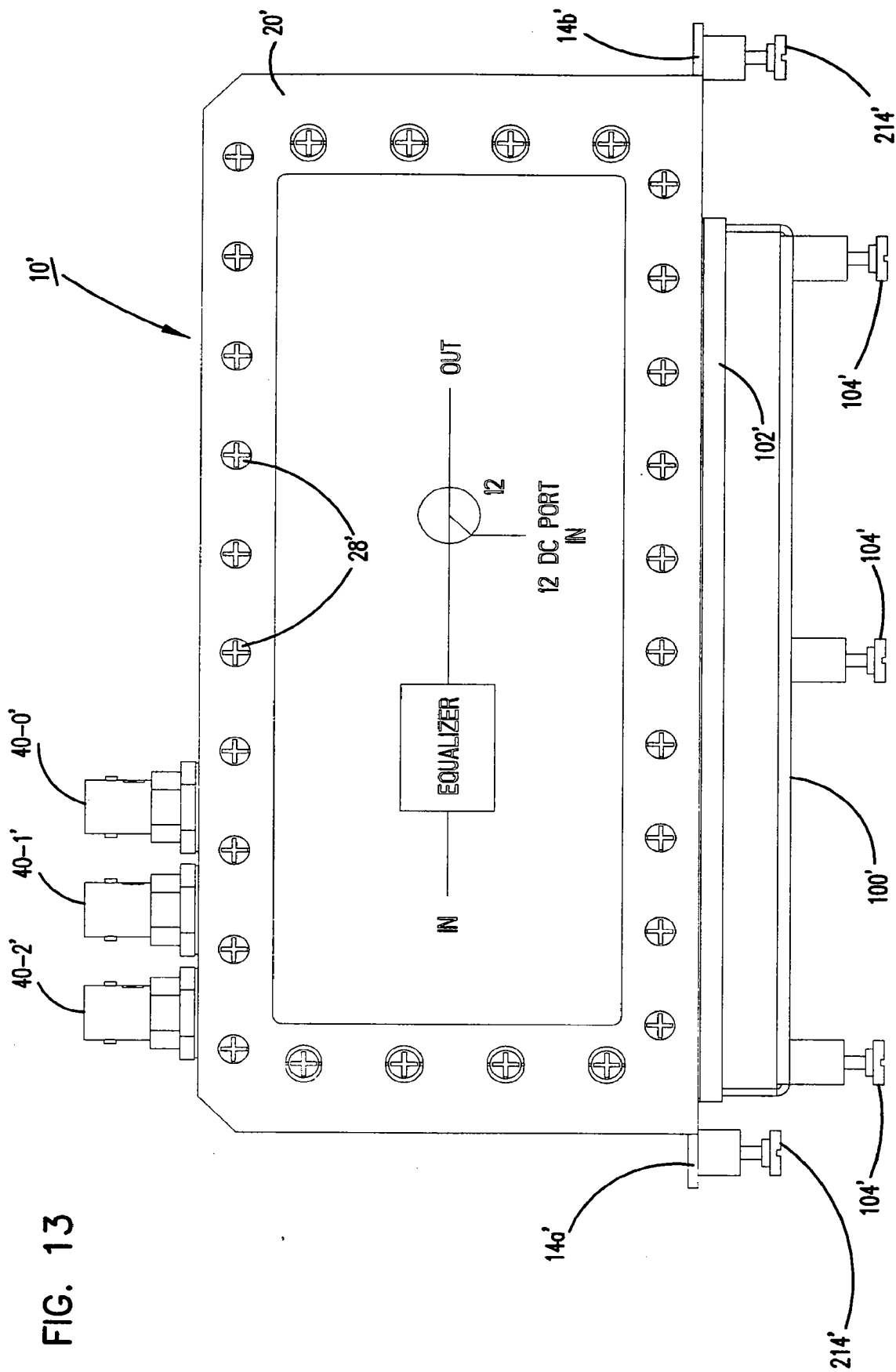


FIG. 13

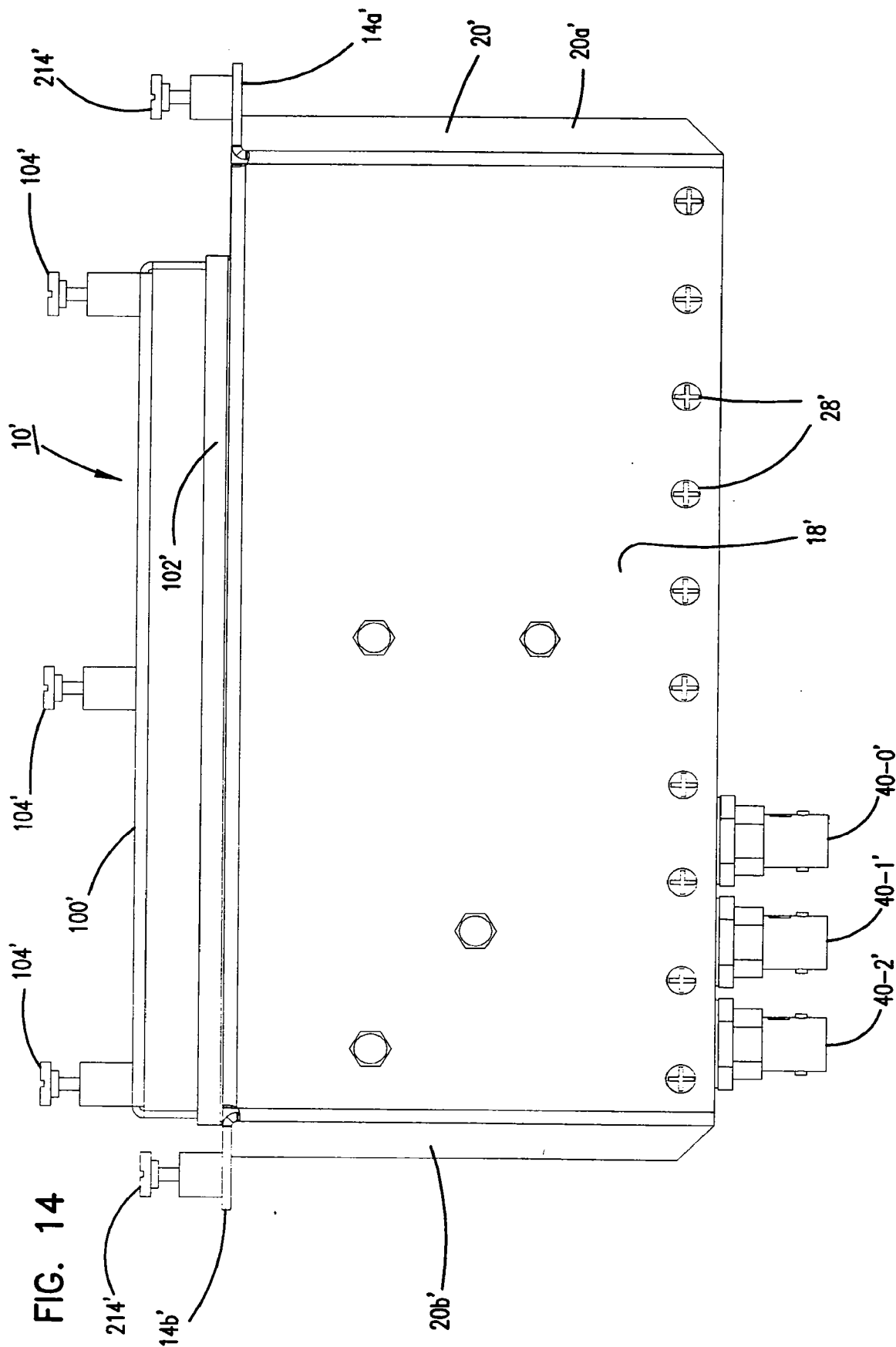


FIG. 15

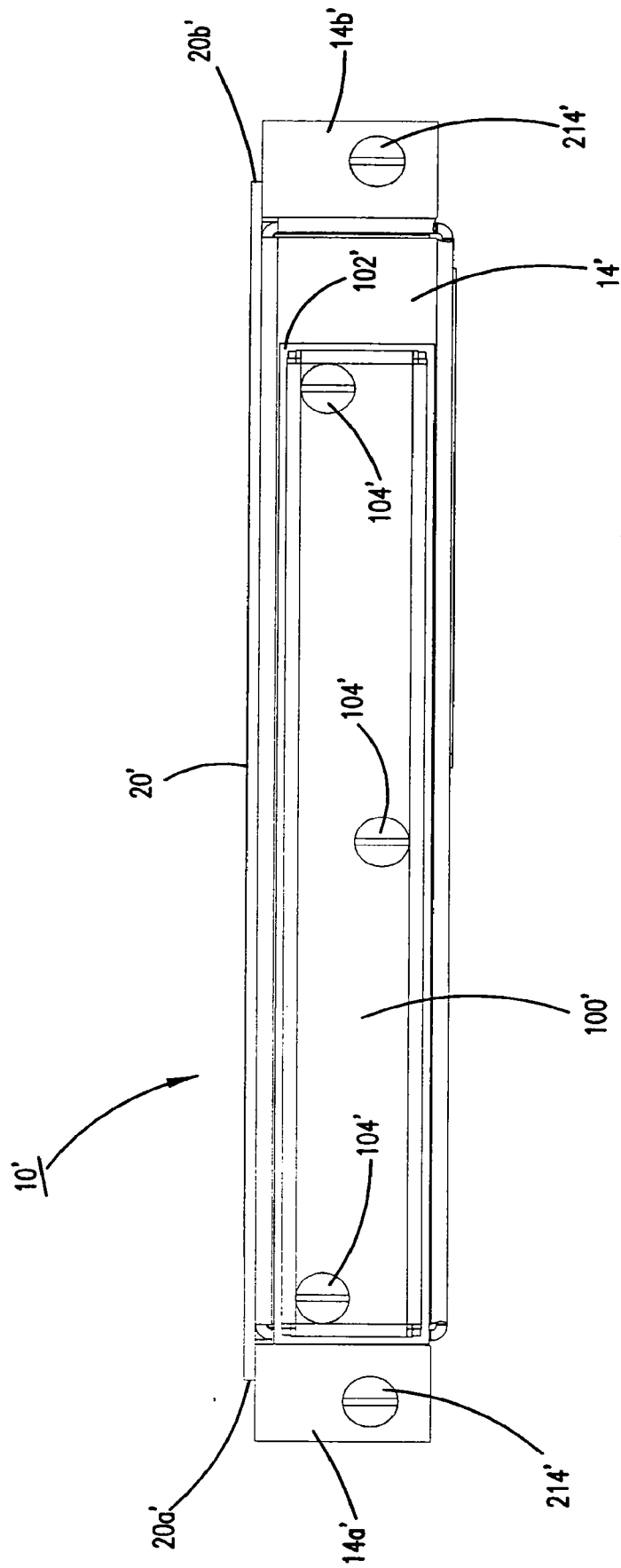


FIG. 16

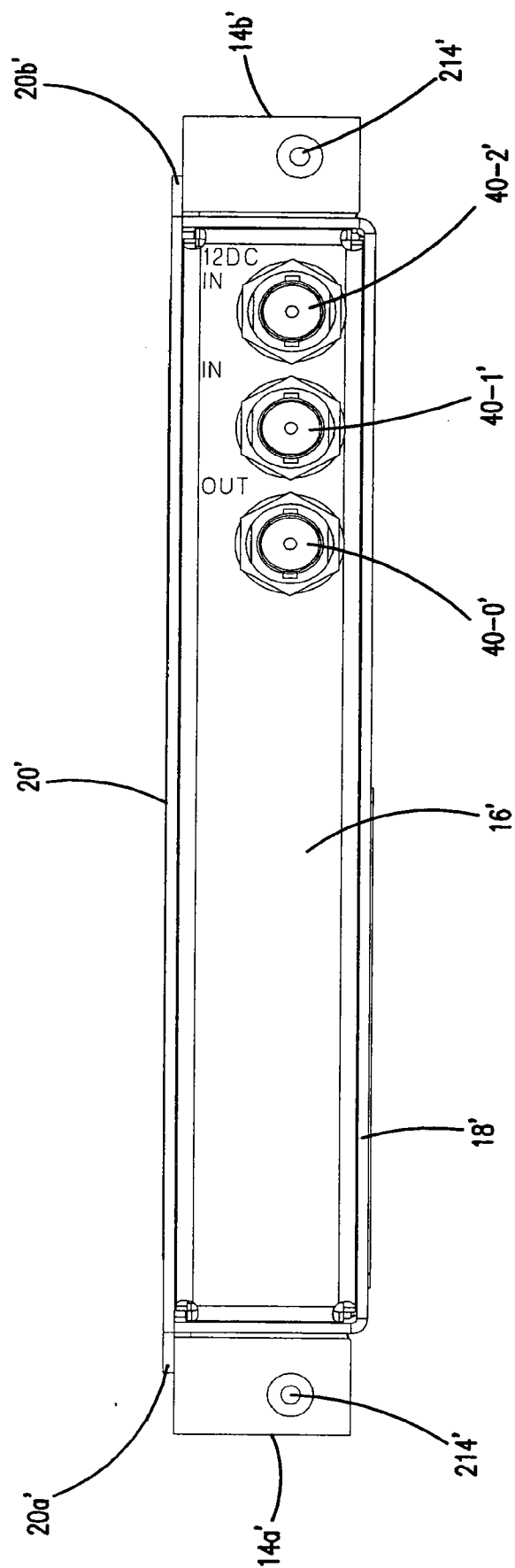


FIG. 17

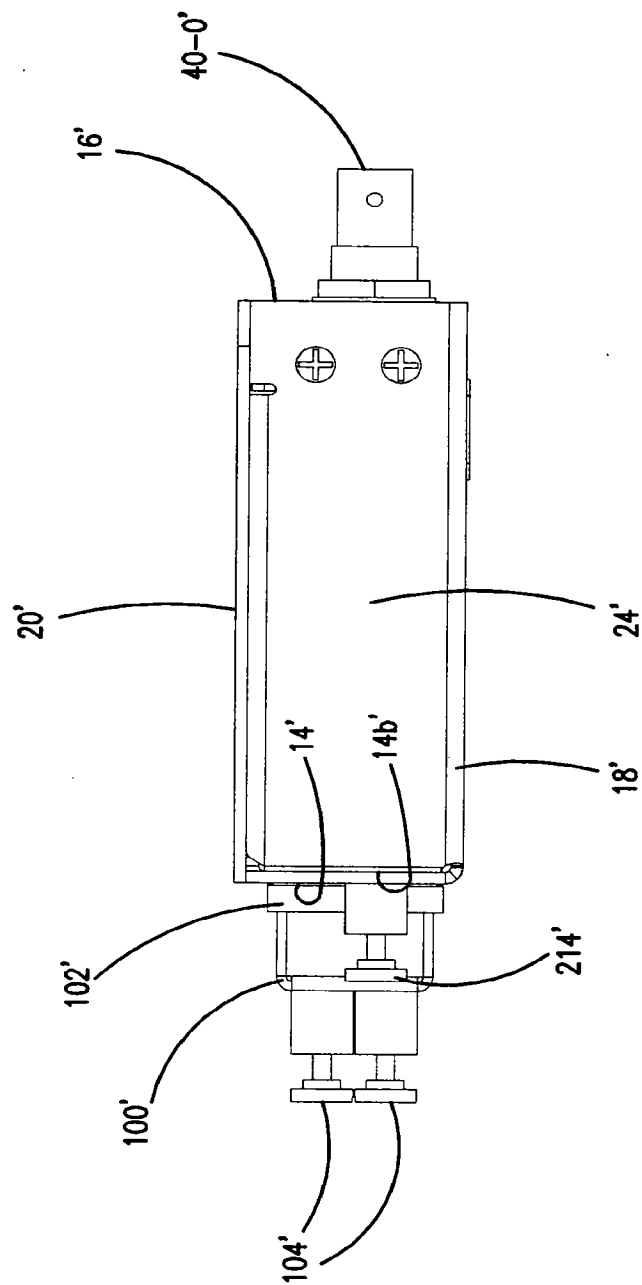
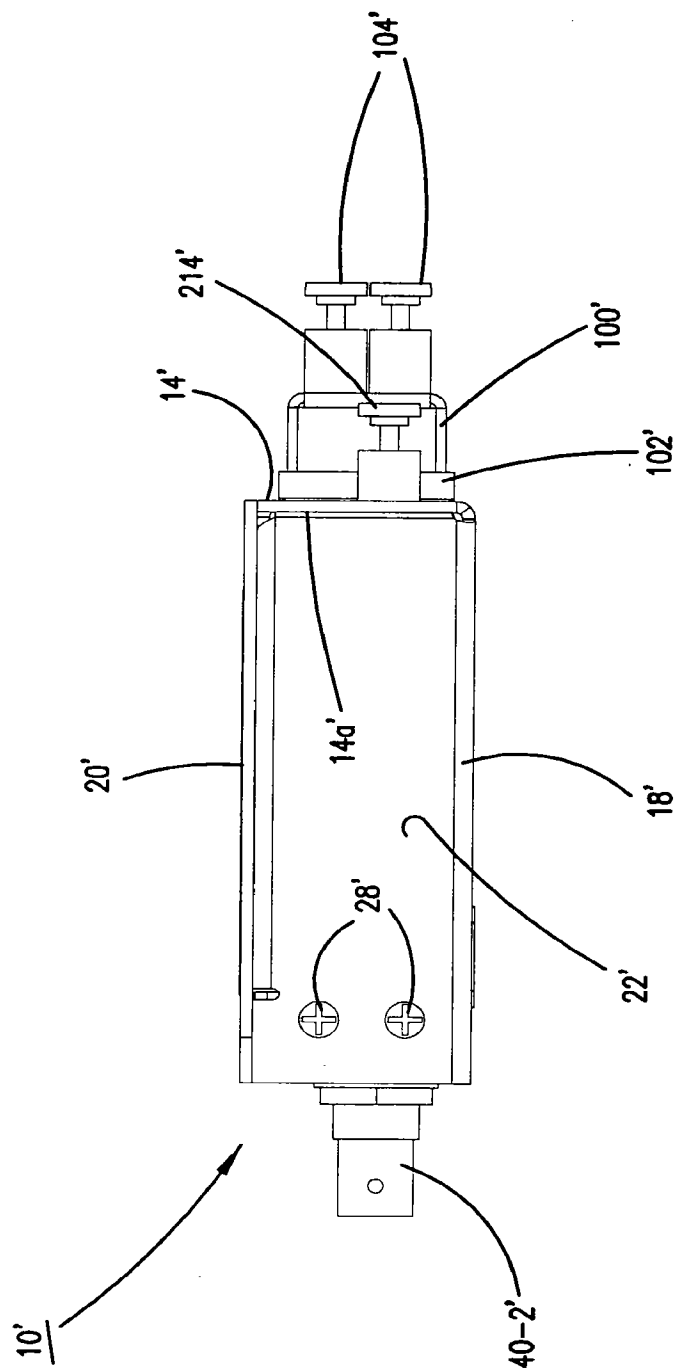


FIG. 18



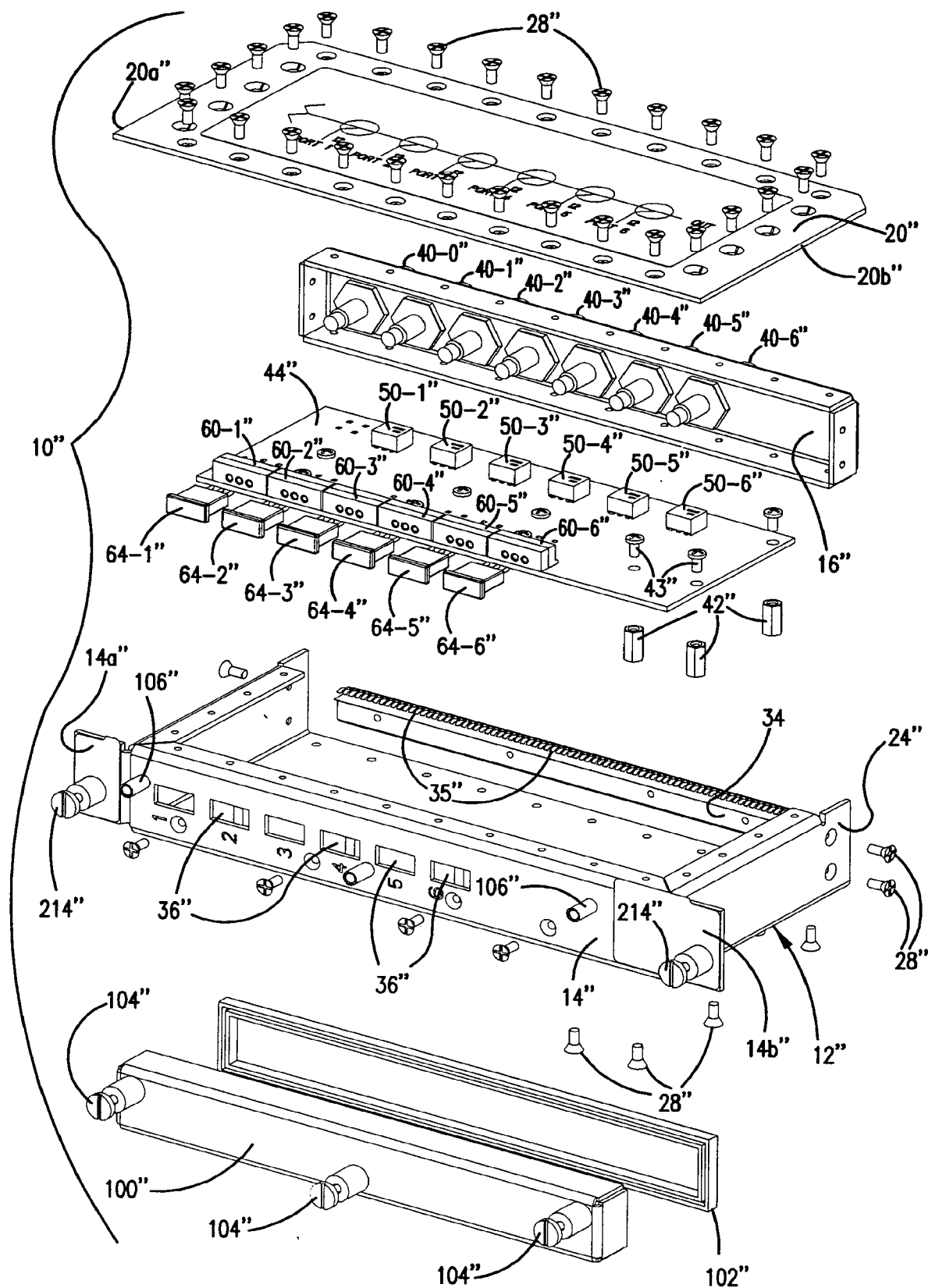


FIG. 19

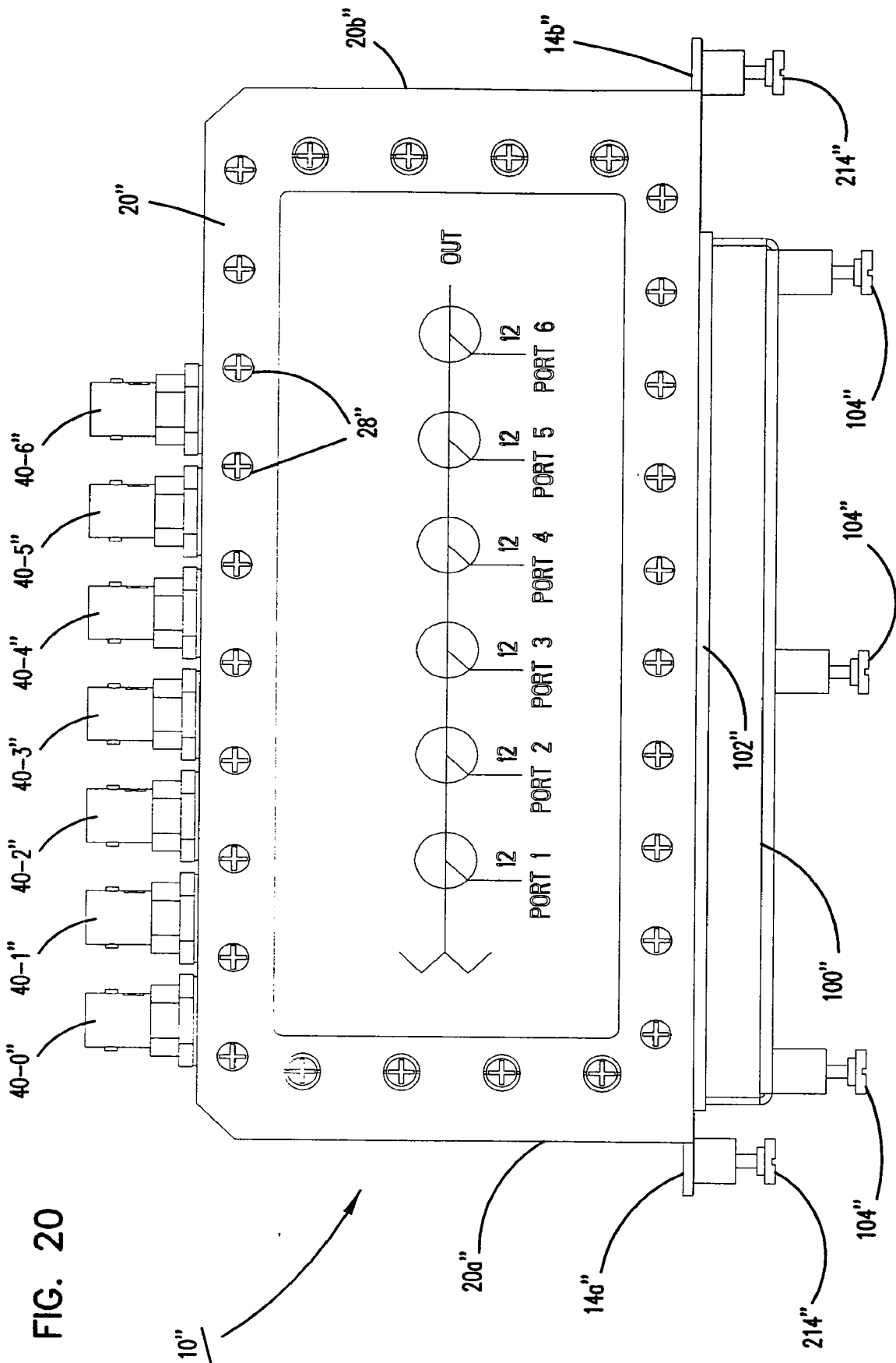


FIG. 20

FIG. 22

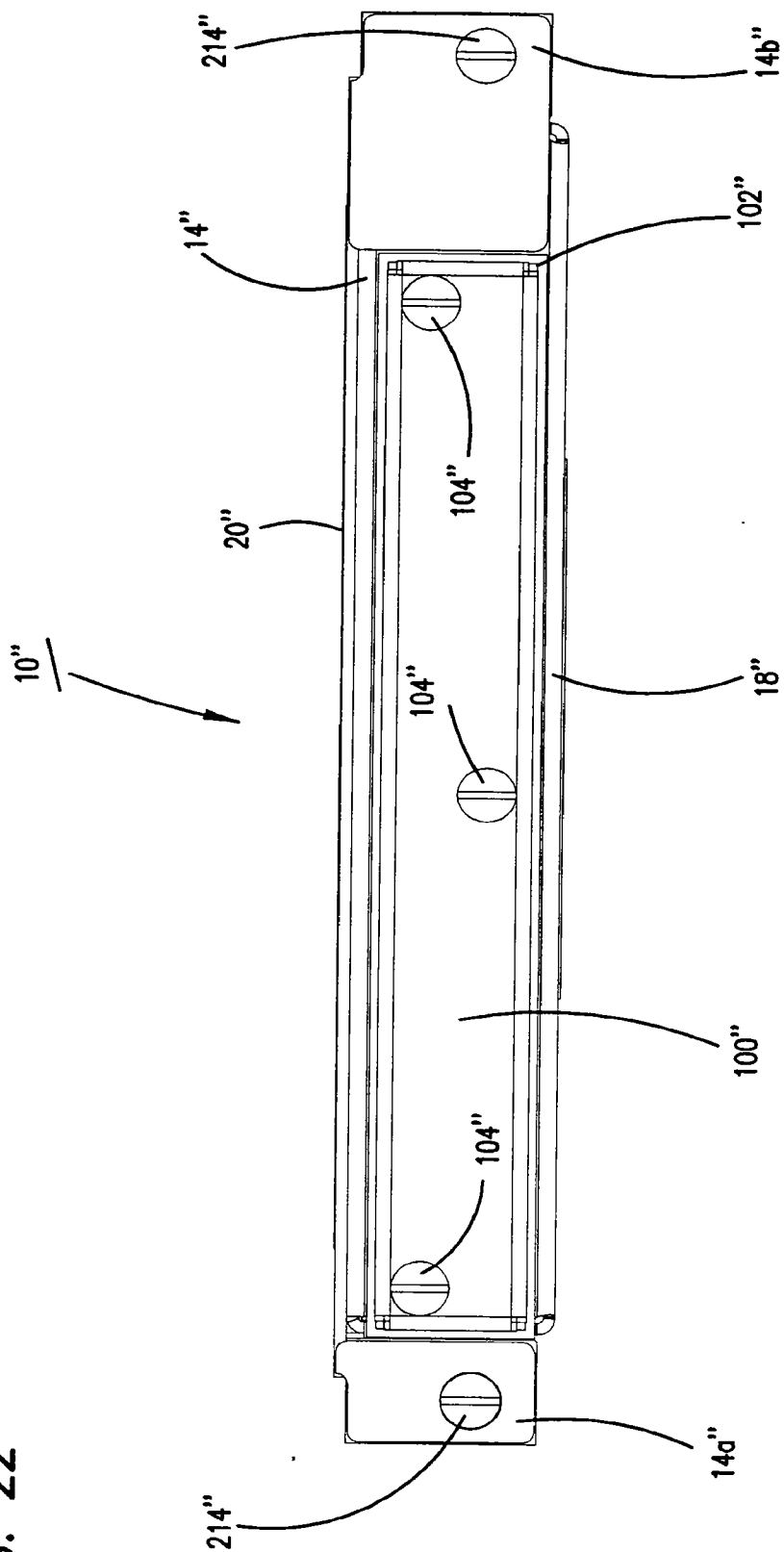


FIG. 23

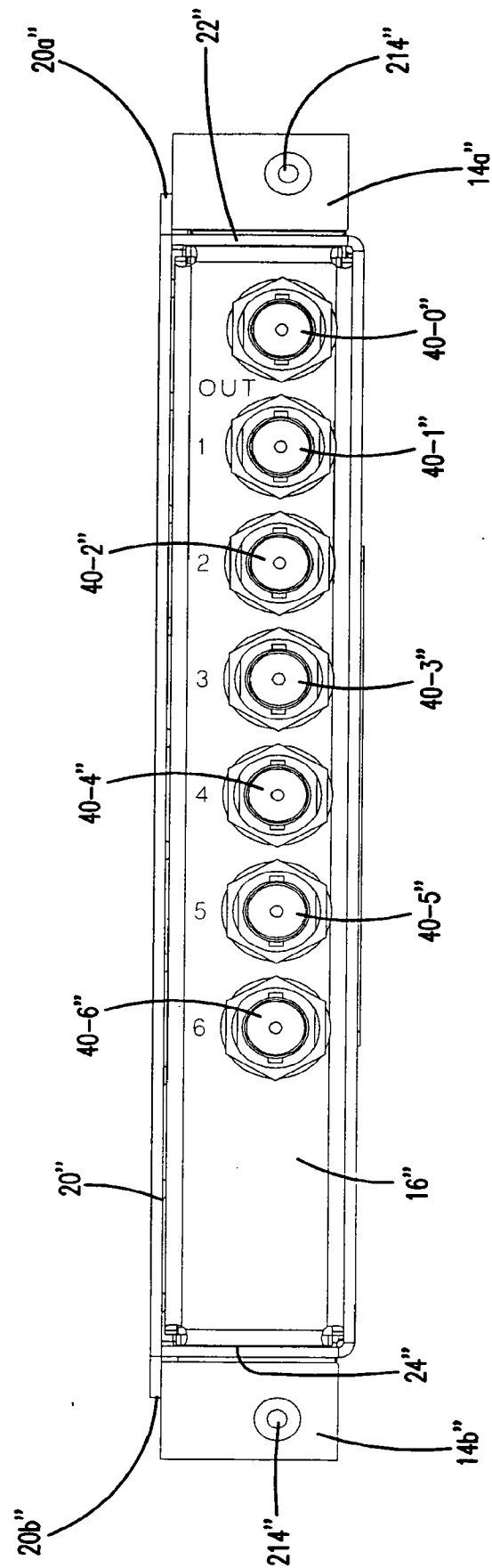


FIG. 24

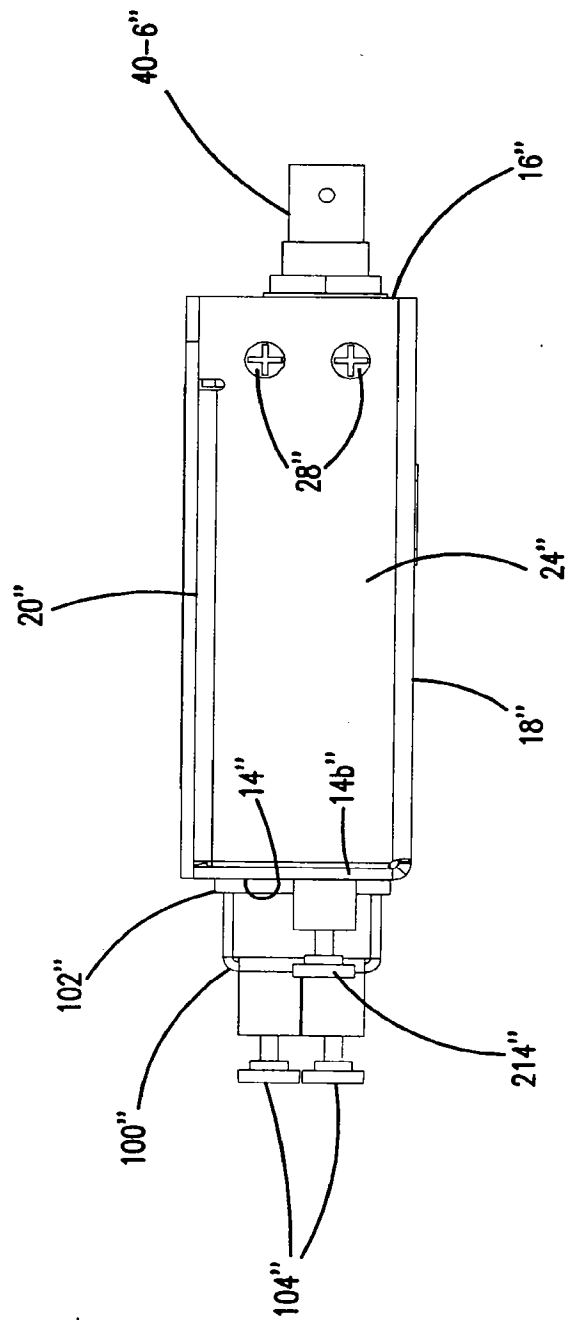
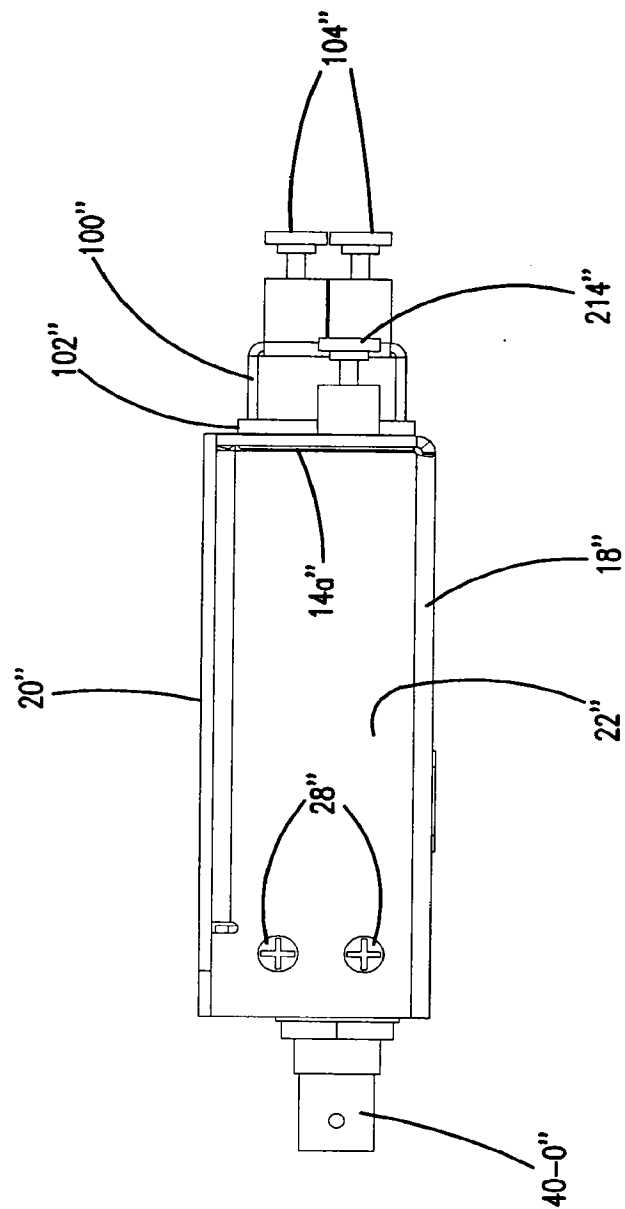


FIG. 25



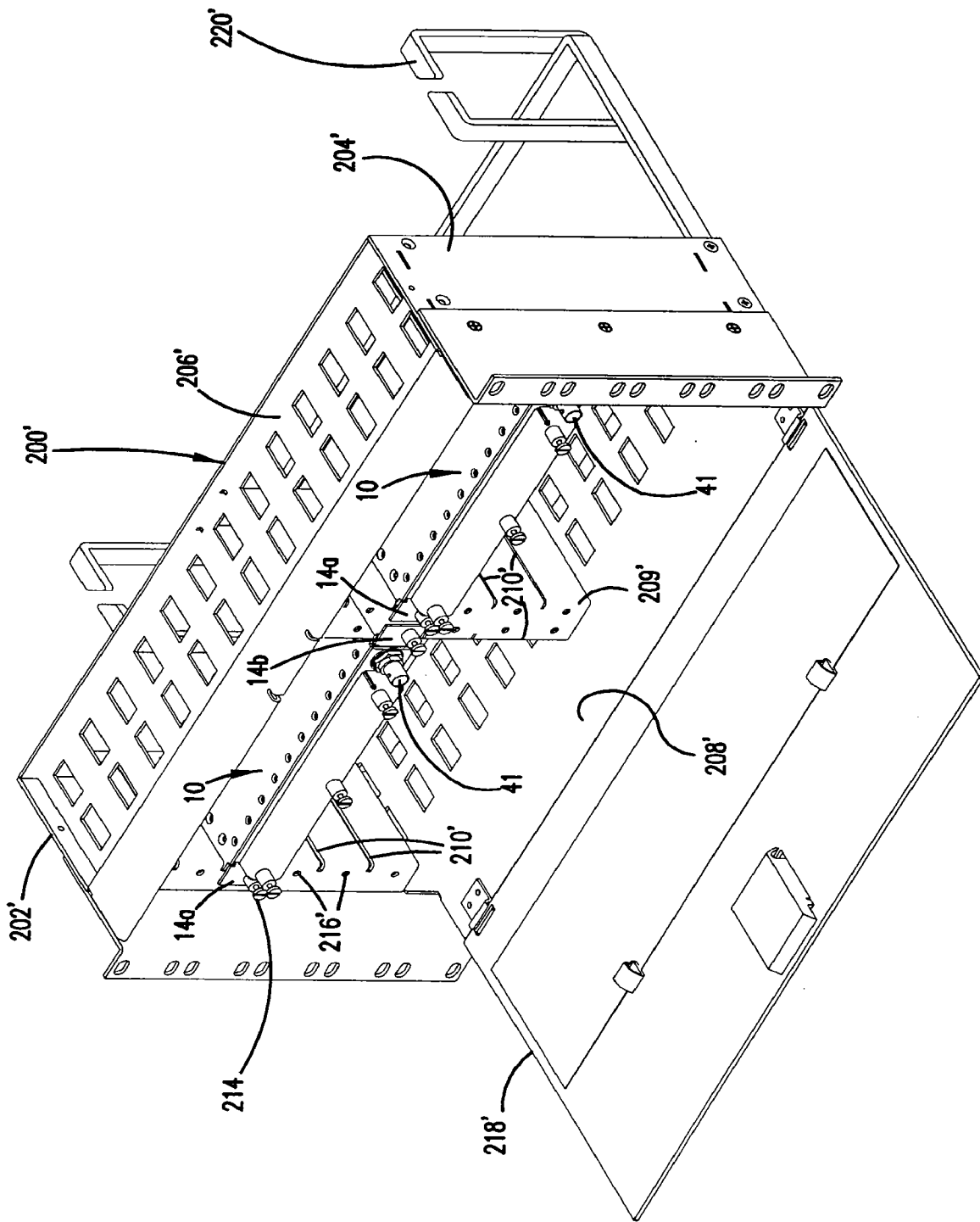


FIG. 27

FIG. 28

