(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 142 233 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 84306021.1

(22) Date of filing: 03.09.84

(51) Int. Cl.⁴: H 01 Q 11/06

(30) Priority: 03.09.83 GB 8323691

(43) Date of publication of application: 22.05.85 Bulletin 85/21

(84) Designated Contracting States: AT BE CH DE FR GB IT LI LU NL SE

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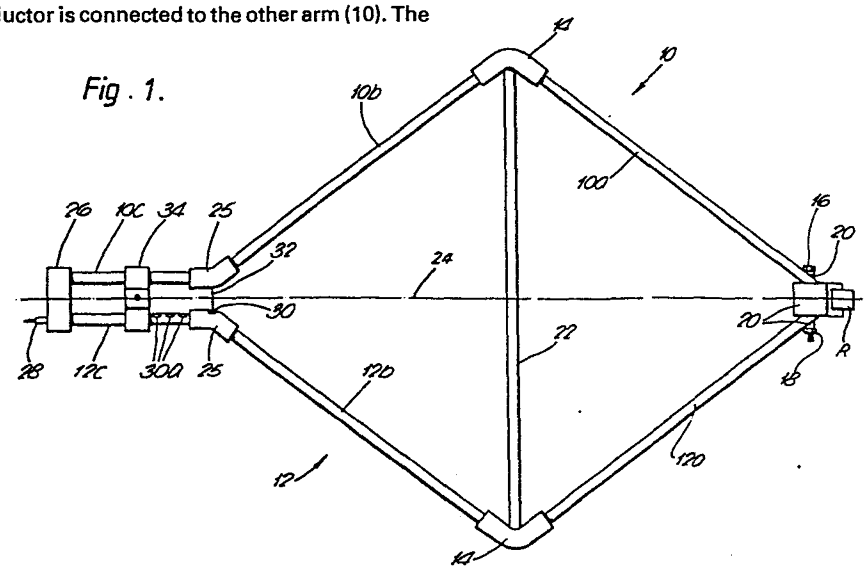
(54) **Rhombic aerials.**

(57) A rhombic aerial has two rigid conductive arms (10, 12) bent to form a rhombus. At one end the arms (10, 12) are connected together by a rigid interconnection (16, 18, 20) whilst conductive extensions (10c, 12c) extend from the other ends of the arms (10, 12). A co-axial cable (28) enters one extension (12c) and extends within that extension (12c) to a point at which its outer conductor is connected to one arm 12 and its inner conductor is connected to the other arm (10). The extensions (10c, 12c) are electrically connected by a movable slide (34) so that they form a balun. This enables the reactance of the aerial to be tuned to match the feed cable. Preferably the position of the slide (34) is adjustable so that the aerial may be tuned to a particular frequency band. The extensions may extend outwardly of the rhombus or may extend inwardly e.g. from one end of an arm to the other.

Fig. 1.



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RHOMBIC AERIALS

This invention relates to aerials suitable for radio reception and transmission, and more particularly to rhombic aerials. Amongst many other applications, these aerials can be used for T.V. reception and transmission.

Details of the basic form of the rhombic aerial were published as long ago as 1931 by Bruce, in connection with long-distance (ionospheric) communication. It consists of two arms formed by wires which can be regarded as a transmission line, arranged in the form of a rhombus (diamond). In this form, such aerials have been used ever since for receiving and transmitting in the h.f. band (3 to 30 MHz). An advantage of this type of aerial is its relatively wide-band frequency performance, since the aerial is a travelling wave aerial (as opposed to standing wave aerials such as Yagi arrays).

In the known rhombic aerials made from wire, the signal is fed to the two wires at one end of the rhombus, and to ensure correct termination it is necessary to connect a suitable resistor between the other ends of the two wires. The angle formed by each wire in the side corners of the rhombus is also important for the performance of the aerial, and its value depends on the wavelength and the aerial dimensions. The value of this angle can be calculated in a known way.

The present invention arises out of work to adapt the known rhombic aerials for use at higher frequencies, e.g. VHF and higher. One use of such an aerial would be for television reception, though of course the invention is not limited to such use, or to aerials for any particular frequency band. For UHF television the usual receiving aerial system used at present is the Yagi array. Yagi arrays can only be designed for specific television group bands. This means that three models are required to cover the whole range in the United Kingdom. This presents stocking problems.

The present invention seeks to overcome this problem so that the aerial may be used at higher frequencies. It does this by providing extensions on each arm of the rhombus, usually from one pair of adjacent ends of the arms, the extensions being electrically conductive and forming a transmission line in or close to the zero potential plane. The two extensions are electrically connected together and so form a balun. This permits the reactance of the aerial to be tuned so as to match that of a feed cable to the aerial.

It the position of the connection is fixed, then it is possible to match the aerial to the cable only at a particular band of frequencies. Therefore it is desirable that the position of the connection is adjustable, e.g. by providing a slide on the extensions.

The extensions may extend outwardly of the rhombus (normally in the plane of a rhombus), in which case it is possible for the cable to extend along one extension or, if the extension is hollow, to extend within it. Normally the extension will be at the ends of the arms of the rhombus to which electrical connection is made to the cable. It is also possible to provide the extension at the other or both ends, and this permits the cable to extend through or along one of the arms as discussed in our European Patent Application No. 84.305136.8.

Another possibility is for the extensions to extend inwardly of the rhombus. One convenient arrangement is then to have each extension extending from one end of a arm to the other so that the arms and extensions from two triangles. The triangles are arranged with the extensions parallel and fastened together. It the extensions are tubular, the cable may then enter the aerial through a mid point of one of the extensions.

It is also possible for there to be four arms forming two rhombi with their planes parallel. The ends of the arms on one side of the zero potential plane may then be connected together and to a common extension, and the ends of the arms on the other side of the zero potential plane connected together and to another common extension, the two extensions then being connected together.

Various embodiments of the invention will now be described by way of example, with reference to the accompanying drawing, wherein:

Figs. 1 to 6 are respective plan views of six embodiments of rhombic aerial,

Fig. 7 is a side elevation of the aerial of Fig. 6,

Fig. 8 is a plan view of a seventh embodiment of rhombic aerial, and

Fig. 9 is a side elevation of the aerial of Fig. 8.

The aerials described below are manufactured from circular section tube. It is believed that all known rhombic aerials use relatively thin wires. However, the use of arms in the form of tubes has a number of advantages and some of these are discussed in our European Application No. 84.305136.8. As mentioned in that application, however, elliptical or pseudo-elliptical tube can be used, or elements of U, L, I or any other cross-section. The material used can be copper, brass, aluminium, various alloys or any other material which can be made to conduct electricity. One further possibility also discussed in our European

Application No. 84.305736.8 is for the arms to be made of conductive plastics material.

The aerial shown in Fig. 1 comprises two arms 10, 12 formed by lengths of tube. The tube of arm 10 is bent into two legs 10a, 10b with a 130° bend between them. An optional reinforcing sleeve 14 is provided at the bend. The tube of arm 12 is similarly constructed of two legs 12a, 12b and a sleeve 14. The two arms are arranged in the same plane in the form of a rhombus. At the front end of the rhombus, they are held together by a nut 16, and a bolt 18 of plastics or other insulating material, with insulating spacers 20. The ends of the tube may be connected by a resistor or other impedence R across the spacer, of a value to terminate the line correctly, but it has been found that this is often unnecessary, particularly when the aerial is a receiving aerial. It is also possible for the spacer 20 to be resistive, in which case it is unnecessary to provide a separate impedance R. The thickness of the tubular conductors forming the arms may be the reason for this. The 130° bends in the tubes are spaced and supported by a plastics boom 22, by means of which the aerial may be affixed to a mast or other supporting structure.

The aerial has a plane of symmetry, 24, which is the earth plane or zero potential plane of the aerial. At the rear end of the rhombus, the tube of each arm 10, 12 is bent at 25 to provide an extension 10c, 12c, extending rearwardly, parallel to each other and to the earth plane. These form a short transmission line in or close to the earth plane. The ends of the extensions 10c, 12c are held mechanically and short-circuited by an end piece 26 brazed to them.

A co-axial signal feed cable 28 is led into the tube of arm 12 at the rear end and passes within the tube along the extension 12c to a hole 30 at the bend 25. The outer conductor of the cable is soldered to the edges of the hole 30. The inner conductor of the cable 32 is taken across the gap between the bends 25 and soldered to the bend 25 of the tube of arm 10. In this manner, the signal feed connection from the unbalanced co-axial cable 28 is made without disturbing the balance of the aerial.

The function of the transmission line formed by the extensions 10c, 12c is to form a balun for tuning out the reactance (the imaginary part of the impedance) of the aerial so as to match the feed cable. If desired, a non-adjustable balun could be formed simply by the extensions 10c, 12c and the end piece 26, the length of the extensions being chosen (in relation to the size of a quarter-wavelength) to give the desired effect. However, this would give an aerial which was perfectly matched only in one particular band of frequencies. To enable the same aerial to be matched for different frequency bands, therefore, an adjustable slide 34 is provided on the extensions 10c, 12c. This slide can be moved to any desired position along the extensions 10c, 12c and secured there (e.g. by a screw fastening) to short together the two tubes. In this way, the effect length of the transmission line can be adjusted to tune the reactance of the aerial precisely for a given frequency band, giving optimum matching over the range of frequency bands at which the aerial is capable of operating.

Fig. 1 also shows another option. The tube extension 12c may be provided with not just one hole 30 but also with a series of spaced holes 30a. The cable outer can be soldered at any one of these, with the cable inner 32 being soldered at an opposing point on the extension 10c. The cable then "sees" not a resistance R_0 (the real part of the impedance of the aerial) but n^2R_0, where n is the turns ratio of the (ideal) transformer formed by the transmission line from the selected hole to the bend 25. By selecting a suitable hole, therefore, the real (resistive) part of the impedance of the cable (its characteristic impedance) can be matched to that of the aerial. The slide 34 is then adjusted to counter (tune out)the reactance of the aerial and transformer combination thus formed. In place of a series of holes 30a, the extension 12c may have a longitudinal slot, and the cable can be positioned at any desired position along the slot.

By way of example, suitable dimensions for the aerial are:

length of each leg 10a,10b,12a,12b	990 mm	(39 inches)
length of extensions 10c,12c	200 mm	(8 inches)
spacing of extensions 10c,12c	38 mm	(1.5 inches)

The embodiment of Fig. 2 is in many respects similar to that of Fig. 1, and where appropriate the same reference numerals have been used, and description of corresponding parts will not be repeated. The difference lies at the front end of the aerial. In place of the insulating spacers 20 and the optional resistor R, the front ends of the tubular legs 10a, 12a are bent at 25a, and have forwardly extending extensions 10d, 12d. These are provided with an end piece 26a and a movable slide 34a, forming a transmission line essentially identical to that at the rear end of the aerial. This enables the reactance at the forward end of the aerial to be turned out, to optimise the termination and improve the aerial efficiency.

Fig. 3 shows a preferred form of this aerial. Again, the same reference numerals have been used as previously where appropriate. In this aerial, however, the transmission line extensions have been provided inwardly instead of outwardly, and the resulting construction is mechanically advantageous. The aerial essentially comprises two simple triangles made of tube. In this example, as a matter of rhombic aerial design with which a skilled man will be familiar, the bends between the legs 10a and 10b and between the legs 12a and 12b are 90° rather than the previous 130°, and the long sides 10e, 12e of the two triangles lie side by side (at a suitable spacing for the transmission lines which they form). Movable slides 34, 34a have the same function as previously. It will be appreciated that the length of tubes 10e, 12e between the two slides is effectively "dead" as far as the aerial is concerned, being in or close to the earth plane, and so metal nuts and bolts 36 can be used in this region to hold the two triangles together at the desired spacing. It will be seen that the tubular sides 10e, 12e effectively provide a mechanical supporting boom for this aerial, which can be fixed to a mast, so that there is no need for a separate plastics boom 22, or for other insulators. Expense of manufacture is further reduced by the fact that the two triangles can be identical, so that the aerial can be made up of two identical modules. The signal cable 28 can feed to the interior of the tubular side 12e via a central hole 38 (which is convenient for the likely position of a supporting mast).

The aerial of Fig. 3 can be modified by dispensing with the slides 34 and 34a. Instead, pairs of pre-drilled holes are provided at various positions along the sides 10e, 12e, at predetermined positions corresponding to the positions of the slides for given frequency bands.

The bolts 36 are then used to fulfil the function of the slides 34, 34a as well as for securing the triangles; the aerial will be supplied with instructions as to which fixing holes should be used for which frequency bands. This system is particularly well suited for T.V. reception aerials, since it can be manufactured cheaply, erected easily, and only one model will cover all the frequency bands in use.

Another modification would be to have the sides 10e, 12e suitably spaced one above the other, rather than side by side as shown. They are then both in the ideal position, in the earth plane, rather than just close to it. Against this, the legs 10a, 10b, 12a, 12b are not quite co-planar.

Figs. 4 and 5 show slight modifications of the aerial of Fig. 3. In Fig. 4, the rear, feed end is provided with a double balun, by reason of the provision of a rearward extension 10f, 12f, giving another transmission line, and including more holes 30a for connection of the feed cable, and a further slide 34b. Thus, this gives more flexibility in ensuring correct matching of both real and imaginary parts of the impedance. Fig. 5 shows a simpler version, with no extra slide 34b, in which the co-axial feed cable is simply connected at the rear end of the transmission line projection 10f, 12f. Thus, a predetermined ratio is provided for matching the real part of the impedance and the imaginary part is tuned out as usual with the slide 34.

Figs. 6 and 7 illustrate how the geometry of the legs 10a, 10b, 12a, 12b can be modified to increase aerial efficiency. Along the usual tubes there are attached metal strips 40, whose width increases from the ends of the aerial towards the middle.

Figs. 8 and 9 illustrate an aerial with two elements, one above another, each substantially as described above, having two tubular triangles 10, 12 and conducting supporting spacers 42 which are used for tuning the reactance. At the front end of the aerial, there is a resistive support spacer 44 vertically between the two elements, and the feed cable 28 enters the lower arm 12 through the space 44. The concept of passing the co-axial cable through one of the arms is discussed in detail in our European Patent Application No. 84.305136.8 This concept is applicable not only to the embodiment of Figs. 8 and 9 but also could be used in the embodiments of Fig. 1 or Fig. 2, although in the latter case the cable would enter the arms 12 through extension 12d. At the rear end of the aerial, each tube 10, 12 has a supporting link member 48 leading to a Y-piece 46, where the cable 28 is connected in a similar manner to that described above. Extending rearwardly from the Y-pieces 46 is another tubular extension transmission line 50, having an end-piece (or if desired, a slider) 52, the position of which is important to tune out the reactance and provide the necessary spacing. The length of the link members 48 is also important, since they effectively provide transmission lines close to the earth plane taking the signal to the upper and lower elements, and thus affect the impedance at the feed point of the co-axial cable. As previously, several holes 30 may be provided at the feed point to adjust this impedance "seen" by the cable.

Claims:

1. A rhombic aerial having two conductive arms (10, 12) bent at an intermediate point (14) thereof and supported on either side of a zero potential plane (24) such that the corresponding ends of the arms (10, 12) are adjacent;

characterised in that:

conductive extensions (10c, 12c) extending from each end of at least one pair of corresponding ens (25) of the arms (10, 12), the extensions (10c, 12c) forming a transmission line in or close to the zero potential plane (24) and being electrically connected together.

2. A rhombic aerial according to claims 1, wherein the extensions (10c, 12c) extend outwardly of the rhombus.

3. A rhombic aerial according to claim 2, wherein both corresponding pairs of ends of the arms (10, 12) each have extensions extending outwardly of the rhombus.

4. A rhombic aerial according to claim 1, wherein the extensions (10e, 12e) extend inwardly of the rhombus.

5. A rhombic aerial according to any one of claims 1 to 4 wherein the extensions are hollow and wherein a transmission line (28) extends within one of the extensions (12c) with one conductor of the transmission line being electrically connected to one arm (10) and the other conductor being electrically connected to the other

arm (12).

6. A rhombic aerial according to claim 4 wherein each extension (10e, 12e) extends from one end of an arm (10, 12) to the other endof that arm (10, 12), such that the arms (10, 12) and extensions (10e, 12e) form two triangles with the extensions (10e, 12e) parallel to and adjacent each other.

7. A rhombic aerial according to claim 6, wherein the extensions are hollow and wherein a transmission line (28) enters one extension (12e) at an intermediate point thereof, extends within that extension to an end thereof, and has one conductor connected to one arm (10) and the other conductor connected to the other arm (12).

8. A rhombic aerial according to claim 6 or claim 7, wherein there are two further extensions (10f, 12f) extending outwardly of the rhombus, the two further extensions (10f, 12f) being electrically connected together.

9. A rhombic aerial according to any one of the preceding claims, wherein the position of the electrical connection (34) of the extensions(10c, 12c) is adjustable.

10. A rhombic aerial according to any one of the preceding claims, having four arms (10, 12) forming two rhombi, the planes of which are parallel and

perpendicular to the zero potential plane, two adjacent ends of the arms (10) on one side of the zero potential plane being joined together and to one extension (50) and two adjacent ends of the arms (12) on the other side of the zero potential plane being connected together and to the other extension (50).

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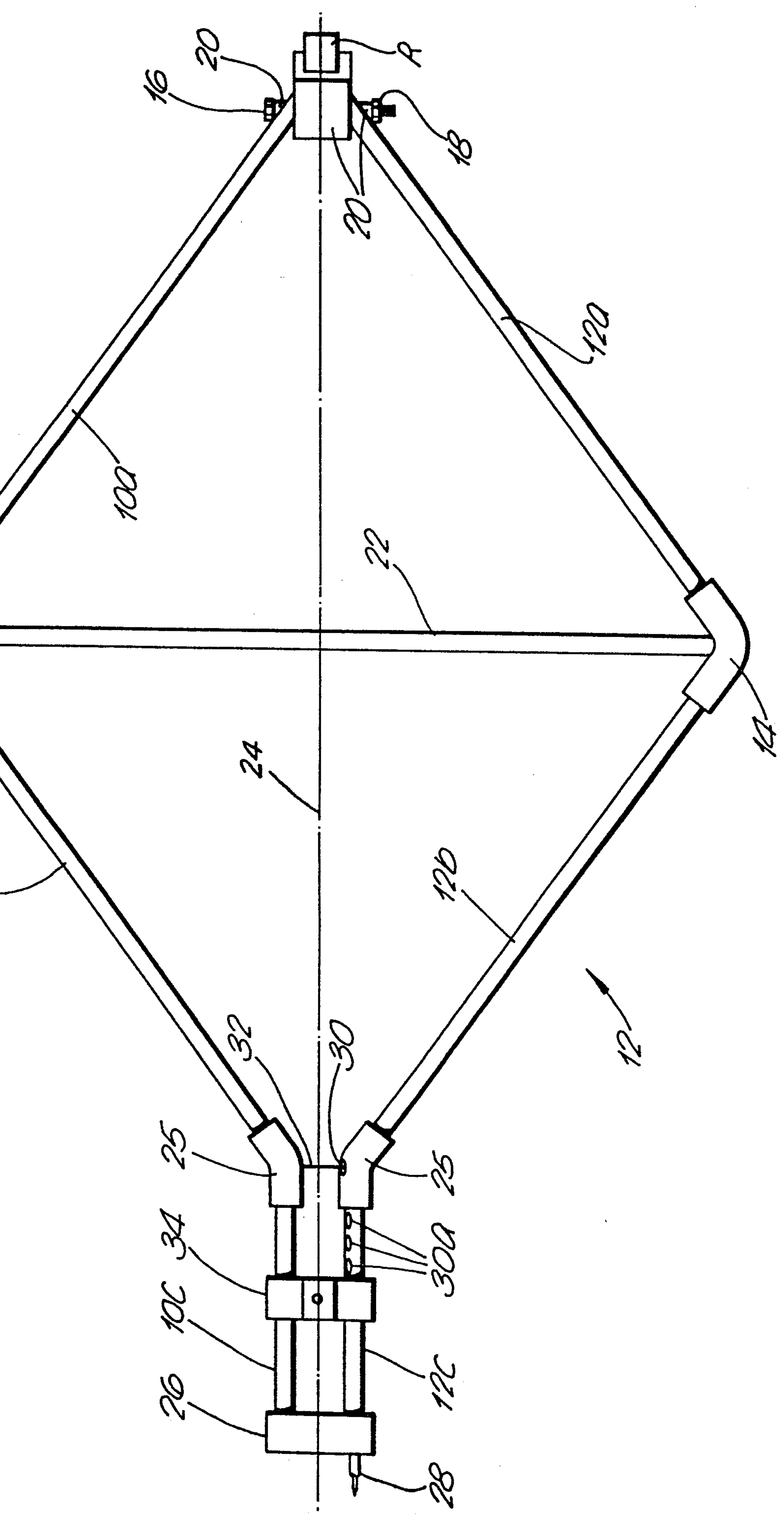

Fig. 1.

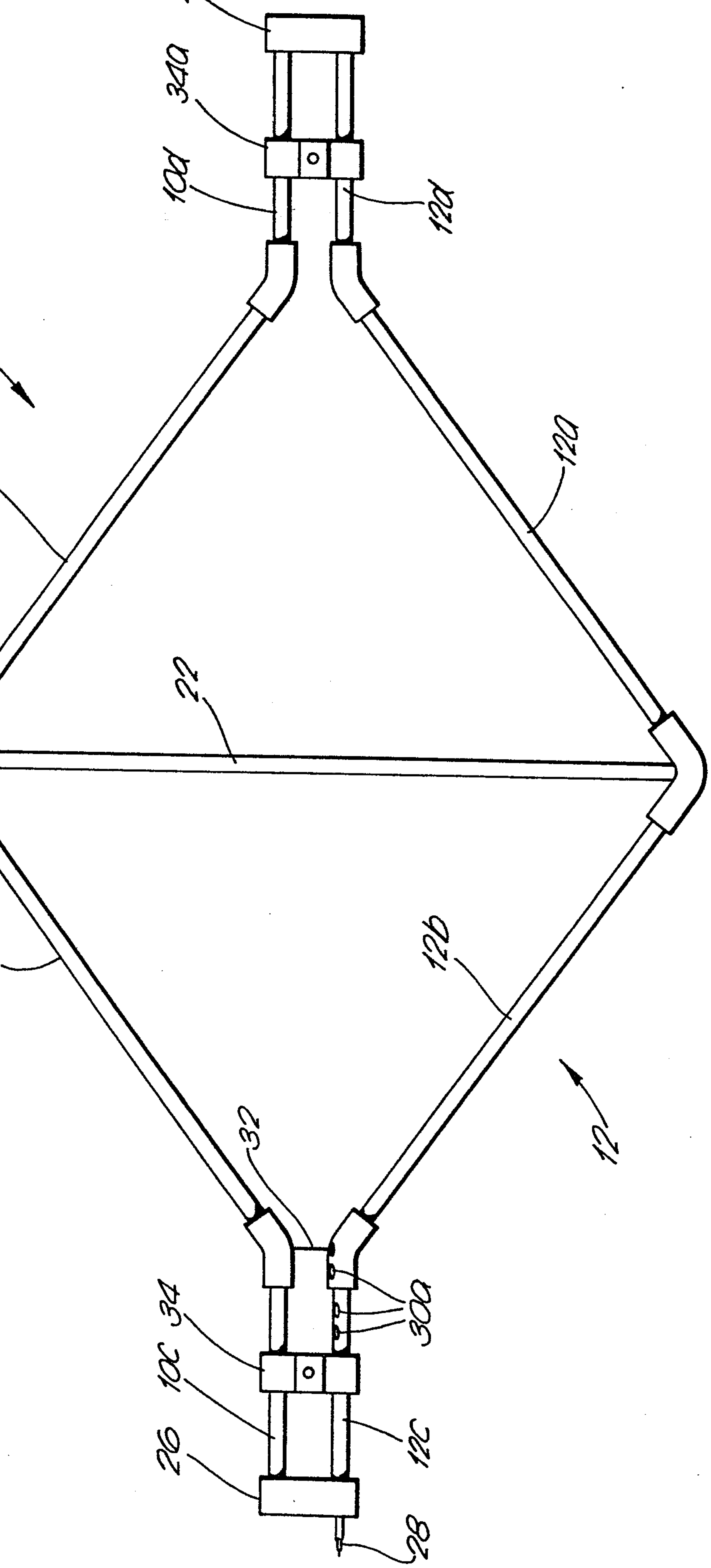

Fig. 2.

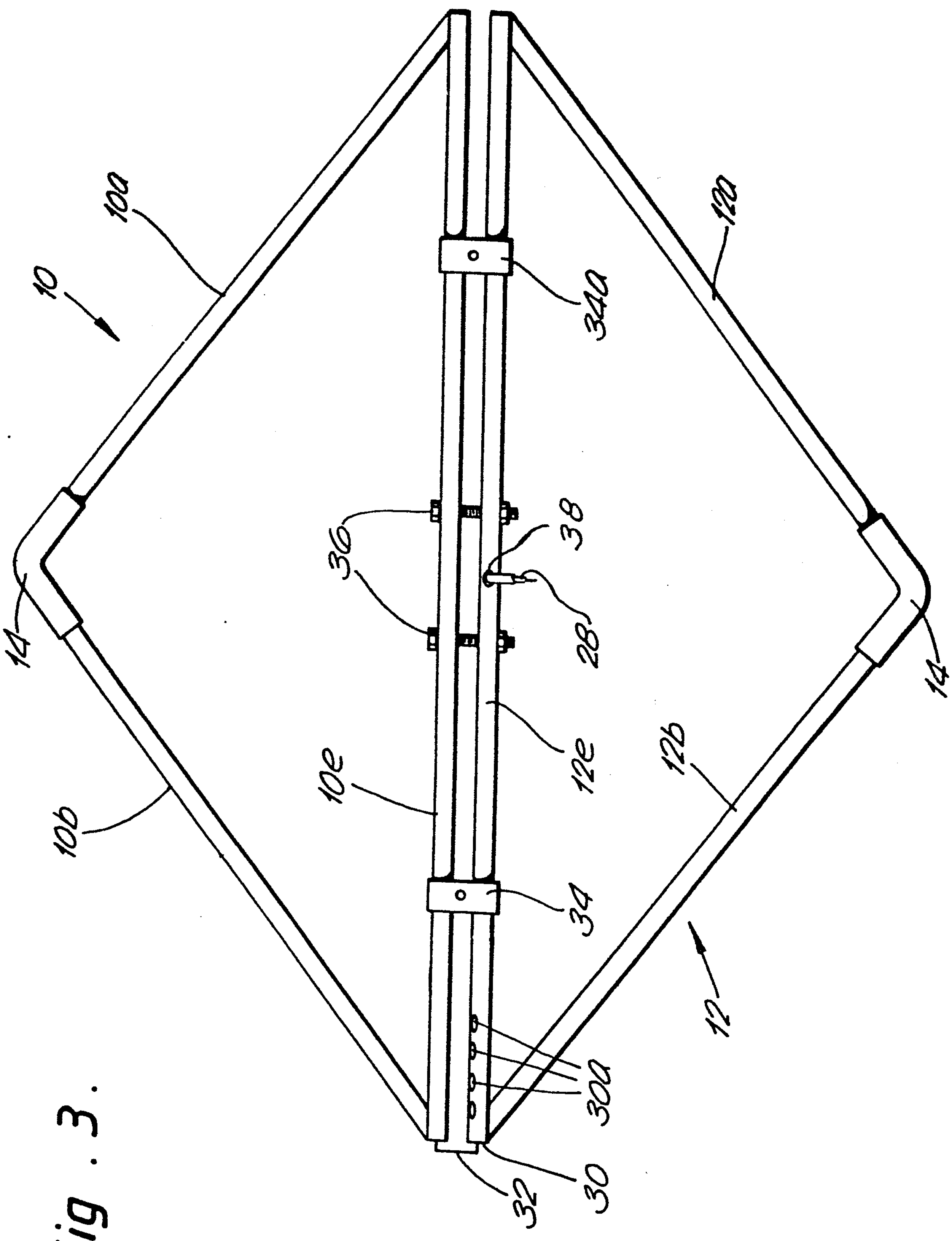

Fig. 3.

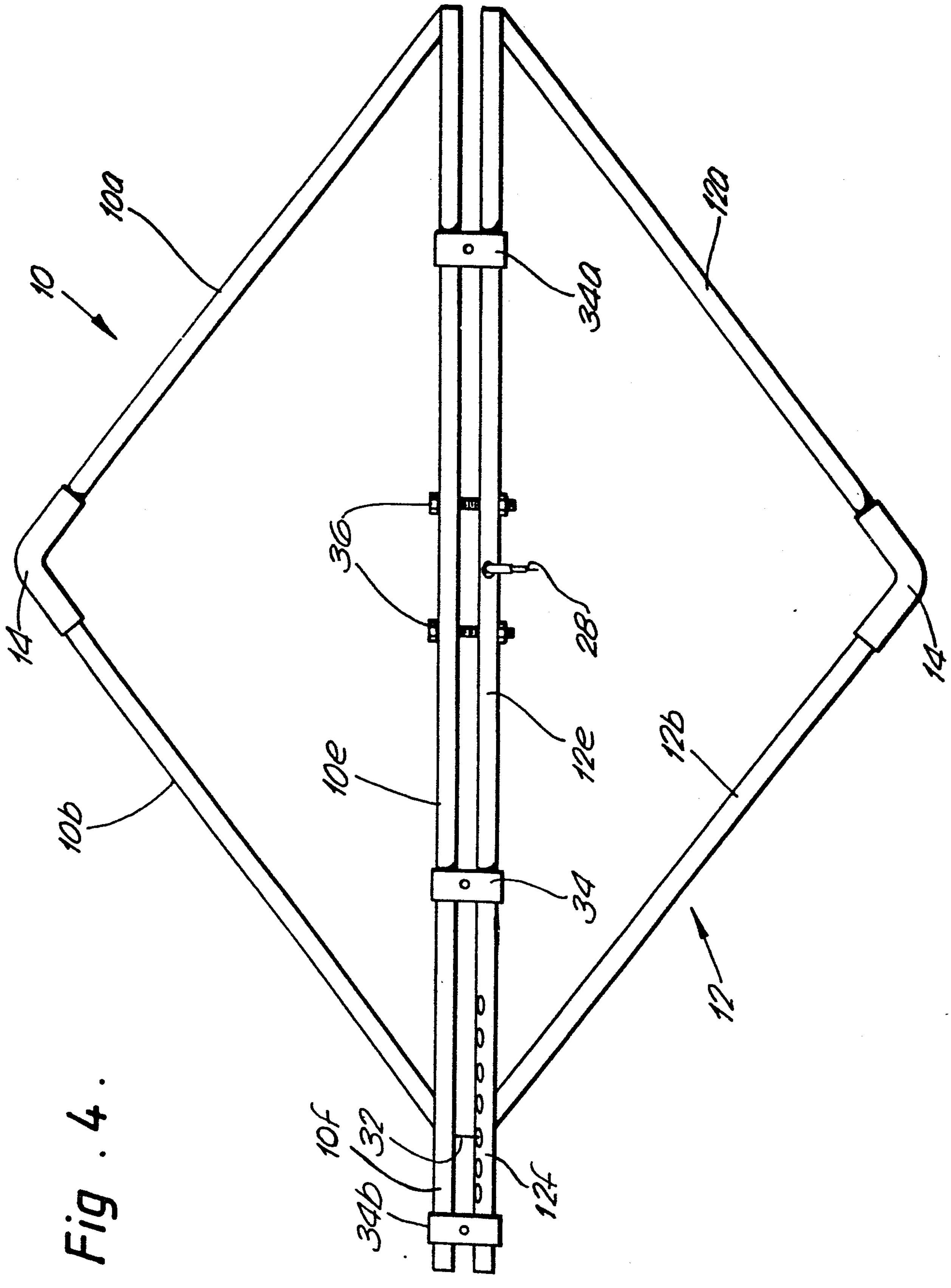

Fig. 4.

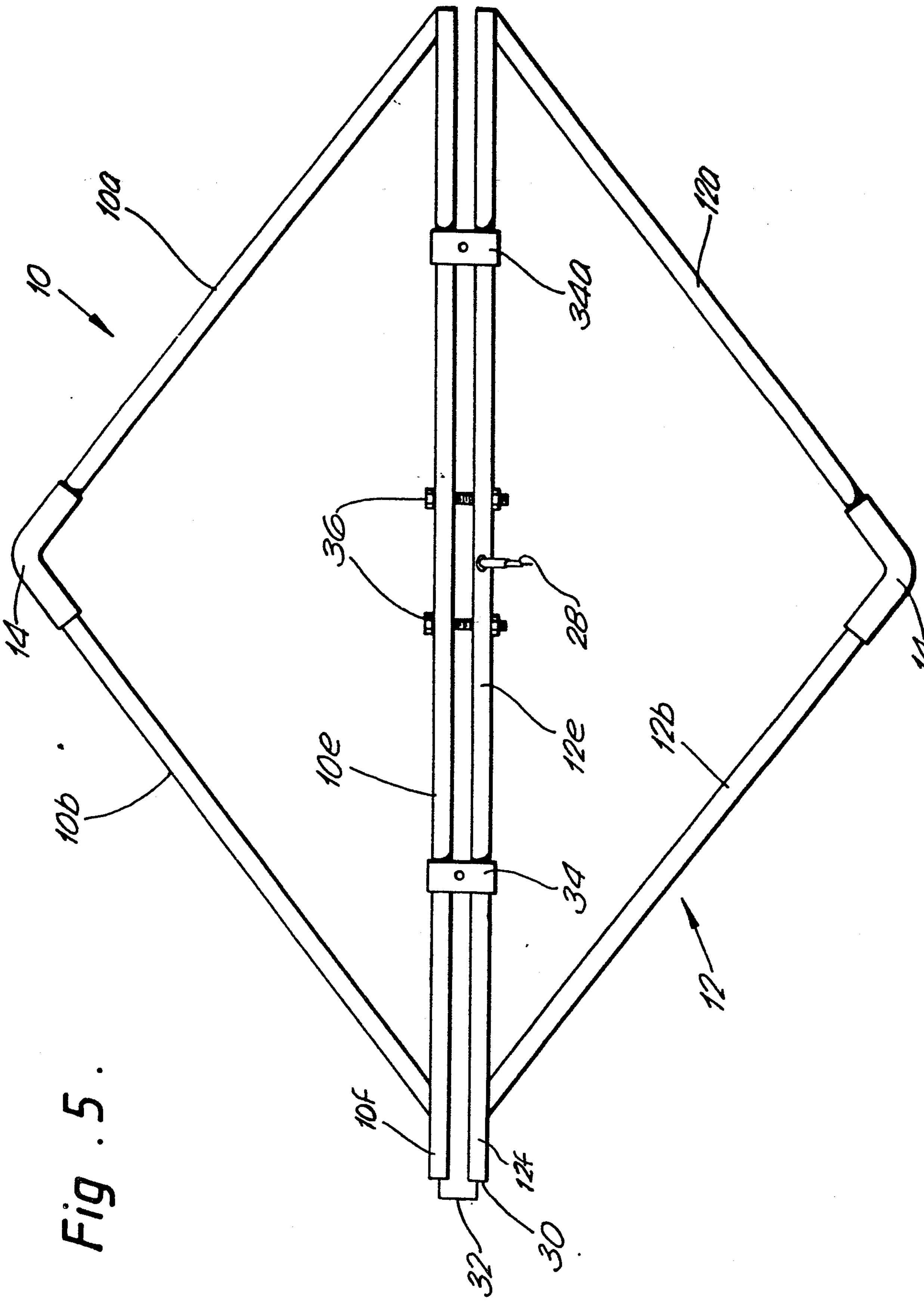

Fig. 5.

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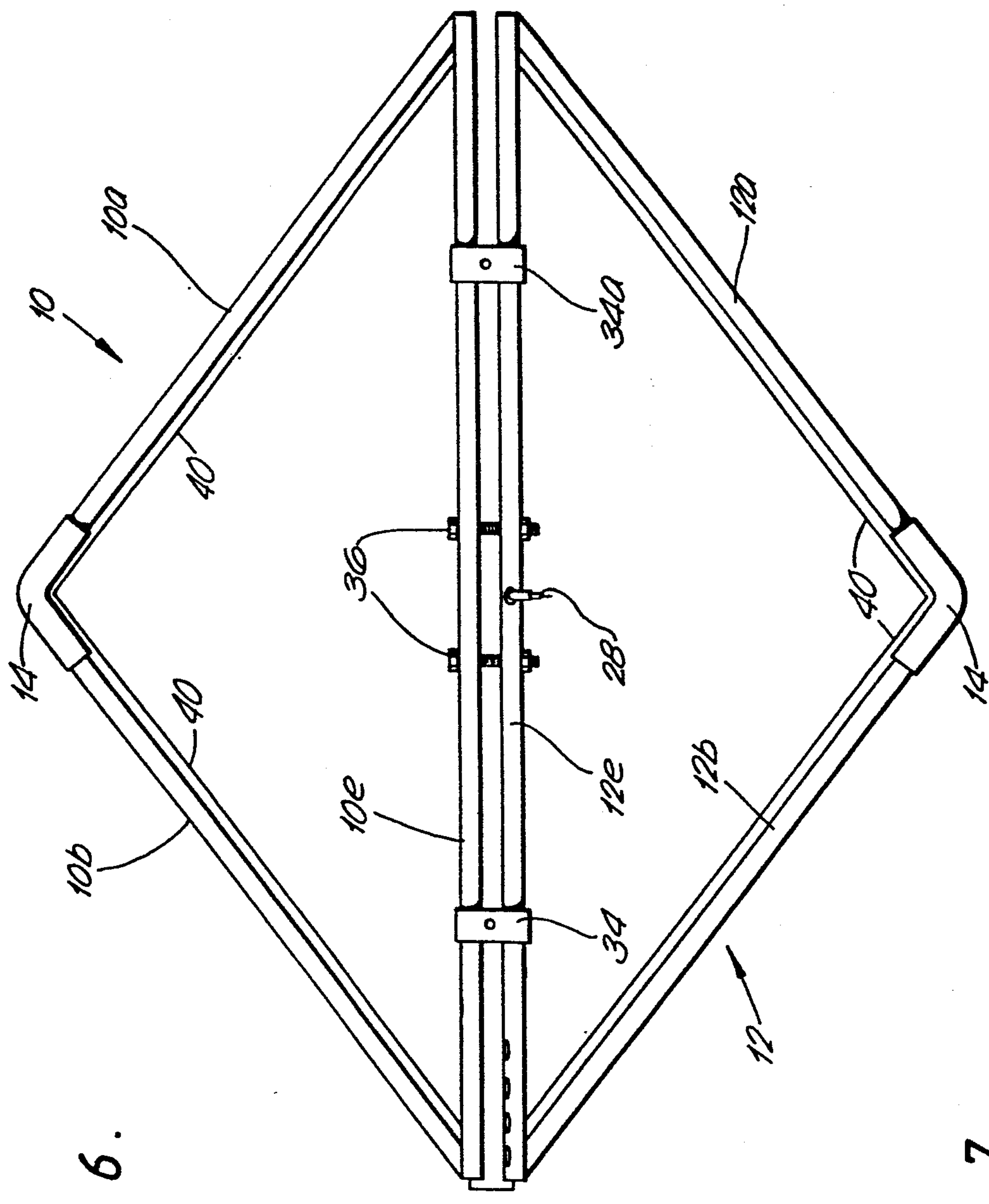

Fig. 6.

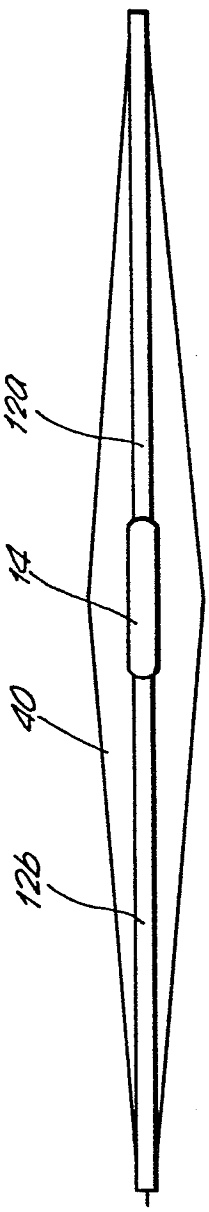

Fig. 7.

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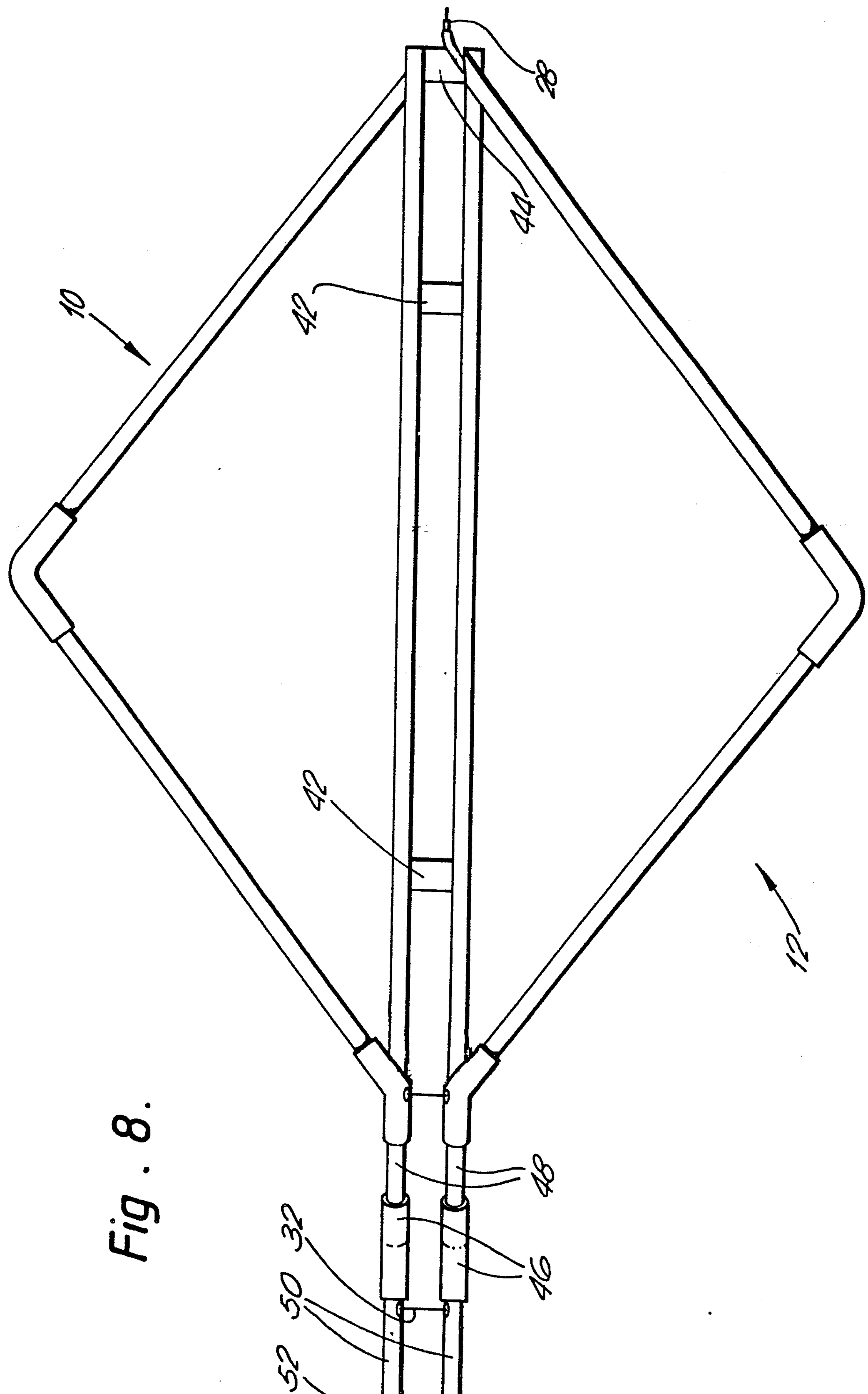

Fig. 8.

Fig. 9.