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SHORT-WAVE ANTENNA

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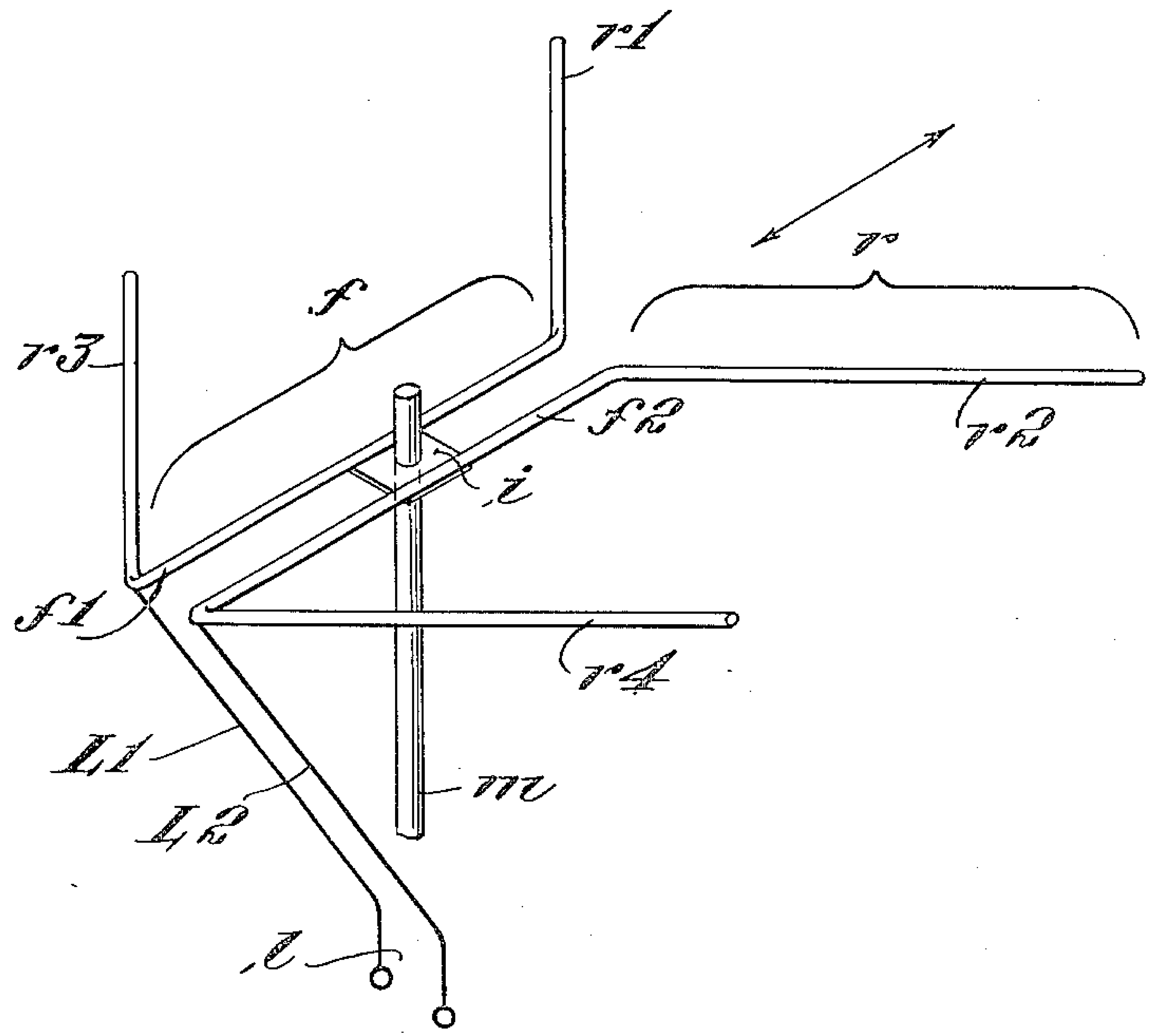

Fig. 1

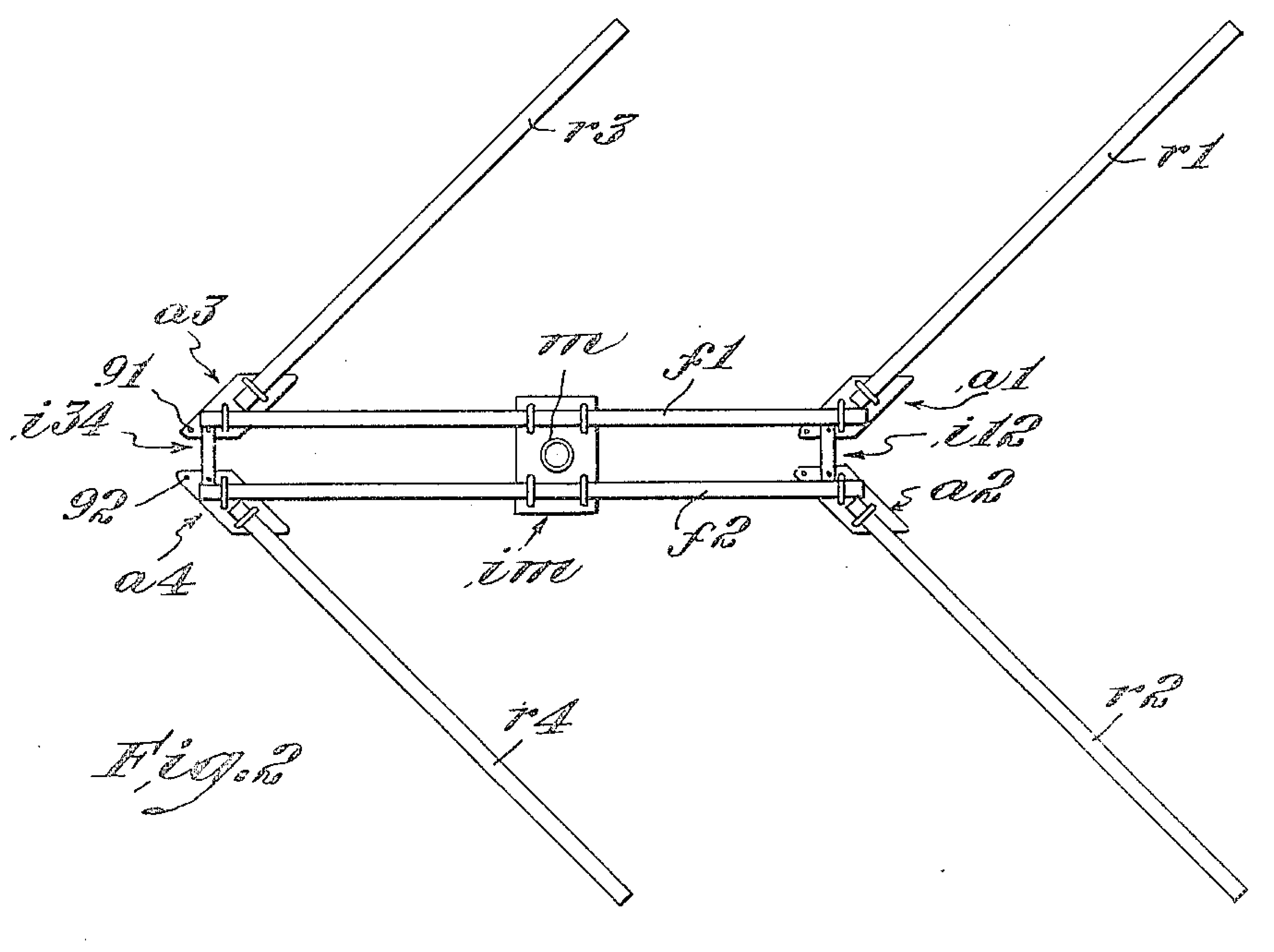

Fig. 2

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Fig. 3

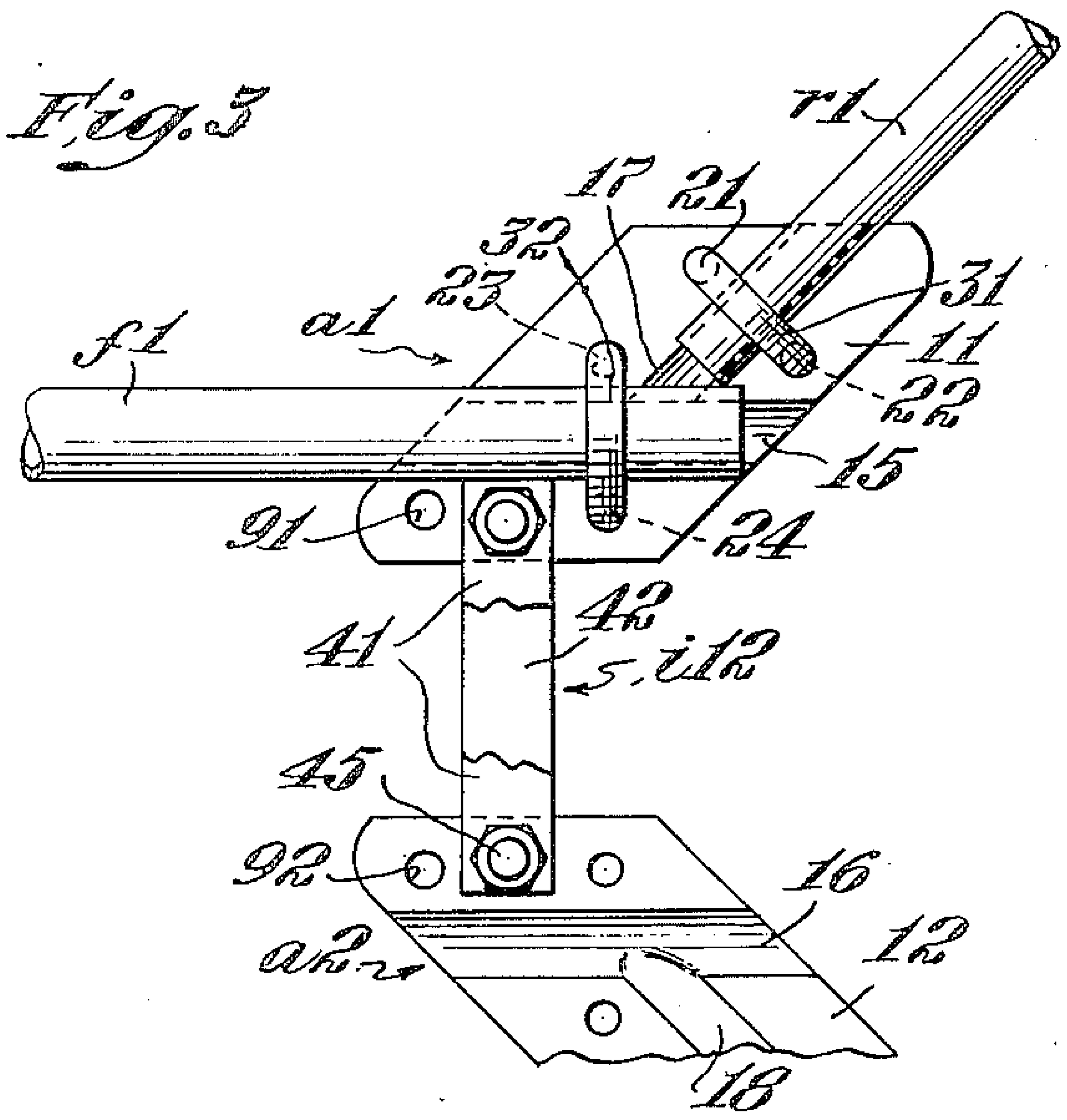


Fig. 4

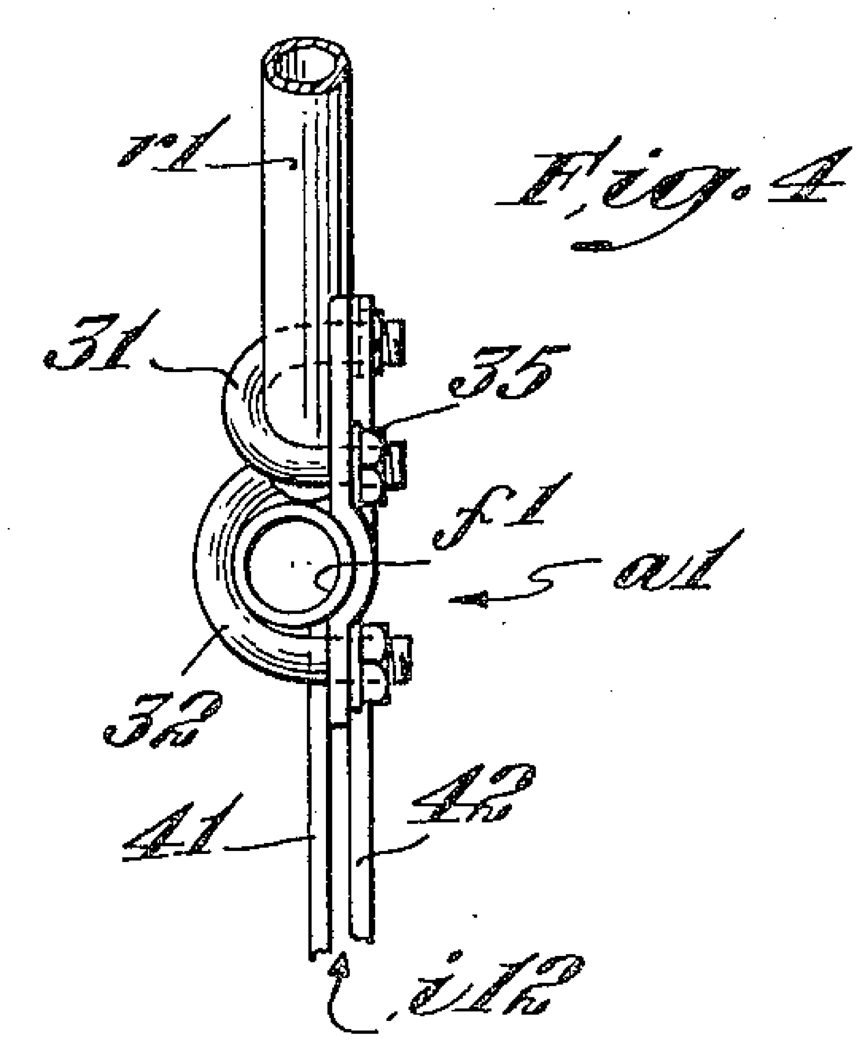


Fig. 5

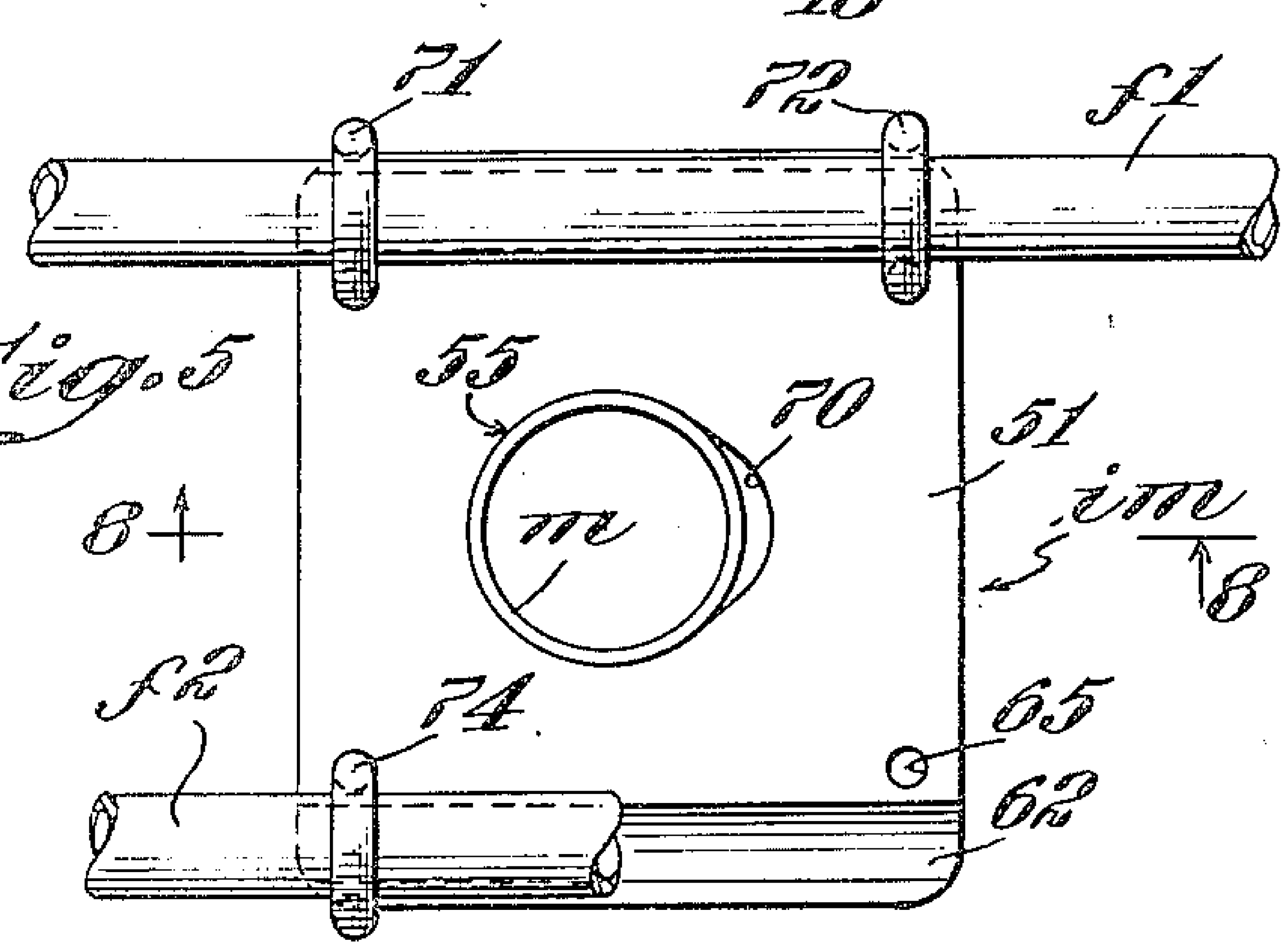


Fig. 6

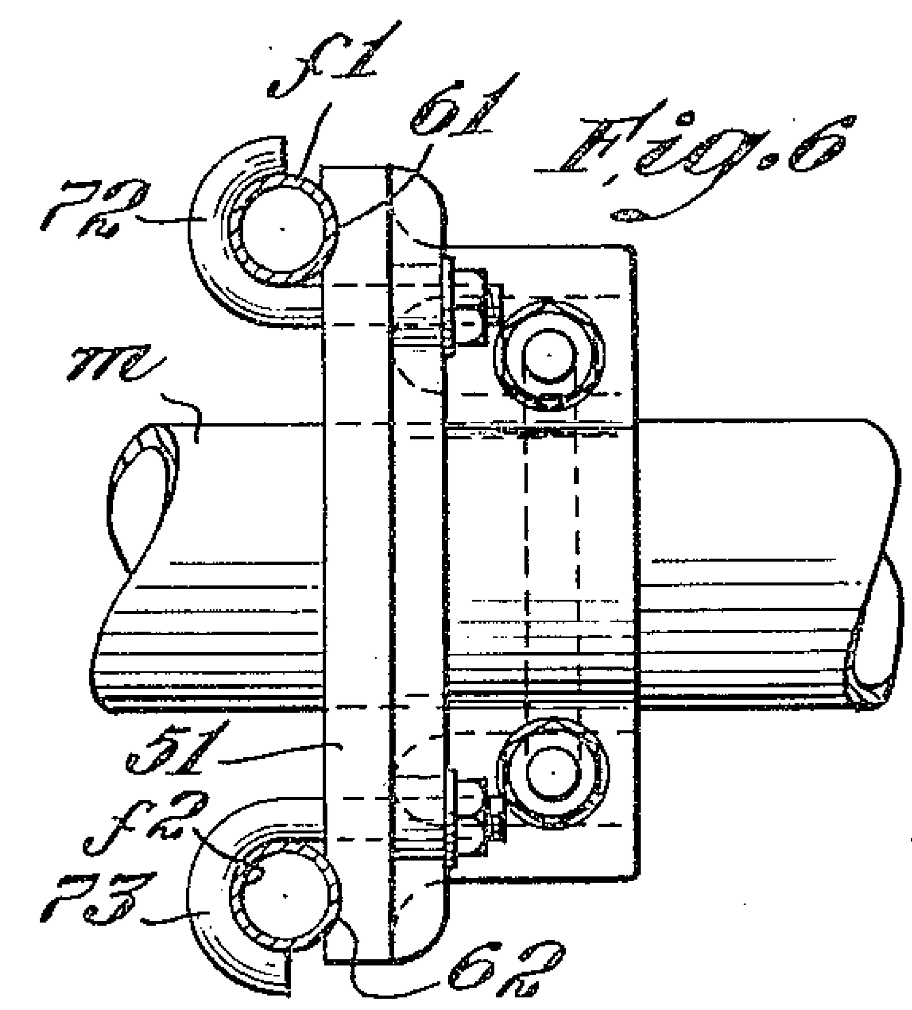


Fig. 7

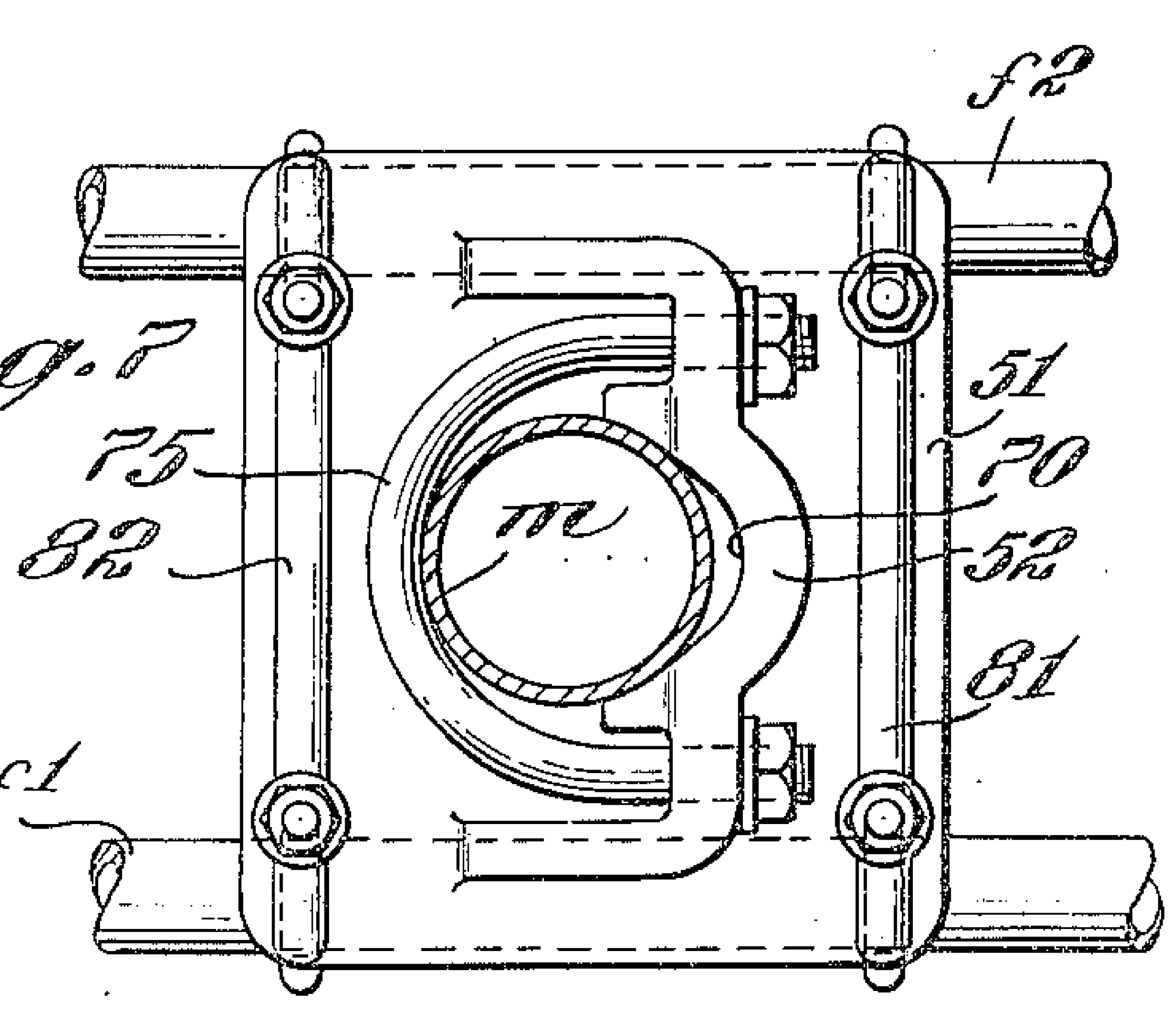
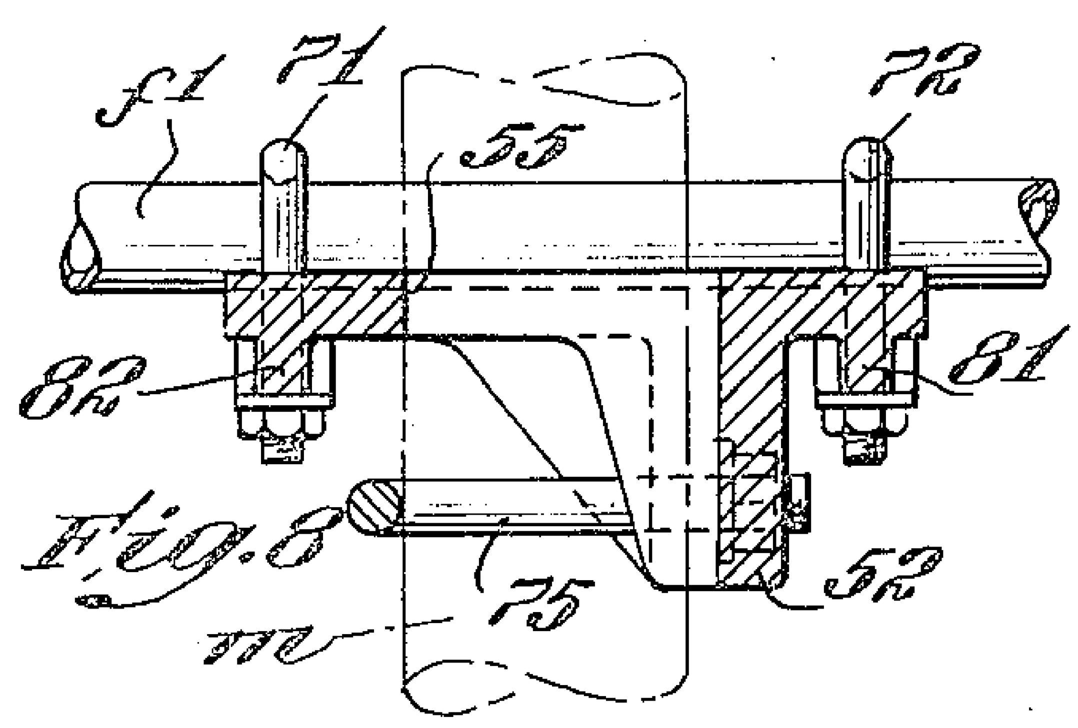


Fig. 8



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Patented Jan. 23, 1951 2,538,915

UNITED STATES PATENT OFFICE

2,538,915

SHORT-WAVE ANTENNA

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Application April 27, 1950, Serial No. 158,544

5 Claims. (Cl. 250—33)

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Various types of receiving antennas for short wave transmission channels, particularly of the television broadcasting bands, have been proposed and introduced into actual practice, but from the point of view of the average owner of a television receiver, antennas with acceptable electrical as well as mechanical characteristics are rather expensive in manufacture as well as installation, whereas those which as to price range and installation costs are suited for the average public leave much to be desired by way of electrical performance and mechanical ruggedness and reliability.

Some of the objects of the present invention are to provide antennas, particularly suited for purposes of receiving television broadcasts, which are of rugged construction that resists corrosion and is equal to the most severe weather conditions; which are easily and quickly assembled by unskilled persons from a minimum amount of simple elements thus saving time and expense; which have optimum performance with a low standing wave ratio over a wide wave length; which have high gain especially also in the difficult to receive higher frequency channels; which have very sharp directivity thus reducing interference and noise; which can be matched directly to the usual transmission line; which lend themselves well to stacking; and generally to provide television receiving antennas which are particularly suited for present day requirements as to low cost and ease of installation and maintenance, without in any respect sacrificing any reasonable requirement of electrical performance.

The invention resides, in one of its main aspects, in providing an antenna array wherein a plurality of sets of angularly arranged conductive radiating elements is combined with two conductive feed elements which electrically connect and mechanically support respective pairs of radiating elements of respective sets, the feed elements being rigidly held parallel to each other by insulating supporting elements. The insulating elements for distancing the feed elements can also be utilized for mounting the antenna array on a support such as a mast. A feed line such as a twin lead ribbon is with each wire connected to a respective one of the feed elements. While it was found that an array with two pairs of parallel radiating elements symmetrically arranged and inclined to the axis defined by the feed elements, is satisfactory for most purposes, the invention is not limited to elements of equal length or to equal angles of the two sets of radiating elements.

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In another very important aspect, the directive antenna array according to the invention is constructed for broad band reception in two bands of lower and higher frequency ranges respectively, each band including several channels; this result is accomplished by combining two sets of angularly arranged conductive radiating rods with two conductive feed rods which mechanically support and electrically connect respective pairs of radiating rods, each of the radiating rods measuring between about three quarters and one, or approximately seven eighths wave lengths of an intermediate channel of the higher frequency range and the feed rods measuring approximately three quarters of the wave length of that higher frequency channel.

Other objects, aspects and features will appear, in addition to those contained in the above summary of the nature and substance of the invention including a statement of some of its objects, from the following description of a typical embodiment thereof illustrating its novel characteristics. This description refers to drawings in which

Fig. 1 is an axonometric diagram of an antenna according to the invention;

Fig. 2 is a top view of an antenna according to Fig. 1, including its mechanical construction;

Fig. 3 is a top view of the corner assembly as shown in Fig. 2;

Fig. 4 is a front elevation corresponding to Fig. 3;

Fig. 5 is a top view of the mast assembly as shown in Fig. 2;

Fig. 6 is a front elevation of the assembly according to Fig. 5;

Fig. 7 is a bottom view corresponding to Fig. 5; and

Fig. 8 is a section on line 8—8 of Fig. 5.

As indicated in Figs. 1 and 2, a short wave antenna incorporating the principles of my invention has four radiating elements such as conductive tubes or rods *r1*, *r2*, *r3* and *r4* herein also referred to as arms, which are rigidly connected with a pair of conductive feed and support elements such as tubes or rods *f1* and *f2* together constituting a feed line. The feed tubes *f1* and *f2*, and the radiating tubes with them are maintained in rigid correlation, with the feeders *f* parallel and the radiators *r* within a plane and symmetrically to the feeder axis, by means of insulating means *i*, which may also be utilized for fastening the antenna array to supporting means such as a mast *m*.

Electrical connection with receiving apparatus is provided by two conductors L1 and L2, such as the components of a twin lead transmission ribbon.

It will be noted that the radiating rods or tubes which are inclined to each other and fastened to respective feed rods or tubes form two antenna sets r1, r2 and r3, r4 respectively. The parallel rods r1, r3 and r2, r4, fastened to a single feed rod of the pair f1, f2, respectively constitute radiator pairs, each pair being a mechanical unit which is electrically insulated from but mechanically rigidly connected to the other pair. The above mentioned transmission wires are joined to the respective feed rods f1, f2 at the regions of intersection with the set r3, r4.

In a preferred embodiment (whose mechanical features are the subject matter of copending application of Raymond Tinkham, Serial No. 158,-535, filed April 27, 1950), the radiating rods are fastened to the feed rods, and the latter are correlated to each other, as shown in Fig. 2, by means of clamping assemblies a1, a2, a3 and a4, insulator strips i12, i34, and an insulating mounting assembly *im*, which details will be described below with reference to Figs. 3 to 8.

The electrical dimensions *r* (length of radiating element) and *f* (length of feed element), indicated in Fig. 1, are according to one aspect of the invention correlated to the wave lengths of certain channels within given transmission bands, as follows.

Assuming within a certain frequency range a low frequency band comprising several channels, and a high frequency band likewise comprising several channels, I found that antennas constructed as above described are most satisfactory if the dimension *r* is approximately ¾ to 1 times the wave length of an intermediate channel of the high frequency band, while the dimension *f* is approximately ¾ of the wave length of an intermediate channel of the high frequency band and ¼ of an intermediate channel of the low frequency band. An angle of 45° between radiator and feed rods, or 90° between rods r1, r2 and r3, r4 respectively was found to be satisfactory. While the above mentioned relation of the electrical dimensions to both channels was found especially satisfactory, it should be understood that the electrical relation between radiating and feed rods, and the high frequency range is particularly important.

The reasons for this practically established efficient unidirectional radiation over two predetermined frequency bands can be theoretically stated as follows.

Such antennas satisfy the following relation between maximum antenna gains approximately at the center frequency of the low and high bands:

$$[G_m]_1 = G_1(\theta_a,\phi_a)$$
$$[G_m]_2 = G_2(\theta_a,\phi_a)$$

where

$[G_m]_1$ is the maximum gain of the antenna at the center frequency of the low band,

$[G_m]_2$ is the maximum gain of the antenna at the center frequency of the high band,

$G_1(\theta,\phi)$ is the gain function of the antenna in terms of colatitude and azimuth angles θ and ϕ in a set of spherical coordinates centered at the antenna, at the center frequency of the low band (compare for example "Fields and Waves in Modern Radio" by Ramo & Whinnery, Wiley 1944, section 2.37),

$G_2(\theta,\phi)$ is the corresponding gain function of the antenna at the center frequency of the

high band, $G_1(\theta,\phi)$ and $G_2(\theta,\phi)$ being essentially unidirectional radiation functions, and having the same direction (θ_a,ϕ_a) for maximum gain at both the lower and upper frequency bands.

Such antennas further satisfy the impedance relation:

$$Z_1 = Z_2 = Z_0$$

where

Z_1 is the impedance of the antenna at the center frequency of the lower band,

Z_2 is the impedance of the antenna at the center frequency of the upper band, and

Z_0 is the characteristic impedance of the input feeding transmission line.

Still further, such antennas satisfy the following gain specifications:

$$G_1(\theta_a,\phi_a) \gg G_1(\theta_a \pm 90,\phi)$$
$$G_1(\theta_a,\phi_a) \gg G_1(\theta,\phi_a \pm 90)$$

and

$$G_2(\theta_a,\phi_a) \gg G_2(\theta_a \pm 90,\phi)$$
$$G_2(\theta_a,\phi_a) \gg G_2(\theta,\phi_a \pm 90)$$

and

$$G_1(\theta_a,\phi_a) \gg G_1(\theta_a + 180,\phi_a)$$
$$G_2(\theta_a,\phi_a) \gg G_2(\theta_a + 180,\phi_a)$$

where

$G_1(\theta,\phi)$ and $G_2(\theta,\phi)$ are the radiation functions of the antenna at the lower and upper bands, respectively, and

(θ_a,ϕ_a) is the direction of maximum gain of the antenna at both the lower and upper frequency bands.

Somewhat differently expressed, antennas according to the invention, including the practical embodiments herein specified, conform to the following relations of above defined values:

$$[G_m]_1 = G_1(\theta_a,\phi_a)$$
$$[G_m]_2 = G_2(\theta_a,\phi_a)$$
$$[G_m]_2 > [G_m]_1$$

It was found that antennas with

$$[G_m]_2 = k[G_m]_1$$

where k is between about 2 and 10, such as approximately 4 for the herein described practical embodiments, give satisfactory operation.

Antennas dimensioned in this manner compensate for natural higher attenuation and losses occurring to the high frequency band transmission, while maintaining a normal gain over the lower frequency band.

As a practical example, *r* is .875 times the wave length of channel 10 of the high frequency band 172 to 213 mc., whereas dimension *f* is ¾ of the wave length of channel 10 and ¼ of the wave length of channel 4 of the low frequency band 54 to 88 mc.

Single array antennas constructed as above described were found to have gains ranging from 1.5 db for channel 2, to 7.0 db for channel 13, with a maximum gain of 7.5 db for channels 10 and 12, whereas a double array, namely two of the above described arrays stacked vertically one above the other, had a gain from 2.5 db for channel 2 to 9.5 db for channel 13, with the maximum gain of about 10.0 db for channels 10 and 11. It will thus be seen that the antenna according to the invention has a particularly high gain in difficult to receive high band channels, whereas the gain is quite satisfactory also for the low channels. It was found that for example as compared with the typical conventional conical antenna, a single stack antenna of the above type had a gain for channel 7 which is considerably higher than that of conventional single stack antennas. For double stack arrays according to the invention, the gain is as high as 11 db over the high band, with directivity as sharp as 30 degrees over that band and a low standing wave ratio over all bands.

The directivity for the radiating elements at an angle of 90° is quite sharp, the spread of the horizontal radiation pattern ranging from about 35° for channel 2 to about 25° for channel 13, the average spread being about 40°.

In antennas according to the invention, the combination of the feed line with the four elements as herein described has an impedance such as to present a good impedance match to transmission lines now commercially available. That is, such an antenna has an impedance which does not deviate widely from the characteristic impedance of the input feeding transmission line at any frequency of either the lower or upper band.

An antenna as above described is matched directly, according to the principles set forth above, to a 300 ohm line for optimum transmission, which close match eliminates an important source of ghosts.

The voltage standing wave ratio is very favorable throughout the above mentioned channels.

Referring now to Figs. 3 and 4, it will be noted that Fig. 3 shows assemblies *a1* and *a2* as indicated in Fig. 2, and it will be apparent that the same assembly can be used for *a3* and *a4*, with the only difference that feed rods *f1* and *f2* extend in opposite directions respectively.

These assemblies consist of metal plates 11, 12 cut in symmetrical right-hand-left-hand relation and having embossed therein grooves 15, 16 respectively which extend from one to an opposite edge of the plates, and grooves 17, 18 respectively which extend from the grooves 15, 16 to a third edge. It will be apparent that the grooves may cross each other.

Adjacent to the grooves of each plate are pairs of holes marked 21, 22 and 23, 24, which accommodate U-bolts 31, 32 respectively. Tightening of the nuts indicated at 35 permits rigid attachment of the rods to the plates.

The pairs of radiating rods with the connecting feeder rod are mechanically connected by means of insulating assemblies *i12*, *i34* and *im* as shown in Fig. 2. Units *i* consists each of two strips of insulating material, indicated at 41 and 42 of Figs. 3 and 4. These strips are fastened to the respective plates by means of bolts 45, which extend through the two strips and the respective plate.

The mounting block indicated at *im* of Fig. 2 is shown in Figs. 5 to 8. It consists of a piece 51, for example molded of Bakelite, which has a mounting platform 51 and a clamping flange 52 which latter is at 70 curved at a radius somewhat smaller than that of a hole 55 of the platform and of the mast into which this block is to be clamped, as clearly indicated in Figs. 5 and 7. The platform has two parallel grooves 61 and 62 shaped to accommodate the feed rods *f1*, *f2*. Two holes, indicated at 65, are provided adjacent to each groove.

In assemblying the antenna, the three tubes *r*, *f* of each radiator pair are clamped together by means of the four plates 11, 12 and the U-bolt 31 and 32. Thereupon they are connected by means of insulating assemblies *i12* and *i34*, and clamped to block *im* by means of J-shaped bolts 71, 72, 73, 74. The antenna array itself can then be applied to the mast by inserting the latter through the opening 55 and fastening it to the groove 70 by means of U-clamp 75.

The leads of the feed line are fastened to the respective feed rods and pairs of radiating rods with conventional means for example terminal bolts fitting holes 91, 92 (Figs. 2 and 3) of assemblies *a3* and *a4*, and the conductor band may be brought down to the mast and fastened thereto with conventional clamp means, as indicated in Fig. 1.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. An antenna comprising a pair of parallel conductive rods, a second pair of parallel conductive rods each connected at one end to the ends of one rod of said first pair of parallel rods and extending at an acute angle therefrom, and a third pair of parallel conductive rods each connected at one end to the ends of the second rod of said first pair of conductive rods and extending at substantially the same acute angle therefrom but in the opposite direction, the second and third pairs of conductive rods being each substantially seven-eighths of an operating wave length long and said first pair of conductive rods being substantially three-quarters of said operating wave length long, said rods being mechanically rigid and each supporting the other.

2. Antenna according to claim 1 wherein said acute angle is substantially 45 degrees.

3. Antenna according to claim 1 wherein said second and third pairs are substantially symmetrical to said first pair.

4. Antenna according to claim 1 wherein said first pair of conductive rods is fastened, between said ends, to a mounting and separating block of insulating material.

5. Antenna according to claim 1 particularly suited for operation over a relatively wide frequency range which includes said operating frequency and a lower frequency, wherein the length of said first pair of conductive rods is substantially one-quarter of said lower frequency.

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