

Dec. 22, 1970

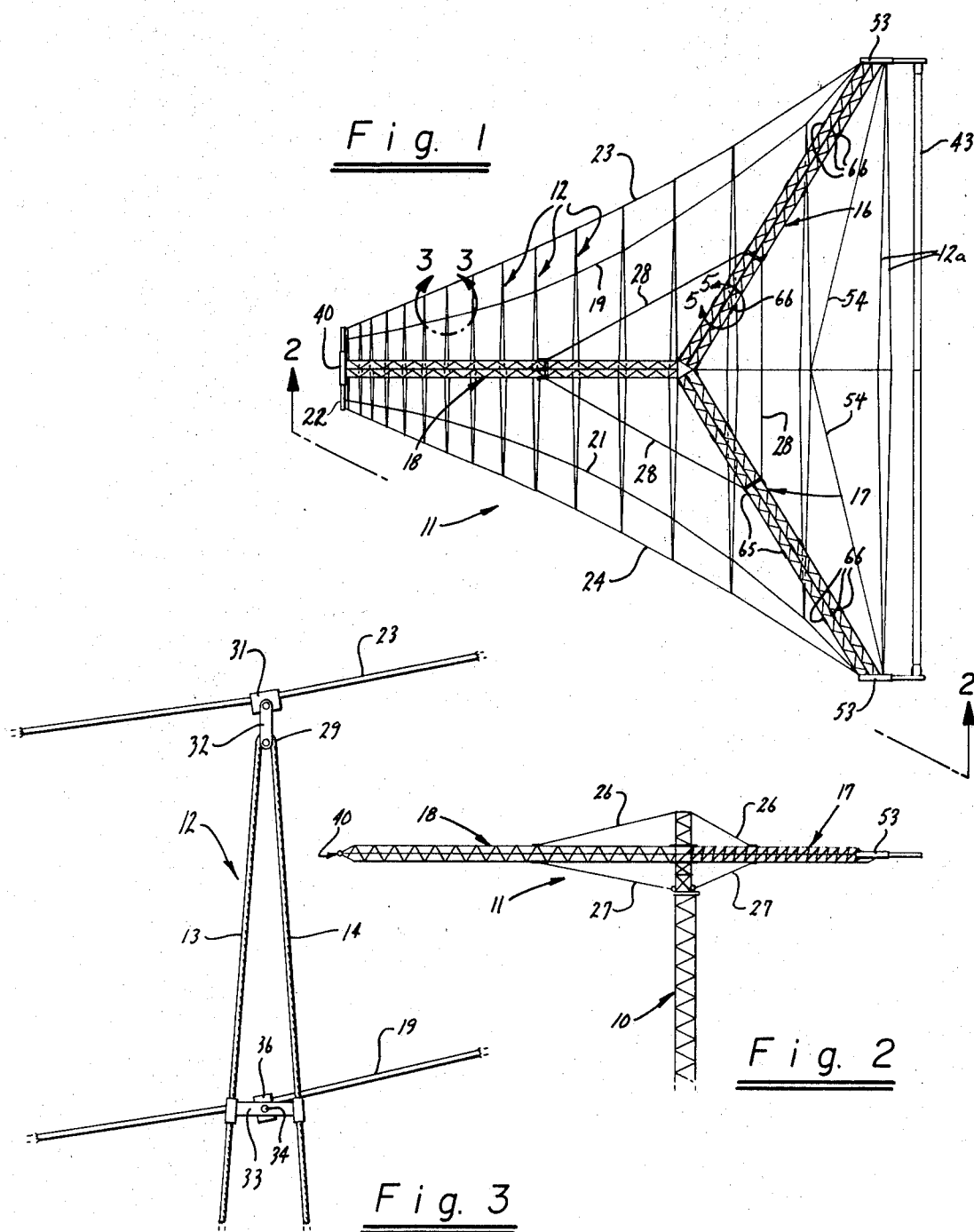
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3,550,140

LOG PERIODIC ROTATING ANTENNA

Filed June 23, 1967

6 Sheets-Sheet 1



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LOG PERIODIC ROTATING ANTENNA

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6 Sheets-Sheet 2

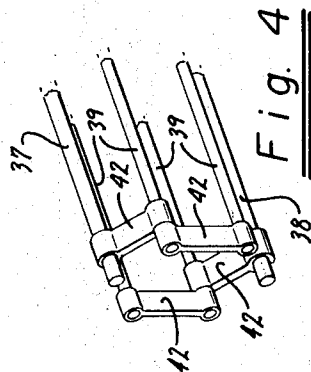


Fig. 4

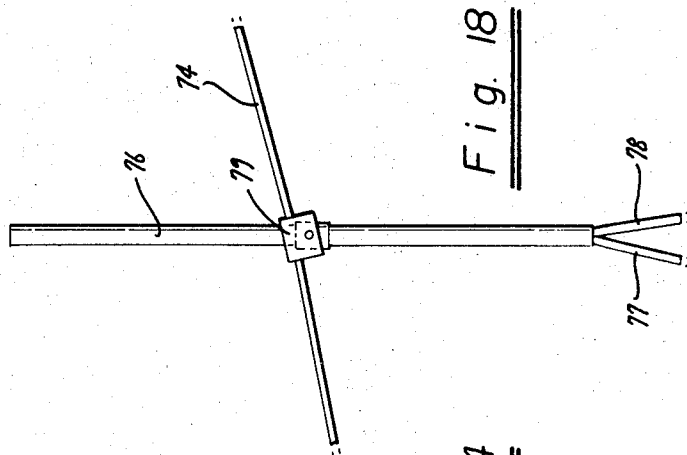


Fig. 18

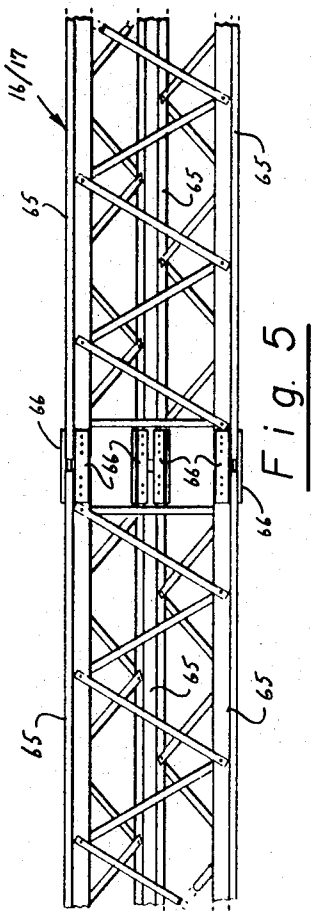


Fig. 5

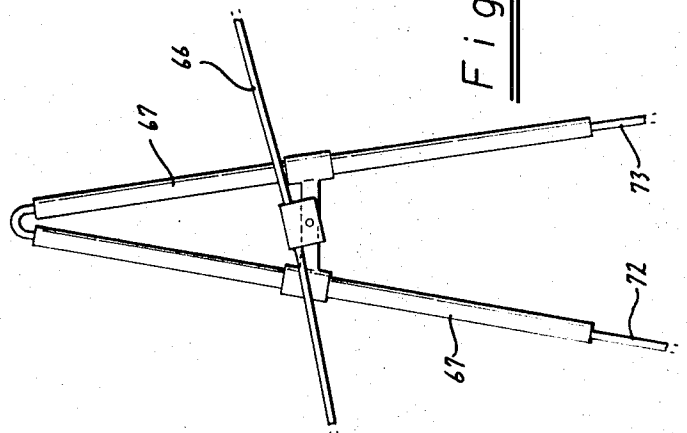


Fig. 14

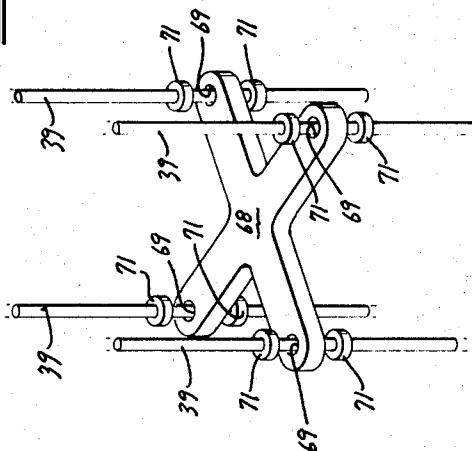


Fig. 15

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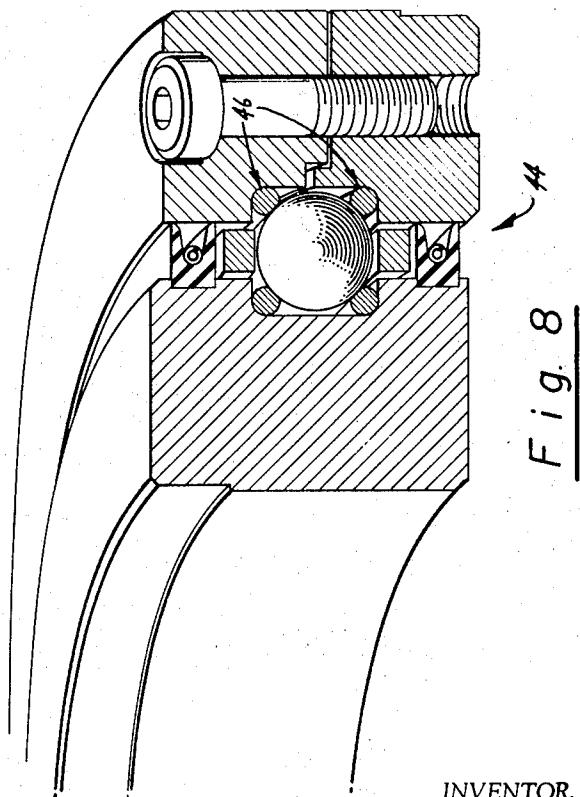
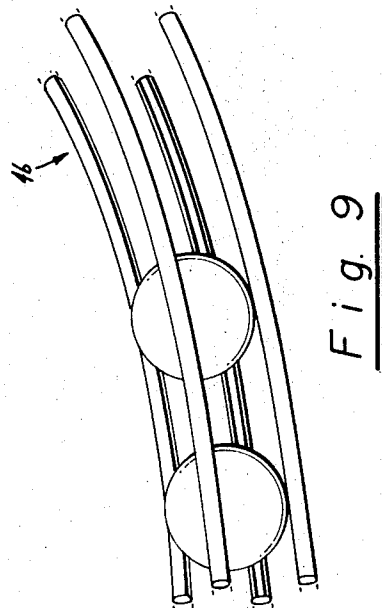
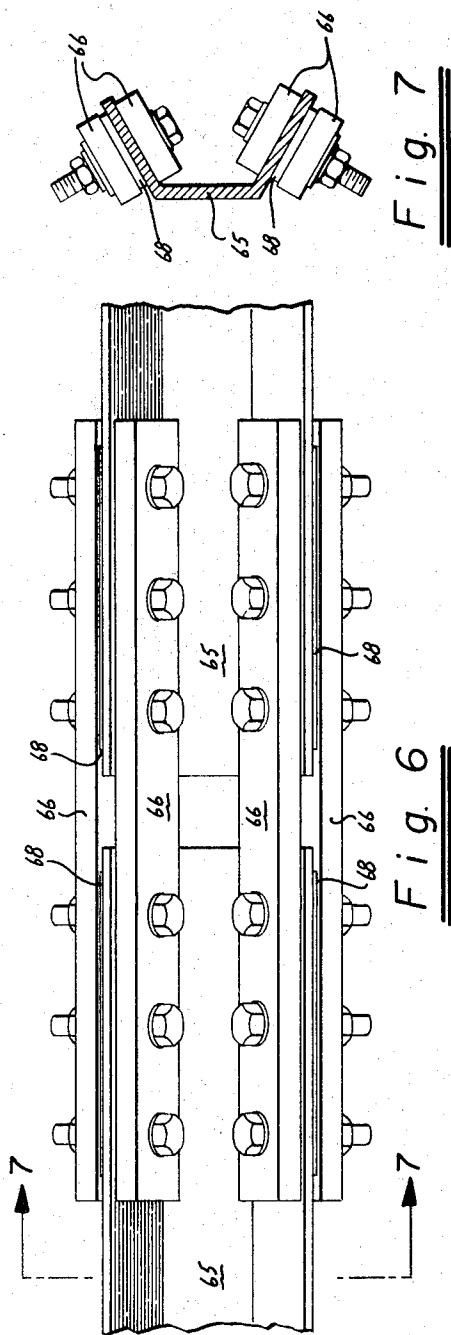
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LOG PERIODIC ROTATING ANTENNA

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6 Sheets-Sheet 3



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LOG PERIODIC ROTATING ANTENNA

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6 Sheets-Sheet 4

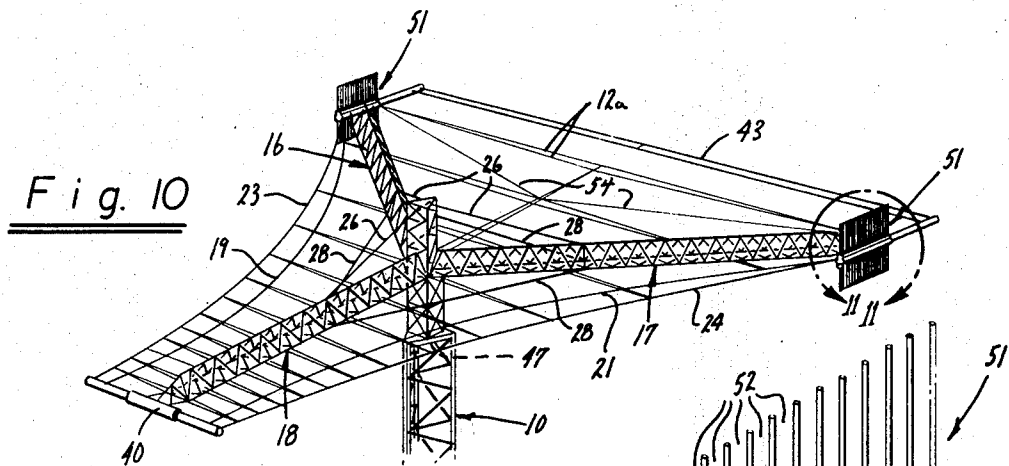


Fig. 11

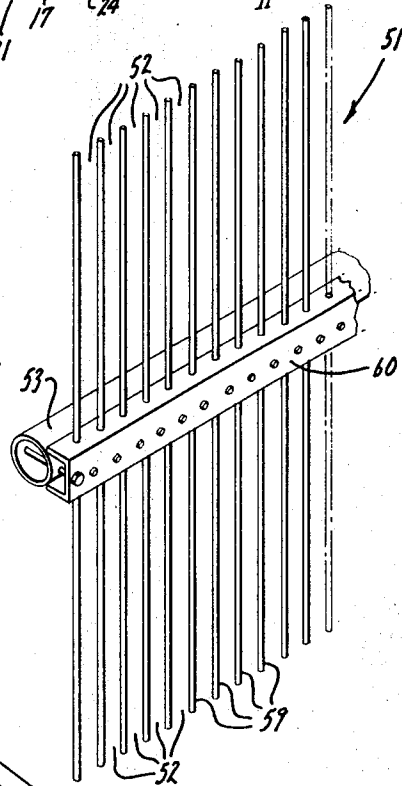
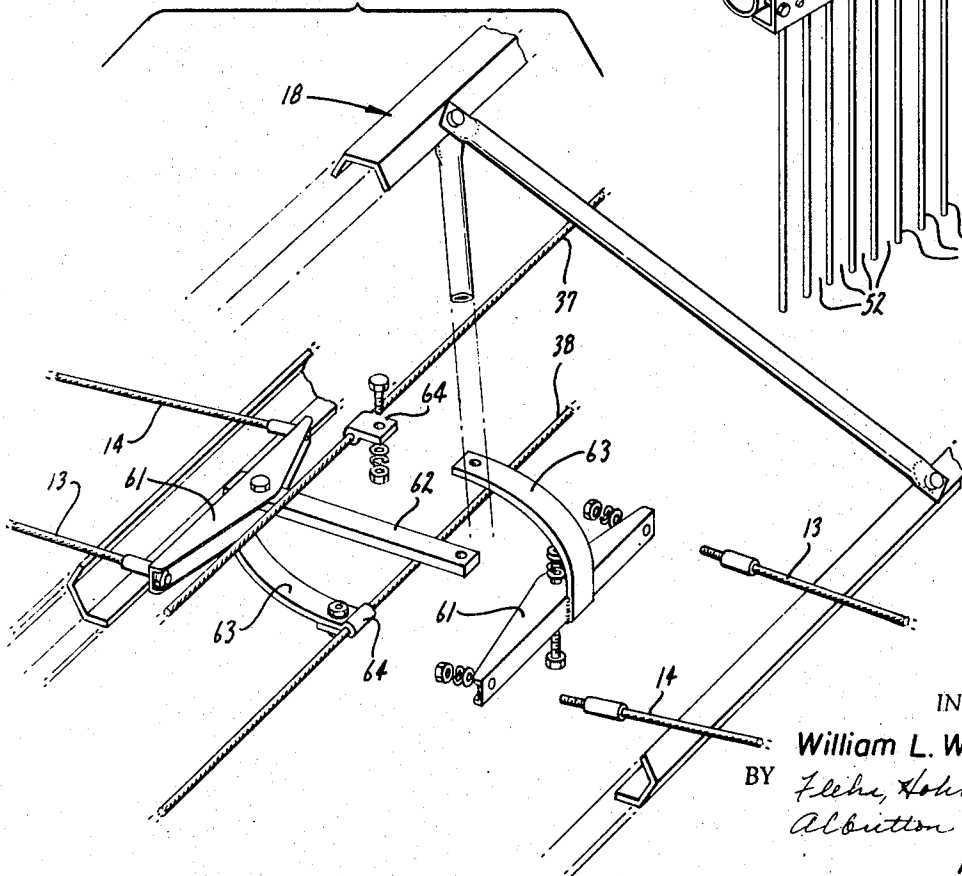


Fig. 12



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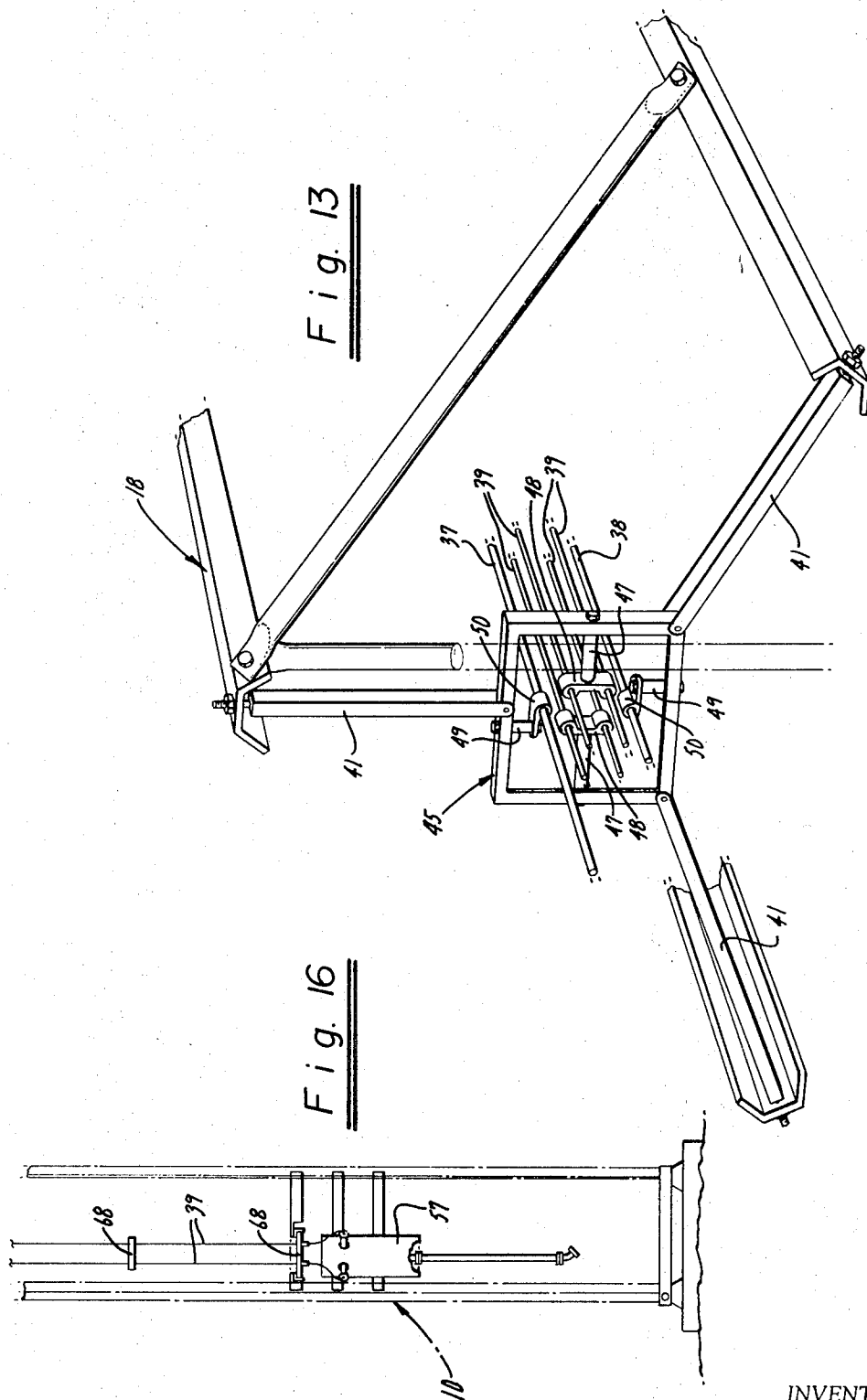
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LOG PERIODIC ROTATING ANTENNA

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6 Sheets-Sheet 5



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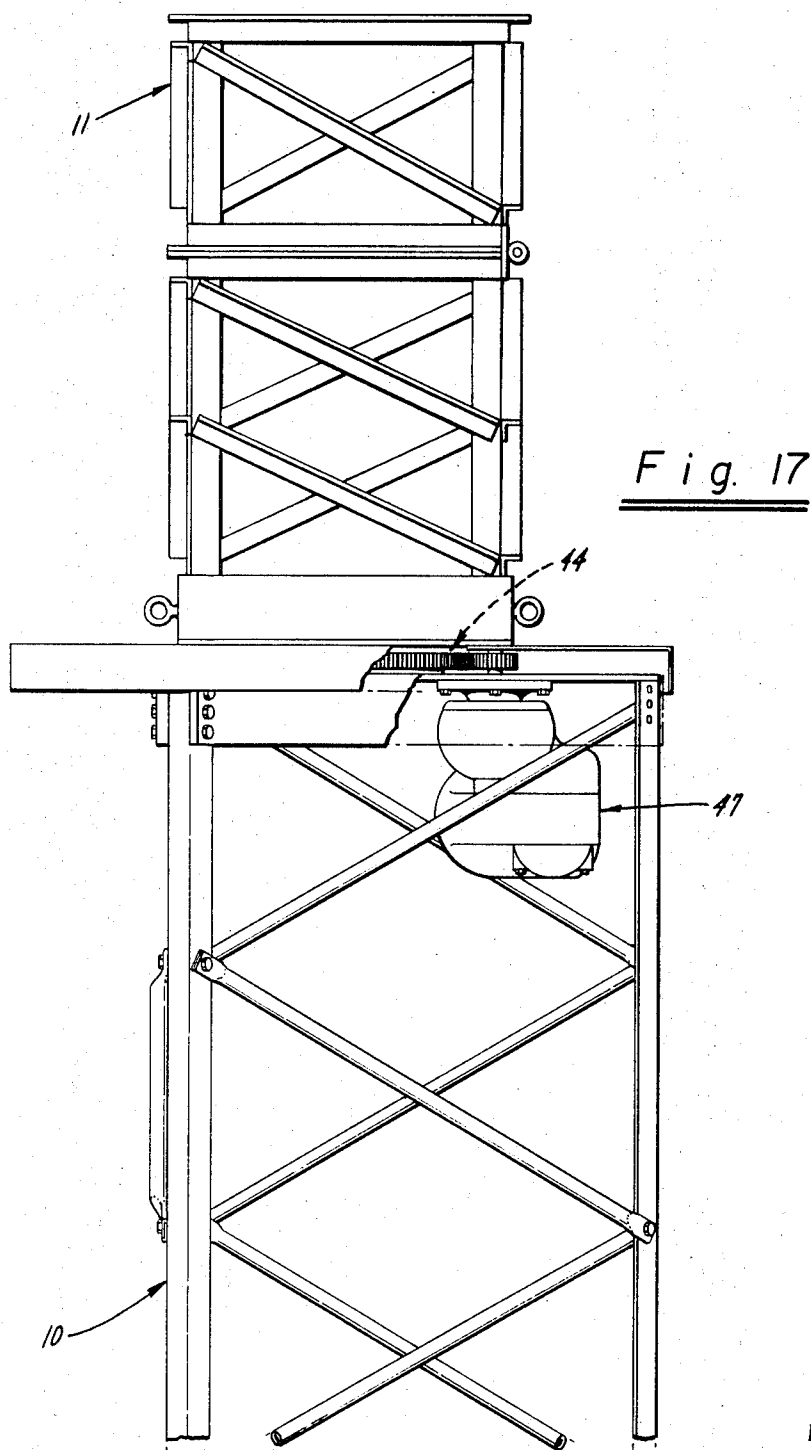
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6 Sheets-Sheet 6



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1

2

3,550,140

LOG PERIODIC ROTATING ANTENNA

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3 Claims

ABSTRACT OF THE DISCLOSURE

An antenna array rotates at the top of a support tower. The array is comprised generally of elongated wire portions of log periodic length relationship supported by three booms and cables strung between the boom ends. Two of the booms comprise spliced portions connected by insulating splices. The upper ends of plural conductors are connected directly to the rotatable array while the lower ends are held stationary. A number of spacers hold the conductors apart along their length during twisting of the column of conductors when the array is rotated. Ice compensating wind vanes are carried at the ends of two booms to become coated with ice and thereby provide aerodynamic balance when so coated or when ice free.

This invention pertains to an antenna system structure, particularly useful as a rotating log periodic antenna.

Log periodic antennas are generally characterized by a number of substantially parallel dipole radiating elements each respectively having a length, and being disposed at spacings, defined by a constant proportion from one to the next. Characteristically, these radiating elements have consisted of long, hollow, tubular members which are cantilevered to extend out from a common "spine" or support boom. Thus, such an array becomes quite ponderous as the radiating elements become longer and longer.

Heretofore, antenna systems, and particularly rotating antenna systems, have been handicapped by their structural configurations whereby their weight, bulk, and awkwardness serve to limit their utility. In directional antenna systems to be rotated to a desired azimuth, the radiating array structure should be as little subject to weather conditions, such as icing, high winds, or both whereby it can remain directionally oriented without undue strain on the structure.

It is generally an object of the present invention to provide an improved antenna system.

It is another object of the invention to provide a generally improved rotating antenna system serving to overcome the foregoing and other problems.

It is another object of the invention to provide a rotating antenna system which is aerodynamically balanced as respects those areas which are exposed to the natural elements so as to avoid the adverse, unbalancing effect of accumulations of ice and of high winds.

It is a further object of the invention to provide a lightweight, low drag array permitting a smaller, more compact rotating assembly to be placed at the upper end of a support tower so as to eliminate conventional tubular members and thereby to simplify the support structure for erecting and lowering the antenna.

It is yet another object of the invention to provide a supporting structure essentially totally confined within the radiating array.

Heretofore, when a uniform thickness of ice attaches to the members of an antenna system such as a log periodic antenna, the resulting aerodynamic center for the antenna shifts and unbalances the antenna on its support tower. At such times, a rotating antenna further expe-

riences a change in the torsional load against which the rotator assembly must work.

It is therefore another object of the present invention to provide means for retaining the aerodynamic center of pressure for the rotating array notwithstanding severe changes in environmental conditions of wind and ice.

It is still another object of the present invention to provide a rotating antenna system having increased reliability by virtue of the elimination of the coaxial rotary joint.

These and other objects of the invention will become more readily apparent from the following detailed description of a preferred embodiment, according to the invention, when considered in conjunction with the accompanying drawings, in which:

FIG. 1 is a plan view of an antenna, according to the invention;

FIG. 2 is a side elevation view of FIG. 1;

FIG. 3 shows an enlarged detail taken along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged detail view showing electrical connection as made between the primary and return radiator feed lines;

FIG. 5 is an enlarged detail view of a dielectric splice in a boom taken along the line 5—5 of FIG. 1;

FIG. 6 is a detail view further enlarged taken along the line 6—6 of FIG. 5;

FIG. 7 is a section view taken along the line 7—7 of FIG. 6;

FIGS. 8 and 9 are enlarged detail perspective views showing the detail of a bearing assembly for supporting the rotatable array atop the support tower;

FIGS. 10 and 11 are respectively a perspective view showing an antenna structure, according to the invention, incorporating ice compensating wind vanes, and an enlarged detail of said vanes;

FIG. 12 is an enlarged perspective exploded view showing the details of radiator attachment to the feed lines carried within one of the booms;

FIG. 13 is an enlarged perspective detail view showing the line supporting and spacing structure within the boom;

FIG. 14 diagrammatically shows another construction for supporting the tip ends of the radiating elements;

FIG. 15 is an enlarged detail view showing spacers for return feed lines;

FIG. 16 is an elevation view of the support tower base showing the balun position and also the vertical feed line construction permitting rotation of the array carried atop the support tower;

FIG. 17 is an enlarged side elevation view of a portion of the support tower of FIG. 2.

FIG. 18 diagrammatically shows another embodiment for supporting the tip ends of the radiating elements.

In general, there is provided herein an antenna system to be carried atop a support tower for rotation with respect to the tower. The antenna system includes a radiating array configuration comprised of spaced flexible radiating elements, and means forming an array-supporting construction having a peripheral configuration on the order of, but not substantially greater than, the periphery of the array configuration. Thus, the radiating array configuration is essentially at least coextensive with the array-supporting configuration carried atop the support tower.

Further, the radiating array, in general, consists of spaced radiating elements wherein each comprises a pair of wire portions supported at their outer ends so as to diverge at a relatively narrow angle from each other. A deep supporting catenary cable engages and carries each of the elongated flexible radiator wire portions at a point well out on the outer half of each radiator element so as to provide the major supporting function therefor.

3

In addition, means are further provided for supporting substantially only the tip ends of the radiator elements, as by means of a second catenary cable. A trio of booms are enclosed by the cable configuration to form a closed loop of tension around the booms as they extend outwardly from the axis of rotation of the radiating array. Thus, all booms are carried in compression atop the tower.

Referring to the drawings, there is generally shown a support tower 10 atop which a rotatable array-supporting assembly 11 has been mounted. Supporting assembly 11 serves to carry a radiating array of log periodic radiating elements 12. In general, and as will be described in greater detail further below, each radiating element 12 includes a pair of stranded aluminum radiator wire portions 13, 14 (FIG. 3) extending outwardly from one of the three support booms 16, 17 and 18. The portions 13, 14 of each element 12 converge at their outer ends at a relatively small angle.

In order to form a supporting configuration for carrying the array of elements 12 in a balanced, vibration damped manner, a deep load carrying catenary cable 19, 21 extends from the outer ends of booms 16, 17 respectively to the ends of a fiber glass tubing support 22 carried by the end of boom 18. Cables 19, 21 not only carry the major load of the elements 12, but serve to apply tension between the ends of booms 16, 17 and the end of boom 18. In addition, the back radiator element 12a also serves to tension the ends of booms 16, 17 whereby there is provided a closed loop of tension encircling the support booms 16-18. This places them in balanced compression at their inner ends which meet at the vertical axis of rotation of the array-supporting assembly 11.

With the foregoing arrangement, the supporting structure of the array lies substantially entirely within the periphery of the radiating portion thereof. This advantageous arrangement is achieved by placing the deep load carrying catenaries well into the array and then employing very shallow, i.e., only slightly drooping, external catenary cables 23, 24 which serve to support only the tips of the wire radiators.

The three boom construction serves to minimize structure and results in a configuration where three substantially equal length and substantially equiangularly spaced booms have been arranged radially about the axis of rotation of the antenna.

In order to further reduce weight, drag, and susceptibility to vibration and fatigue, each boom has been guyed near its midpoint by stays 26, 27 extending radially from the axis of rotation of the array, both above and below the booms and by further providing the "closed" arrangement of three tension members 28 joining each boom at the guyed points. Tension members 28 lie in a common horizontal plane.

As thus arranged, the result is a balanced structure employing the structural efficiency of guyed towers. The horizontal and radial stays preferably are of fiber glass rod assemblies, or other strong, dielectric cable material.

Catenary cables 19, 21 and 23, 24 are preferably formed of a fiber glass rod to provide essentially a noncorrosive strong cable not particularly subject to changes in length in response to changes of temperature and weather conditions, as well as by aging.

The tip ends 29 of wire portions 13, 14 are supported from cable 23 (FIG. 3) by means of bonded aluminum drop fittings 31 and a pivotally supported pair of links 32 forming a clevis serving to carry the tip end 29 of portions 13, 14.

An aluminum spreader bar 33 is compression swaged at its ends to each wire portion 13, 14 and by means of a pivotal connection 34 is carried by another drop fitting 36 secured fast to cable 19. The major weight of elements 12 is carried by the deep load carrying catenaries 19, 21.

Briefly, as described further below, the primary feed lines 37, 38 extend along the inside of boom 18 from the

4

leading end 40 thereof to the back radiator 12a so-called "return feed lines" 39, coupled to lines 37, 38 at end 40, trace along boom 18 to the axis of rotation of the array and then descend down the interior of the support tower 10.

For making feed line connection, radiator wire portions 13, 14 (FIG. 12) are secured at their inner ends to a pivotally mounted spacer support arm 61. The arms 61 are separated by an insulator bar 62, preferably of a high grade ceramic material, such as steatite. A pair of arcuate support brackets 63 carry an associated one of swiveled support arms 61 at one end (as by welding) and at their other ends are coupled to one of feed lines 37, 38 by means of a compressed clip 64 fastened thereto. The symmetrical arrangement of feed lines 37, 38 serves to eliminate electrical interference therebetween.

Feed lines 37, 38 are further supported along the length of boom 18 by means (FIG. 13) of longitudinally spaced support frames 45 carried within boom 18 by tie rods 41. Insulators 47 carry spacers 48 in the form of aluminum fittings swaged to lines 39. Similarly, insulators 49 carry swaged aluminum fittings 50 so that lines 37, 38 and the return feed lines 39 are all symmetrically arranged. The feed line connections to the radiator elements, as described above, are made intermediate the frames 45.

Near the boom end 40, electrical coupling is made between line 37 and two of lines 39, and between line 38 and the other two lines 39 as shown in FIG. 4, using the swaged aluminum spacers 42.

Inasmuch as return feed lines 39 extend no further rearwardly than to tower 10, the primary feed lines 37, 38 are carried by the connections shown in FIG. 12 rearwardly to the back radiator 12a. However, a dielectric bridle 54, comprised of fiber glass cables extending from lines 37, 38 rearwardly to the outer ends of booms 16, 17, serves to tension the lines 37, 38 and maintains them taut.

Each of booms 16, 17 contain dielectric splices formed as shown in FIGS. 5, 6 and 7, the boom comprises 60° channel members 65 held together at their adjacent ends by a pair of dielectric plates 66 and a flat filler plate 68 which serves to cause the structure to wash clean so as to remove electrically deleterious material which could serve to short circuit across the adjacent ends. Plates 66 and 68 are bolted to sandwich and span the adjacent ends of channel members 65.

Thus, the boom construction of the rear booms is considerably less expensive than if made entirely of insulative material while achieving enhanced operation.

A parasitic element in the form of an additional spaced wire radiator element 43 serves to provide good low frequency electrical performance with a minimized array size.

It has been observed that the usual high "Q" normally experienced with wire radiators can be readily controlled by employing the dual radiator wires as above described in the slender triangular arrangement of elements 12. In this way, any desired L/D ratio can be attained with a uniform proportionality retained over the entire array, while providing superior electrical characteristics.

It has been further observed that a preferred alpha (α) angle (defined between the axis of boom 18 and the line of tips 29 of elements 12, i.e., along cable 23 or cable 24) preferably could be formed at an angle on the order of 25°.

Thus, by employing the mutually divergent wire portions of radiator elements 12, it will be readily apparent that the kite-like configuration of the radiating array is considerably foreshortened as compared, for example, to a wire-strung Isbell antenna system.

Means for rotatably supporting and driving assembly 11 includes the use of a single large diameter four-point contact type ball bearing assembly 44 (FIGS. 8 and 9), which combines thrust and overturn moment capability in a single unit thereby enhancing simplicity and long term durability. This type of bearing has previously been used

5

with success in the rotation of large parabolic reflectors, cranes, heavy construction equipment, and gun turrets, and further description is not believed necessary in the light of its conventional employment.

The bearing is characterized by its four-point wire race 46.

By the unusually lightweight and low drag configuration of the construction carried atop tower 10, a smaller, more compact rotator assembly can be employed. Further, by making it feasible to easily rotate assembly 11, the small drive motor 47 can be positioned atop tower 10 rather than at ground level and in this manner there is eliminated the considerable weight and redundancy of a full length tubular mast as normally employed within antenna support towers. In addition, by locating motor 47 at the upper end of tower 10, the task of erecting and lowering the antenna tower and array can be greatly simplified.

Contributing to the ease with which array 11 can be rotated, means serving to equalize the aerodynamic center of pressure acting upon the array have been provided and are effective notwithstanding relatively widely varying extremes of wind and ice conditions.

With conventional antenna systems a one-half inch coating of ice accumulated radially of a radiating element will cause a conventional log-periodic array to become unbalanced. Inasmuch as the thickness of ice is applied uniformly to all the members of the antenna, the result is that with ice the aerodynamic center of the array shifts several feet from the aerodynamic center without ice.

As disclosed herein, the aerodynamic center remains substantially fixed. Thus, means for compensating for accumulations of ice upon assembly 11 and upon the radiating array have been provided herein as now to be described with particular reference to FIGS. 10 and 11.

Vane assemblies 51 are carried at the ends of booms 16, 17 by elongated fiberglass tubes 53. Wind vane assemblies 51 include spaced slots 52 on the order of one inch apart formed between aluminum tubes 59. Tubes 59 extend through holes formed through the upper and lower flanges of a channel member 60 bolted to tubes 53.

These slots 52 fill in solidly with ice by the time one-half inch of radial ice has been accumulated upon radiating elements 12 of the antenna. The overall size of vane assemblies 51 is selected to provide aerodynamic balance for any ice conditions expected to be encountered. The amount of material between slots 52 is also selected to provide aerodynamic balance for the ice-free condition when slots 52 are fully open and totally free of ice.

At the bottom of tower 10, a balun 57 has been supported by conventional means. Balun 57 converts the 200 ohm balanced impedance of the antenna feed point to the 50 ohm unbalanced impedance of the coaxial input line.

Power transmitted to ground level from the rotating assembly 11 ordinarily might be expected to be coupled through a conventional coaxial feed joint construction in order to accommodate rotation of the array. It has been observed, however, that conventional feed joint constructions provide a relatively unreliable rotary joint for coaxial coupling. Thus, the coaxial feed joint of prior constructions has been eliminated and there has been provided herein an improved construction whereby a flexible balanced line, fabricated from an Alumoweld cable, is disposed on the center line of support tower 10. Alumoweld is an aluminum covered steel wire with a thick cladding of pure aluminum over a high strength steel core. A feature of Alumoweld is that it is characterized by its method of manufacture utilizing the controlled atomic weld process. This technique assures a ductile and permanent weld between the two metals under all operating conditions.

The upper end of the line extends through the rotator and turns with assembly 11. The lower end of the line terminates on a structural bracket designed to withstand the preload and environmental load. Continuous

6

clockwise and counter-clockwise rotation through 360° is provided by the line twisting no more than 180° in each direction from its neutral position.

Thus, as shown in FIGS. 15 and 16, the column of wires comprised of return feed lines 39 includes a number of X-shaped spacers 68 of high grade ceramic, such as steatite material. The ends of each arm of the X includes a drilled hole 69 through which one of the lines 39 passes. Closely spaced above and below the holes 69, each line 39 is fitted with a compression fitting or collar 71 so as to define the longitudinal position of each spacer 68.

By disposing spacers 68 at intervals on the order of at least every five feet, the lateral spacing between lines 39 is preserved within close limits during twisting of the column of wires 39 through $\pm 180^\circ$. Without means for maintaining the spacing of lines 39 they would, of course, cross over each other upon twisting of the column 180°.

It is presently considered that a capability of twisting the column of leads 39 through $\pm 180^\circ$ is sufficient for most purposes, taking advantage of the elasticity of the feed lines where the bottom and top ends of lines 39 are rigidly fixed, as herein. However, by reducing the displacement between spacers 68 and/or by resiliently anchoring the lower end of lines 39, rotation of the array relative to tower 10 can be achieved well beyond $\pm 180^\circ$.

By arranging the feed lines 39 in the above manner, not only is the relatively unreliable rotary joint avoided, but also the very expensive coaxial cable normally employed within antenna support towers of the above general type has been removed.

The transmission lines used in the antenna system are of the open wire, balanced configuration. The twistable four wire line running up support tower 10 to the feed point of the antenna array 11 makes possible the elimination of the less reliable rotating joint as noted above. The four-wire configuration allows a 200 ohm impedance to be achieved with the desired conductor sizes and spacings needed for adequate power handling capacity. High quality ceramic feed line insulators are used throughout to reduce loss and eliminate the possibility of destructive breakdown.

As noted above, in addition to the deep supporting catenary cable 19, 21, additional means have been provided for supporting essentially only the tip ends of each radiator element 12.

According to another embodiment, as shown in FIG. 14, a deep supporting catenary cable 66 supports substantially rigid aluminum tubes 67 fixed to cable 66 in a manner to extend outwardly therefrom so as to engage and support the tip ends of wire elements 72, 73. Thus, the hollow aluminum tubes 67 are attached at their inner ends to radiator element portions 72, 73 and made fast at their mid-points by being bolted or otherwise clamped to cable 66.

Another embodiment of the tip supporting construction, (FIG. 18), employs a catenary 74 and hollow aluminum tube 76. The inner end of each tube 76 is attached to a pair of radiator elements 77, 78. The approximate mid-point of each tube 76 is fastened to catenary cable 74 by a clamp or swaged fitting 79.

What is claimed is:

1. An antenna system to be carried atop a support tower comprising an array of spaced radiating dipole elements, said radiating elements each comprising a pair of wire portions, cable means defining the periphery of the array and serving to support said wire portions of each of said pairs at their outer ends to mutually diverge at a relatively narrow angle from each other to form a radiating dipole, said radiating elements being dimensioned and disposed in a predetermined proportional relation to the next preceding element, and a trio of three booms disposed to extend radially outwardly of the tower, said cable means being carried at the ends of the booms to define said periphery and to hold said booms

7

mutually in compression while enclosing the array as viewed in plan whereby the array is disposed substantially entirely within said periphery.

2. In an antenna system, a support tower, an array of radiating elements atop said tower, said array being rotatable with respect to said tower, electrical conductors carried by the tower to extend upwardly to said array, and means supported solely by said conductors at intervals along said conductors serving to space same along their length and permitting said array to rotate 180 degrees clockwise and counter-clockwise from a predetermined neutral position while substantially maintaining said spacing.

3. In a rotatable antenna system apparatus comprising a support tower, a trio of three booms extending radially from the upper end of the tower, the radially inner ends of the booms meeting at the top of the tower, support cable extending between the radially outer ends of the booms to enclose the booms as viewed in plan, and serving the place the booms in compression, a radiating array comprising a plurality of radiating elements extending laterally of one of said booms, and in a substantially horizontal plane, said elements including pairs of flexible cable portions converging at their outer ends, said support cable carrying the outer ends of said radiating ele-

8

ments and substantially enclosing the radiating array, and means for rotating said array and booms atop the tower about an upright axis in the tower.

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TIM VEZEAU, Assistant Examiner

U.S. Cl. X.R.

343—792.5, 886, 890