Feb. 14, 1950 F. D. BRADDON 2,497,065

STABILIZED TOWER SUPPORTED ANTENNA

Filed Dec. 26, 1947

Fig. 1.

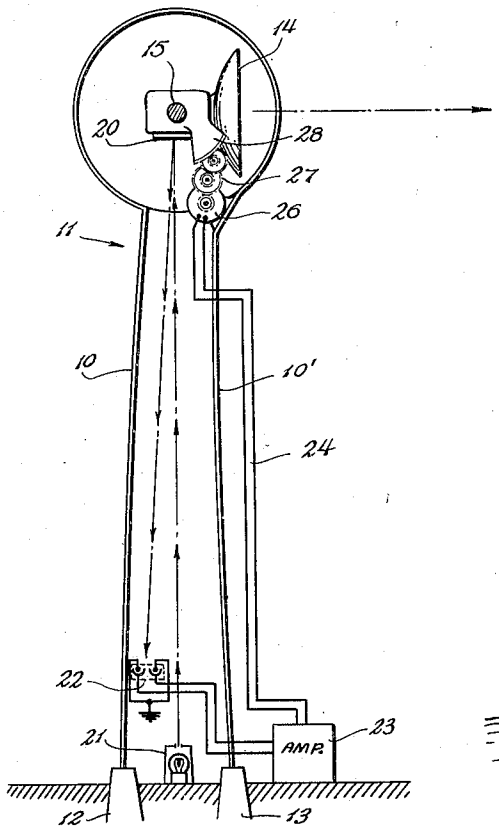
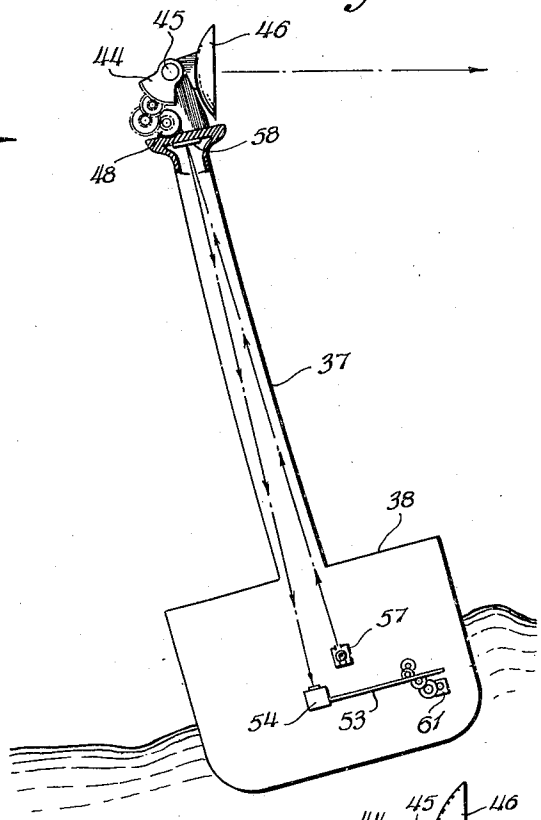



Fig. 2.



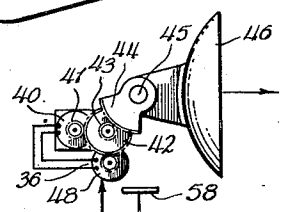
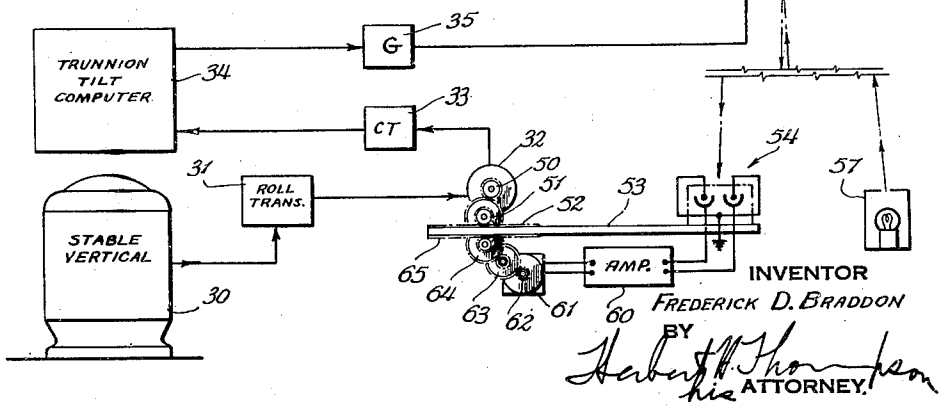




Fig. 3.




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## STABILIZED TOWER SUPPORTED ANTENNA

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10 Claims. (Cl. 250—33.65)

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This invention relates to tower-supported antennas and has for its object the provision of an apparatus for stabilizing scanners or antennas mounted on masts or towers which are subject to flexure due to the motion of the base upon which the tower is constructed or the effect of high winds.

The invention will now be described with reference to the accompanying drawings of which,

Fig. 1 shows a stabilization system for an antenna tower structure such as might be used in connection with cross-country microwave transmission systems;

Fig. 2 shows a stabilized antenna supported on a mast of a ship; and

Fig. 3 is a drawing showing schematically one form of a circuit arrangement for stabilizing the antenna of Fig. 2.

In cross-country microwave transmission systems, highly directional antennas are mounted on towers arranged sufficiently close to each other to establish a line of sight from one antenna to another. The towers which are usually of skeleton steel framework construction are required to support a comparatively light antenna structure. Such towers have some inherent flexibility, and high winds may bend them sufficiently to deflect the transmission beam enough to interfere with the operation of the transmission system. Winds acting on towers in the direction of the transmission beam are more serious since the antennas tend to be deflected in a vertical plane with respect to the normal position of the beam. Accordingly, in one embodiment of the invention, shown in Fig. 1, it is proposed to detect bending of the tower in the direction of the transmission beam by a simple photo-electric apparatus which controls a single axis servo system that maintains the antenna in fixed predetermined angular relationship with the ground.

The tower which is shown schematically in Fig. 1 comprises upright members 10 and 10' supported by foundation sections 12 and 13. An antenna structure 14 is supported by the tower for limited displacement in a vertical plane about the axis of a horizontally disposed pivot arrangement 15 attached to the top of the tower by any suitable means, not shown. It is assumed that the antenna is part of a transmission system and cooperates with a remote antenna, not shown, in accordance with the usual practice.

The apparatus for detecting bending of the tower preferably is of the photo-electric type wherein such bending causes relative movement of a ray of light and a light sensitive cell, the

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latter controlling circuits for actuating a servomotor which maintains the antenna in correct angular position. The arrangement shown in Fig. 1 provides a very long light beam, and for convenience, the source of light and the photo-electric cell are located at the base of the tower. A plane mirror 20 secured to the under surface of antenna receives a beam of light from a light source 21 disposed near the base of tower 11. The mirror projects the ray back at a small angle to a photo-electric cell device 22 coupled with the input of an amplifier 23.

The output of the amplifier is connected through circuits 24 to a servomotor 26 fixed to the top of tower 11. The servomotor is coupled by suitable reduction gearing 27 with a gear sector 28 fixed to the antenna structure.

Assuming that the photo-electric cell pick-up arrangement 22 is of any suitable type such as one having a central null portion on either side of which are active portions and that under normal conditions a ray of light from the light source 21 is reflected by the mirror 20 downward, impinging on the null area of the photo-electric cell apparatus. Under these conditions the servomotor is inoperative as the antenna is in correct angular position. Now, if a strong wind should flex the tower either toward the right or left hand edges of the drawing, the resulting angular displacement of the mirror will deflect the beam of light so that it will strike an appropriate one of the active portions of the photo-electric cell apparatus causing the operation of the amplifier and the servomotor which drives through the gearing 27 to displace the antenna until the mirror again deflects the ray of light onto the null portion of the photo-electric cell pickup, whereupon the servomotor stops. When the tower springs back into its normal vertical position, the arrangement operates in the reverse manner to restore the antenna to its normal angular position.

Masts for antennas or other scanning apparatus on board the ship are necessarily lighter and less bulky, due to weight and space limitations, than towers which might be erected on land for a similar purpose. Consequently, the shipborne masts are less resistant to bending from wind pressure. The masts are subject to further stresses which tend to cause bending arising from the instability of the ships' decks on which they are mounted.

A second embodiment of the invention, shown in Figs. 2 and 3 relates to a stabilizing apparatus for an antenna or other scanning device mounted

on a ship's mast. The invention contemplates providing correction for the antenna about two axes to compensate for bending of the supporting mast. The antenna is considered to be adjustably controlled in the known manner through a trunnion tilt computer. A suitable trunnion tilt computer is disclosed in Patent No. 2,069,417, issued Feb. 2, 1937 to Hugh Murtagh, et al. In addition to permitting adjustment of the angular position of the antenna from suitable control apparatus, not shown, the trunnion tilt computer stabilizes the antenna against pitch, roll and yaw of the ship.

In Fig. 3 a portion of a trunnion tilt corrector apparatus for correcting the position of the antenna about the roll axis is shown by a block diagram in connection with applicant's arrangement for compensating for the bending of the mast. A similar arrangement, not shown, would be used for the pitch axis. Further details of the trunnion tilt corrector and associated apparatus have been omitted as they are not part of the invention. A trunnion tilt corrector receives level plane data from the roll and pitch axes of a gyro vertical. A gyro vertical **30**, shown in Fig. 3, actuates a roll transmitter **31** which is connected to one set of windings of a differential synchro transformer **32** of a known type having a set of polyphase stator windings and a corresponding set of rotor windings. The second set of windings of transformer **32** is connected through a synchro transmitter **33** to an input of the trunnion tilt computer **34**. A transmitter **35** of the synchro type actuated from the output of the trunnion tilt computer drives a control synchro receiver **36** which is mounted on top of a mast **37** of a ship **38**. When synchro receiver **36** receives a signal from transmitter **35** it controls through a known circuit arrangement, a servomotor **40**. A gear **41** on the output shaft of the servomotor is connected by suitable reduction gears **42** and **43** with a gear sector **44** fixed to a scanning device **46** which is supported for displacement about the axis of a horizontal shaft **45**. Gear **42** also meshes with a gear **48** fixed to the shaft of the synchro control motor **36**. This arrangement provides a follow-up system by which the servo when actuated by a signal from the control motor, drives the rotor of the control motor to such angular position as to cause the signal controlling the servomotor to disappear, at which point the servomotor stops, and the scanning device **46** which is coupled in fixed relation to the shaft of the servomotor is in the correct angular position in elevation. The arrangement for displacing the scanner in azimuth is not shown since it is substantially the same as that for the elevation axis.

The data transmitted from gyro vertical **30** is corrected for bending of mast **37** in accordance with the present invention by the apparatus about to be described.

A gear **50** fixed to the rotor shaft of differential synchro transformer **32** is coupled by a gear **51** to a rack **52** formed on the upper surface of a bar **53** which carries a photo-electric pickup apparatus **54**. A source of illumination **57** disposed near the base of mast **37** projects a ray of light upwards to a plane mirror **58** fixed to the top of the tower **37** in substantially the same manner as the corresponding mirror of Fig. 1. The mirror reflects the beam of light downward to the photo-electric pickup **54** which controls amplifier **60** and servomotor **61** whenever bending of the mast causes the beam of light to be deflected to one side or the other of the null portion of the photo-electric pickup. The differential synchro transformer **32** is so geared to the servo that its angular rotation properly represents the angular tilt of mirror **58** on the base supporting the scanner with respect to the deck plane.



A gear **62** on the shaft of servomotor **61** operates gears **63** and **64**, the latter being in mesh with a rack **65** formed on the under surface of the bar **53**.

The operation of the arrangement just described is substantially the same as the embodiment of the invention shown in Fig. 1. Bending of the mast causes the beam of light to shift from the central null area to either of the operative areas of the photo-electric pickup **54** producing a signal which is amplified by the amplifier **60** causing servomotor **61** to operate in the appropriate direction to displace the bar **53** and position the beam of light over the central null portion of the photo electric pickup. When the bar **53** is thus moved, rack **52** displaces the rotor of the differential synchro transformer **32** thereby modifying the roll signal data from roll transmitter **31** to correct the same for the bending of the mast. When the mast assumes its normal upright position the reverse operation takes place restoring the normal angular relation of the rotor and stator windings of the differential synchro transformer **32**.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departure from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An apparatus for stabilizing an antenna mounted on a tower which includes means for detecting bending of the tower comprising a light projecting device and a photo-electric pickup apparatus, one of which is disposed near the top of the tower and the other of which is disposed near the base of the tower, and servo means operatively coupled with the antenna and controlled by the pick-up apparatus for compensating the position of the antenna in accordance with the bending of the tower.

2. An apparatus for stabilizing an antenna pivotally mounted at the top of a supporting tower against flexure of the tower comprising a light projecting device fixed to the antenna, a photo electric pick-up apparatus disposed near the base of the tower cooperating with a beam of light from said device for detecting flexure of the tower, and a servomotor for correcting the angular position of the antenna controlled by the photo electric pick-up apparatus.

3. In an apparatus of the type described, a tower, a relatively movable antenna supported thereon, means providing a beam of light directed from one end of the tower movable with respect to the tower due to the flexure thereof, a movable photo electric pick-up device at the other end of the tower cooperating with the beam of light, a servo motor controlled thereby for effecting relative movement between the pick-up device and the light beam, and means controlled by the servomotor, when thus moving the pick-up device, for angularly displacing the antenna to compensate for flexure of the tower.

4. In an apparatus of the type described, a tower, an antenna movably supported thereon, a

mirror coupled with the antenna, a photo electric pick-up disposed near the base of the tower normally in substantial alignment with the surface of the mirror, means for projecting a beam of light onto the surface of the mirror at such angle that the beam is reflected by the mirror into the photo electric pick-up, and a servomotor controlled by the photo electric pick-up effective on relative movement of the beam of light with respect to the photo electric pick-up due to bending of the tower to compensate the angular position of the antenna accordingly.

5. In an apparatus for maintaining a radio scanning device pivotally mounted on a ship's mast in a predetermined line of sight, wherein said device is stabilized about said pivotal mounting against rolling of the ship by a servomotor controlled in part from a gyro vertical, an improvement therein for preventing errors in the line of sight due to bending of the mast comprising means for producing a reversible signal upon flexure of the mast in either direction including a photo-electric device disposed near one end of the mast and a beam of light directed from the other end of the mast, and means for correcting said servomotor by said signal means to compensate for flexure of the mast.

6. In an apparatus of the type described wherein a scanning device is supported on a ship's mast and stabilized thereon against rocking movements of the ship by a trunnion tilt computer, a gyro vertical, circuits controlled thereby for controlling the trunnion tilt computer, adjustable transformer means included in the circuits, means for detecting flexure of the mast including a photo-electric pick-up apparatus disposed near one end of the mast and a cooperating beam of light directed from the other end of the mast relatively movable with respect thereto due to flexure of the mast, and servo means controlled by the photo-electric pick-up effective to adjust the transformer means to compensate for flexure of the mast.

7. In an apparatus of the type described wherein a scanning device is supported on a ship's mast and stabilized thereon against rocking movement of the ship by a trunnion tilt computer, the improvement which comprises a gyro vertical, circuits controlled thereby for furnishing level reference data to the trunnion tilt computer, adjustable differential transformer means included in the circuits, means for detecting flexure of the mast including a photo-electric pick-up disposed near one end of the mast, a cooperating beam of light directed from the other end of the mast relatively movable with respect thereto due to flexure of the mast, servo means controlled by the photo-electric pick-up tending to maintain the latter in predetermined position with respect to the beam of light, and means controlled by the servo means for adjusting the differential transformer means to compensate the level reference data for flexure of the mast.



8. In an apparatus of the type described wherein a scanning device is supported on a ship's mast and stabilized thereon against rocking movements of the ship by a gyro vertical, circuits controlled thereby for controlling the stabilization of said device, adjustable differential means included in the circuits, means for detecting flexure of the mast including a photo-electric apparatus disposed near one end of the mast and a cooperating beam of light directed from the other end of the mast relatively movable with respect thereto due to flexure of the mast, and servo means controlled by the photo-electric apparatus effective to adjust the differential means to compensate for flexure of the mast.

9. An apparatus for stabilizing a scanning device mounted on a ship's mast which comprises a gyro vertical, circuits controlled thereby including servo means for stabilizing the scanning device against rocking movements of the ship, adjustable differential means included in the circuits, means for detecting flexure of the mast including a photo-electric pick-up apparatus disposed near one end of the mast and a cooperating mean of light directed from the other end of the mast relatively movable with respect thereto due to flexure of the mast, and further servo means controlled by the photo-electric apparatus effective to adjust the differential means to compensate for flexure of the mast.

10. An apparatus for stabilizing a scanning device mounted on a ship's mast which comprises a trunnion tilt computer, servo means controlled thereby and operatively coupled with the scanning device for stabilizing the scanning device against rocking movements of the ship, a gyro vertical provided with output circuits connected with the trunnion tilt computer for furnishing level reference data thereto, adjustable differential means included in the circuits, means for detecting flexure of the mast including a photo-electric pick-up apparatus disposed near one end of the mast, and a cooperative beam of light directed from the other end of the mast relatively movable with respect thereto due to flexure of the mast, and further servo means controlled by the photo-electric apparatus effective to adjust the differential means to compensate the level reference data for flexure of the mast.

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