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ANTENNA REFLECTOR SUPPORT

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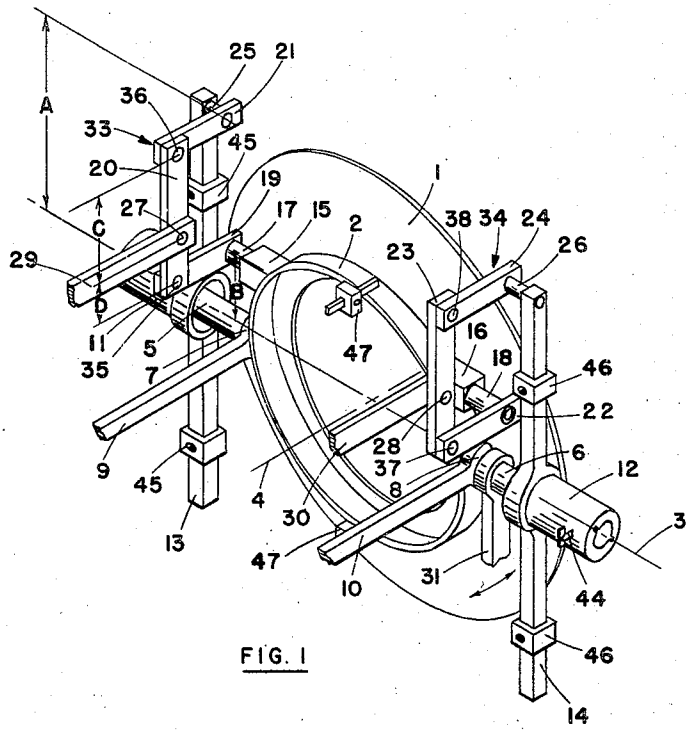


FIG. 1

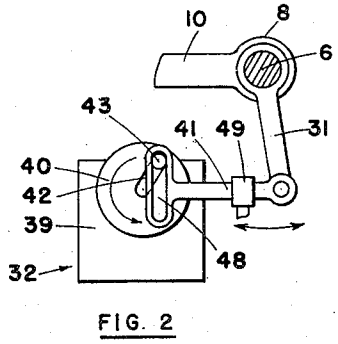


FIG. 2

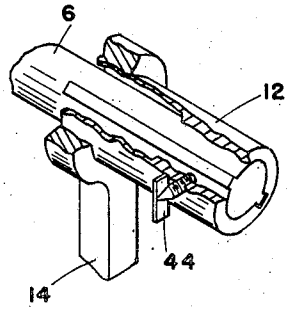


FIG. 3

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ANTENNA REFLECTOR SUPPORT

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This invention relates to an antenna reflector support and more particularly to a support for a radar antenna reflector that will allow the reflector to oscillate rapidly about an axis and is so conceived that no reactions are reflected into the adjacent structure upon which the support is mounted during periods of oscillation or during periods of acceleration or deceleration from this state of oscillation.

In designing a radar installation the problem of motivating the antenna equipment so as to describe a prescribed search pattern involves several factors. Ordinarily the pattern combines a high speed scan or oscillation to provide the necessary resolution superposed over a slow-speed scan to provide a search field of suitable dimensions.

Generally it is thought desirable to scan by moving the radar reflector through the desired path rather than by moving the wave guide because of the precision with which the design dimensions of the wave guide must be maintained in order to obviate undue attenuation of energy conducted thereby. Having decided upon this approach, the problem is to provide suitable means for counteracting the unbalanced, dynamical forces which would otherwise be reflected into the adjacent structure, such as an airframe upon which the antenna is mounted, due to the high-speed oscillation of the reflector and particularly during periods of acceleration and deceleration from this state of oscillation.

It is known that in an oscillatory spring-mass system one of the physical properties of the system is its natural frequency. If the frequency of the driving oscillation is the same as its natural frequency, the system is said to operate in resonance and it is found that a minimum amount of driving force need be applied to said system in order to maintain its oscillation at the resonant frequency.

It is contemplated by this device to make use of this resonant characteristic in order to keep the required driving power to a minimum.

It is also contemplated by this device to dynamically balance the antenna reflector system so as to prevent the transmission of undesirable reactive forces to the adjacent structure upon which the system is adapted to be mounted.

It is, therefore, an object of this invention to provide a support for an antenna reflector in which no reactive forces will be transmitted into the adjacent structure during periods of oscillation of the reflector.

It is a further object of this invention to provide a support for an antenna reflector in which no reactive forces will be transmitted into the adjacent structure during periods of acceleration or deceleration of the reflector to or from its condition of a steady state high-speed oscillation.

It is a further object of this invention to provide a support for an antenna reflector which is both compact and lightweight.

It is yet another object of this invention to provide a

support for an antenna reflector which will require a minimum of power to oscillate said reflector.

Other objects of invention will become apparent from the following description taken in connection with the accompanying drawings, in which

Fig. 1 is a semi-schematic isometric view of the basic embodiment of this invention;

Fig. 2 is a partial side elevation view of the device of Fig. 1 showing the drive unit coupled to the antenna reflector shaft;

And Fig. 3 is an enlarged isometric view partially broken away to show structure of the torsion bars of the device of Fig. 1.

Fig. 1 shows antenna reflector 1 backed by support frame 2 which may either be rigidly secured to reflector 1 or formed integrally therewith. Rigidly attached to opposite sides of frame 2 and coaxial with primary axis 3, shown normal to optical axis 4 of reflector 1 and coplanar therewith, are shafts 5 and 6. The inner ends of shafts 5 and 6 adjacent to frame 2 are supported in bearings 7, 8 which in turn are secured to extensions 9, 10 of an adjacent structure, such as an airframe, to which antenna reflector 1 is adapted to be mounted. The outer ends of shafts 5, 6 are rigidly attached to the outer ends of concentric tubes 11, 12. The inner ends of tubes 11, 12 are respectively rigidly attached to inertial masses 13, 14 which in themselves are inertially symmetrical with respect to axis 3.

Symmetrically disposed with relation to an axis normal to an intersecting axes 3, 4 are a pair of linkages 33, 34 which include stub brackets 15, 16 secured to frame 2 and terminating in stub shafts 17, 18 spaced from frame 2. Pin connected links 19, 20, 21, and 22, 23, 24, respectively link stub shafts 17, 18 and stub shafts 25, 26 which are rigidly attached to ends of inertial masses 13, 14. At points intermediate of links 20 and 23 pivotal connections are made to adjacent structure extensions 29, 30 as by pivot pins 27, 28, respectively. Pivot pins 35, 36, and 37, 38 respectively interconnect links 19, 20, 21, and 22, 23, 24.

Fig. 2 shows drive mechanism 32 (which is secured to the adjacent structure) connected to driving crank arm 31 which is rigidly secured to shaft 6 at a point adjacent bearing 8. Drive mechanism 32 is shown comprising motor 39 to whose shaft is coupled driving disc 40 having pin 43 adjustably secured in radially directed slot 42. Scotch yoke link 41 is pin-connected at one end to crank arm 31 and pin 43 is adapted to reciprocate in the yoke-slot 48 in link 41. Guide 49 maintains link 41 in linear motion. Drive mechanism 32 is adapted to supply a driving force of some pre-selected frequency to crank arm 31. This causes frame 2 and reflector 1 to oscillate in synchronism about axis 3. The adjustability of pin 43 from the central position on disc 40 to the eccentric position shown allows the system to be oscillated only at a constant frequency by retaining pin 43 in the central position until motor 39 has reached design speed. When motor 39 has reached the predetermined frequency, pin 43 may be moved to the eccentric position to increase the amplitude of oscillation of reflector 1. Normally this would result in intense reactive forces being reflected back into drive mechanism 32 and thereby into the adjacent structure with the resultant effect that rather substantial vibrations would be set up therein. The features of this invention provided to eliminate this undesirable condition will now be considered.

The elemental combinations incorporating shaft 5, tube 11, and inertial mass 13 on one side and shaft 6, tube 12, and inertial mass 14 on the other side comprise units that establish a state of resonance for the assemblage at the driving frequency previously mentioned. To achieve this

condition the design constants of the individual elements must be properly selected. First, the centers of gravity of the reflector **1**, frame **2**, tubes **11** and **12**, shafts **5** and **6**, and inertial masses **13** and **14** must be coincident with axis **3**. Second, the moment of inertia of each of the inertial masses must be equal to one-half the moment of inertia of the combined reflector **1** and frame **2**, all with respect to axis 3. Third, the two torsion bar units composed of shaft **5** and tube **11** and shaft **6** and tube **12** respectively, must be properly dimensioned and fabricated of materials having the proper elastic coefficients to give a spring rate to these units such that the system will oscillate in resonance at the driving frequency and these units will not be unduly stressed. As a result of selecting a design for resonant operation the system inherently requires little power to be made to oscillate.

Since the inertial masses **13, 14** are spring-connected (the torsion bar units act as springs because of their elasticity) to reflector **1**, they act as dynamic balancers. All of the vibration is taken up in the "spring-mass" assembly instead of being transmitted to the adjacent structure. Therefore, it can be seen that when this reflector support assemblage reaches a state of stable oscillation at the design frequency, there are no reactive forces reflected into support bearings **7, 8**. Also, once the system is in oscillation, only the friction and windage losses need be supplied through crank arm **31** by drive mechanism **32**; so any reactive forces between drive mechanism **32** and crank arm **31** are so small as to be negligible.

It will be seen that amplitude of oscillation of reflector **1** is controlled by the amplitude of the driving oscillation supplied by drive mechanism **32**. However, because of the fact that inertial masses **13, 14** are in effect spring-connected to reflector **1**, their amplitudes, if not otherwise controlled, would increase in amount and disturb the balance of the system. Linkages **33, 34** are therefore provided for controlling the amplitudes of oscillation of inertial masses **13, 14** and for keeping inertial masses **13, 14** in the desired phase relationship with reflector **1**.

Taking linkage **33** as shown in Fig. 1 as representative, the links are proportioned as follows: the distance between axis **3** and the axis of stub shaft **25**, referred as *A* is to the distance between axis **3** and the axis of stub shaft **17**, referred to as *B*; as the distance between pin **27** and pin **36**, referred to as *C* is to the distance between pin **27** and pin **35**, referred to as *D*. This simple relationship provides an inverse unity coupling between the two inertial structures and assures that the angular amplitudes of oscillation of reflector **1** and support frame **2** and inertial mass **13** will be identical at all times. Hence, no forces will react through the linkage during periods of steady state oscillation at which times the angular amplitudes of oscillation of reflector **1** and support frame **2** and inertial mass **13** are identical. Linkage **34** is similarly proportioned to perform a like task.

As previously inferred, drive mechanism **32** which supplies the driving force to crank arm **31** is secured to an adjacent structure (such as an airframe) as are extensions **9, 10, 29**, and **30**. Thereafter, rotations of links **20, 23** take place about fixed positions designated by pins **27, 28** respectively. As drive mechanism **32** accelerates or decelerates reflector **1** and support frame **2**, either increasing or decreasing their amplitude of vibration, a reaction is reflected back into the adjacent structure through drive mechanism **32**. This reaction is counterbalanced by reactions developing at pins **27, 28** transmitted to the adjacent structure through extensions **29, 30**, due to the efforts of the linkages to similarly accelerate or decelerate the inertial masses **13, 14** whose coupled motion is 180° out of phase with the motion of reflector **1** and support frame **2**. The resultant effect is to minimize the reactive forces acting externally due to efforts to alter the steady state condition obtaining in the system at a particular time.

Whereas the present description has treated a simplified embodiment of the invention reduced to its more essential elements, in actual design practice certain refinements are in order. For instance, it is desirable to spline the connections between shafts **5, 6** and tubes **11, 12** respectively, as shown in Fig. 3. These shafts and tubes are normally of the same material, namely a high quality steel such as SAE 4130, and are each twistable in operation. Normally shafts **5** and **6** will supply most of the twist but tubes **11** and **12** are also capable of twisting in an opposite direction since they are not rigidly connected. The combinations of shafts and end attached tubes allow for the spring torsion action of the torsion bar units. This, in combination with adjustable clamp **44** for securing the respective elements together, allows altering the lengths of the shaft-tube combinations and thereby, in effect, tuning the system precisely to the design frequency. Further, the torsion bar (i. e., the shaft-tube combination) may be secured at its vibrational node to the adjacent structure (i. e., the air frame). The vibrational node of a torsion or other vibrating device is, of course, a point on that vibrating device which is stationary or of zero amplitude. In a torsion bar the position of a vibrational node is dependent on the relative spring rates within the torsion bar. Again, it is likewise desirable to provide symmetrically disposed movable masses **45, 46** in combination with the inertial masses **13, 14** such that the moment of inertia of the two inertial masses can be adjusted to that of reflector **1** and support frame **2**. In this same connection it is desirable to attach adjustable mass **47** to the back of support frame **2** so that the assemblage consisting of reflector **1** and frame **2** can have its center of gravity adjusted to coincidence with axis **3**.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

We claim:

1. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising a torsion bar secured to said reflector at said primary axis and having a spring rate such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, said bar being adapted to be secured to an adjacent structure, and an inertial mass secured to said bar at a point spaced from said reflector and having a moment of inertia about said primary axis equal to the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bar, and said inertial mass being coincident with said primary axis whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

2. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising a torsion bar secured to said reflector mounted for rotation about said primary axis and having a spring rate such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, a bearing adapted to be secured to an adjacent structure for mounting said bar, and an inertial mass secured to said bar at a point spaced from said reflector and having a moment of inertia about said primary axis equal to the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bar, and said inertial mass being coincident with said primary axis whereby when said reflector is oscillated at said prede-

termined frequency no reactive forces are transmitted to said structure.

3. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each secured to an opposite side of said reflector at said primary axis and having spring rates such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, said bars being adapted to be secured to an adjacent structure, two inertial masses each secured to one of said bars at a point spaced from said reflector and each having a moment of inertia about said primary axis equal to one-half the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

4. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each secured to an opposite side of said reflector and mounted for rotation about said primary axis and having spring rates such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, bearings adapted to be secured to an adjacent structure for mounting said bars, and two inertial masses each secured to one of said bars at a point spaced from said reflector and each having a moment of inertia about said primary axis equal to one-half the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

5. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each including a longitudinally extending shaft, one end of which is secured to said reflector and mounted for rotation about said primary axis, and a coaxial tube surrounding a portion of said shaft near the other end of said shaft opposite said one end and secured to said shaft at said other end, said torsion bars having a spring rate such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, bearings adapted to be secured to an adjacent structure for mounting said shaft, and two inertial masses each extending radially from and secured to one of said tubes at a point toward said reflector from said other shaft end and having a moment of inertia about said primary axis equal to one-half of the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

6. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each secured to an opposite side of said reflector and mounted for rotation about said primary axis and having a spring rate such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, bearings adapted to be secured to an adjacent structure for mounting said bars, two inertial masses each secured to one of said bars at a point spaced from said reflector and each having a moment of inertia about said primary axis equal to one-half the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis, and two inverse unity couplings interconnecting said reflectors, said structure, and said inertial masses so as to maintain the amplitudes of oscillation of said inertial masses equal to that of said reflector and keep in the desired phase relationship the oscillations of said reflector and said inertial masses whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

7. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each including a shaft, one end of which is secured to said reflector and mounted for rotation about said primary axis, and a coaxial tube surrounding a portion of said shaft near the other end of said shaft opposite said one end and secured to said shaft at said other end, said bars having spring rates such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, bearings adapted to be secured to an adjacent structure for mounting said shafts, two inertial masses each extending radially from and secured to one of said tubes at a point toward said reflector from said other shaft end and each having a moment of inertia about said primary axis equal to one-half the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis, and two inverse unity couplings interconnecting said reflector, said structure, and said inertial masses so as to maintain the amplitudes of oscillation of said inertial masses equal to that of said reflector and keep in the desired phase relationship the oscillations of said reflector and said inertial masses whereby when said reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

8. An antenna reflector and support assembly including a reflector adapted to be mounted on an adjacent structure and a minimum-power driving means to oscillate said reflector about a primary axis normal to its optical axis at a predetermined frequency, said support assembly comprising two torsion bars each including a shaft, one end of which is secured to said reflector and mounted for rotation about said primary axis, and a coaxial tube surrounding a portion of said shaft near the other end of said shaft opposite said one end and secured to said shaft at said other end, said bars having spring rates such that said support assembly and said reflector oscillate in resonance at said predetermined frequency, bearings adapted to be secured to an adjacent structure for mounting said shafts, two inertial masses each secured to one of said tubes at a point toward said reflector from said other shaft end and each having a moment of inertia about said primary axis equal to one-half the moment of inertia of said reflector about said primary axis, the centers of gravity of said reflector, said bars, and said inertial masses being coincident with said primary axis, and two inverse unity couplings each including a first link connected by a first pivot pin to one of said inertial masses, a second link connected by a second pivot pin to said reflector, and a third link connected by third and fourth pivot pins to said first and second links, respectively, and by a fifth pivot pin intermediate said third and fourth pivot pins to said adjacent structure, the ratio of the distance between said primary axis

and said first pin to the distance between said primary axis and said second pin being the same as the ratio of the distance between said third pin and said fourth pin to the distance between said fourth pin and said fifth pin so as to maintain the amplitudes of oscillation of said inertial masses equal to that of said reflector and keep in the desired phase relationship the oscillations of said reflector and said inertial masses whereby when said

reflector is oscillated at said predetermined frequency no reactive forces are transmitted to said structure.

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