United States Patent

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[31] 1,506,648

[54] **ACTIVE COMMUNICATION SATELLITE**
11 Claims, 7 Drawing Figs.

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[51] Int. Cl. B64g 1/00
[50] Field of Search 244/155, pubs.; 343/705S

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ABSTRACT: An active communications satellite which is stabilized as to attitude and to orbit includes at least one directional antenna rigidly mounted on a body portion. The antenna part of the generated surface of the body of the satellite in the operating condition is oriented toward earth. The other parts of the surface of the body are penetrated by control engines and their connecting parts which serve to control the attitude and orbit stabilization of the satellite. Some of the control engines are enclosed in the operative condition of the satellite by at least two unfoldable solar battery areas which are mounted on pivot arm members to permit them to be swung outwardly when the satellite is in space. A fly wheel is carried by the body for the attitude stabilization of the satellite and it rotates about the axis of symmetry parallel to the antenna plane. The satellite is advantageously constructed such that the apogee motor, the fly wheel, the electronic equipment and the fuel tanks are disposed so that they will be rotationally symmetric to the axis of symmetry of the satellite.

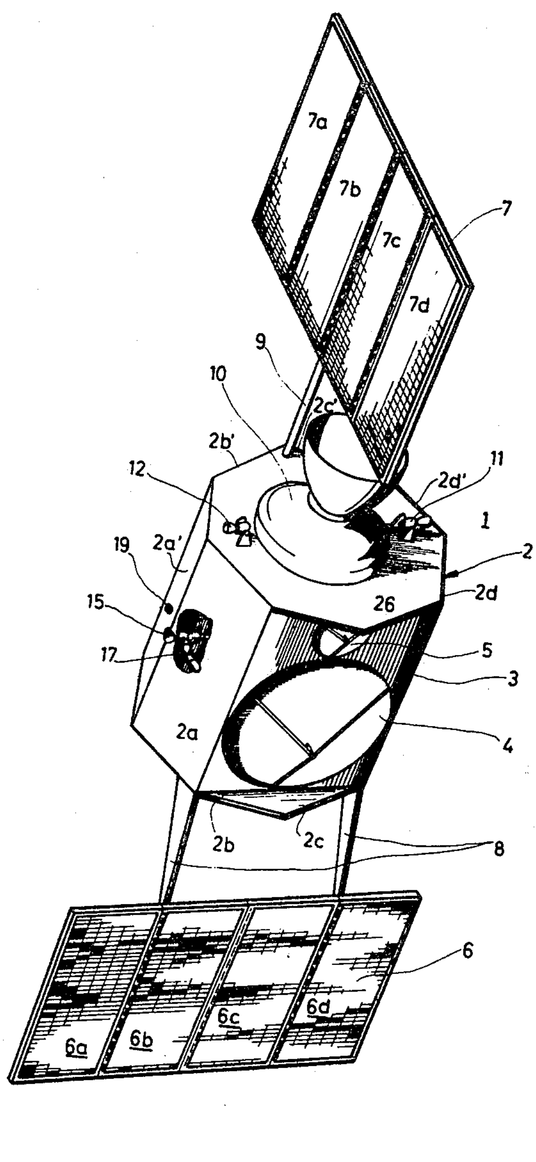
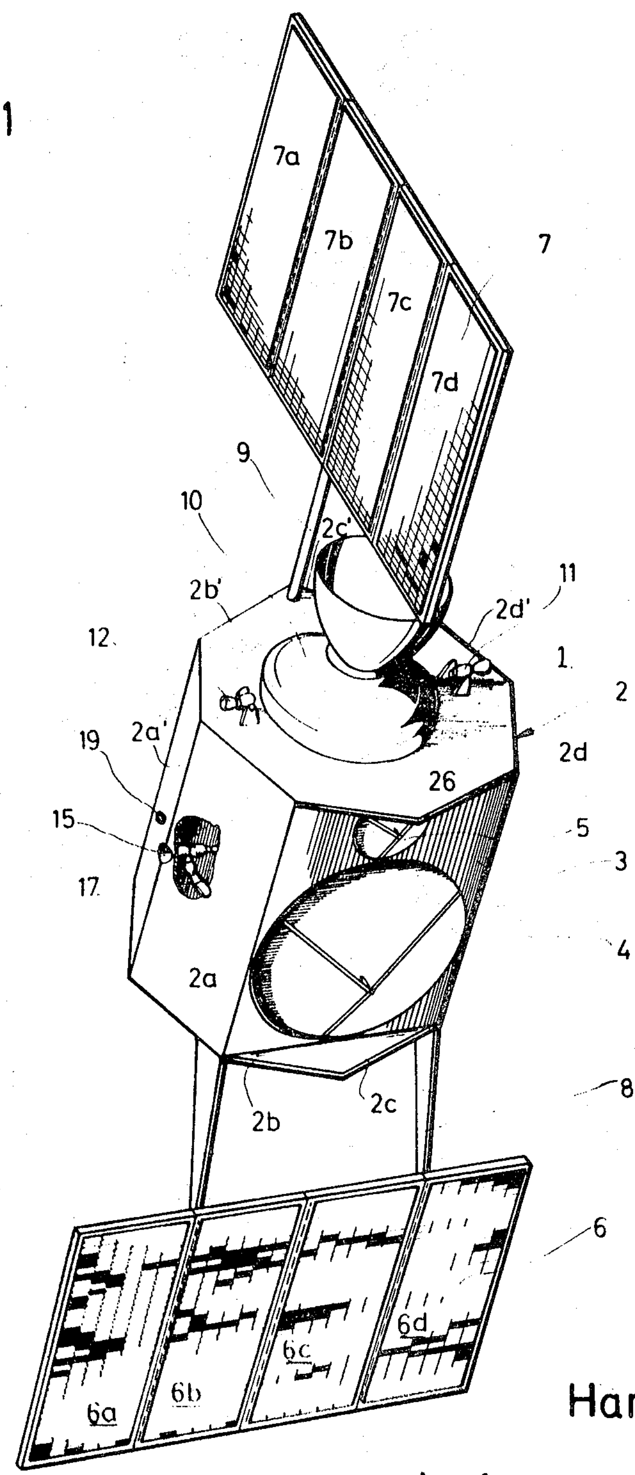


Fig. 1



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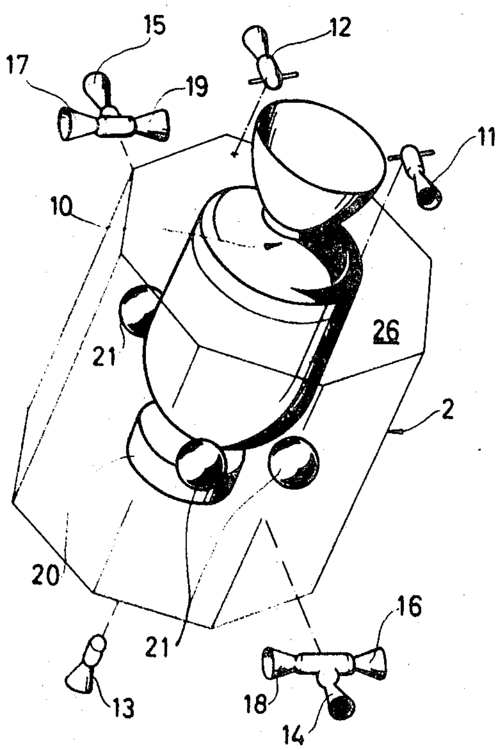

Fig. 2

Fig. 3

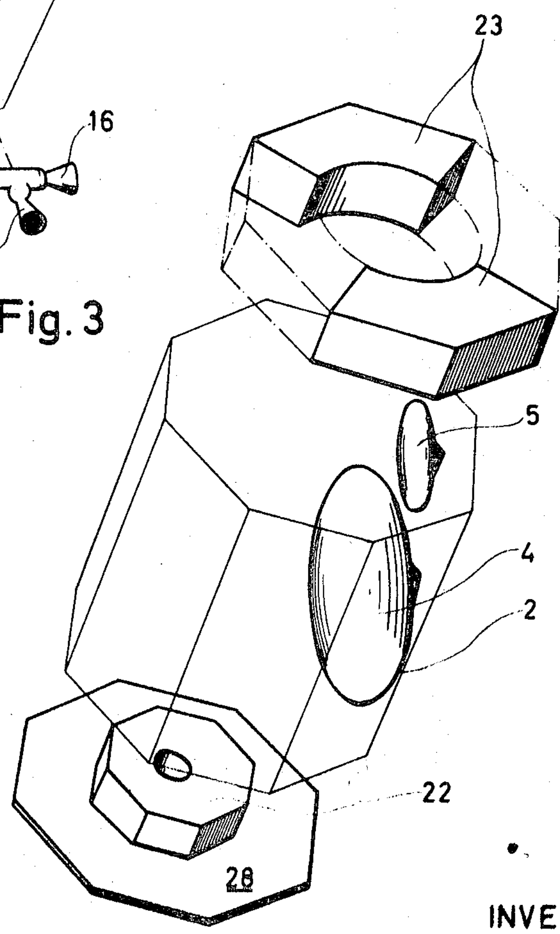

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Fig. 4a

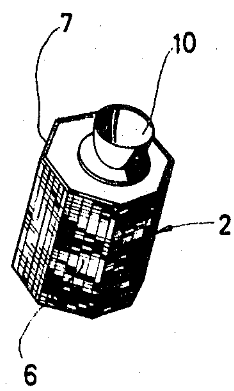


Fig.4b

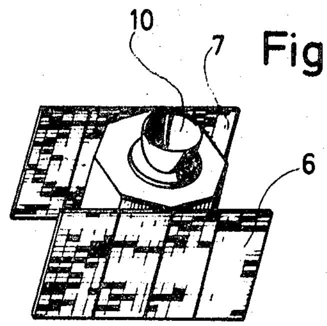


Fig. 4c

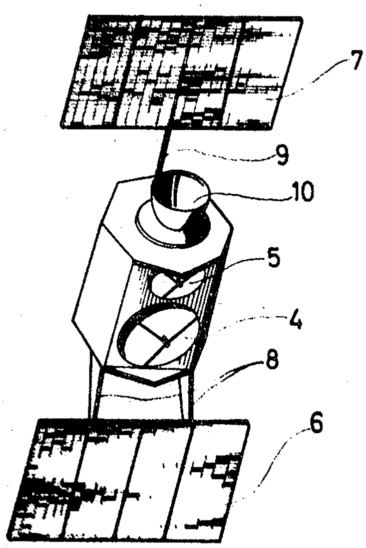
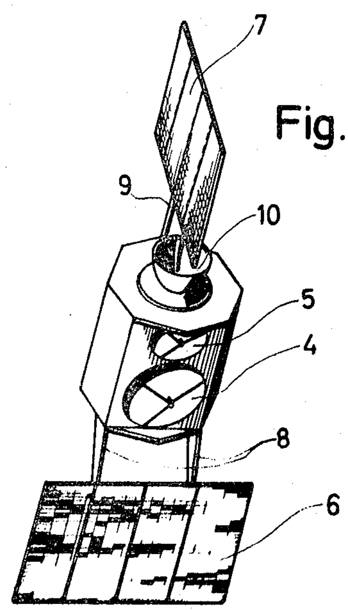


Fig. 4d



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ACTIVE COMMUNICATION SATELLITE

SUMMARY OF THE INVENTION

This invention relates in general to the construction of satellites or orbiting devices and in particular to a new and useful active communications satellite which is stabilized as to attitude and orbit and has at least one directional antenna rigidly secured to it.

Active communications satellites in the most varied configurations and of varied technical design principles are already known and in use. A main problem associated with such satellites is that a strongly beaming directional antenna is required at the satellite for beaming the greatest possible received input on or from the satellite. This requires a very accurate orientation of the satellite body with respect to the earth or with respect to another reference system such as a fixed star. It also requires a correct orientation of the electrically or mechanically pivotal directional antenna with respect to the satellite body.

Besides the barrel-shaped spin stabilized communications satellites which are already in use and which have a rigid antenna system which is secured to the satellite body and whose main beam direction is oriented for instance electronically with respect to the earth and against rotation of the satellite body, there are designs of communications satellites which have parabolic directional antennas stationarily built into the satellite body. Such satellite bodies therefore must always be oriented toward the earth so that the side carrying the antenna faces the earth. For example, a communications satellite of barrel-shaped configuration having parabolic directional antennas which are fixed in the face of the satellite is known. In its respective orbit, the satellite must be stabilized in order to orbit and assume an attitude that disposes the side having the main beam direction of the parabolic directional antenna toward the earth. The portion of the generated surface of the satellite which is located between the two parabolic directional antennas is covered with solar batteries in order to supply the satellite with energy. The part which accommodates the solar batteries and possibly other components of the satellite is therefore in the shape of a cylindrical ring which can rotate around the actual core of the satellite to which the two directional antennas are rigidly attached. Such a rotating cylindrical ring takes care of the spin stabilization of the satellite so that the core with the antenna attached stands still in relation to the earth. This configuration has the disadvantages that only a small part, that is the outside surface of the cylindrical ring only, is available for accommodation of the solar batteries. The electrical components are housed in the cylindrical ring and they must be connected with the satellite core through slip rings. A further difficulty is that the bearings which permit the rotation of the cylindrical ring relative to the core must have an outlet into the vacuum of space so that the bearing design becomes very difficult and their life is considerably shortened. Relatively small parts of the satellite are available for accommodation of the parabolic directional antennas, that is, the parts which are adjacent to the faces or surfaces.

In accordance with the invention there is provided a communications satellite which has an adequate area for the assembly of the directional antennas as provided with an accommodation for solar batteries of as large a size as possible and which does not have any rotatable parts and bearings for supporting such parts which require outlet to the space vacuum. The construction includes an active communications satellite having a body which is stabilized to attitude and orbit and which carries at least one directional antenna which is rigidly fixed in position. All parts of its generated surface which in the operating condition are oriented toward the earth are penetrated by at least one directional antenna. The other parts of the generated surface are penetrated by engine mounting elements for controlling the attitude and orbit stabilization. The directional antennas and part of the controlling engines are enclosed in the inactive condition of the satellite by at least two unfoldable solar battery areas which are made to conform to the configuration of the satellite and which in the unfolded condition can open up into positions located outside the range of the satellite's generated surface

By the configuration of the communications satellite in accordance with the invention it is possible to reserve a portion of the generated surface for the assembly of the directional antennas which in relation to the total area of the satellite is very large. Since the surface is preferably in the form of a planar surface, the antenna type which is best suited for the application can be selected with a great deal of freedom. For instance, the antenna plane may accommodate a dipole and emitter field, a phased array antenna, several parabolic antennas or a honeycomb antenna. Since the solar battery areas enclosing the satellite body are swung out from the satellite's generated surface region in one single unfolding operation when the satellite has reached its orbit, a very large solar battery covered area is achieved. The solar battery covered area may be divided into partial areas or panels which may be oriented independently of each other so that a maximum of the solar batteries available is radiated by the sum simultaneously at any one point of the satellite's orbit. The panels are unfolded and such a construction provides an additional advantage inasmuch as the field of the antenna plane is not disturbed by any obstructions and the control engines which are enclosed by the solar battery areas during the inoperative or starting phase become active without obstruction when the satellite reaches its orbit.

In accordance with a further feature of the invention a fly wheel is provided for the attitude stabilization of the satellite. The fly wheel preferably rotates about the satellite body's axis of symmetry parallel to the antenna plane. It has a speed which can be regulated in the upper range of its nominal speed. By such a fly wheel which is housed in the interior of the satellite body, the attitude of the satellite may be stabilized because of the gyro effect and because of the rotational impulse exchange between the fly wheel rotor and the satellite body. Acceleration and deceleration of the fly wheel rotor relative to the satellite body permits change in the attitude to control the stabilization. The rotor with all bearings and the drive motor can be encapsulated, and this does away with any requirement for a vacuum bearing.

According to a further advantage of the invention, the apogee motor, the fly wheel, the electronic equipment and the fuel tanks are disposed in a rotationally symmetrical plane in respect to the axis of symmetry of the satellite body. In this manner, the spin of the entire satellite body during the burning phase of the apogee motor can be controlled until the starting up of the fly wheel after orbit.

The solar battery areas are advantageously covered with solar batteries on both sides. This arrangement is particularly advantageous when unfolding the solar battery areas so that they are spread into several partial areas. This arrangement makes the percentage of solar batteries radiated by the sun at any point of the orbit particularly great.

The control engines required for attitude and orbit stabilization are disposed in the satellite body in a manner such that there is one engine for inclination corrections on the axis of symmetry opposite to the apogee motor and having a thrust direction opposed to the latter. Two orbit correction engines are located in a plane perpendicular to the axis of symmetry and contained in the plane of the center of gravity. These orbit correction engines have mutually opposing directions of thrust and are directed parallel to the antenna plane and radial to the axis of symmetry. Two additional pairs of engines are located in the same plane for the generation of a turning moment acting upon the axis of symmetry; and two more engines are provided for the generation of a precession moment in the proximity of the face of the satellite. The latter two engines are located in the proximity of the face of the satellite in a plane perpendicular to the antenna plane and in a plane which contains the axis of symmetry. The satellite's electronic equipment is combined in functional units located directly adjacent the faces of the satellite body. Such an arrangement of the equipment has the advantage that temperature regulation is possible by means of flaps provided in the satellite's face.

In a preferred form of the invention, the satellite is of octagonal configuration, preferably in the form of a prismatic column of octagonal cross section. The antenna plane is a plane established parallel to the axis of symmetry in the area that would be occupied by two panels of the octagonal configuration.

Accordingly it is an object of the invention to provide a communications satellite which includes a body which is generated by surface parts which in the operating condition are oriented toward the earth and which carry the directional antenna or antennas; the other parts of the generated surface carrying control engines for attitude and orbit stabilization, and the outer surface s being enclosed by at least two unfoldable solar battery areas or panels which in the inoperative position enclose the satellite body sides but which in the operative position may be extended outwardly from the satellite body.

A further object of the invention is to provide a communications satellite in the form of an octagonal column having an apogee engine mounted on one end and at least one antenna located in a plane parallel to the axis of symmetry, the body sides being closable by a solar battery panel assembly arranged on each end of the satellite and with panel elements which are foldable to coincide with the octagonal sides of the body.

A further object of the invention is to provide a communications satellite having a fly wheel for controlling the attitude of the satellite which includes an element rotatable about the axis of symmetry parallel to the antenna plane but which advantageously may be encapsulated and located within the antenna body or an appendage thereof.

A further object of the invention is to provide a communications satellite which includes an apogee motor, a fly wheel, and electronic equipment for operating the antenna, as well as fuel tanks which are disposed in a rotational symmetrical plane in respect to the axis of symmetry of the satellite body.

A further object of the invention is to provide a communications satellite which is simple in design, rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a communications satellite in orbit constructed in accordance with the invention;

FIG. **2** is a schematic perspective view of the satellite indicated in FIG. **1** but on a slightly reduced scale;

FIG. **3** is an exploded perspective view, partly schematic, of portions of the satellite indicating the assembly of the various units;

FIG. **4*a*** is a perspective view of the satellite similar to FIG. **1** but on a reduced scale and showing the solar batteries in an inoperative launch position;

FIG. **4*b*** is a view similar to FIG. **4*a*** but showing the initial stages of the unfolding of the solar batteries;

FIG. **4*c*** is a view similar to FIG. **4*a*** showing the batteries in a further stage of unfolding; and

FIG. **4*d*** is a view similar to FIG. **4*a*** showing the solar batteries in the final position of unfolding comparable to that indicated in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing in particular, the invention embodied therein comprises a communications satellite having a satellite body generally designated **2** of generally octagonal prismatic column formation. Two of the eight sides of the body **2** are removed and a planar surface **3** which is parallel to the plane of symmetry of the body **2** defines a mounting base for two parabolic antennas **4** and **5** which are rigidly affixed to the planar surface **3**.

In accordance with a feature of this invention, the satellite body **2** carries swivel arms **8** and **9** having swivel joints (not shown) which permit the arms to be shifted from the inoperative position (FIG. **4*a***) in which the arms are not shown to the operative position in which the arms are swung out and support solar battery assemblies generally designated **6** and **7**. The solar battery assemblies each include four panel areas **6*a***, **6*b***, **6*c*** and **6*d*** and **7*a***, **7*b***, **7*c*** and **7*d*** which carry solar cells on each side or surface. The panel areas **6*a*** to **6*d*** and **7*a*** to **7*d*** are of a size such that they cover the side panels or side panel areas **2*a*** to **2*d*** and **2*a'*** to **2*d'***, respectively.

The satellite body **2** includes an end face **26** mounting an apogee motor **10** and two control engines **11** and **12** which are disposed in the plane of symmetry and are symmetrical to the body's axis of symmetry.

In FIG. **2**, the satellite body **2** is shown schematically and without the solar battery areas in order to indicate the arrangement of the control engines associated with it. On the satellite body's end face **26**, the apogee motor **10** and the control engines **11** and **12** are mounted in a plane which contains the axis of symmetry and which is parallel to the antenna plane. On or below the opposite face of the axis of symmetry is the control engine **13** having a thrust direction opposite to the apogee motor **10** and provided for inclination corrections to the communications satellite. Two more control engines **14** and **15** are disposed on a side face of the satellite body **2** in a plane perpendicular to the axis of symmetry and containing the center of gravity. The thrust direction of the engines **14** and **15** is parallel to the antenna plane and radial to the axis of symmetry.

Two additional pairs of control engines; **16** and **17** on one side, and **18** and **19** on the opposite said; are mounted to produce a turning moment around the axis of symmetry. The turning moment produced by the engine pair **16** and **17** opposes the turning moment produced by the engine pair **18** and **19**.

A fly wheel **20** is mounted within the body **2** adjacent a panel **28** at the end opposite from the panel **26**. The fly wheel acts to stabilize the attitude of the satellite and is disposed in the axis of symmetry of the satellite body **2**.

A plurality of fuel tanks **21** containing fuel required for the control of the control engines are arranged around the axis of symmetry adjacent the apogee motor **10**. Pairs of the tanks **21** are positioned symmetrical to the axis of symmetry and communicate with each other through fuel lines (not shown) so that the fuel needed for the control engines is always taken uniformly from a pair of tanks and fed off so that the symmetry in respect to the center of gravity is maintained.

Electronic components **22** and **23** are located adjacent the respective panels **28** and **26** within the interior of the satellite body **2**. The electronic component **22** has an opening in its axis of symmetry for the control engine **13**.

When the communications satellite is assembled and ready for orbiting, it assumes the configuration indicated in FIG. **4*a***. The communications satellite is then moved out into space on a carrier missile or rocket and located in its final orbit during the burning phase of the apogee motor **10**. When this orbit is reached and the satellite spin is broken up, for instance by starting the fly wheel **20** or by other means, the solar battery areas **6** and **7** which initially form the outer surface of the satellite body **2** are pivoted and opened from the configuration shown in FIG. **4*a*** to the configuration shown in FIGS. **1** and

4*d*. During the initial stages of the unfolding of the solar batteries, they assume the position indicated in FIG. 4*b* in which they are oriented substantially parallel to each other from which location they are transferred upwardly and downwardly to the location 4*c*. The swivel arms **8** and **9** first position the solar batteries as indicated in FIG. 4*c* and then the arm **9** is rotated to shift the solar battery **7** perpendicular to the solar battery area **6**. This takes place only after the apogee motor **10** is burned out. The solar batteries **6** are located so that the engine **13** can function without any difficulty. The unfolding and the swivel operation of the solar cell areas **6** and **7** is carried out in a known manner by mechanical energy accumulators such as springs after exploding a holding or tensioning band, for example.

The communications satellite performs a spinning motion after separation from its carrier rocket during the burning period of the apogee motor **10**. Therefore, in order to steer the satellite easily into its final orbit and to compensate for the construction inaccuracies which might exist in respect to the axis of symmetry, the spin of the satellite must be controlled in orbit so that the antenna plane **3** will be constantly oriented toward the earth. The breaking up of the spin is accomplished by the fly wheel **20** which provides the orbital stabilization of the satellite by giving it a turning moment after the fly wheel is started. The reaction turning moment acting upon the satellite body **2** counteracts the spin of the satellite body. The fly wheel **20** is operated at a far greater number of revolutions than would be the number of revolutions of a spin stabilized satellite. In this manner, the turning impulse produced by the fly wheel is about the same as that of the spin stabilized satellite. In this manner, the turning impulse produced by the fly wheel is about the same as that of the spin stabilized satellite rotating at fewer revolutions so that the weight of the fly wheel **20** can be kept proportionately low. The speed of the fly wheel can be regulated for operation in the upper range of its nominal speed to provide compensation of the external interference moments about the fly wheel shaft to provide stabilization of the axis and with it of the satellite by a gyro effect.

The control engines **11** and **12** are provided to impart a precession moment to the satellite body when the fly wheel is running so that the gradual migration of the axis of rotation of the fly wheel **20** out of the orbit normal can be corrected from time to time through precession maneuvers.

The control engine pairs **16**, **17**, **18** and **19** serve to impart to the satellite body a spin or despinning moment. Engines **14** and **15** serve the orbital velocity, that is, the orbit stabilization. Similarly, the engine **13** permits the correction of the orbit in respect to inclination. A precise attitude stabilization of the satellite is achieved through a combination of these engines in order to provide for the exact orientation of the antenna plane **3** for the earth. After the unfolding of the solar battery areas **6** and **7**, the antenna plane **3** is free for constant orientation to the earth and the control engines may operate without interference with the solar batteries.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

I claim:

1. An active communications satellite stabilized as to attitude and orbit, comprising a satellite body having a planar surface with at least one directional antenna affixed to said planar surface said planar body surface with said antenna being orientable toward the earth, control engine means on said body for stabilizing said body in orbit and in attitude for orienting said antenna toward the earth, and solar battery means carried on said body and adapted to enclose at least a portion of said body and being unfoldable from covering said body for orientation at a position outside the surface of said body.

2. An active communications satellite according to claim **1**, wherein said solar battery means comprises at least two unfoldable battery panels.

3. An active communications satellite according to claim **1**, wherein said control engine means includes a fly wheel for stabilizing the attitude of said satellite, said fly wheel being mounted on said body for rotation about an axis of symmetry parallel to the plane of said antenna.

4. An active communications satellite according to claim **1**, including an apogee motor mounted on said body and oriented for discharging thrust gases from one end of said body, electronic equipment carried within said body, said control engine means including a fly wheel and fuel tanks, all of said apogee motor, said fly wheel, said electronic equipment and said fuel tanks being disposed rotationally symmetrical to the axis of symmetry of said satellite.

5. An active communications satellite according to claim **1**, wherein said solar battery means comprises a panel having solar batteries on each side.

6. An active communications satellite according to claim **1**, including an apogee motor mounted on said satellite body and having a nozzle thrust discharge extending outwardly from one end thereof, said control engine means including an engine mounted on said satellite body and having a thrust nozzle discharge oriented in an opposite direction to said apogee motor, said control engine means including at least two orbit correction engines arranged on substantially diametrically opposite sides of said satellite and having a thrust discharge extending outwardly in respective opposite directions away from said satellite in a plane perpendicular to the axis of symmetry and which contains the center of gravity of said satellite body, and at least two pairs of engines on respective diametric opposite sides of said satellite body having thrust discharges extending in a direction for obtaining a turning moment about the axis of symmetry of said satellite body, at least two additional control engines mounted at one end of said satellite body on each side of said apogee motor for the generation of precession moments in the vicinity of the end of said satellite body and in a plane parallel to the antenna plane and in a plane containing the axis of symmetry.

7. An active communications satellite according to claim **1**, including electronic equipment contained in said satellite body having portions located adjacent each end of said satellite body.

8. An active communications satellite stabilized as to attitude and orbit, comprising a satellite body having a surface with at least one directional antenna affixed thereto for orientation toward the earth, control engine means on said body for stabilizing said body in attitude and in orbit, and solar battery means carried on said body and adapted to enclose at least a portion of said body and being unfoldable from covering said body for orientation at a position outside the surface of said body, said satellite body being of octagonal prismatic column configuration, a planar surface on a side of said body defined within two octagonal side areas, said antenna being mounted on a side of said satellite body on said planar surface, said planar surface being parallel to the axis of symmetry of said satellite body.

9. An active communications satellite comprising an octagonal prismatic column body, having an octagonal first end and an octagonal second end, an apogee motor mounted adjacent said octagonal first end and having a thrust discharge extending outwardly from said octagonal first end, a control motor mounted on said octagonal second end and having a thrust discharge extending outwardly from said second octagonal end in an opposite direction to said apogee motor, said satellite body having planar side faces with one of said side faces extending over two portions of the octagonal configuration and being a planar surface in a plane parallel to the axis of symmetry of said body, first and second solar battery panels each including four foldable panel areas having solar batteries, each area being of a configuration to enclose a corresponding side face area of the octagonal prismatic column body, and means mounting said solar battery panels for orientation around the sides of said satellite body to cover said sides and for shifting to the exterior of said satellite body at a spaced location from each end for respective orientation of said first and second battery panels at opposite ends of said satellite when in orbit.

10. An active communications satellite according to claim 9, wherein there are at least two directional antennas affixed to said planar surface of said octagonal body.

11. An active communications satellite according to claim 9, including control engine means on said body for stabilizing said body in attitude and in orbit.