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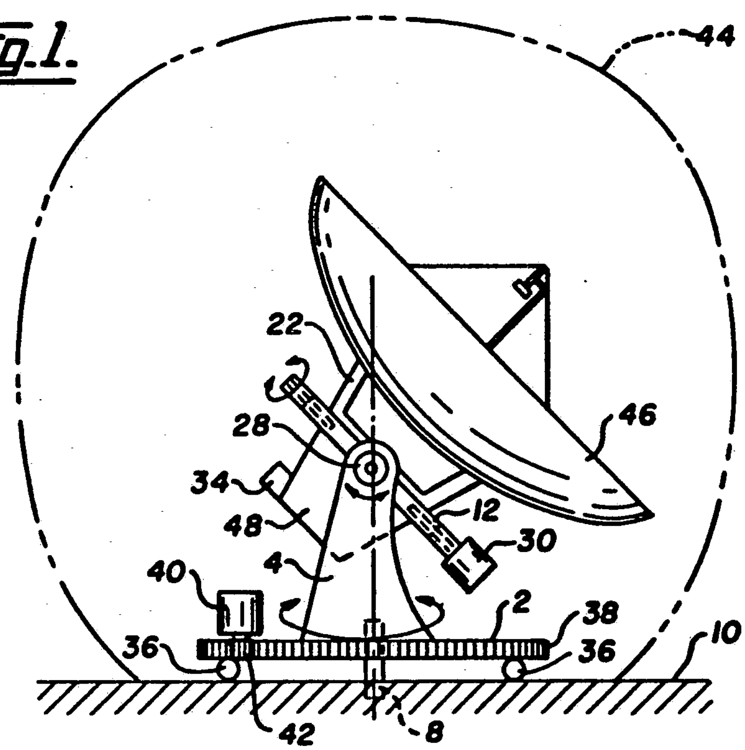
(54) Stabilized mount for a platform

(57) A stabilized mount for a platform (22), particularly for a tracking antenna (46), has a support with a gimbal ring (12) mounted on the support by diametrically opposed gimbals. Further diametrically opposed gimbals mount the platforms on the gimbal ring. One shaft extends through one of the first gimbals and a first motor (28) is attached to that shaft. A further shaft extends through one of the gimbals mounting the platform (22) on the gimbal ring (12) and another motor (30) is attached to that shaft. The mount has a sensor (34) to sense absolute movement of the platform. Thus any movement of the platform (22) induced by movement of the gimbal ring (12) and transmitted to the platform through gimbal friction may be compensated for by torque applied by a motor.

Fig.1.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

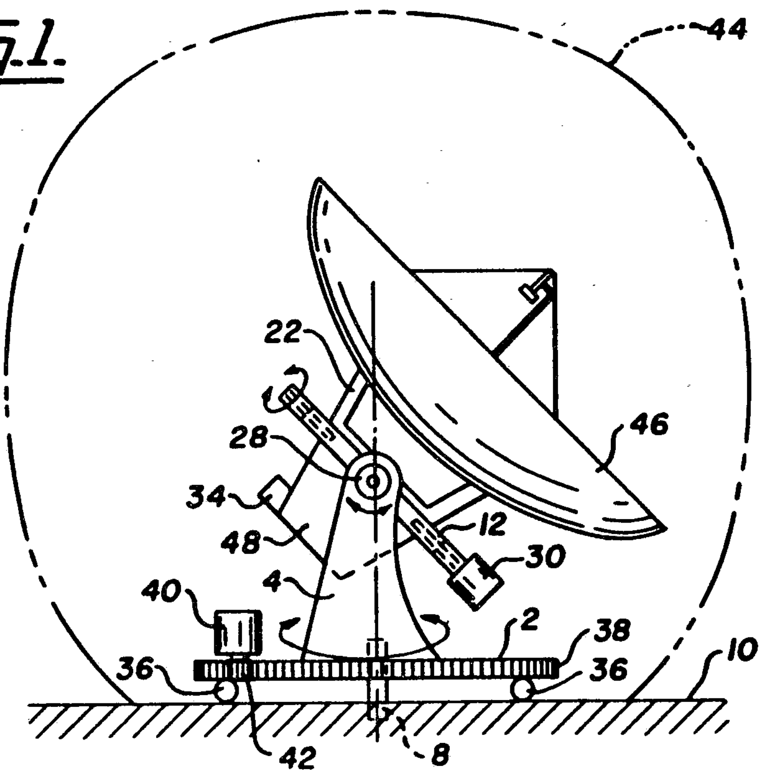
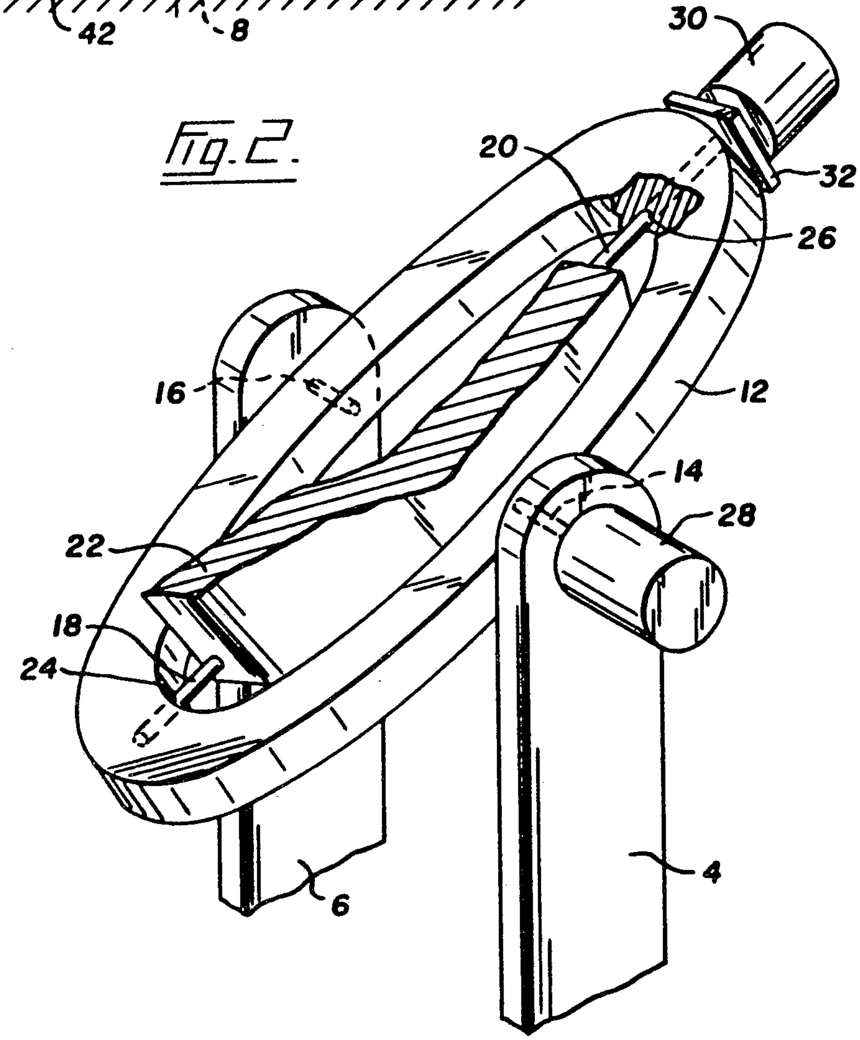


Fig.2.



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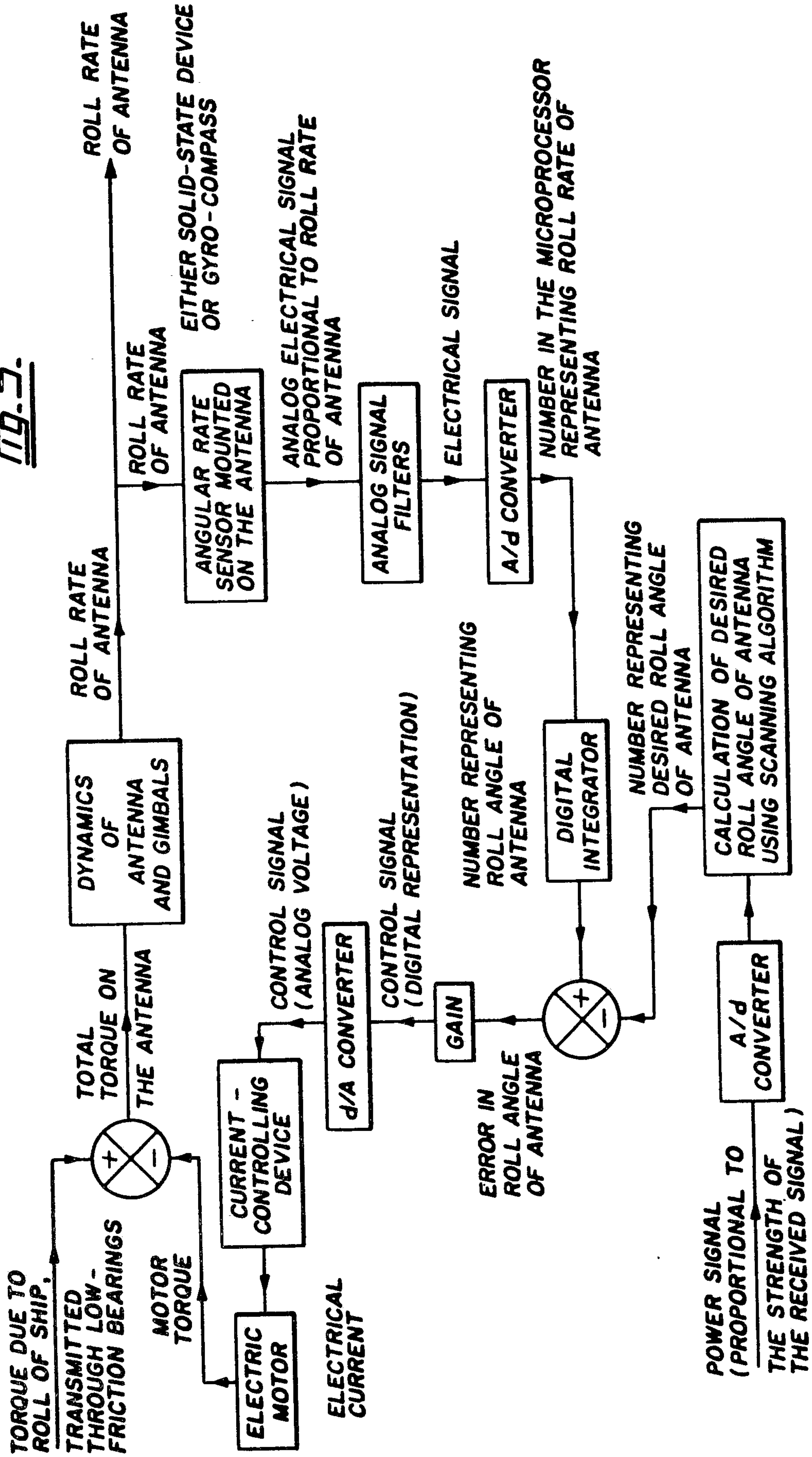

Fig. 3.

SPECIFICATION

A stabilized mount for a platform

This invention relates to stabilized mount for a platform, particularly a stabilized mount for a platform of an antenna to track a satellite. The mount can be used on a fixed surface but is intended principally for use on a moving vehicle, such as a ship at sea or a large land vehicle.

In tracking a signal from, for example, a satellite, it is essential that accurate tracking be carried out as quite small deviations by the antenna can result in a loss of the signal. The signal reception is independent of simple translations of the antenna base because the satellite is so far away that small motions of the antenna do not noticeably change the azimuth or elevation of the satellite as detected by the antenna. However signal strength falls off very suddenly as the axis of the dish deviates from the correct alignment. The axis of a dish is a line normal to the surface of the dish at the centre of the dish. For example angular errors of greater than 0.5° can cause a loss of operating capability. The power signal at 0.5° error will be about 1.5 volts less than it is with correct alignment and reception of pilot signals from the antenna will be lost when the angular error is about 2°. Up to that point the power signal will be positive.

It is therefore important to provide an antenna with a motion compensation system which will enable the antenna to function correctly despite movements of the carrying vehicle affecting the alignment of the antenna with the signal. A stabilization system to be effective must prevent the platform from rotating relative to fixed space even though the carrying vehicle is doing so. A stabilization system cannot, of course, isolate the platform from accelerations of the vehicle along the axis of the antenna.

Known platform stabilization systems have been either the passive or active. A typical passive stabilization system balances the platform on gimbals with low friction bearings. With careful balancing sideways acceleration of a platform support will not cause the platform to rotate. The only rotational force on the platform will be small amounts of torque transmitted by the gimbal bearings. But the inertia of the platform will tend to make it stay aligned in absolute space. A gyroscope is an example of a passive system. A gyroscope relies on the low friction of its gimbal bearings to prevent the stabilized platform from rotating. The spinning flywheel found in a gyroscope serves to increase the effective inertia of the platform.

An active system differs in having instruments for sensing motion of the platform and control system that determines how quickly to rotate the platform relative to its supports to reduce the motion to a minimum. All active control systems send out a control signal that corresponds directly to a rate of rotation of the platform relative to its support structure. If the instrument sensing motion of the platform detects a roll rate of a ship to be 0.5° per second a signal will be sent to the control system to drive the stabilized platform at a rate of minus 0.5° per second relative to the ship so that the net rotation of the platform will be 0.

With passive systems friction ensures that a perfect system is not possible. That is friction cannot be eliminated completely in the gimbal bearings and therefore deviation of the platform from the required position is inevitable. A problem with active systems is their relative complication and the fact that errors are still inevitable both in sensing the motion and sending the appropriate compensating motion to the platform.

The present invention offers a combination of active and passive systems. In the present invention the platform is balanced on low friction gimbals to isolate it from rotations of its support structure. However instruments are used to measure the motion of the platform and a control system is used to counteract any motion that is observed. However it should be emphasized that in the present invention the active control system does not control the motion of the platform relative to the support structure. In normal operation the platform is allowed to swing freely in its gimbals and the active control system merely gives the platform boosts of torque only when the platform starts to swing away from correct orientation.

Thus, in a first aspect the present invention provides a stabilized mount for a platform comprising a support; a gimbal ring mounted on the support by a diametrically opposed first gimbal; diametrically opposed second gimbal to mount the platform on the gimbal ring; the improvement whereby a first shaft extends through one of the first gimbals; a first motor attached to the first shaft; a second shaft extending through one of the second gimbals; a second motor attached to the second shaft; sensing means to sense movement of the platform whereby any movement of the platform induced by movement of the gimbal ring and transmitted to the platform through gimbal friction may be compensated for by torque applied by a motor.

An embodiment of the invention is illustrated, merely by way of example, in the accompanying drawings in which:

Figure 1 is a side view of a stabilization system according to the present invention;

Figure 2 is an elevation, partly in section, of the stabilized platform; and

Figure 3 illustrates a control system useful with the stabilization system shown in Figs. 1 and 2.

Figs. 1 and 2 show a stabilized mount comprising rotatable circular base 2 having gimbal support arms 4 and 6 rigidly rotated on its upper surface. The circular base 2 is located by a pin 8 extending downwardly to engage a deck 10 of a ship. There is a gimbal ring 12 mounted between the support arms 4 and 6 on horizontal, diametrically opposed shafts 14 and 16 that extend outwardly from the gimbal ring 12 to engage the support arms 4 and 6. There is a further pair of diametrically opposed shafts 18 and 20 rigidly fixed in a platform 22, a portion of which is shown in Fig. 2 - but located in low friction bearings 24 and 26 in the gimbal ring 12. There is a first electric motor 28 attached to the shaft 14 and a second electric motor 30 mounted on plate 32 and attached to the shaft 20. The shaft 20 extending from motor 30 rotates freely in the gimbal ring 12 but is rigidly connected to the platform 22. Shaft 14 extending from motor 28 is rigidly connected to the gimbal ring 12 but rotates freely in the platform support 4 in low friction bearings. All bearings used have low starting torque and both electric motors 28 and 30 are selected as low friction electric motors.

There is an angular rate 34 - see Fig. 1 - able to detect movement of the platform 22 in the two directions permitted by the gimbal ring structure.

The platform 2 is mounted on rollers 36 and is provided with teeth 38 on its periphery. An electric motor 40 is mounted on the platform 2 and has a gear 42 on its drive shaft to permit rotation of the platform 2 by driving motor 40. The system is protected by a cover 44 often referred to as a radome to protect it from the weather. A particularly important function of the radome is to protect the antenna from gusts of wind.

A conventional antenna 46 is mounted on the platform 22 and its angular inclination is preset either automatically or by hand. An optional automatic sky-scanning function of the active system is possible.

Operation of the device is shown in the control system illustrated as a block diagram in Fig. 3. Fig. 3 shows a control system for only one of the two motor actuators 28 and 30. The system is duplicated for the other motor 28 or 30.

Before discussing Fig. 3 some general comments are appropriate. The stabilized mount illustrated in Fig. 2 has three axes of rotation. There is an axis of rotation around pin 8 which, with the aid of electric motor 40, provides a coarse azimuthal orientation of the assembly. There are two axes in the gimbal for precise control of the direction of the antenna. For an antenna system on an anchored vessel, for example an oil rig, where the heading of the vessel is not changing the coarse azimuthal orientation can be preset and the base clamped to the stand. However on ships that are liable to change their heading, electric motor 40 is used and is desirably connected to a signal provided by the ship's compass.

Finer control of the mount is provided actively and passively. The platform 22 is free to rotate on the gimbal ring 12 and the active control gives the platform boosts of torque only when the platform starts to swing away from correct orientation for the antenna. The control system never "knows" how fast the antenna is rotating relative to the ship only how fast it is rotating in the absolute frame of reference. This is in contrast to the prior art systems discussed above where, of course, active systems are constantly controlling movement of the platform relative to the ship.

The antenna 46 carried by the platform 22 is carefully balanced on its gimbals so that lateral acceleration of the ship's deck will not induce torque on it. To achieve this, the centre of gravity of the rotating member, that is the antenna, the low noise amplifier associated with the antenna and the stabilization equipment, must be exactly in the centre of the gimbal mounting and thus in line with both axes of rotation of the gimbal. Thus counterweight 48 is used and, furthermore, as indicated the counterweight must be able to receive small masses to trim the balance of the antenna.

With the antenna free swinging on its gimbal the only force that will cause it to rotate will be torque transferred through the gimbal bearings as friction. If the bearings were frictionless there would, of course, be no need for the active control system. The antenna would remain pointing in the same direction while the vessel rolled beneath it simply because no forces would be transmitted through the gimbal ring. However, the active system is necessary to compensate for friction. In this regard it should be emphasized that it is important to use bearings with as low friction as possible. The rotation rate will be slow so that bearings with high starting friction, that is large break away torque, must be avoided. Further the bearings must be low maintenance and suitable for use in salt spray. However bearing tolerances are not critical and the load is small.

Further concerning friction the motors 28 and 30 should be close coupled to the rotating shafts 14 and 20 and they never rotate through a full turn and never go faster than about 2° per second. The normal condition of the motors is to have zero current through them and in this state they are free to rotate and therefore do not add significantly to the friction of the motor gimbals. When additional torque is needed to compensate for the effects of friction in the gimbals a controlled amount of current is put through the motor by a control algorithm described below. It should be noted that th active controller according to the present invention never has direct control of the motion of the antenna. It only gives the antenna boosts in one direction or the other.

Thus the control system illustrated in Fig. 3 is a control system concerned only with the absolute motion of the antenna and does not control the speed that the antenna moves relative to the ship. The antenna is isolated from rotation of the ship by low friction bearings so that its inertia keeps it properly oriented. The control system uses inertia sensors to monitor the absolute motion of the antenna and applies rotational torque to boost the antenna back onto track only if the antenna starts to drift from its proper orientation.

Fig. 3 illustrates one half of that control system, used to control the "roll" angle of the antenna. Referring to Fig. 3, the torque due to the roll of the ship, the torque applied by the motor and the dynamics of the antenna and the gimbals determine the roll rate of the antenna. This roll rate is measured by the angular rate sensor mounted on the antenna. That angular rate sensor may be a gyro-stabilized inertial platform or a solid state device. The device produces an electrical signal proportional to the roll rate of the antenna and that signal is filtered to an analogue filter and the information fed to an A/d converter. From there a signal is passed through the microprocessor part of the control system, which is that part between the A/d converter and the d/A converter. Also fed into the microprocessor is information derived from the power signal, which is proportional to the strength of the received signal and which is fed through an A/d converter to provide a calculation of the desired roll angle of the antenna using a scanning algorithm. This part of the control system will be discussed below.

The microprocessor sends out a control signal to the current controlling device and the current controlling device then sends the necesary current to an electric motor 28 or 30, depending on which motor is controlled by the particular circuit, which sends a boost or torque to the attached shaft.

It is desirable that the control system be supplemented with a signal tracking control system that will drive the antenna towards an alignment where the power signal is strongest. Such a system will refer to the power signal as its primary controlling variable and will move the antenna through an arc to scan for an orientation where the signal is strongest.

CLAIMS

1. In a stabilized mount for a platform comprising:

a support;

a gimbal ring mounted on the support by diametrically opposed first gimbals;

diametrically opposed second gimbals to mount the platform on the gimbal ring, the improvement whereby:

a first shaft extending through one of the first gimbals;

a first motor attached to the first shaft;

a second shaft extending through one of the second gimbals;

a second motor attached to the second shaft;

sensing means to sense absolute movement of the platform whereby any movement of the platform induced by movement of the gimbal ring and transmitted to the platform through gimbal friction may be compensated for by torque applied by a motor.

2. A mount as claimed in claim 1 including a circuit linking the sensing means to the motors so that the torque application may be controlled.

3. A mount as claimed in claim 1 in which each of the first and second motors is a low friction direct current electric motor.

4. A mount as claimed in claim 3 in which the motors have armatures that are free swinging in the absence of a current.

5. A mount as claimed in claim 1 in which the support extends upwardly from a base.

6. A mount as claimed in claim 5 in which the base is fixed.

7. A mount as claimed in claim 5 in which the base is rotatable but can be fixed at a desired location.

8. A base as claimed in claim 6 in which the base includes a motor to rotate the base to establish a coarse starting position for the mount.

9. A mount as claimed in claim 1 in which the platform is an antenna to track a satellite.

10. A mount as claimed in claim 9 including couterweights to position the center of gravity of said platform and gimbal rings at the center of rotation of the gimbals.

11. A stabilized mount for a platform substantially as herein described with reference to the accompanying drawings.

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