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Serial No. : 149,983  
Filing Date : 6/4/71

NASA Case No. KSC-10622

**APPLICATION FOR LETTERS PATENT**

**TO ALL WHOM IT MAY CONCERN:**

**BE IT KNOWN THAT Frank S. Howard, citizen of the United States of America, employee of the United States Government, and resident of Indian Harbor Beach, in the County of Brevard, Florida, has invented certain new and useful improvements in ZERO GRAVITY SHADOW SHIELD ALIGNER for which the following is a specification:**

Serial No.: 149,983  
Filing Date: 6/4/71

NASA Case #. KSC-10622-1

### Awards Abstract

#### Zero Gravity Shadow Shield Aligner

An apparatus for use in a zero gravity environment, such as outer space for aligning objects such as shadow shields and cryogenic storage tanks with the sun. The apparatus includes a plurality of equally spaced vanes having a reflective outer surface so that when the pressures exerted by the light waves from the sun are equal on all of the vanes the shadow shield is aligned with the sun.

In accordance with the present invention, it has been found that difficulties encountered with aligning objects with a reference in space can be overcome by providing a novel aligning mechanism. This aligning apparatus, when used for automatically aligning shadow shields with the sun, includes the following basic parts: (1) A central member, (2) means attaching the object to be aligned with the sun to the central member, and (3) a plurality of vanes extending outwardly from the central member in a balanced configuration. The vanes are equally spaced circumferentially about the center of the central member and taper rearwardly from the central member at the same angle. The vanes also correspond in shape and are the same size. A reflective outer surface is provided on the vanes for receiving light waves from the sun so that the apparatus when located in outer space automatically aligns with the sun by utilizing the pressure created by the light waves from the sun striking the vanes.

INVENTOR: Frank S. Howard

~~EVALUATOR: W. Z. Mims~~

EMPLOYER: NASA/KSC

ABSTRACT OF DISCLOSURE

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This invention described herein was made by an employee of the United States Government, and may be manufactured and used by or for the Government for Governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to an apparatus for aligning objects, such as cryogenic storage tanks, located in a zero gravity environment, such as outer space, with the sun.

15 As space exploration develops it has become apparent that in order to explore the universe it will necessary to refuel space vehicles in outer space. This requires cryogenic storage tanks to be placed in orbit for refueling the space vehicles. One problem in placing storage tanks of fuel in orbit is maintaining the temperature of the cryogenic propellants, such as liquid hydrogen and oxygen, below a predetermined level so that it will remain in its liquid state. If the storage tanks were merely placed in orbit without any protective shielding, the rays from the sun would heat such up causing

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the liquid cryogenic propellant to boil off more rapidly than it would in an unshielded container. It has been found that if the storage tanks were provided with a shadow shield so that it would remain in the shadow of the shield at all times the temperature of the liquid within the tank could be maintained low to minimize boiling off. There are many devices presently being utilized, such as gyroscopic guidance systems, for aligning objects with the reference point, however these devices normally consume energy and are relatively complicated and expensive.

While the context of this invention is being described in aligning a shadow shield with the sun so that a cryogenic storage tank remains at all times in the shadow of the shield, the aligning device could have many other applications, such as aligning cameras, or maintaining solar cells continuously pointed towards the sun.

In accordance with the present invention, it has been found that difficulties encountered with aligning objects with a reference in space can be overcome by providing a novel aligning mechanism. This aligning apparatus, when used for automatically aligning shadow shields with the sun, includes the following basic parts: (1) A central member, (2) means attaching the object to be aligned with the sun to the central member, and (3) a plurality of vanes extending outwardly from the

central member in a balanced configuration. The vanes are  
equally spaced circumferentially about the center of the  
central member and taper rearwardly from the central member  
at the same angle. The vanes also correspond in shape and are the  
5 same size. A reflective outer surface is provided on the vanes for  
receiving light waves from the sun so that the apparatus when  
located in outer space automatically aligns with the sun by  
utilizing the pressure created by the light waves from the  
sun striking the vanes.

10 Accordingly, it is an important object of the present  
invention to provide an apparatus for use in a zero gravity  
environment, such as outer space, for automatically aligning  
objects with the sun.

15 Another important object of the present invention is to  
provide an aligning apparatus which utilizes the pressure  
created by light waves for automatically positioning a  
shadow shield between the sun and a cryogenic storage tank.

20 A further important object of the present invention is  
to provide a simple, inexpensive, lightweight, and non-power  
consuming apparatus which can operate in outer space for aligning  
objects with the sun.

25 Other objects and advantages of this invention will become  
more apparent from a reading of the following detailed description  
and appended claims, taken in conjunction with the accompanying  
drawing wherein:

Figure 1 is a perspective view illustrating an apparatus which can be used in a zero gravity environment, such as outer space, for aligning a cryogenic storage tank with the sun,

5 Figure 2 is a side elevational view of a modified form of the invention utilizing a single shadow shield shown in a position of alignment with the sun,

Figure 3 is a side elevational view illustrating the aligning apparatus in Figure 2 out of alignment with the light waves from the sun, and

10 Figure 4 is a side elevational view of another modified form of the invention showing a different way for attaching a cryogenic tank to the shadow shields and the aligning device.

Referring in more detail to the drawing, Figure 1 illustrates an apparatus which can be used in a zero gravity environment, such  
15 as outer space, for aligning a plurality of stacked shadow shields 10 with the sun so that a cryogenic fuel tank 11 will automatically be maintained in the shadow of the shields 10. The apparatus includes a square central member 12, which may be constructed of  
20 any suitable lightweight material, having vanes 13 equally spaced, circumferentially about the center of the central member 12. The vanes taper rearwardly from the edge of the central member at an angle of approximately 45 degrees. Each of the vanes is substantially rectangular in shape and are the same size. The vanes 13 may be  
25 constructed of any suitable lightweight highly reflective material such as mylar, and have an aluminized highly reflective coating 14 on the outer surface. The inner surfaces of each of the vanes 13 are

black producing a non-reflective surface 15.

As can be seen, the vanes are spaced equally around the central member at 90 degrees. Opposite vanes are in alignment. However, it is to be understood that the aligning apparatus may be of a design configuration other than that shown in Figure 1. For example, there may be three vanes or more, or the reflective coating may be placed on a cone shaped member.

When operating in an environment of zero gravity, such as outer space, the radiant energy from the sun in the form of light waves striking the reflective surface 14 of the vanes creates a pressure thereon. When the apparatus is in proper alignment with the sun, such as illustrated in Figure 2, the areas as indicated by arrows 12a of the vanes 13 being struck by the light waves 12b are equal, thus producing equal pressures on all four vanes. Since the pressures on all four vanes are equal and the vanes are equally spaced around the central member, the apparatus stays in alignment with the sun. However, if for some reason the apparatus tilts, such as illustrated in Figure 3, wherein the area of one vane, which in Figure 3 would be the lower vane, receives more radiant energy from the sun than the vane opposite it, such as the upper vane in Figure 3, then a greater force will be exerted on the lower vane. This tends to pivot the apparatus back to the position illustrated in Figure 2 wherein the surface areas receiving radiant energy from the sun are equal on all of the vanes.

While the pressure created by radiant energy is extremely

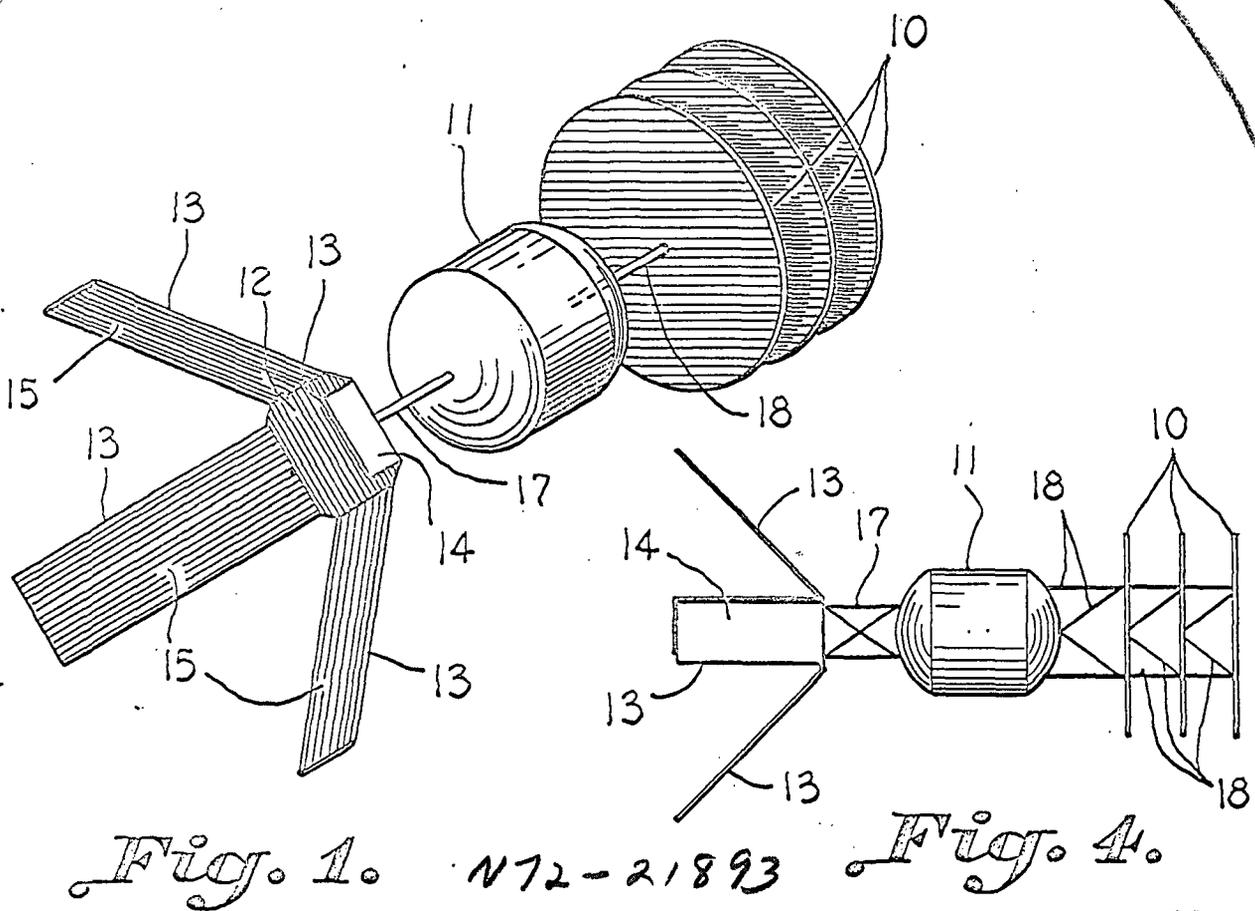
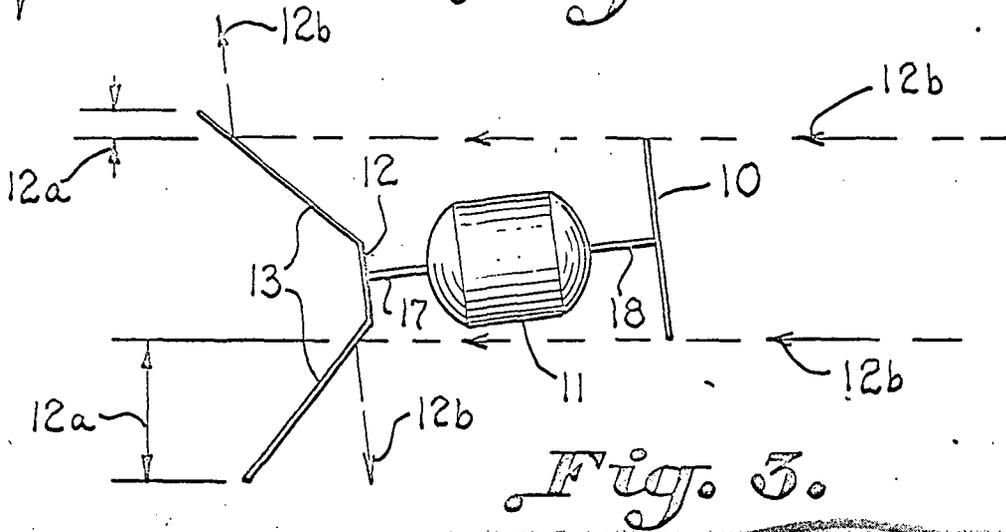
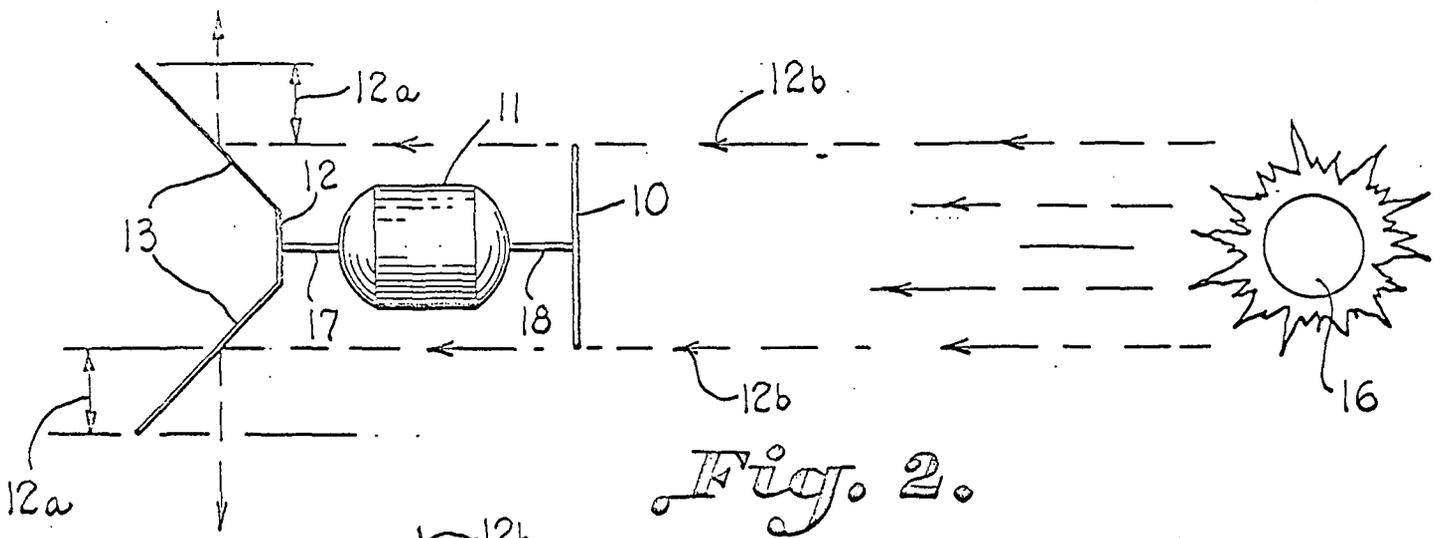
small, in outer space where there is a zero gravity, such is sufficient to maintain the shadow shield 10 in alignment with the sun 16 so that the cryogenic fuel tank 11 is positioned in the shadow produced by the shields 10 at all times.

5           There are many ways of assembling the apparatus, and one suitable way includes using a thin metal rod 17, which has one end secured to the center of the central member 12 by any suitable means with the other end secured to the center of the bottom of the cryogenic tank 11.

10           The shadow shields 10 may be connected to the top of the tank by a metal rod 18. Similar rods (not shown) are used to maintain the shadow shields 10 in spaced relation and couples them together at their center.

          The number of shadow shields required in stacked relation  
15 depends on the amount of reradiation produced by the light waves striking them. Normally, it is best to construct the shadow shield of material which produces a minimum of reradiation. One suitable material is mylar with an aluminized reflective coating on the outer surface thereof for reflecting the light  
20 waves.

          Figure 4 illustrates using a plurality of rods 18 connected  
between shadow shields 10 and also, between the shadow shields  
and the cryogenic tank 11 for making a more stable apparatus.  
A similar arrangement of rods 17 is provided for connecting  
25 the central member 12 to the lower portion of the cryogenic



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