Sept. 16, 1969 T. G. BERRY ET AL 3,467,328

SELF-EXTENDING ANTENNA

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FIG. 1

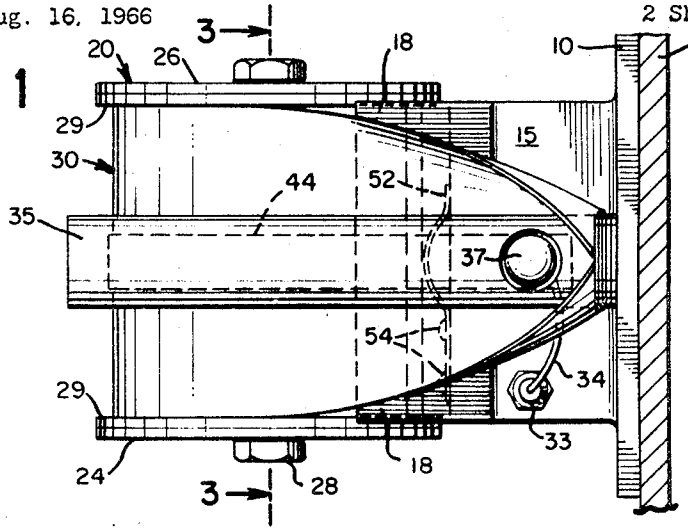


FIG. 2

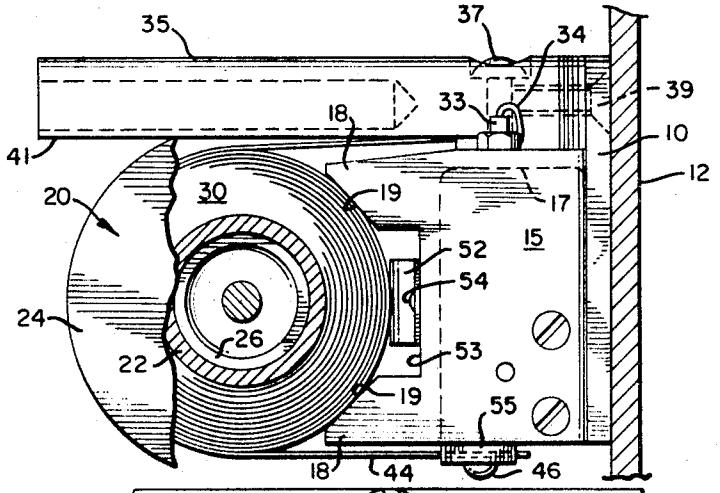
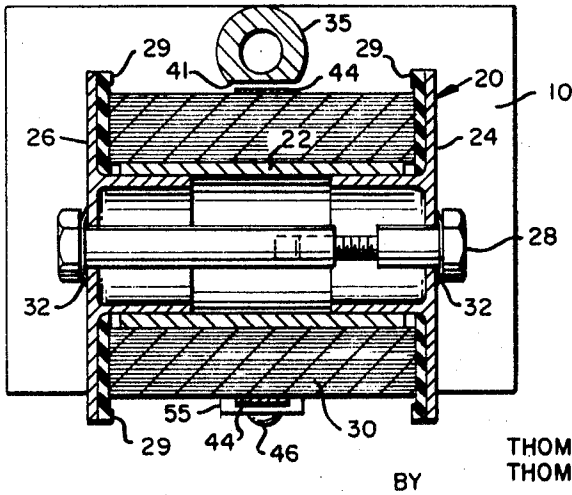


FIG. 3



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FIG. 4

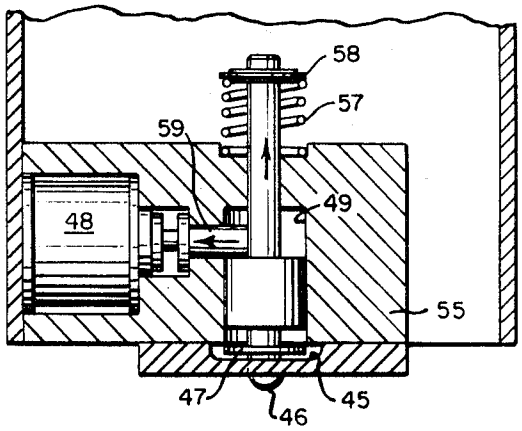


FIG. 5

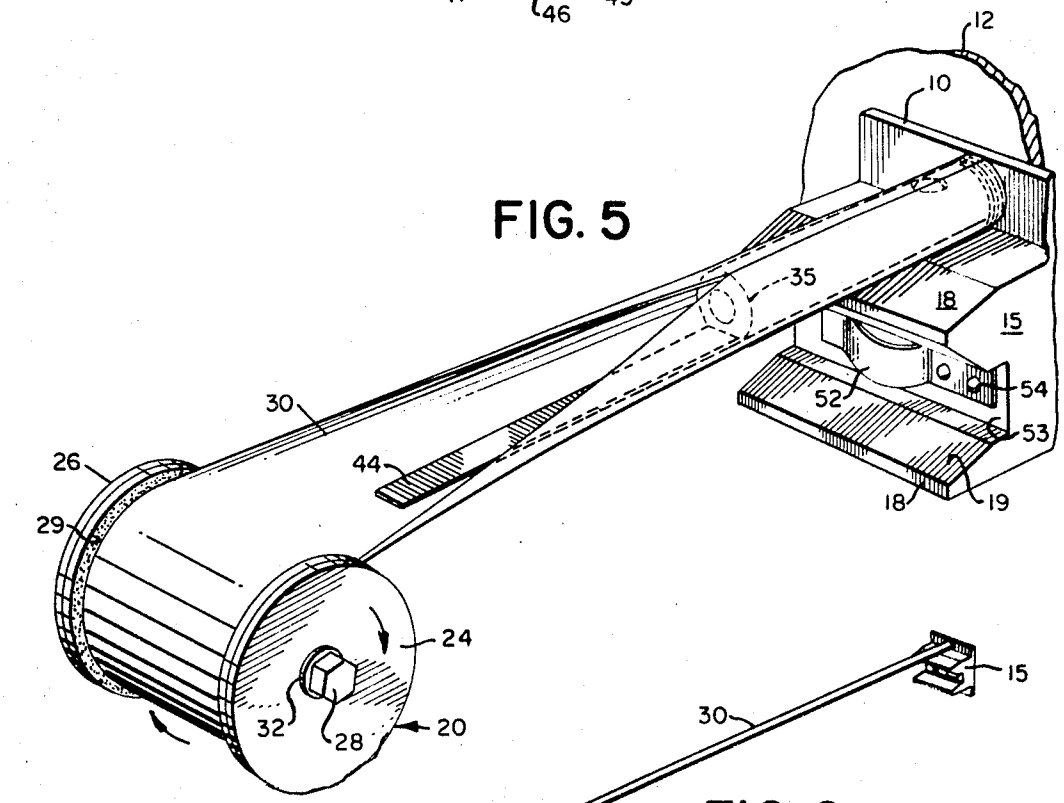
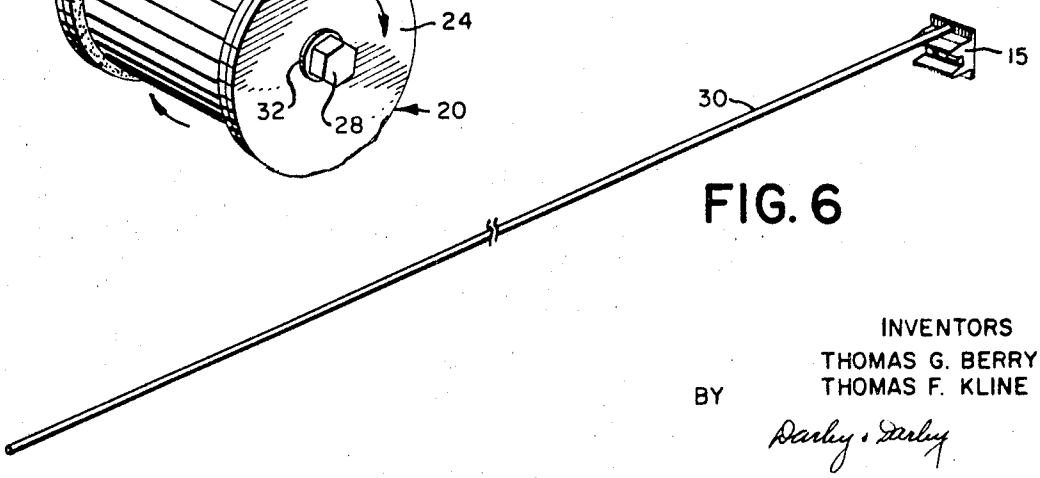


FIG. 6



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United States Patent Office 3,467,328
Patented Sept. 16, 1969

3,467,328

SELF-EXTENDING ANTENNA

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Filed Aug. 16, 1966, Ser. No. 572,743
Int. Cl. B65h *74/34;* E04h *12/18*
U.S. Cl. 242—54 8 Claims

ABSTRACT OF THE DISCLOSURE

A self-extending structure comprising a storage reel on which is wound in a flattened condition an elongated strip of material having stored energy enabling it to form into a tubular structure when unwound from the reel. The free outer end of the strip is fastened to a stationary member and the reel is held by a restraining means. Upon release of the restraining means the strip unwinds from the storage reel carrying the reel with it. A kicker spring is also provided to give the reel an initial push when released.

This invention relates to extendible structures and more particularly to a self-extendible structure which is useful as an antenna.

Extendible structures which have a small volume in their stored condition and can be extended to a relatively long length have a variety of uses. One such use is as an extendible antenna for an aircraft or other type of vehicle.

The present invention relates to a novel self-extendible structure. In accordance with the invention, a length of tape having certain stored energy characteristics is wound on a spool in a substantially flat condition. The spool is held to a mount and when the mount is released, the tape unwinds from the spool by releasing its stored energy. As the tape unwinds it carries the spool along with it until the time when it is fully extended. At this point the spool is ejected from the structure leaving only the fully extended tape.

The extendible structure of the present invention has several advantages. First of all, it requires no externally supplied electrical or mechanical driving energy to unwind the tape thereby doing away with the requirements for corresponding energy sources. Also, since the energy for extending the tape is stored in the tape itself and is supplied as the tape is released one layer at a time, trouble-free erection of the extendible structure is insured. The structure also is a substantially minimal weight configuration since the spool is ejected after the tape is completely unwound.

It is therefore an object of the present invention to provide a self-extendible structure.

Another object is to provide a self-extendible structure in which tape stored substantially flat on a spool is released in a predetermined manner to extend the structure.

Another object is to provide an extendible antenna utilizing metal tape which is held in a substantially flat condition on a spool between the flanges by a resilient material.

A further object is to provide a self-extendible antenna formed of a metallic tape in which the tape storage spool is at the extending end of the antenna as the tape is unwinding and the stored energy of the tape provides the energy for unwinding it from the spool.

Other objects and advantages of the present invention will become more apparent upon reference to the following specification and annexed drawings in which:

FIG. 1 is a top view of the antenna;

FIG. 2 is a side view with a portion of the spool broken away;

FIG. 3 is a front view taken in cross section through lines 3—3 of FIGURE 1;

FIG. 4 shows the spool restraining spring release mechanism; and

FIGS. 5 and 6 are perspective views of the antenna in a partially and fully extended position, respectively.

Referring to the various figures of the drawing the self-extending antenna of the present invention includes a spool support mounting plate **10** which is fastened to the surface or skin of another object **12** by any suitable fastening arrangement (not shown). Both the surface portion **12** and the entire antenna can be housed within the body of a larger object if desired, and covered with a retractable panel to preserve the object's aerodynamic configuration. Such retraction mechanism forms no part of the subject invention and it therefore is not shown.

A mounting bracket **15** is fastened to the plate **10** by any suitable means such as screws (not shown). Bracket **15** encloses a housing **17** which holds a solenoid for operating the structure. This is described later. The end of the bracket **15** remote from plate **10** terminates in a pair of spaced arms **18** having generally tapered or somewhat curved surfaces **19** to generally conform to the outer surface of a cylindrical object.

A spool **20** is used to store a roll of the tape which is to serve as the antenna. The storage spool is formed by three pieces and includes a hollow, generally cylindrical drum **22** and separate hubs **24** and **26**. The inside of each flange **24** and **26** are faced with a suitable resilient material, such as a silicone sponge rubber sheet **29** which is applied by any suitable technique, such as by an adhesive. The spool is assembled by inserting the heads of the hubs **24** and **26** into the bore of drum **22** and tightening a thru-bolt **28**.

The antenna element is formed by a desired length of a suitable material, for example a beryllium copper alloy, which is wound over the drum of the spool and stored thereon in a substantially flat condition. When unrestrained, the tape will try to unwind due to its coil-spring like property. The tape also is pre-stressed longitudinally (along its long axis) for example, by an age forming technique. The pre-stressing causes the tape to curl when unrestrained. In the present invention, the unwound tape forms a tube-like configuration with the tape edges overlapped (see FIG. 5). The age forming technique allows the antenna element to maintain the desired characteristics of being storable on the spool in a flat condition and upon release to form an open section, overlapped tube having substantial torsional strength and flexural rigidity. As described below, the induced strain energy of the tape resulting from its flat stored condition is controlled and utilized as the propulsion source for its own extension.

The stored strain energy of the tape is maintained by the reel storage spool **20**. The tape **30** is first wound on the rool drum **22**, the drum flanges **24** and **26** are assembled onto the drum and then the thru-bolt **28** is inserted. The edges of the stored antenna tape slightly compress the sponge rubber pieces **29** on the inside faces of the spool flanges. This holds the tape substantially flat and constrains stored strain energy. The sponge rubber sheets **29** also allow only one wrap of the tape to release at a time.

To compensate for any dimensional changes of the storage spool, which may result for example from extreme temperature changes, a spring type Belleville washer **32** is used, with one being shown on each end of the thru-bolt. This maintains the strain energy integrity.

After the storage spool is assembled, the free end of the tape on top of the spool is fastened to a force moment supporting tube **35** by a bolt **37**. Tube **35** is held to

the mounting plate **10** by a screw or other suitable fastener **39**. An RF connector **33** is mounted on the bracket **15** and has a wire **34** electrically connected to the end of tape **30** connected to the force moment tube **35**. Electrical communication apparatus (not shown) is electrically connected to the connector **33**.

As shown in FIG. 1, the portion of the tape between the fastened end on tube **35** and the constraining points on the spool flanges show the curl in accordance with the released strain energy. As best seen in FIG. 3, the lower end of the force moment tube **35** has a flat **41** whose function is described later.

The complete spool with antenna tape element wound thereon is held to the brackets **18** of the housing by a restraining spring **44**. The brackets **18** lie within the flanges and the tapered edges **19** contact the uppermost wrap of the tape. Spring **44** securely engages a portion of the outer wrap of tape **30** wound on the spool. One end of the spring is held by bolt **37** while the other end fits into a slot **45** in an extension of a mounting block **55** which houses a plunger **46** of a spring loaded solenoid **48** (see FIG. 4). This end of the spring **44** has a hole (not shown) into which the bottom of plunger **46** fits, the spring being held between the bottom wall of slot **45** and the bottom of block **55**.

A kicker spring **52** is mounted by suitable fasteners **54** in a recess **53** located between the arms of mounting bracket **15**. With the spool held to the bracket by restraining spring **44** the kicker spring **52** is compressed (see FIG. 2). Both the springs **52** and **44** are made of any suitable material, for example, beryllium copper.

FIG. 4 shows the details of the operating solenoid. The shaft of plunger **46** has a shoulder **47** which travels within a bore **49** of mounting block **55**. The plunger shaft **46** is loaded by a spring **57** acting against the top of block **55** and the bottom of a washer **58** which urge the plunger **46** upwardly. The plunger **59** of solenoid **58** extends through a bore in the mounting block **55** and engages the top of the boss **47** to prevent the plunger **46** from moving upwardly with the solenoid de-energized.

The antenna is deployed in the following manner. Electrical current is supplied to the solenoid **48** causing its plunger **59** to retract (move to the left as shown in FIG. 4) thereby releasing plunger **46** to permit it to move upwardly. When plunger **46** moves upwardly it releases restraining spring **44** which snaps outwardly and lays against the flat **41** of the force moment tube **35**. Since there is no restraint the kicker spring **52** flexes and gives the spool **20** an initial outward push to start the unrolling of the antenna tape **30**. This is seen in FIGURE 5 where the antenna is shown in the initial stages of deployment. It should be noted that restraining spring **44** now extends outwardly and within the first portion of the tubular structure formed as the tape curls.

The stored strain energy in the tape element **30** propels the storage spool and the tape forward one wrap at a time until the entire length of the tape element is extended. To understand the operation of the unrolling of the tape and the propulsion of the spool, it should be considered that with no restraint present the upper wrap of tape will always be in the process of curling into the tubular shape. As the upper layer unwraps from the spool, the stored strain energy which makes it curl also produces a force component along the longitudinal axis of the tube formed. This propels the spool outwardly from the force moment tube **35**. It also should be understood that the rubber layers **29** prevent the unwinding of more than one wrap of tape at a time.

As the tape unwraps to form the tubular structure, the spool has an accelerating velocity. When the tape reaches its maximum extension, the storage spool **20** has maximum velocity and is hurled into space leaving only the fully extended tubular antenna and mount shown in FIGURE 6. This of course represents a reduction in the weight that the vehicle carrying the antenna has to carry.

As should be apparent the pre-stressed condition of the tape makes it curl into a tube as it is releasing its stored strain energy. This tubular structure has substantial strength with minimum weight.

What is claimed is:

1. A self-extending structure comprising storage means, an elongated flexible member formed with stored energy which tends to make the member curl into a tubular shape wound on said storage means in a flattened condition, support means, means connecting the free end of the elongated member to said support means, and releasable restraining means for holding said storage means to said support means, said restraining means upon release permitting the elongated member to unwind and carry the storage means with it.

2. A self-extending structure as in claim **1** wherein said elongated member is a flat metallic tape which is prestressed to have a component of strain-energy stored therein.

3. A self-extending structure as in claim **1** further comprising means for fixedly connecting one end of said restraining means to said support means, and releasable means for holding the other end of said restraining means.

4. A self-extending structure as in claim **3** wherein said restraining means is a spring which overlies the storage means and which extends outwardly from the support means when released.

5. A self-extending structure as in claim **4** wherein the portion of the support means to which the one end of the restraining means in fixedly connected is a rod which extends in the direction of unwinding of the flexible member.

6. A self-extending antenna as in claim **1** further comprising a resilient means on said support means engaging said storage means, said resilient means imparting an initial force to said storage means to push it outwardly when the restraining means is released.

7. A self-extending structure as in claim **2** wherein said storage means comprises a spool and resilient material covering the inner face of at least one of the spool flanges to engage an edge of the elongated member wound on the spool.

8. A self-extending antenna as in claim **7** further comprising a resilient means on said support means engaging said storage means, said resilient means imparting an initial force to said storage means to push it outwardly when the restraining means is released.

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U.S. Cl. X.R.

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