Aug. 11, 1964 G. J. KLEIN 3,144,215

COILABLE EXTENSIBLE APPARATUS

Filed April 27, 1961 2 Sheets-Sheet 1

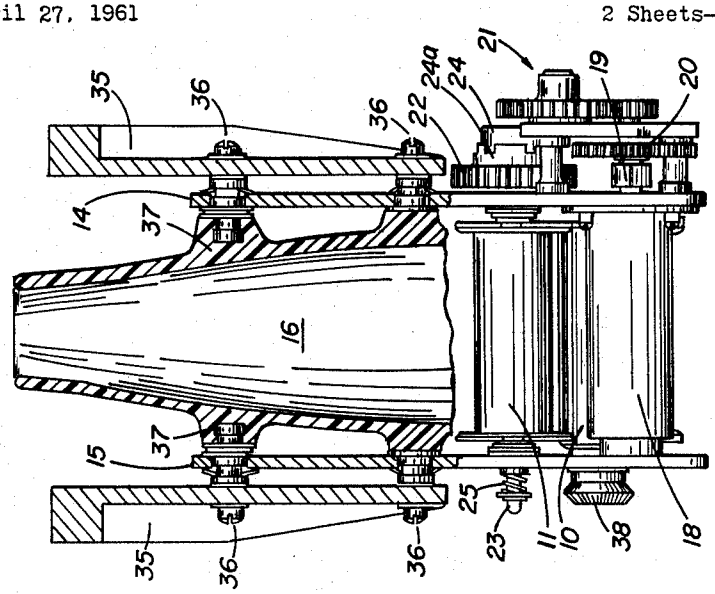

FIG. 3

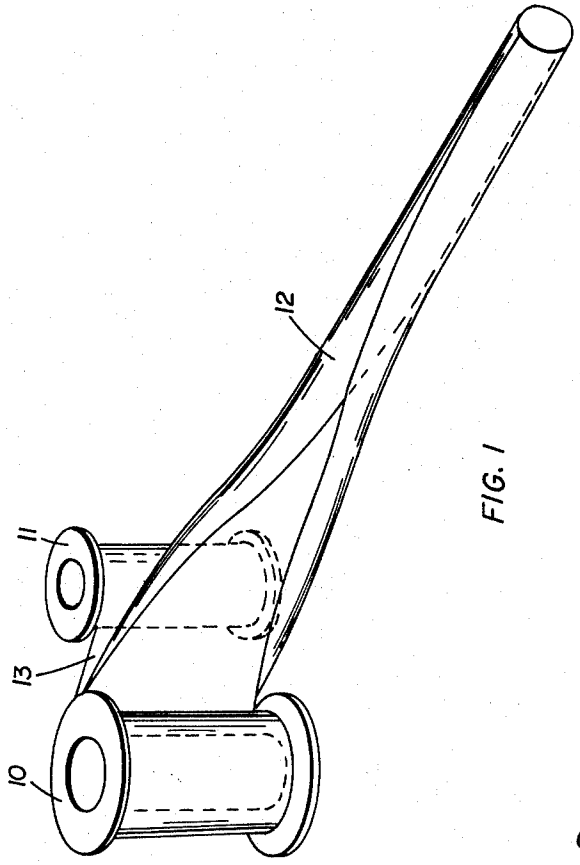

FIG. 1

INVENTOR
GEORGE J. KLEIN
BY- Smart + Biggar
ATTORNEYS

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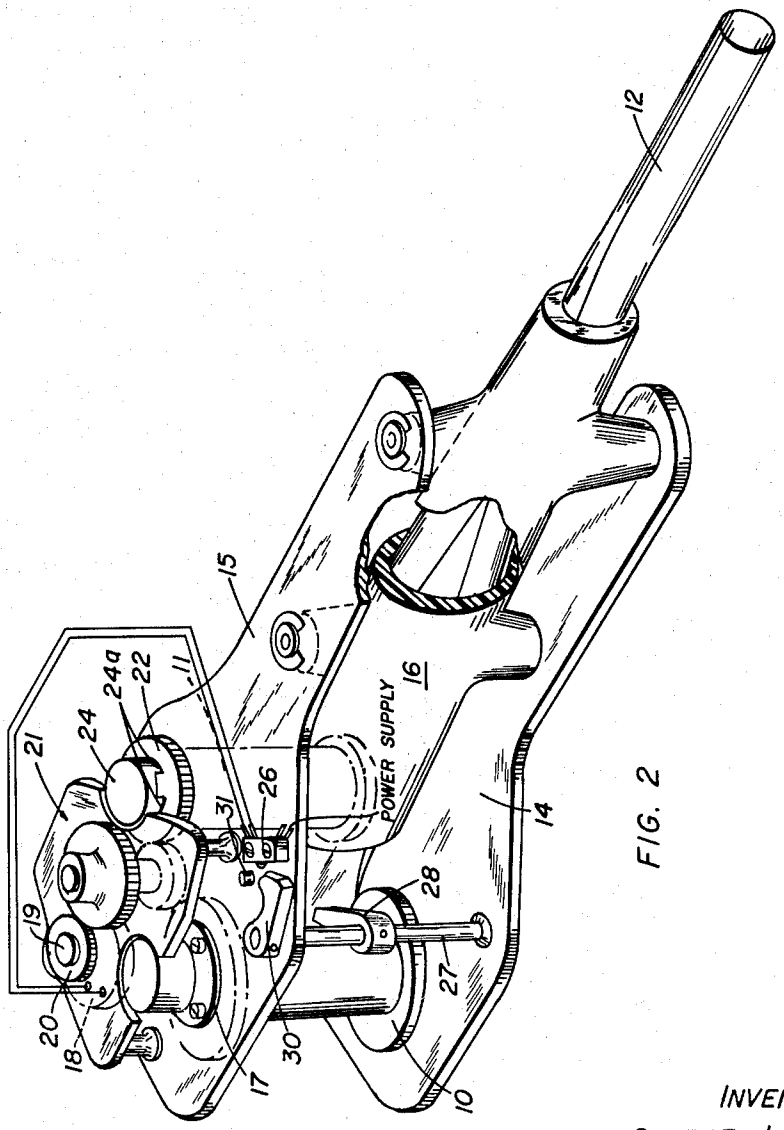

FIG. 2

INVENTOR
GEORGE J. KLEIN
BY- Smart & Biggar.
ATTORNEYS

United States Patent Office 3,144,215 Patented Aug. 11, 1964

3,144,215

COILABLE EXTENSIBLE APPARATUS

George J. Klein, Ottawa, Ontario, Canada, assignor, by mesne assignments, to The De Havilland Aircraft of Canada Limited, Downsview, Ontario, Canada

Filed Apr. 27, 1961, Ser. No. 106,124
Claims priority, application Canada Jan. 19, 1961
1 Claim. (Cl. 242—54)

This invention relates to a coilable extensible apparatus. The apparatus of the invention is especially useful as an antenna or as a means for extending an instrument a desired distance outwardly from a body in which the apparatus of the invention is mounted, for example, a satellite, the apparatus of the invention acting as a carrying boom for the instrument in question.

The apparatus of the invention appears at present to be particularly valuable in space satellite applications where the satellite, at the time of launching, must not be encumbered by elements projecting any substantial distance outwardly from its walls, while, once the satellite is in orbit, it is desirable to project an antenna from the body of the satellite or position some measuring instrument at a known distance away from the body of the satellite. The apparatus is useful in other fields as well, and could, for example, advantageously be included amongst the emergency equipment stowed in lifeboats and aircraft, or could be used as a liner for holes produced by diamond drilling in mining operations and the like, to keep the drilled holes clean.

It is known that tempered spring steel and other spring materials which are hardened and tempered by heat treatment may be formed into a desired shape, without substantially altering the temper or other physical qualities of the material, by means of elastic deformation applied concurrently with a stress relieving heat treatment at a temperature slightly less than the original tempering temperature. The present inventor found that if a strip of tempered spring material of considerably greater length than width is elastically deformed into a tubular formation extending in the direction of its longitudinal axis with substantial overlap of the longitudinal edges of the strip, and if the strip is concurrently stress-relieved as just described, then even if the strip is subsequently tightly coiled at right angles to its longitudinal axis, it will, whenever free to do so, revert to the tubular formation. A strip which has been so treated may therefore be described as having been preformed to assume, whenever free to do so, a tubular formation extending in the direction of the longitudinal axis of the strip with substantial overlap of the longitudinal edges of the strip. The present inventor further realized that if apparatus could be provided which would stow such a strip of material in a compact space yet would permit erection of the strip so that it could adopt the tubular formation which it had been biased to assume by the deforming and stress relieving steps, the strip would be useful both as an antenna or as a carrying boom for instruments as mentioned above, particularly in the case of space satellites.

The apparatus of the invention meets these desiderata and stows the extensible strip in a very compact manner which is of course a desirable feature in any space vehicle.

The apparatus of the invention may be generally defined as a coilable extensible apparatus comprising a thin strip of metal of much greater length than width which has been pre-formed to assume, whenever free to do so, a tubular formation extending in the direction of the longitudinal axis of the strip with substantial overlap of the longitudinal edges of the strip, a frame, a stowage reel rotatably mounted within said frame and adapted to stow the strip by winding it on the reel at right angles to the

longitudinal axis of the strip, and a guide means mounted within said frame, said guide means having a base which is disposed at a tangent to said reel and a guiding section which is generally tubular and decreases in internal width with distance away from said reel.

The apparatus of the invention preferably includes a pull-out tape which may be inter-wound with the metal strip upon the stowage drum and is attached to a second reel which is positively driven by a small motor also located within the frame. The motor drives the second reel and the second reel draws the pull-out tape off its stowage reel and thus positively drives the metal strip through the guide sleeve, at the same time supporting the partly spread out end of the metal strip in the region where it leaves the stowage reel to prevent it from buckling due to axial loading.

As the thin metal strip, tempered spring steel which is a few thousandths of an inch thick, or beryllium copper of the same order of thickness, are preferably employed. The pull-out tape itself may also be made of a thin strip of metal but any strong thin tape may be employed to play this role. One product which has been found useful as the pull-out tape is a tape made of a polyethylene terephthalate resin which is sold under the registered trademark "Mylar" by E. I. du Pont de Nemours & Co.

In drawings illustrating one presently preferred form of the apparatus of the invention:

FIGURE 1 is a schematic view showing the winding arrangement of the pull-out tape and the metal strip,

FIGURE 2 is a perspective view of the apparatus of the invention, with a part of the tubular guide sleeve broken away so as to better show the thin metal strip in the process of forming itself into the tubular formation, and

FIGURE 3 is a central vertical section through the apparatus of the invention with the pull-out tape and the metal strip removed from the reels on which they are normally stowed.

In FIGURE 1, **10** indicates a reel for stowing the metal strip in interwound formation with the pull-out tape, while **11** indicates a reel upon which the pull-out tape is wound when it is drawn off the reel **10** so as to extend the metal strip. The metal strip itself, which is preferably formed of tempered steel or beryllium copper is indicated at **12** while the pull-out tape has been labellel **13**. The metal strip is one which has been preformed to assume a tubular formation as previously described and it will be noted that, as soon as the strip **12** leaves the stowage reel **10**, it commences to curve inwardly so that it assumes a full tubular formation when within a very short distance of the stowage drum.

Turning now to FIGURES 2 and 3, it will be noted that the stowage reel **10** and the pull-out tape reel **11** are mounted by means of suitable shafts within a frame made up of a pair of similar side plates **14** and **15**. Interposed between the side plates **14** and **15** is a guide sleeve **16** which is generally tubular and decreases in internal width with distance away from the reel **10**. The guide sleeve **16** is mounted with its base generally tangentially disposed with respect to the reel **10** and the guiding section of the sleeve preferably has an inner surface which generally corresponds to the shape which would be assumed by the strip in the region of said reel if the strip were fed tangentially off the stowage reel in the absence of any guide sleeve.

In the embodiment of the invention illustrated in FIGURES 2 and 3 the strip of metal **12**, when extended is intended to function as an antenna. To this end an antenna feed connection **17** is provided in the form of a multifingered contact cup which rides on the end of the antenna stowage reel shaft. The inner end of the antenna tube material is fixed to the shaft (in a manner not shown),

while the contact cup is fixed relative to the frame so that the shaft rotates within it while the antenna is being extended.

Also mounted within the frame made up of the two side plates **14** and **15**, is a motor **18** which is best seen in FIGURE 3. The motor **18** is preferably a small electric motor which is powered by a nickel-cadmium battery (not shown). The motor **18** has a drive shaft **19** which carries a gear **20**, and this gear **20**, through a gear reduction assembly which has been indicated generally by reference numeral **21**, drives a gear wheel **22** which is freely rotatably mounted on a shaft **23** which is employed to rotatably mounted the pull-out tape reel **11**. Fixed to the third shaft **23**, as indicated at **24** in the drawings is a clutching member carrying teeth **24***a* which are normally engaged in detents formed in the hub of the gear wheel **22**. An expansion spring **25**, concentrically mounted on the shaft **23**, serves to normally bias the clutching member **24** into engagement with the gear wheel **22**, so that member **24**, and in turn, the reel **11**, will normally be rotated, though at a reduced speed, whenever the drive shaft **19** of the motor **18** is rotated.

Thus, to extend the strip **12** so as to form an antenna it is only necessary to energize the motor **18** whereupon said motor will rotate its shaft and in turn drive the pull-out tape reel **11**. The pull-out tape **13** will then draw the metal strip **12** off the stowage reel **11** and cause said strip to pass through the tubular guide sleeve **16**, whereupon it will form the desired extended tubular formation with the longitudinal edges of the strip overlapping.

Mounted upon the outer surface of the side plate **15** is a microswitch **26** which is wired in known manner, so that when depressed, it will act to cut-off the power supply to the electric motor **18**. Rotatably mounted by the side plates **14** and **15** of the frame is a rod **27**. A follower arm **28** is rigidly mounted on the rod **27**, and the rod **27** is biased by spring means (not shown) to rotate counterclockwise, as viewed in FIGURE 2, thus causing the free end of the follower arm **28** to ride against the cylindrical surfaces of the reel **10**, or whatever is wound upon the reel. The cylindrical surface of the reel **10** is provided with a slot (not shown) which will not be exposed until the metal strip has become fully extended because that slot will ben ormally covered by the parts of the metal strip **12** and tape **13** wound on the reel **10**. However, once this slot is uncovered, the end of the biased follower arm will drop into it and thus lock the stowage reel **10** against further rotation.

The end of the rod **27** extends slightly beyond the side plate **15** and has fixed to it a micro-switch cam **30** which, whenever the follower arm **28** drops into locking position in the slot in the reel **10**, will rotate and come to a halt against a stop pin **31** on the upper surface of the side plate **15**. As this occurs the micro-switch **26** will be depressed by the cam **30**, thus deenergizing the motor **18**.

The apparatus may be mounted in brackets **35** secured to the satellite or other unit in which the apparatus is to be employed by means of bolts **36** which pass through the

side plates **14** and **15** and enter projections **37** which space the tubular guide sleeve **16** from the two side plates.

The apparatus may be adapted to be manually rewound by providing a squared head on the projecting end of the shaft which rotatably mounts the stowage drum **10**. A gear such as the bevelled gear **38** may be locked upon the projecting end of this shaft to facilitate the rewinding. During rewinding the shaft **23** should be pressed downwardly so as to disengage the clutching member **24** from the gear wheel **22**, thus disconnecting the tape reel **11** from the reduction gearing **21**.

What I claim as my invention is:

A coilable extensible antenna comprising a thin strip of metal of much greater length than width which has been pre-formed to assume, whenever free to do so, a tubular formation extending in the direction of the longitudinal axis of the strip with substantial overlap of the longitudinal edges of the strip, a frame, a stowage reel rotatably mounted within said frame and adapted to stow the strip by winding it on the reel at right angles to the longitudinal axis of the strip, a guide means mounted within said frame, said guide means having a base which is disposed at a tangent to said reel and a guiding section which is generally tubular and decreases in internal width with distance away from said reel, a pull-out reel rotatably mounted within said frame, a pull-out tape anchored at one of its ends to said pull-out reel and partially wound thereon, said pull-out tape being anchored at its other end, together with said strip of metal, to said stowage reel, whereby said metal strip and pull-out tape may both be interwound and stored on said stowage reel, and means for positively driving said pull-out reel mounted within said frame whereby said pull-out tape may be caused to draw the strip, when stowed on the stowage reel, off said stowage reel, whereupon the unwound part of said strip will be projected through said guide sleeve and will assume a tubular formation extending in the direction of the longitudinal axis of the strip with substantial overlap of the longitudinal edges of the strip, said pull-out reel being mounted on a rotatable shaft, said means for driving the pull-out reel being an electric motor having a drive shaft, said apparatus including means for operatively connecting the drive shaft of said motor to said rotatable shaft, said last-mentioned means including a gear wheel freely mounted on said last-mentioned shaft and a clutching member attached to said shaft and engageable with said gear wheel to bring about rotation of said pull-out reel whenever said gear wheel is rotated with said clutching member engaged with said gear wheel, and means normally biasing said gear wheel and clutching member into the engaged position.

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