Aug. 28, 1956 R. B. COTTON 2,760,777

COMBINATION TURBINE AND REEL PACKAGE

Filed Feb. 17, 1954 3 Sheets-Sheet 1

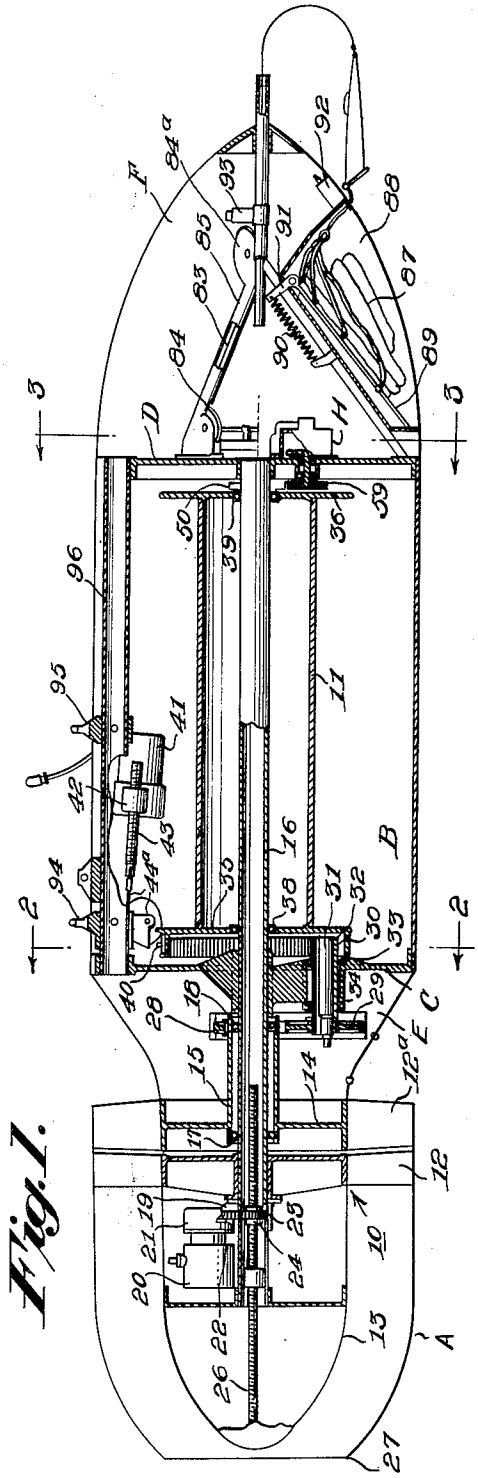


Fig. 1.

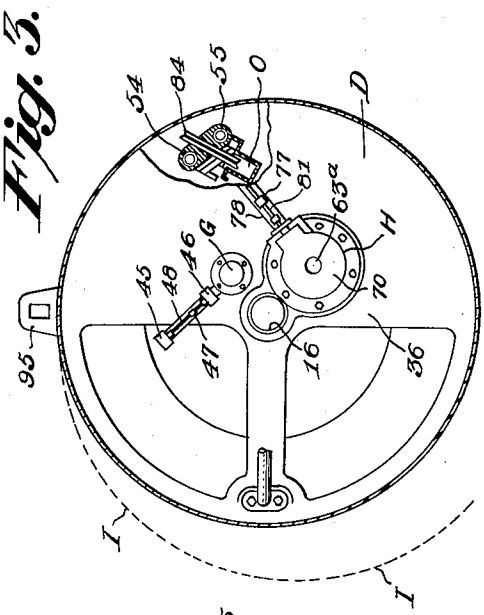


Fig. 3.

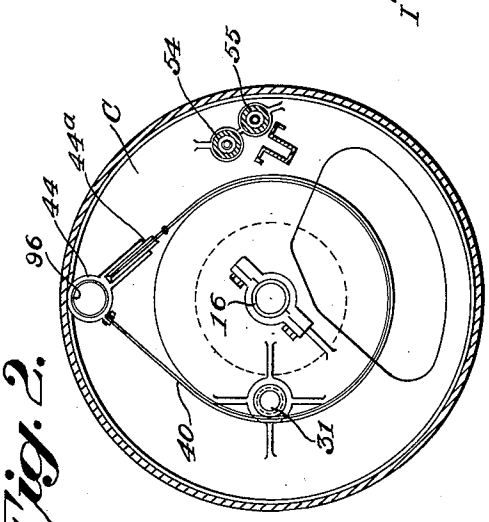


Fig. 2.

INVENTOR
Robert B. Cotton.

BY Herbert M. Birch
ATTORNEY

Aug. 28, 1956 R. B. COTTON 2,760,777

COMBINATION TURBINE AND REEL PACKAGE

Filed Feb. 17, 1954 3 Sheets-Sheet 2

Fig. 6.

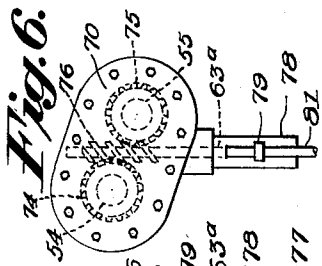


Fig. 5.

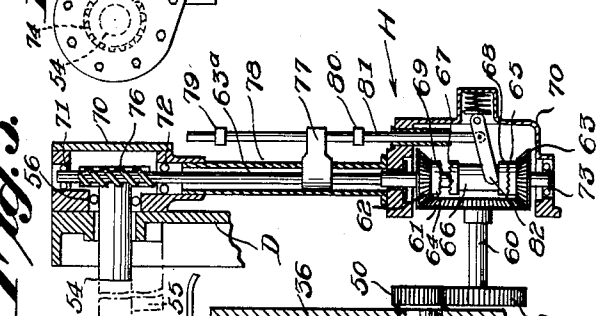


Fig. 4.

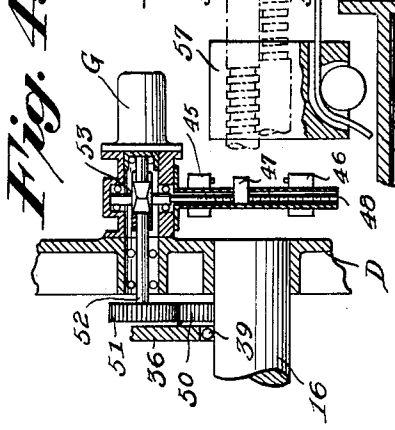


Fig. 7.

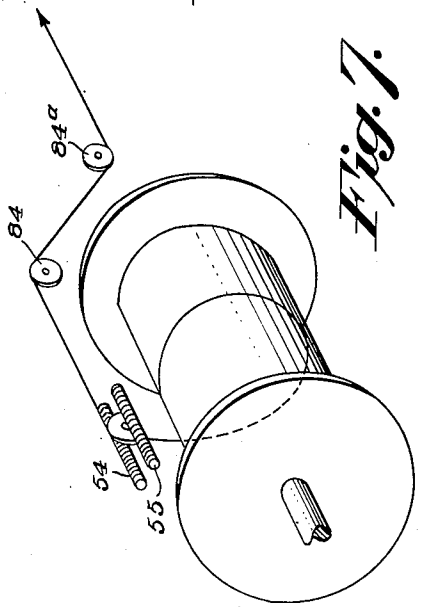
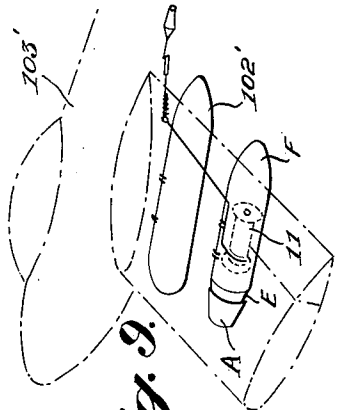


Fig. 9.



INVENTOR

Robert B. Cotton

BY Herbert M. Birch

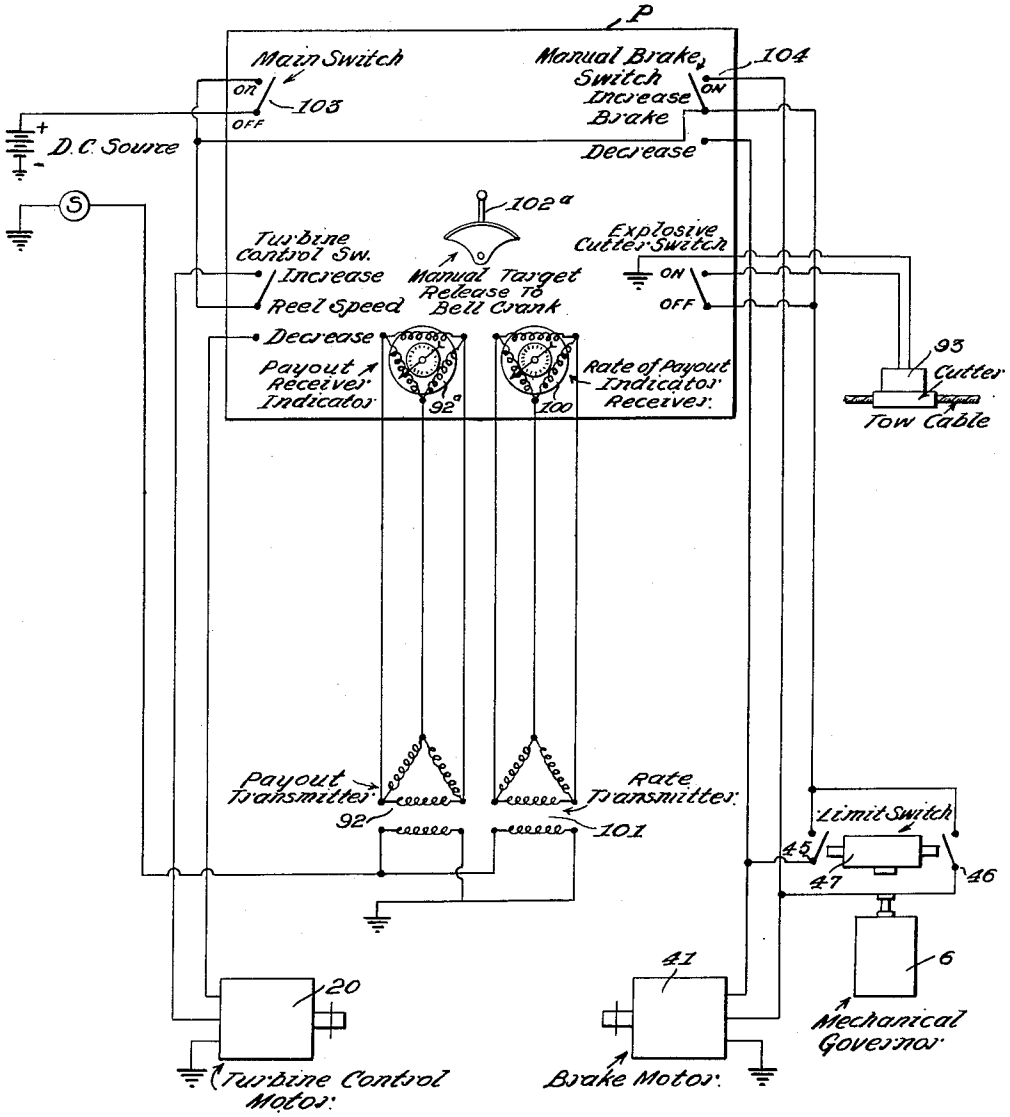
ATTORNEY

Aug. 28, 1956 R. B. COTTON 2,760,777

COMBINATION TURBINE AND REEL PACKAGE

Filed Feb. 17, 1954 3 Sheets-Sheet 3

Fig. 8.



INVENTOR

Robert B. Cotton

BY Herbert M. Birch

ATTORNEY

United States Patent Office

2,760,777

Patented Aug. 28, 1956

2,760,777

COMBINATION TURBINE AND REEL PACKAGE

Robert B. Cotton, Media, Pa., assignor to All American Engineering Co., Wilmington, Del., a corporation of Delaware

Application February 17, 1954, Serial No. 410,801

8 Claims. (Cl. 273—105.3)

The present invention relates generally to airborne target towing, line severing and line rewinding means with remote control and cable length and rate payout indication.

More particularly this invention relates to a novel streamlined unit, which may be readily attached and detached to the usual bomb rack of an aircraft and contemplates a unit of particular efficiency for use with aircraft of the high speed type.

The principal object of this invention is to provide in a single streamlined housing package or in a bullet-shaped shell, the combination of a target storage compartment, a target tow reel and a turbine internally mounted within the nose of the housing or shell, said turbine being driven by the mass flow of the airstream passing through the turbine, said turbine being in driving connection with the target tow reel.

Heretofore, in my prior Patent No. 2,464,073, issued March 8, 1949, and which is by mesne assignments the property of All American Engineering Company, the assignee of my present invention, there is shown an airborne reel package with an exteriorly mounted varible pitch air impeller. This exteriorly mounted impeller uses remote control means to vary the impeller blade angle to control the reel speed. While this exteriorly mounted impeller has proven to be very satisfactory for use with low speed aircraft, it has been discovered that with the present day high speed aircraft, such exterior mounted air impellers have a basic disadvantage, namely, air drag, which is incompatible with high speed aircraft.

Accordingly, another object is to provide an airborne streamlined target tow reel package including an internal turbine having a set of nozzle blades with a fixed pitch, whereby air drag, which is incompatible with high speed aircraft is eliminated.

A further object is to provide in a turbine driven airborne streamlined target tow reel unit, remote control means for turbine and reel speed control, comprising means to regulate the mass flow of the air stream, said means being movably mounted at the nose of the unit, to thereby vary the mass flow of the airstream passing through the turbine.

A further object is to provide a remotely controlled reel brake with a maximum speed control governor responsive to excessive R. P. M.

Still a further object is to provide in the tow reel package, a cable reel-out speed and length of cable reel-out indicator of the self synchronous induction type, known in the art as an "Autosyn" or "Selsyn" telemetric system.

And yet a further object is to provide a tow cable emergency severing system, such as a remotely controlled explosive means for cutting the towing cable after a target connected thereto has become too mutilated for further target use.

Still another object is to provide a novel drum construction of rolled-sheet material, such as aluminum with end flanges adapted to facilitate easy assembly and simple and inexpensive manufacture.

Various other more detailed objects and advantages of the present invention, such as develop in connection with the practice of a practical embodiment will in part become apparent as the description of the invention proceeds. For example, a full and more complete understanding of one embodiment of the invention, may be had by reference to the following description and accompanying drawings, wherein,

Figure 1 is a longitudinal cross section view of a complete streamlined unit showing the interior turbine, tow reel, driving connections and line payout and tail end storage compartment.

Figure 2 is a transverse section taken along the section line 2—2 of Figure 1 showing the reel brake.

Figure 3 is a transverse cross section view taken along the line 3—3 of Figure 1.

Figure 4 is a cut-away cross section view of the limit switches and an automatic cut-off for the reel speed governor driven off of the reel, which controls the circuit to the reel brake.

Figure 5 is a cut-away view in cross section of the reversible screw drive to the level wind shafts.

Figure 6 is a view partly in elevation of the worm shaft and gear drive inside its housing for the reversible or two-way drive to the level wind mechanism.

Figure 7 is a partial diagrammatic illustration of the tow cable lead screws and the cable pay-out from the tow reel.

Figure 8 is a diagram of a circuit arrangement such as may be used from the control panel in the aircraft.

Figure 9 is a modification of the general arrangement and mounting of the streamlined unit, showing an additional target storage package.

Referring in detail to the several Figures of the drawings and first with particular reference to Figure 1, there is illustrated a streamlined target tow unit comprising a front or nose portion A for internally confining an air-driven turbine **10**, a target reel compartment B, with end walls or partitions C and D, for housing a target tow reel including a rotary drum **11**, an intermediate speed reduction gear train E supported on partition C, drivably connecting the turbine **10** with the reel, and a tail compartment F adapted to serve as a storage space for the target, the payout tubes for the tow cable, and the transmitters of a self-synchronous telemetric indicator system to indicate cable payout length and rate of payout to be hereinafter described.

The rearmost partition D of the reel compartment B serves as a mounting for a reel speed governor G, see Figure 4, and also for a reversible two-way drive arrangement H, see Figures 5 and 6. Also in Figure 3 is shown a door I for access to the reel or drum **11** in compartment B.

Turbine

The internal turbine mounted in the nose A of the unit is comprised of a set of fixed impeller blades **12**, as distinguished from the prior art variable pitch blades. These fixed blades are of a predetermined pitch angle and are used to turn the mass air flow to a more efficient angle and also serve to support the nose portion A, see Figure 1. Rearwardly of blades **12** are blades **12*a*** rotatably driven by the mass flow of the air stream passing through the turbine. The air mass flow is controlled by means, such as valve **13**. This valve is reciprocated to control the mass flow and turbine speed by a reversible motor. The turbine rotatable blades **12*a*** form part of a turbine wheel **14** having a central elongated hollow hub **15** journalled on a hollow shaft **16** by bearings **17** and **18**, respectively. The shaft **16** in turn is centrally mounted in a non-rotatable manner in the partitions C and D at each respective end of the target tow reel compartment B

and extends beyond the exterior side of partition C through the hub 15 to the valve 13 in the nose portion A.

Mounted on the shaft 16 between the turbine 14 and the valve 13 on a bracket 19 is a valve actuator means, such as an electric reversible motor 20 with a drive shaft connected to a speed reduction gear unit 21. This gear unit includes a power take-off gear 22, which meshes with a driven gear 23 having a centrally threaded hub 24 mounted on a screw shaft 26 in the bore of the hollow shaft 16. The hub 24 and gear 23 are held against longitudinal movement in a suitable position within the hollow shaft 16, but gear 23 is freely mounted for rotation either clockwise or anti-clockwise, with the gear teeth thereof extending from a slot in the shaft 16 for engagement with drive gear 22. Thus when the reversible motor is energized rotation is transmitted from drive gear 22 to driven gear 23, to thereby rotate the screw shaft 26 either forward, that is, clockwise, or reverse, that is, anti-clockwise and project the valve 13 fixed to the end thereof forward to vary the degree of the nose opening 27 in the nose portion A of the unit.

The amount of nose opening controls the mass flow to the fixed specially pitched turbine blades 12 and to the rotatable blades 12*a*, to thereby regulate the driving speed of the reel drum 11 in the target tow reel compartment B. For example, as the rotatable part of the turbine revolves, a spur gear 28 formed or mounted on the end of elongated hub 15 is rotated correspondingly and drives a reduction gear system, comprising gears 29 and 30 on a shaft 31 journalled in a bearing sleeve 32 by bearings 33 and 34 respectively. This shaft and bearing sleeve extend through the partition C, so that gear 32 is rotatable within the reel housing B.

Reel drum

The reel comprises a drum 11 preferably formed of two half cylindrical sections of light weight material, such as aluminum, positioned together to form a cylinder, and at each end the cylinder is closed by annular plates 35 and 36 grooved to receive the ends of the sections hereinafter called the end flanges. The end flange 35 is cupped exteriorly to form a ring gear with internal teeth in mesh with the gear 32. As each flange 35 and 36 is journalled by bearings 38 and 39 on the hollow drum shaft 16, the drum 11 is rotated by the power from the turbine 14 and the hereinbefore described reduction gear unit, which may be of any desired output ratio, such for example as 12 to 1.

The brake and governor control

A friction brake 40 is mounted on the annular exterior drum surface of the ring gear flange 35, which serves as a brake drum. The brake 40 is remotely applied by energizing an actuator motor 41 having a worm gear take-off 42 and screw shaft 43 connected to an oscillatable eccentric ring 44 by a cable and pulley 44*a*, see Figures 1 and 2. The brake motor 41 is connected through suitable electric conductor leads, see Figure 8, to oppositely spaced limit switches 45 and 46, respectively of any known type, see Figure 4. These switches are closed by a screw driven follower 47 on the screw shaft 48 between the said switches. The screw shaft is driven by the reel governor G which in turn is driven by the reel on shaft 16, which carries a spur gear 50. This spur gear 50 meshes with a smaller spur gear 51 on a governor shaft 52, see Figure 4, which extends through the partition D and is drivably connected to the governor G by a worm drive gear train 53 adapted to drive a limit switch shaft 48. Thus when a predetermined maximum R. P. M. of the reel 11 is reached the governor closes one of the limit switches and energizes the motor 41 to apply the brake 40. For example, switch 45 may control the speed of the reel during the payout of the cable and switch 46 may control the speed of the reel during the rewind operation.

Level wind

The level wind and the drive means therefor are illustrated in Figures 5 and 6 in detail and the drive comprises two lead screws 54 and 55. Each end of each of the lead screws is journalled by a roller bearing, such as 56 mounted in the spaced apart partitions C and D and these screws serve to threadedly support a level wind carriage 57 adapted to travel over the drum 11 in a line parallel to the drum shaft 16 between the flanges 35 and 36 thereof. The level wind mechanism, see Figure 5, is driven by the spur gear 50 supported on the exterior of the drum flange 36, which gear 50 is in mesh with a driven spur gear 59 on the end of a take-off shaft 60 with a bevel gear 61 on its end, thereby forming a two-way drive for a reversing arrangement, comprised of opposed bevel gears 62 and 63 on a drive shaft 63*a*. These gears are in mesh with the reel take-off bevel gear 61. Each gear 62 and 63 respectively is free to rotate on shaft 63*a* and includes toothed clutch collars 64 and 65 in aligned spaced relation to each other adapted to be engaged and disengaged by an interposed two-way clutch sleeve 66 having clutch teeth 67 and 68, respectively at each end, to thereby provide a two-way jaw clutch.

The shaft 63*a* is journalled to rotate in a gear housing 70 by means of bearings 71, 72 and 73. The gear housing 70 encloses the projecting ends of the level wind lead screw shafts 54 and 55 and their respective worm gears 74 and 75, see Figure 6. These gears 74 and 75 are in reversible driving connection with a worm shaft gear 76 on the shaft 63*a*. As the level wind carriage 57 comes adjacent the side flange 36, it is necessary to change the direction of rotation of the lead screws to return the level wind carriage 57 in the opposite direction. This is accomplished by the travelling lug 77 projecting from a slot in a hollow slotted shaft or sleeve 78, see Figure 5. The sleeve 78 may be eliminated, if desired. For example, as the screw shaft 63*a* is rotated the lug 77 will travel and strike one or the other of a pair of vertically spaced limit stops 79 and 80 on a clutch shaft 81. This shaft 81 is pivoted to a spring-loaded over-center arm 82 connected to the two-way clutch, sleeve 66, see Figures 5 and 6.

The payout of the cable 83 is through an opening O in partition D over a sheave 84, see Figures 1 and 3, through tube 85, under a second sheave 84*a*, through tube 86 and out the tail end of the streamlined package to a target 87 in a target storage space 88 in the tail compartment F. The target may be released by suitable remote control of a target kick-out pallet member 89, normally retained in the storage space 88 by an expanding spring 90 and a bell-crank lever connection 91, see Figure 8.

As the cable unwinds and the target drag develops on the reel, it is caused to rotate, the turbine being substantially idle and the transmitter "Autosyn" 92 with a suitable cable engaging pulley or wheel not shown, is angularly positioned, to thereby transmit a signal to a similar synchronous receiver "Autosyn" 92*a* mounted on an instrument panel P, so as to determine the length of cable payout. A similar "Autosyn" system 100 and 101 is used to determine rate. After the target has been shot away or mutilated beyond use, then a cartridge type cable cutter 93, such as generally known to the art may be fired remotely from a switch on the control panel and the cable severed to drop the used target.

The entire unit may be made to connect to the usual or standard bomb rack of an aircraft by means of bails 94 and 95 secured on a support rod 96, which also serves to support the brake actuator motor 41 and its eccentric ring 44 and pulley 44*a* previously referred to, see Fig. 1.

Another feature of the present invention is generally suggested in Figure 9 of the drawings and includes the addition of an auxiliary streamlined target storage cocoon 102', which is mounted on the craft 103' within access of the pilot.

Operation

Assuming a target to payout and tow is stored in compartment 88 on the kick-out pallet 89, the same is launched or pettisoned by a manual release lever 102 connected by cable, not shown, to the bell-crank lever 91.

Prior to release the main switch 103 is moved to on position and the torque of the turbine 14 is reduced by restricting the airflow, to less than the torque on the reel caused by cable drag and target pull. The target will cause the reel cable to unwind, rotate the reel drum 11, to thereby cause the level wind carriage to traverse the lead screws 54 and 55, until the lug 77 strikes a stop lug 79 or 80, whereby the two-way clutch H is reversed and the level wind carriage 57 reverses its travel direction.

If during payout the speed of the reel 11 becomes in excess of a predetermined R. P. M., the governor G will actuate one of the limit switches 45 or 46 and energize the brake motor 41 to reduce the reel R. P. M. speed. While a section of cable is thus unwinding the self-synchronous transmitter and receiver systems will be angularly positioned to indicate the length and the rate of cable payout, respectively.

After a desired length of cable is unwound the manual brake switch, 104, is closed and the brake is applied to hold the reel against rotation.

In order to reel in, the air flow is increased, until turbine torque exerted on the reel is greater than the torque excited on the reel by cable drag. This is accomplished by energizing the flow control actuator 20 to retract the valve dome 13 from opening 27 and thereby increase the mass of air flow to the turbine. Unlimited speed control is possible by merely changing the airflow through the stationary turbine blades 12, as the electric reel speed governor, if desired may be deenergized.

The level wind carriage 57 will operate in the same manner as during cable payout actuation, and the brake 40 may be applied when desired by closing a suitable manual brake switch, 104.

The cable severing unit may be used in any emergency requiring a quick severance and dropping of the target and tow cable.

There is thus developed a novel target and airborne reel package for high speed aircraft, which is highly efficient in action, simple to manufacture, extremely light in weight, and thereby easily installed, rugged and effectively controlled by remote control means, and wherein all parts are readily accessible for interchange and repair.

While only one embodiment of the invention has been illustrated and described, other changes and modifications, which will now appear to those skilled in the art, may be made without departing from the scope of the present invention. Reference should be had to the appended claims for a definition of the scope of the present invention.

What is claimed is:

1. In a streamlined housing having a nose portion with a central opening, said housing being readily attached to the underside of an aircraft, the combination of a rear target storage compartment, a tow reel, a turbine internally mounted within the nose portion of the housing rearwardly adjacent said central opening, said turbine being driven by the mass flow of the airstream passing through the said nose opening and the turbine, said turbine being in driving connection with the said tow reel, said reel supporting a target tow line, a target connected to the free end of the said line, and valve means for closing said opening to the intake of air from the airstream.

2. An airborne streamlined package including an air turbine and a reel, said package having a nose portion with a central opening enclosing said turbine, valve means for controlling the opening and closing of said opening to the intake of air from the air stream, an intermediate compartment enclosing said reel, and a rear target storage compartment, said turbine having a set of air directing blades of a predetermined pitch and an adjacent set of blades carried by a rotatable turbine wheel, said reel being rotatably mounted in said intermediate compartment on a shaft extending longitudinally of said package, gear reduction drive means drivably connecting said turbine wheel to said reel, a tow cable superimposed around the reel connected to a target in said storage compartment and pilot operated jettison means for discharging said target from said storage compartment.

3. A device of the class described in claim 2, wherein said reel includes an electrically actuated brake, an electric motor for actuating said brake, switch means operatively connected to said brake motor, and a speed responsive control governor for closing said switch means to energize said brake motor in response to excessive R. P. M. of said reel.

4. An aircraft bomb rack supported streamlined package including a first forward compartment having a nose portion with an opening into the airstream, a remotely controlled valve in said forward compartment registerable with said opening for restricting or closing said nose opening to the airstream, a turbine also mounted in said forward compartment rearwardly of said opening and said valve, said turbine being rotatable by the mass flow of the airstream regulated by said valve, a second compartment rearwardly adjacent said first compartment, a cable winding apparatus mounted in said second compartment having a drum rotatably mounted between the end walls of said compartment on a fixed shaft, said shaft likewise rotatably supporting said turbine in the first compartment, a reduction gear train, said gear train drivably connecting the said turbine with said reel drum, a distributor block for distributing cable on said drum from an airplane towing device in superimposed layers as the cable is wound thereon and for unwinding cable therefrom in reverse order, a pair of rotatable lead screws mounted between the walls of said second compartment and on which said distributor is traversable, reversible drive means at the ends of said lead screws to reverse the movement of said distributor, and cable pay-out sheaves adapted to direct the said cable in a direction substantially parallel to the axis of said drum.

5. In an airborne turbine driven tow reel package, said package being provided with a nose portion formed with an opening adjacent said turbine, a valve for opening or closing said opening to the air stream to control the turbine operation, a reel drum mounted on an axle extending longitudinally of said package, means for distributing a tow cable on the reel drum comprising a pair of elongated lead screws rotatably journalled in the side walls of a compartment in said package, a distributor block threadedly mounted on said screws, said block having a cable directing sheave mounted for rotation in said block on an axle, said sheave axle being at right angles to the longitudinal axle of said reel drum, a gear reduction drive for rotating said drum from a source of power, and means operatively associated with said lead screws for reversing the direction of rotation thereof to thereby move the said block over the reel drum to unwind or wind the tow cable thereon.

6. In an airborne streamlined target towing housing having a nose with a central opening, an air driven turbine in the housing adjacent said nose opening, a reel drivably connected with said turbine, valve means for controlling the speed of said turbine in operative opening and closing relation to said opening, a tow cable in winding and unwinding connection with said reel, and a target connected to the free end of said tow cable.

7. In an airborne streamlined target towing housing having a nose with a central opening, an air driven turbine in the housing adjacent said nose opening, a reel drivably connected with said turbine, valve means for controlling the speed of said turbine in operative opening and closing relation to said nose opening, a tow cable

in winding and unwinding connection with said reel, a target connected to the free end of said tow cable, brake means mounted around an end of said reel, and a speed responsive means driven by said reel adapted to actuate said brake at predetermined revolution speeds of said reel.

8. An article of manufacture comprising a streamlined hollow body having a hollow nose portion formed with an opening, said body including longitudinally aligned adjacent compartments, a fluid driven turbine rotatably mounted and enclosed by said hollow nose portion positioned rearwardly of the said opening, a reciprocating valve disposed adjacent said nose portion and being operative for opening and closing the opening therein, a reversible motor operatively connected to said valve for reciprocating the same to and from the open and closed

positions, a reel rotatably mounted for rotation on an axis longitudinally of the said body in the next aligned adjacent compartment, means drivably connecting the said reel to the rotatable part of the said turbine, and a storage compartment aligned adjacent to said reel compartment formed in the trailing end of said body.

References Cited in the file of this patent

UNITED STATES PATENTS

1,104,458	Weber	July 21, 1914
1,887,712	Goddu	Nov. 15, 1932
2,183,540	Campbell	Dec. 19, 1939
2,257,764	Ridgway	Oct. 7, 1941
2,421,269	Joyce	May 27, 1947
2,464,073	Cotton	Mar. 6, 1949
2,523,738	Trimbach	Sept. 26, 1950