

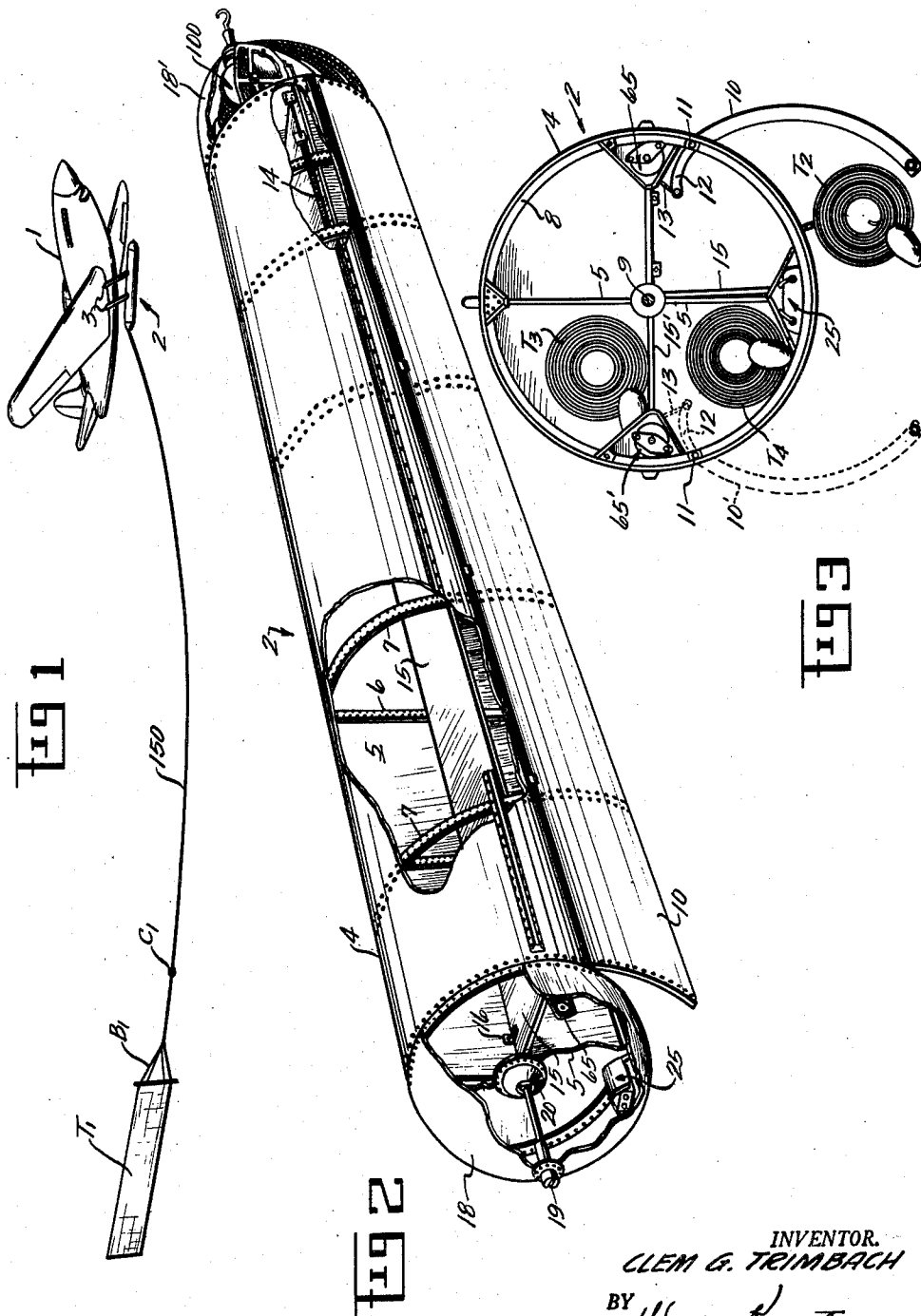
Sept. 26, 1950

C. G. TRIMBACH
TOW TARGET CARRIER

2,523,738

Filed March 21, 1949

9 Sheets-Sheet 1



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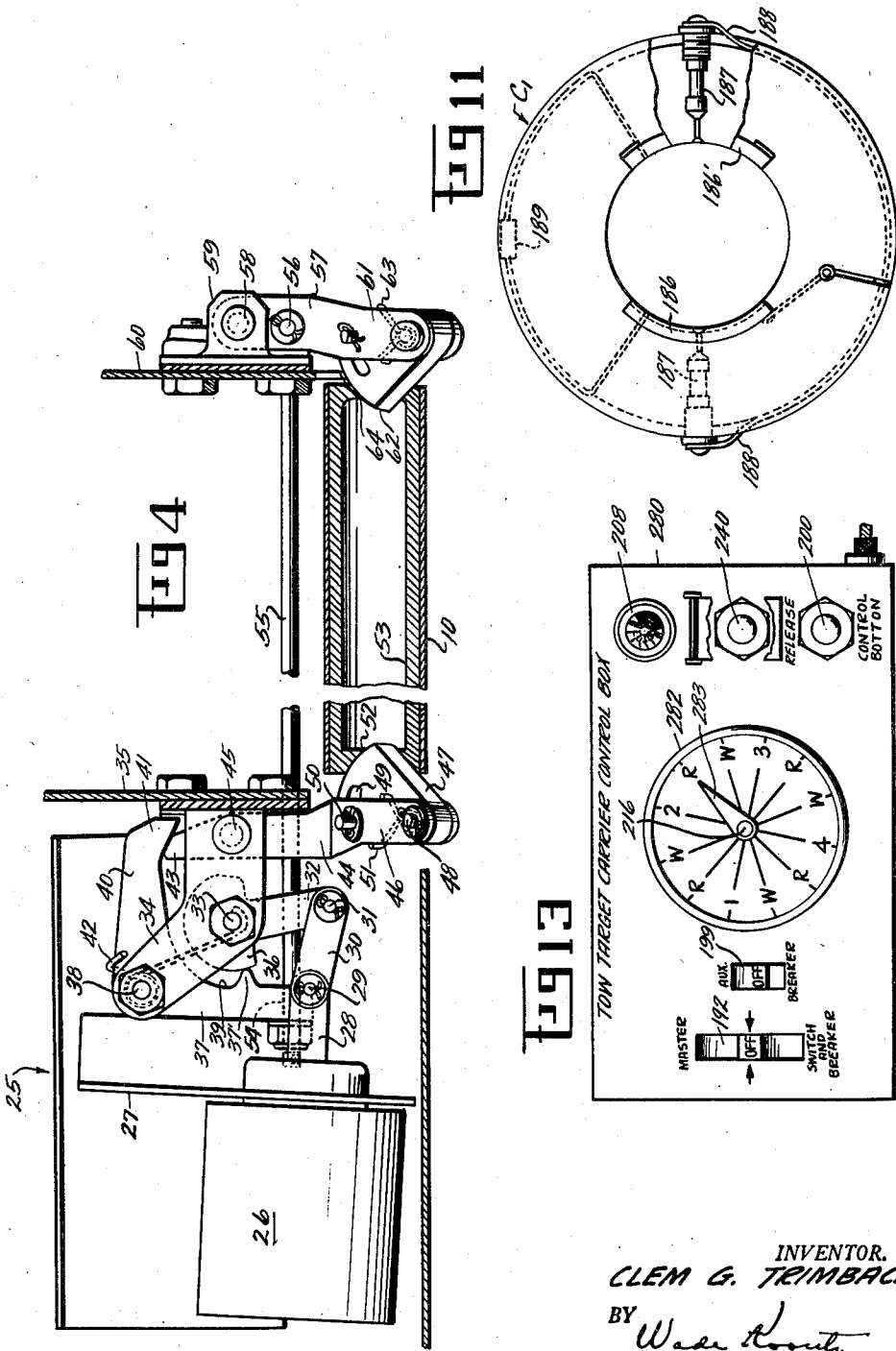
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9 Sheets-Sheet 2



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9 Sheets-Sheet 4

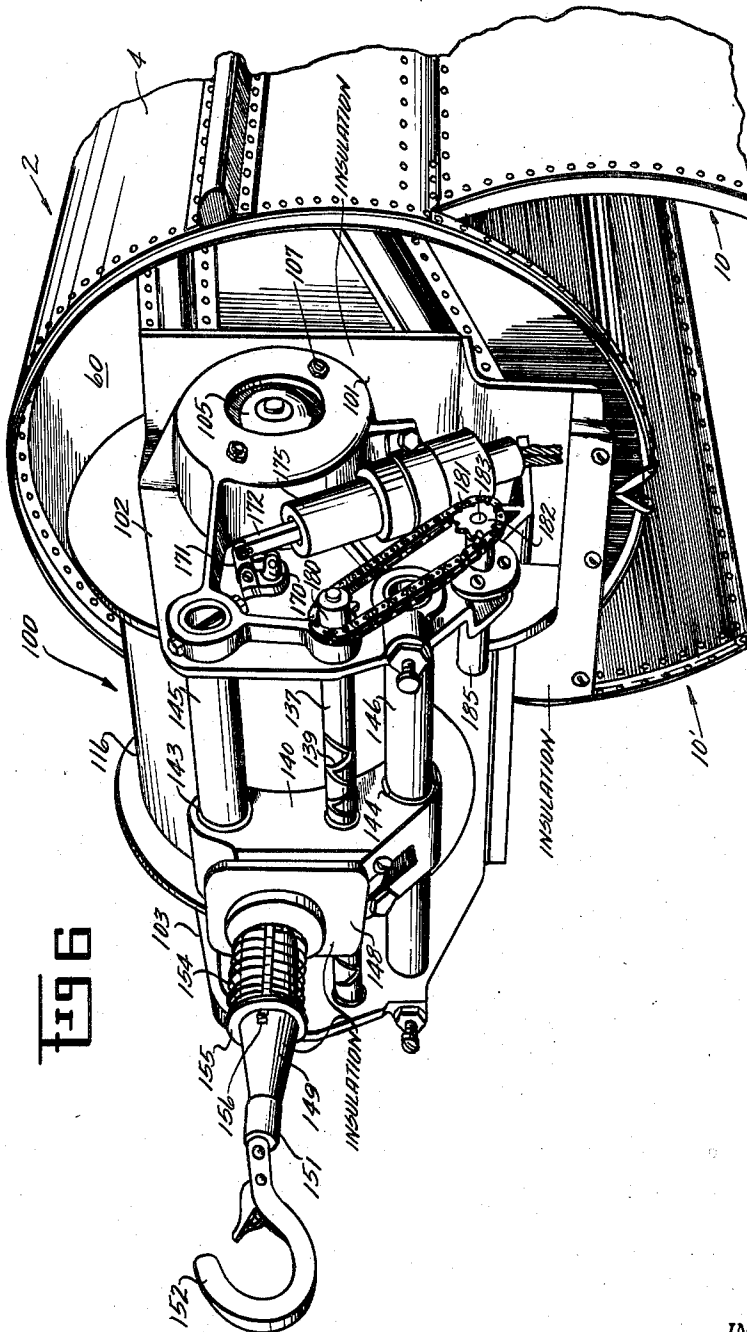


Fig. 6

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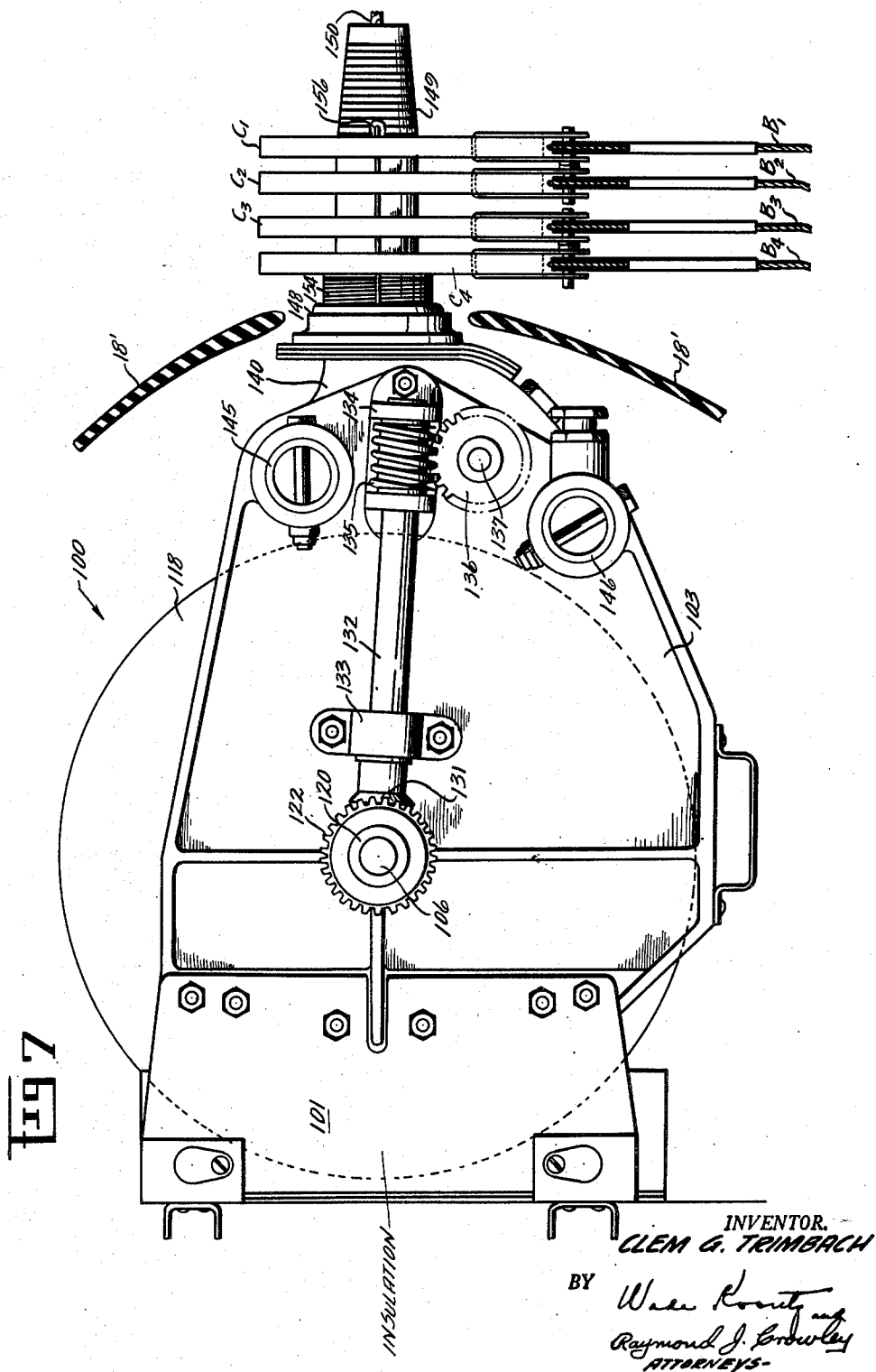
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9 Sheets-Sheet 5



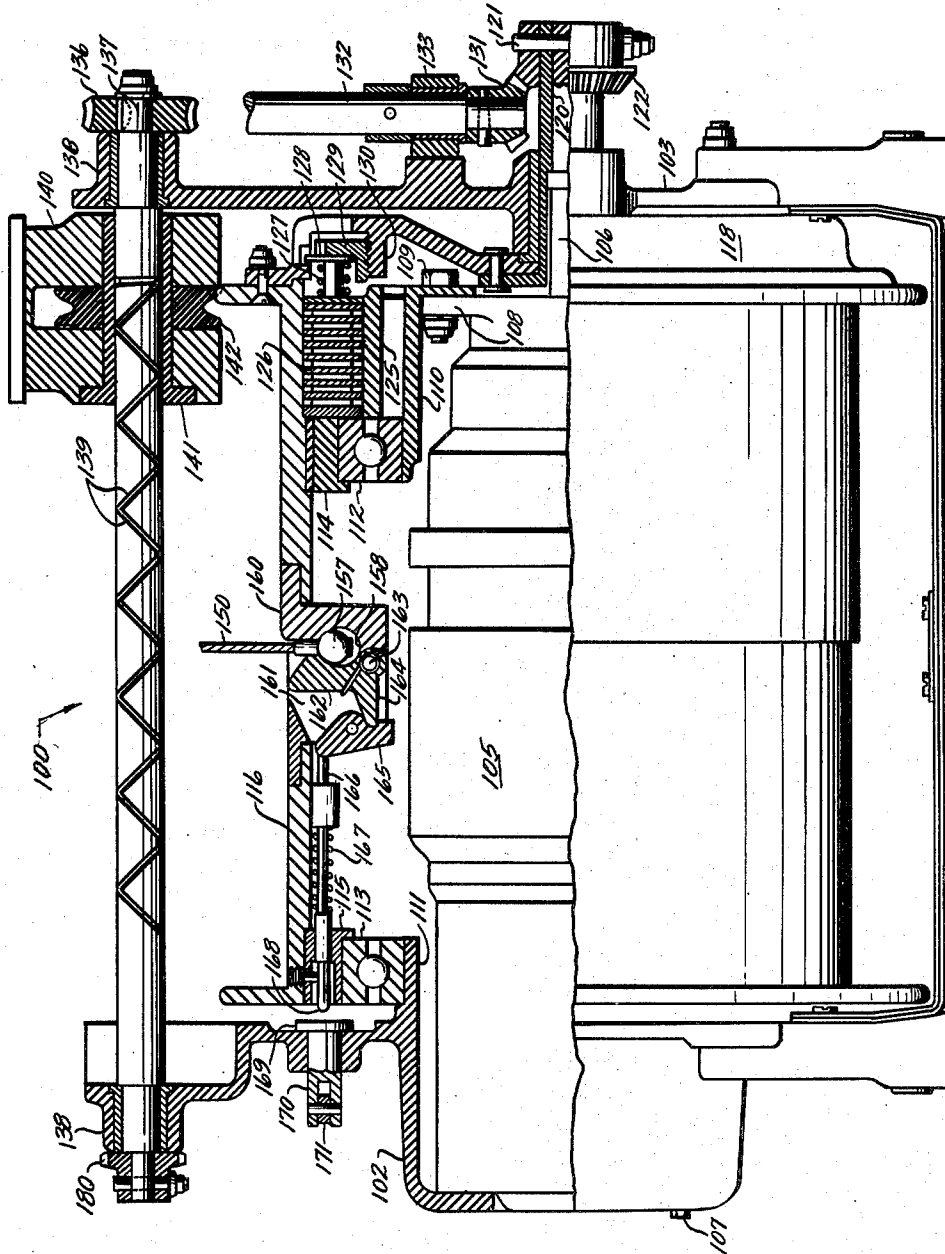
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9 Sheets-Sheet 6



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Fig 8

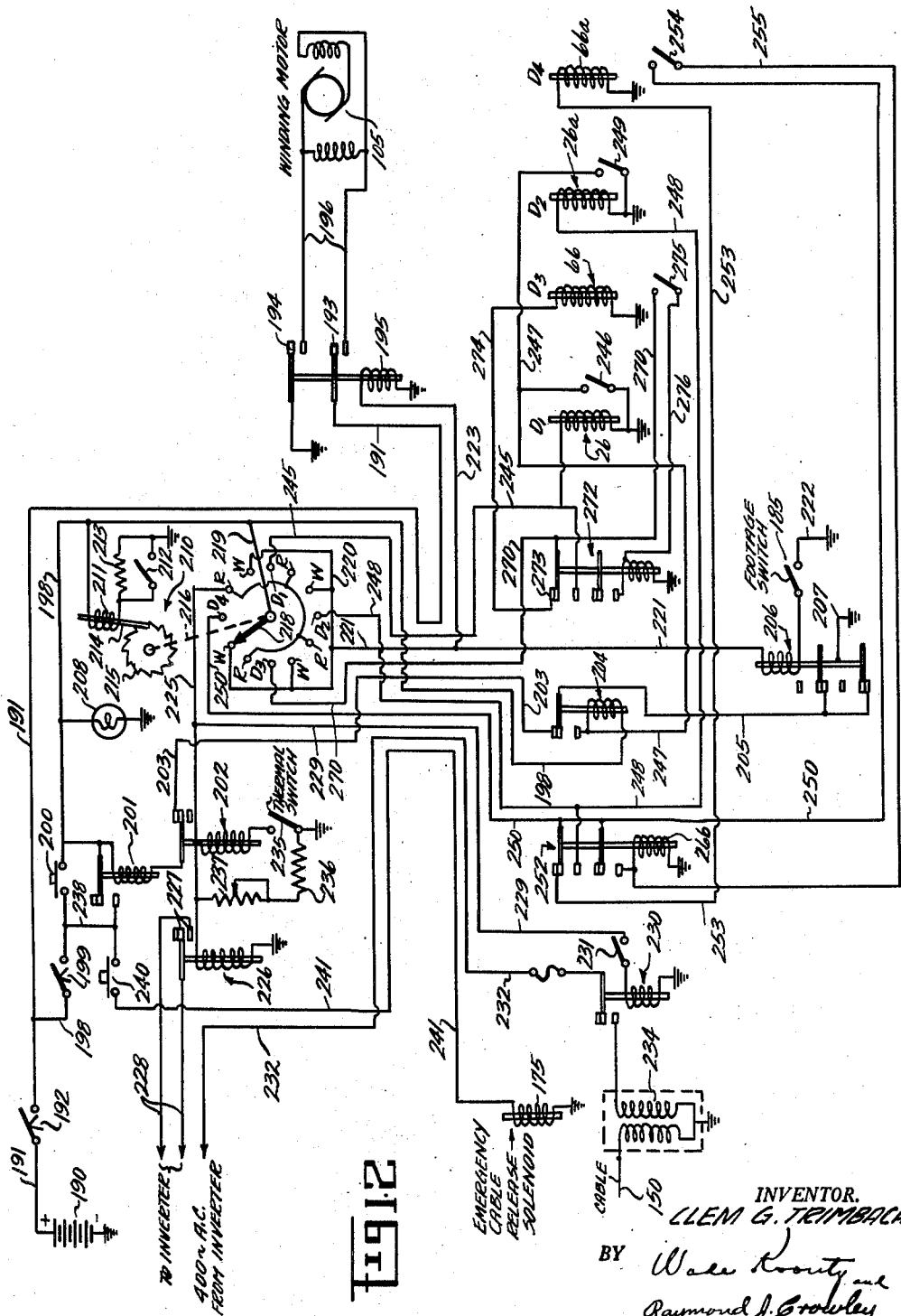
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Sept. 26, 1950

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TOW TARGET CARRIER

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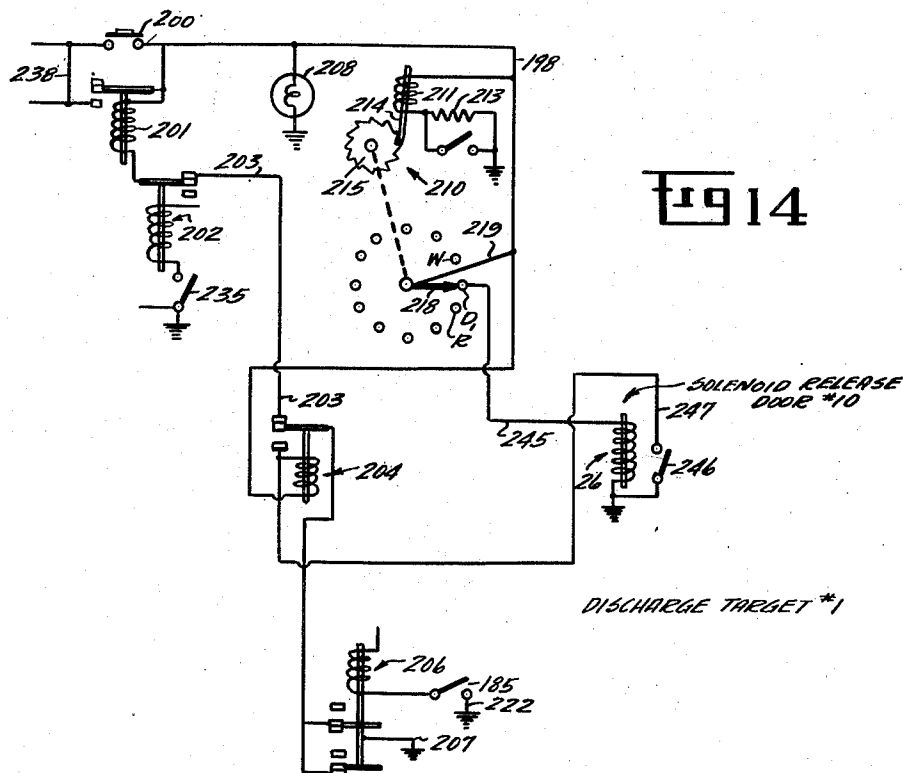


Fig 14

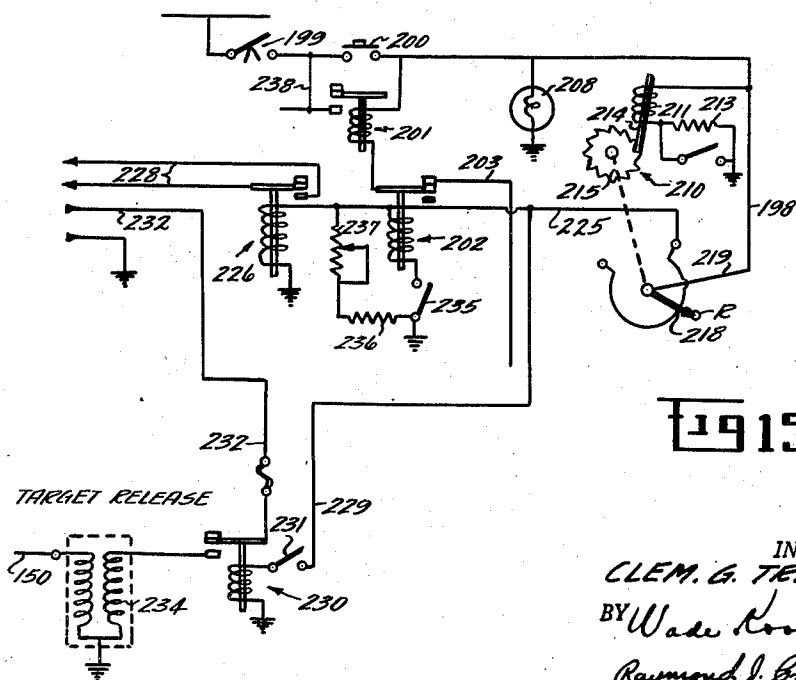


Fig 15

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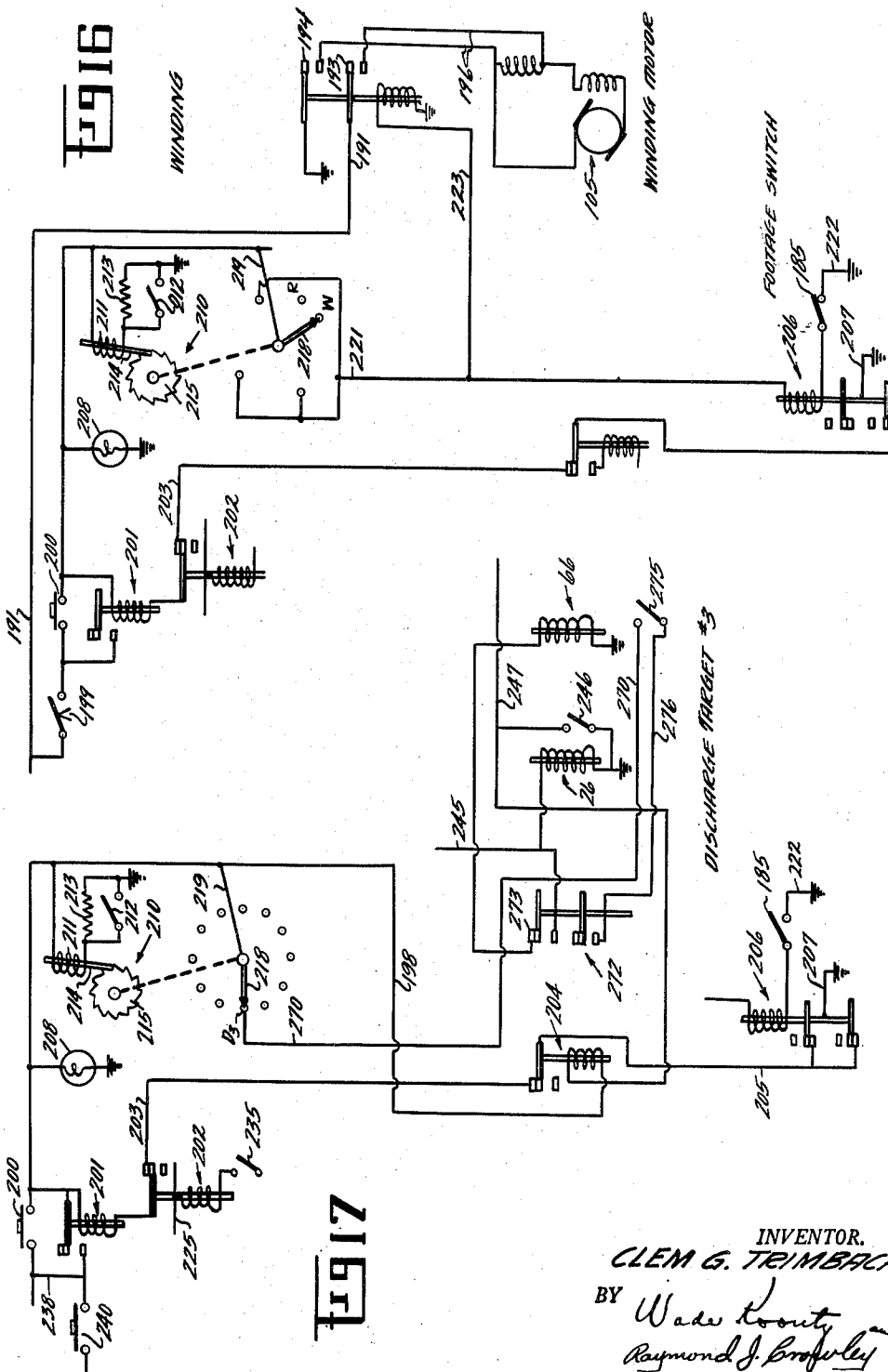
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9 Sheets-Sheet 9



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UNITED STATES PATENT OFFICE

2,523,738

TOW TARGET CARRIER

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Application March 21, 1949, Serial No. 82,696

10 Claims. (Cl. 273—105.3)

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The present invention relates to means for carrying, discharge and release of aerial tow targets from high speed aircraft and including means to permit actuation of the equipment by the pilot through remote control.

The towing of aerial targets at high speed by single seat fighter aircraft while very desirable raises many problems not present in releasing and towing targets from slow speed cargo aircraft where crew members other than the pilot are available to operate the release and towing equipment. Space in the fuselage is insufficient for storage of the targets and because of shock loads the targets cannot be released and exchanged by allowing the targets to slide along the cable to actuate automatic release and exchange mechanism at the end of the tow cable.

In one experimental system the targets were housed in containers mounted under the wing on opposite sides to the aircraft and discharged by gravity through the rear of the container. The targets were each provided with individual tow cables which were disconnected from the aircraft when individual targets were to be released and dropped to the ground. This system had the disadvantage of imposing high shock loads on the aircraft, excessive weight due to the individual tow cables required, liability of cable fouling during discharge and generally in loss of the cables due to tangling after the targets reached the ground.

In accordance with the present invention the tow targets are housed in a streamline container or carrier preferably mounted by struts below the fuselage of an aircraft such as a fighter plane. The carrier is provided with a bottom opening closed by doors which may be automatically released to allow a target to drop therethrough. A winding reel having a tow cable thereon is positioned in the after portion of the carrier, the reel being friction braked during unwinding of the cable and driven by an electric motor during the reeling operation. The respective targets are provided with explosive ruptured frangible connecting rings mounted on a guide and adapted upon discharge of a target to engage a hook on the tow cable. The aerodynamic drag of the target then causes the cable to be slowly payed out avoiding any heavy shock load. The targets are released from the end of the tow cable by electrically detonating the explosive in the connecting ring to thus drop the target. An automatic emergency release is also provided for disconnecting the cable from the winding drum so that the cable may be dropped if the necessity for such action arises.

All of the functions of automatically discharging the targets sequentially, releasing the same and winding in the cable after each release is controlled by a pilot actuated stepping switch having

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indicating means indicating which operation is being performed and provides for the operations being accomplished only in a predetermined sequence. By means of a separate switch the pilot may effect emergency release of the tow cable when necessary.

It is accordingly an object of this invention to provide a carrier for aerial tow targets comprising a housing adapted to be mounted on a high speed aircraft, the carrier having means for housing the targets and automatically sequentially discharging the same, the carrier having a power actuated reeling mechanism positioned therein such that the targets are coupled to a tow cable on the reeling device after discharge to cause paying out of the cable and the latter being reeled after release of a target being towed to effect a target exchange upon discharge of a succeeding target, the means for coupling the target to the tow cable being an explosive device electrically actuated by energizing the tow cable, there being a remote control system controlled by the pilot for automatically effecting target discharge, target release and reeling in a predetermined sequence.

It is a further object of the invention to provide in a tow target carrier and release system of the character described to provide indicating means to indicate the system operation last performed.

It is another object of the invention to provide, in a tow target system of the character described, a means controlled by the pilot for automatically disconnecting the tow cable from the reeling device to permit the cable to be dropped in case of an emergency.

Other objects and features of the invention will appear by reference to the detailed description hereinafter given taken in conjunction with the appended drawings in which:

Fig. 1 is a perspective view illustrating the mounting of the carrier on a fighter airplane and the manner in which a target is towed in flight;

Fig. 2 is an isometric view partly in section illustrating the general construction of the carrier;

Fig. 3 is a front view of the carrier or housing of Fig. 2 with the nose section and support removed;

Fig. 4 is a view, partly in section, illustrating a solenoid actuated mechanism for releasing the external doors on the carrier;

Fig. 5 is a view similar to Fig. 4 illustrating a similar mechanism employed in releasing internal partitions or tow target supports;

Fig. 6 is an isometric view illustrating the automatic tow line reeling mechanism mounted on the carrier structure;

Fig. 7 is a side elevation partly in section fur-

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ther illustrating the reeling device shown in Fig. 6;

Fig. 8 is a top plan view partly in section illustrating the reel driving and braking mechanism;

Fig. 9 is a fragmentary view illustrating a solenoid for actuating an automatic tow cable release shown in Fig. 8;

Fig. 10 is a top plan view partly in section of the solenoid actuator of Fig. 9;

Fig. 11 is a view illustrating details of the explosive release coupling between a tow target and the tow cable;

Fig. 12 is a general circuit diagram of the tow target control system;

Fig. 13 is a front elevation view of the control box and indicator of the control system of Fig. 12;

Fig. 14 is a fragmentary circuit diagram illustrating the portions of the circuit diagram, Fig. 12, operative in discharge of the first target;

Fig. 15 is a fragmentary circuit diagram illustrating the circuit components of Fig. 12 operative in explosively releasing a target;

Fig. 16 is a fragmentary circuit diagram illustrating the components of the control system of Fig. 12 employed in control of the reeling in of the cable after target release; and

Fig. 17 is a fragmentary circuit diagram illustrating components of the circuit of Fig. 12 employed in control of the discharge of targets housed in the upper part of the carrier.

Referring to the drawings, Fig. 1 illustrates a conventional fighter aircraft 1 capable of speeds in excess of three hundred miles per hour and having the tow target carrier or housing generally indicated by reference numeral 2 positioned below the airplane fuselage and suitably supported by struts 3. A flexible metal tow cable 150 extends from the carrier 2 and connects by means of an explosive rupturable coupling to the bridle B₁ of a conventional banner type aerial tow target T₁ preferably incorporating metallic fibers so as to serve as a reflector for a tracking radar.

As seen in Fig. 2 the tow target carrier, generally indicated by the reference numeral 2, comprises a generally cylindrical sheet metal container 4 made from light aluminum alloy sheet or the like. The container is provided with a rigid central vertical wall or partition 5 suitably stiffened by vertical stiffener members 6, the outer shell of the container being suitably supported from the central partition by means of circular stiffening rings 7. At its forward end the carrier 2 is provided with a circular ring 8, strengthened by tubular members 9, the ring 8 serving as an attachment point for hinges 11 of doors 10 and 10' which cover the open bottom of the carrier 2 and are movable outward similar to conventional bomb bay doors, note also Figs. 3 and 6 for discharge of targets from the interior of the container. Each of the doors 10 and 10' are provided with lever extensions 12 which are connected by means of cables 13 to springs 14, only one of which is shown in Fig. 2, for retracting the doors 10 and 10'. The weight of the tow targets resting on the doors is sufficient to open the same after release of suitable latching means and the springs 14 are of sufficient strength to close the doors against the effects of air resistance.

As seen in Fig. 2 internal transverse partitions 15 and 15' are hinged to the vertical wall or partition 5 by means of hinges such as indicated at 16 so that the internal partitions may be

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dropped, such as in the position shown for partition 15 in Fig. 3, permitting a target supported above the partition to drop into the lower portion of the carrier housing 4 and to be subsequently discharged therefrom by opening of door 10 or 10'. The hinged partitions 15 and 15' of Fig. 2, when latched in position, serve as a means for supporting targets thereabove and when the doors 10 and 10' are closed two additional targets may be housed within the carrier 2. The target positions are indicated in Fig. 3 by the target indicia T₂ to T₄, inclusive, the targets being of the banner type and wound in a roll and extending throughout a considerable portion of the length of the carrier.

As seen in Fig. 2 the carrier may be closed at its forward end by means of a dome shaped streamlined nosepiece 18 which is removably secured by means of a fastener stem 19 and fastener element 20 which is mounted at the intersection of the supporting tubular structure 9. (Note Fig. 3.) The carrier 2 is also inclosed at its rear end by a removable plastic housing 18' which must be made of an electrical insulating material to avoid accidental contact with high-voltage electricity, as will be subsequently explained. The rear portion of the carrier 2 also serves as the mounting or support for a reeling structure 100 to be later described.

As seen in Figs. 2 and 3 the latching mechanism for the doors 10 and 10' is generally indicated by the reference numeral 25 and comprises two identical, but separately actuated, latching mechanisms only one of which is shown in Fig. 4 and will now be described.

Referring to Fig. 4, the door latching mechanism generally indicated as 25 has one of the two door latching mechanisms illustrated as including an electrical spring biased solenoid 26 of conventional construction supported from a vertical mounting wall 27 and having a plunger element 28 which is normally extended by the spring within the solenoid 26 and retracted to the left by electrically energizing the solenoid. The plunger 28 is pivoted at 29 to a link 30 which in turn is pivoted at 31 to a lever 32 which in turn is rockable about a pivot 33 provided in a bracket 34 rigidly mounted on a front supporting bracket 35. The lever 32 is provided at its upper end with an arcuate shaped cam 36 which normally is in engagement with a projection 37' on one arm of a bell crank 37 which is pivotally supported at 38 from the bracket 34. The lever arm 37 has an arcuate recess therein as shown at 39 such that when cam 36 is rotated in a clockwise direction until a lower edge of the cam is in register with the recess 39, lever 37 can then rock about its pivot 38.

The bell crank 37 has a horizontally extending arm 40 which terminates in a toe portion 41 which is urged by means of a rat trap spring 42 into camming engagement with an inclined surface 43 of a lever 44 pivotally supported at 45 from bracket 34. The lever 44 has a laterally and downwardly extending fork 46 in which an arcuate latch member 47 is pivoted at 48. The latch 47 is slotted at 49 to receive a guide pin 50 and is urged by a biasing spring 51 to extend in the latching position as illustrated, the latch entering an aperture 52 in the end of a tubular member 53 secured along the outer edge of door 10.

By energizing solenoid 26 plunger 28 will be retracted to the left from the position as seen in Fig. 4 and through link 30 and lever 32 will

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rotate cam 36 until the lower edge thereof clears the projection 37' and enters the recess 39. The weight of the door 10 acting on latch 47 can then rotate lever 44 and by camming action on toe 41 rotate bell crank arm 40 until the latch 47 clears the tube 53 unlatching the door 10 and permitting the same to drop due to the weight of a target resting thereon. Retraction of door 10 by means of the action of retraction spring 14 (Fig. 2) causes the latch member 47 to be cammed inward against the resistance of spring 51 until the latch is registered with the aperture 52 and the door is again locked. The structure so far described is effective to latch and support only one end of the target release doors and supplemental latching mechanism for the rear end of the doors will now be described.

The lever 37 is pivotally connected as at 54 to an extension rod 55 and which extends within the carrier casing 4 the length of door 10 and the far end of the rod 55 is pivotally connected as at 56 to a latching lever 57 pivotally supported at 58 by a bracket 59 from the rear end wall 60 of the target carrier 2, the end wall construction being clearly shown in Fig. 6. The force transmission rod 55 serves to actuate the lever 57 simultaneously with movement of lever 44 and lever 57 is provided with a forked extension 61, arcuate latch 62, spring 63 and other parts corresponding to elements 46 through 51, inclusive, associated with lever 44. The latch 62 is adapted to enter an aperture 64 in tube 53 and cooperates in latching door 10 in the same manner as latch 47. It will be noted that the contacting cam surfaces 41 and 43 never become disengaged so that upon deenergization of solenoid 26 the door 10 can be retracted by spring 14, Fig. 2, and moved into latched position by camming the latches 47 and 62 against the resistance of biasing springs 51 and 63, respectively. The door latching mechanism employed with the other lower door 10', Figs. 3 and 6, is identical to that shown in Fig. 4, and hence need not be further described except that in the circuit diagrams the door solenoid actuator for the door 10' will be indicated by reference character 26'.

The latching mechanism for the interior hinged partitions 15 and 15', Fig. 2, as indicated in general in Fig. 3 by the respective reference numerals 65 and 65'. Each of these latching mechanisms is identical in construction and only one such mechanism is illustrated and described in conjunction with Fig. 5. Referring to Fig. 5, the interior door or hinged partition latching mechanism, as generally indicated by reference character 65, is seen as including a conventional spring biased electrical solenoid 66 mounted on a suitable vertical bracket 67 and having a plunger 68 which is drawn inward from the position shown in Fig. 5 upon electrically energizing the solenoid 66. The solenoid plunger 68 is pivotally connected at 69 to a link 70 which in turn is pivotally connected as at 71 to the lower end of the lever 72 pivoted at 73 to a bracket 74 mounted on a suitable vertical mounting plate 75 secured to the carrier structure. Lever 72 is provided at its upper end with an arcuate cam 76 which is normally in engagement with the inner side of lever arm 77 of a bell crank pivotally supported at 78 on the bracket 74. The bell crank arm 77 is provided with an arcuate recess 79 which permits rotation of the bell crank lever whenever the cam surface 76 is rotated in a clockwise direction until it is in register with the recess 79. The bell crank arm 80 is provided with a toe

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portion 81 which is in camming engagement with an inclined surface 82 on a lever 83 pivotally mounted at 84. The lever 83 is provided with a latching detent 85 which is adapted to enter the open end of a tubular member 86 secured along the outer edge of droppable partition 15.

Supplemental latching means are provided in which an elongated force transmission rod 89 is pivotally connected at 88 to the bell crank arm 77 with a biasing spring 90 which urges the lever 77 in a direction to cause the bell crank arm 80 to cam the latching lever 83 in the latching direction and also tensions rod 89. The rod 89 is pivotally connected at its other end as at 91 with a latching lever 92 having a latching projection 93 which is adapted to enter the rear open end of tube 86 to additionally support and latch the interior door or partition 15.

The operation of the latching mechanism of Fig. 5 is similar to that of Fig. 4 such that with the parts in the position shown, energizing solenoid 66 causes plunger 68 to retract and through link 70 and lever 72 rotates cam 76 until the same registers with recess 79. The weight of a target resting on partition 15 is then sufficient to cause rotation of latching levers 83 and 92 in opposite directions against the resistance offered by biasing spring 90 to direct tension force in rod 89 and to force produced by cam action at surfaces 82 and 81 transmitted through bell crank arms 80 and 77 to the spring 90 so that the latching elements emerge from latching engagement with the tube 86 and allow the partition to drop.

When the partition or door 15 is dropped after it moves approximately fifteen degrees a switch (shown in the wiring diagram) is actuated to deenergize the solenoid 66 and spring 90 returns the parts to the latched position and the partition 15 can be relatched by manually raising the same on the ground and manually retracting the solenoid plunger so that the tube 86 may cam the latching detents apart and permit the same to enter the tube ends.

Since the latching device generally indicated as 65' Fig. 2 is identical to that of the device of Fig. 5 both as to structure and operation, further description of the same is unnecessary except that the solenoid actuator thereof will be subsequently identified in the general wiring diagram, Fig. 12, by the reference character 66'.

Reeling mechanism

As previously described with reference to Fig. 2, the reeling mechanism generally indicated by reference numeral 100, is employed for the purpose of target exchange, the reeling mechanism being best understood from the disclosures of Figs. 6, 7 and 8. As seen in Fig. 6, the reeling mechanism comprises insulating mounting brackets 101 suitably supported from the rear end wall 60 of the target carrier, the insulation serving to electrically isolate the reeling structure from the carrier body and airplane, since during target release the reel is subjected to an electrical potential of thirty thousand volts with respect to ground. The reeling structure proper comprises a pair of side plates 102 and 103, respectively, secured by bolts or the like to insulated mounting brackets 101. An electric driving motor 105 having a built-in gear reduction is secured by means of bolts 107 to the end wall 102, and as seen in Fig. 8 includes a driving shaft 106 suitably journaled in the end wall 103 in a manner hereafter described for driving the reeling drum. The

motor housing is provided with lugs 108 which by means of bolts 109 support an inwardly directed flange member 110 which serves as a seat for a ball bearing 112. A similar inward turned flange 111 of end wall 102 serves as a seat for the similar bearing 113. The outer races of the bearings 112 and 113 have bearing rings 114 and 115, respectively, pressed thereon which in turn are secured to the cylindrical winding drum or reel 116. The cable receiving winding drum 116 has a flanged drum 118 secured at one end thereto, which drum is secured to a flange sleeve 120 arranged concentric with shaft 106 and pinned to the shaft by means of a taper pin 121 which also serves to mount a bevel gear 122 on the outer end of the sleeve 120. Rotation of motor shaft 106 through sleeve 120 is thus enabled to drive the drum 116 to wind in cable.

The in-turned flange member 110, which serves as a bearing support for the drum bearing 112, is pierced by longitudinally extending cooling apertures, and its periphery 125 is splined to secure alternate plates of a friction brake generally indicated at 126, the other pairs of plates being suitably splined to the drum 116. Suitable friction facing is applied to alternate plates of the friction brake which is maintained under compression by means of a loading spring 127 suitably supported by projections on an abutment plate 128 which abuts an internally threaded ring 129 and which is adjustable upon an externally threaded inwardly directed flange 130 integral with drum member 118 so that the spring loading on the brake may be adjusted through a suitable aperture in the drum 118 to apply a constant braking force on the winding drum. The braking force applied by brake 126 is just sufficient to enable the tow cable to be payed out with a target attached at a safe speed but not unduly overload motor 105 during the reeling operation.

As seen in Fig. 8 the pinion gear 122 meshes with a smaller pinion 131 secured to one end of the shaft 132 which is rotatably supported in a bearing journal 133 secured to the end frame member 103. The shaft 132 at its outer end is journaled in a suitable bracket 134 and has a worm 135 thereon which meshes with a worm wheel 136 and is adapted to drive a shaft 137 journaled at each end by means of bearings 138 formed in the end frame members 102 and 103. The shaft 139 is provided with right and left hand intersecting threads 139 thereon to form a conventional level wind for a cable guide head 140, which is provided with a pin, not shown, which engages an alternate one of the threads 139 in each direction of traverse relative to the shaft 137. The guide head 140 is provided with a guide pulley 142 over which the tow cable passes.

As seen in Fig. 6 the cable guide head 140 is provided with bearing guides 143 and 144 which are slidable upon parallel tubular guide members 145 and 146 respectively which are secured transversely of the cable drum 116 to the end frame members 102 and 103. It will be seen that during winding and unwinding operations of the drum 116 the shaft 132 will drive shaft 137 to cause the winding guide 140 to reciprocate back and forth on the guides 145 and 146 so that the cable lays are wound, one adjacent the other in uniform layers. This level winding mechanism is of the type well known in the art whose operation is believed to require no further explanation.

As seen in Figs. 6 and 7 the cable guide 140 is provided with an outwardly projecting hollow stem 149 which is made of insulating material

having a suitable rectangular base for attachment to the body of the guide member 140. The stem portion 149 is hollow and serves as a guide for the tow cable 150 which passes therethrough and which is provided at its outer ends, as shown in Fig. 6, with a stop member 151 upon which is secured a conventional snap hook 152 to which the target bridles are secured. A spring 154 mounted concentric on the guide stem 149 engages a collar 155 which is actually slidable on the guide stem and is retained by means of stops 156 from slipping off the end of the guide stem 149. The spring 154 and collar 155 serve as a means to push explosive coupling members C₁ to C₄, inclusive, up against the stops 156 so that the coupling members may be respectively pulled over the stops off the guide member 149 and onto the cable 150 whenever a respective target, connected to the coupling member by a respective bridle, B₁ to B₄, inclusive, exerts a sufficient pull thereon after the target is released from the carrier. By this means successive targets may slide by means of their coupling members down the tow cable to ultimately engage the snap hook 152 to couple the target in towing relation to the cable. The means for explosively releasing the target will be subsequently described.

Emergency cable release

By reference to Fig. 8 it is seen that the inner end of the tow cable 150 is provided with a ball terminal 157 which is releasably seated in an aperture 158 formed in a member 160 secured to and inwardly projecting from the winding drum 116. Member 160 is provided with a further aperture 161 in which is mounted a spring pressed latching lever 162 pivotally supported at 163 and having a latching detent 164 adapted to engage a pivotally mounted catch 165, which upon release will allow a latching member 162 to rotate about its pivot 163 releasing the ball terminal 157 to allow the same to emerge from member 160 and thus release the cable from connection to the winding drum. The catch 165 is adapted to be actuated by means of a plunger 166 which is urged by a spring 167 from engagement with the catch member 165. Plunger 166 slidably mounted in the ring member 115 has its outer end 168 rounded off and normally projecting from the side of the winding drum but out of engagement from a tripping member 169 formed as a cam on the end of a rod 170 slidably mounted in a suitable bearing in the end frame member 102. The rod or plunger 170 is pivotally connected to a bell crank 171 which, as seen in Figs. 9 and 10, is connected to the plunger 172 of an actuating solenoid 175 which is secured by means of a removable bracket 176 to the end frame 102. It will be clear from Figure 10 that when the solenoid 175 is energized the plunger 172 will rotate the bell crank 171 and plunger 170 to move the cam actuator 169 outward so that the same will be engaged by the rounded tip 168 of plunger 166 pushing the same inward to actuate catch member 165 and thus release the ball 157 from its retaining socket 58 and free the tow cable 150 from connection with the winding drum. The solenoid 175 is adapted to be energized by means of an emergency control which will be described in connection with description of the wiring diagram.

By again referring to Fig. 6 it will be seen that the shaft 137 has mounted on its free end a sprocket 180 which is adapted to drive chain 181 to in turn drive a sprocket 182 and shaft 183 which is externally threaded and adapted by

means of a feed nut mounted thereon to actuate a switch mechanism 185. The switch 185 is effective to deenergize the reel driving motor 105 when the tow cable is wound up on the reel it thus serves as a limit switch for the winding motor to prevent the motor being burnt out due to excessive current. After the cable is reeled in the stop 151, Fig. 6, engages the stem 149. The switch 185 actually is operated slightly before the cable is completely wound in. Motor overrun takes care of the remainder of the winding operation.

Fig. 11 illustrates the construction of one of the explosive connecting rings C₁, etc. employed to connect a tow target to the tow cable. The body C₁ of the connector is made of a molded plastic insulating material such as nylon in the form of a ring with a pair of metallic conductor segments 186 and 186' secured to the inner periphery of the ring. A pair of electrically ignited explosive cartridges 187 are imbedded in the ring C. The cartridges 187 are provided with internal spark gaps not shown and each is electrically connected to one of the segments 186 and 186' and further connected in series by means of a conductor 188. The conductor segments 186 and 186' are shunted by means of a leakage resistor 189 which prevents the collection of static on the tow cable from exploding the cartridges. In use the tow target bridle such as B₁ (Fig. 7) engages one of the conductor segments such as 186 while segment 186' will be engaged by the hook 152 on the tow cable. When the tow cable is energized by a potential of from fourteen to thirty thousand volts, the distributed capacity between the tow cable and the target is sufficient to permit sparks to jump the gaps in the cartridges 187 exploding the same.

The explosion of the charges in cartridges 187 bursts the connector ring which permits the target and bridle to become disconnected from the tow cable and the weight of the tow hook 152 is sufficient to maintain the cable 150 sufficiently loaded to enable it to be reeled in.

It is noted that the foregoing description of the construction of the explosive connecting rings adapted to release tow targets does not per se form any part of the present invention and is disclosed and claimed in the copending application of James P. Welsh and John L. Jewett, Ser. No. 20,634, now Patent Number 2,499,012, which is assigned to the Government of the United States.

General wiring diagram

Referring to Fig. 12 which illustrates the general wiring diagram it is seen that reference numeral 190 indicates a conventional direct current source, such as an airplane battery, for energizing the system. The negative side of the battery is grounded and all return circuits in the system are grounded in common with the battery to form a conventional grounded return system. The battery 190 has its positive terminal connected to a conductor 191 which has a conventional overload current release 192 connected in series therein. The conductor 191 terminates in the lower contact 193 of a power relay generally indicated at 195, the contact 193 and a similar upper contact 194 being adapted to engage contacts connected to conductors 196 which supply current to the winding motor 105, previously described. Contact 194 is connected to ground to form the return side of the system, and upon actuation of relay 195 motor 105 will be energized to reel in the tow cable.

Conductor 191 has a branch conductor 198 connected thereto and also is provided with an overload release 199 and a push-button switch 200 connected in a series therewith. A holding relay, generally indicated by reference numeral 201, has its coil connected to conductor 198 beyond the push button 200 and is operative such that when the coil is energized the normally open contacts of the holding relay shunts the switch 200 to complete a circuit irrespective of whether the switch 200 is thereafter released. The coil of relay 201 is connected to the normally closed contacts of a normally inactive relay 202, the contacts of which are connected to a conductor 203 which is connected to the normally closed contacts of a normally inactive relay 204 and from thence by means of conductor 205 to the contacts of a normally inactive relay 206 and from thence to ground by means of a conductor 207. It will be understood that, upon operation of push button 200 a circuit will be formed through holding relay 201, the contacts of relay 202, conductor 203, contacts of relays 204 and 206 to ground so that current may continue to flow through the shunt around push button 200 into conductor 198. After push-button 200 is released conductor 198 is connected to the coil of relay 204 which in turn is connected to the conductor 247 which may be connected to ground through a number of separately actuated switches later to be described for the purpose of breaking contact between the normally closed upper contacts from relay 204 to release the holding relay 201. Conductor 198 has a signal lamp 208 connected thereto and to ground such that whenever the push-button 200 is actuated and holding relay 201 completes a circuit signal lamp 208 will be energized. The conventional step-by-step relay, generally indicated at 210, is connected in parallel to the conductor 198 and has its actuating coil 211 connected through a normally closed switch 212 to ground so that each time the push-button 200 completes a circuit through conductor 198 coil 211 will be energized. The switch 212 is shunted by means of a resistor 213 so that when the solenoid plunger member 214 is actuated by energizing coil 211, switch 212 is opened and current flow through the relay coil 211 is reduced to minimum value by means of the resistance 213 being directly in series therewith, thus preventing the step-by-step relay from overheating. The relay solenoid plunger 214 actuates a star wheel 215 through the arcuate distance of the space of one tooth each time the plunger 214 is moved to cause a corresponding step-by-step rotation of the shaft 216 which is connected to a switch arm 218. The switch arm 218 is adapted to engage a respective one of a plurality of radially arranged contacts seriatim each time the star wheel 215 is rotated. Switch arm 218 is directly connected by means of conductor 219 to the conductor 198 to receive current therefrom and to deliver current to the respective step-by-step relay contacts which are arranged in parallel connected groups. All of the switch contacts indicated by reference character R are connected in parallel and operative to initiate the target release operation and similar spaced parallel connected contacts indicated by reference character W controlling the winding operation and other spaced contacts indicated by the reference characters D₁ to D₄, respectively, controlling discharge of respective targets. The relay contacts are so arranged that they fall in the sequence D₁-R-W, D₂-R-W etc. Each time the step-by-step relay 210 is actuated switch

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contact 218 is moved in a clockwise direction from one contact to the next and the relay operating time of all of the relays employed in the system are so arranged with respect to the operating time of the relay 210 that the switch arm 218 can move from its last engaged contact to the succeeding contact without causing operating of the components of the system.

All of the contacts indicated by reference character W, there being four in number, are connected in parallel by means of a conductor 220 which in turn is connected by means of a conductor 221 to the coil of relay 206 which in turn is connected to ground by means of conductor 222, the latter conductor having a normally open footage switch 185 and closure of this switch upon reeling in of predetermined amount of cable energizes relay 206 to break the path to ground from holding relay 201 to conductor 207, previously described, to deenergize the system at the completion of a winding cycle.

The step-by-step relay contacts indicated by reference character R are all connected in parallel to a conductor 225 such that when the switch arm 218 engages any of the R, or release contacts, current from conductor 198 through conductor 210 and the switch arm 218 will energize the conductor 225 which in turn will energize the coil of a relay generally indicated at 226 to cause the relay to close normally open contacts 227 and to complete a circuit through conductors 228 to start up the motor unit of a conventional motor generator set or inverter, not shown, the generator of which delivers four hundred cycle alternating current through conductor 232. A conductor 229 connected in parallel to conductor 225 is energized concurrently therewith and delivers current through a normally closed switch 231 to the coil of a relay 230 and thence to ground to thereby actuate the relay so that the contacts thereof complete a circuit from conductor 232 to the primary of a high-voltage autotransformer generally indicated by reference numeral 234. Switch 231 is a protective switch which is opened whenever the insulating cover 18' (Fig. 7) is removed. The high-voltage secondary of the transformer 234 is connected through the cable drum and contacting parts directly with the tow cable 150 such that when the transformer primary is receiving four-hundred cycle alternating current from conductor 232, the secondary delivers a potential of from fourteen to thirty thousand volts, with respect to ground to tow cable 150 for the purpose of explosively releasing a connected target as will be subsequently described. Conductor 225 is connected directly to the upper terminal of the coil of relay 202 which is normally inactive through a normally open thermal switch 235 to ground and the coil of relay 202 is shunted by means of a control potentiometer 237 and heater resistance 236 for the switch 235 such that while conductor 225 is conducting current, heater 236 heats the thermal switch 235 such that the same closes after a predetermined time such as five seconds. When thermal switch 235 is closed the coil of relay 202 is energized to break the circuit through its normally closed contacts from holding relay 201 to conductor 203 and thus opens the circuit through conductor 198 to thereby deenergize conductor 225 and relay 226 to shut down the inverter connected to conductors 228 and 232 and causing the tow cable 150 to be electrically deenergized.

When the step-by-step relay switch arm

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218 contacts the switch contact D₁ a circuit is completed from bus conductor 198 to conductor 245 and the coil of door release solenoid 26, Fig. 4, to release the door 10, Fig. 2, and allow the target housed in the lower right-hand compartment of Fig. 3 to be discharged by gravity. As soon as the door 10 (Fig. 2) is opened through an angle of fifteen degrees a switch 246 is actuated by the door closing a circuit from conductor 247 to ground. Current then flows from conductor 198 through the coil of relay 204 and conductor 247 energizing the relay and breaking the circuit through its contacts and conductors 203 and 205 and thus deenergizing the holding relay 201 which deenergizes the system including door release solenoid 26.

When relay switch arm 218 engages the contact D₂ current is conducted from the switch arm and contact through a conductor 248 to the coil of door release solenoid 26a which forms a part of the release assembly 25, Fig. 3, and causes the release of door 10' to effect discharge of the target T₄. Movement of door 10', Fig. 3, through an angle of fifteen degrees effects actuation of a switch 249 to connect conductor 247 to ground and by energizing relay 204 effects deenergizing a holding relay 201 opening the circuit to the coil of release solenoid 26a and renders the system electrically dead.

When the switch arm 218 engages contact D₃ the conductor 270 is energized to complete a circuit through relay armature contact 273 of a relay, generally indicated at 272, to complete a circuit through conductor 274 to energize the coil of the inner door release solenoid 66 of the release solenoid assembly 65, shown in Fig. 5, thus allowing the inner partition door 15 to drop permitting target T₂ to fall from the upper compartment of container 4 into engagement with outer release door 10. Movement of the inner partition door 15 in Fig. 2 through an angle such as thirty degrees causes a switch 275 to be closed completing a further circuit from conductor 270 to a conductor 276 and the coil of relay 272 to ground. Relay 272, upon being energized, opens the contacts at 273 and breaks the circuit through conductor 274 deenergizing door release solenoid 66, but in so doing engages further contacts to complete a circuit from conductor 270 to conductor 245, thus energizing the coil of release solenoid 26 causing door 10, Fig. 3, to be released and to open due to the weight of target T₂ resting thereon, and permitting the gravity discharge of the target in the same manner as previously described. Opening movement of door 10, Fig. 2, again actuates switch 246 to energize relay 204 and to open the circuit through holding relay 201 to deenergize the system in the manner previously described.

When relay 272 is energized lower contacts thereof complete a holding circuit through its coil to maintain the relay energized until the holding relay 201 is deenergized by actuation of switch 246 in the manner above described.

Engagement of step-by-step relay switch arm 218 with contact D₄ energizes a conductor 250 which through the upper parallel connected contacts of a relay 252 energizes a conductor 253 to actuate the release solenoid 66a to release the inner partition door 15' of Fig. 2, allowing an inner target T₃, Fig. 3, to be dropped into engagement with lower door 10'. Movement of the partition door 15' actuates a switch 254 to complete a further circuit from conductor 250 to a conductor 255 to energize the coil 266 of relay 252

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which pulls the relay armature downward to complete a holding circuit through the relay 266 and also completes a circuit from conductor 250 to conductor 248 to actuate door release solenoid 26a to release the door 10' and permit the gravity discharge of the target T₃ from the container 4, Fig. 3. Release of door 10' actuates switch 249 which through conductor 247 actuates relay 204 to open the circuit through holding relay 201 and deenergizes the system in the same manner as previously described.

In order that the pilot may be at all times aware of the operating condition of the system there is provided as seen in Fig. 13 a panel 280 on which is mounted a dial 282 having indicia angularly spaced thereon indicative of the last operation performed and a pointer 283 adapted to cooperate with the indicia and actuated by an extension of the shaft 216 of the stepping relay 211 which is mounted on the back of the panel. The main control push button 200, the emergency push button 240 and the signal lamp 208 are also mounted on the panel as well as the master switch and circuit breaker 192 and the auxiliary switch and circuit breaker 193. Each time push button 200 is actuated signal lamp 208 will be illuminated and as the stepping relay 211 (Fig. 12) indexes the switch arm 218 the shaft 216 will also position the pointer 283 relative the indicia on dial 282 to indicate the operation being performed.

Although the operation of the system has been described with respect to the general wiring diagram a further detailed description of the sequence of operation will now be described. With reference to Fig. 14 it will be assumed that the step-by-step relay switch arm 218 was last at rest on the contact W immediately above contact D₁ as seen in this figure. In order to effect discharge of the first target the pilot then closes push-button switch 200 which energizes conductor 198 and illuminates signal lamp 208 and energizes the armature winding 211 of the step-by-step relay 210, causing the armature 214 to move downward and rotate the star wheel 215 through the space of one ratchet tooth moving switch arm 218 onto contact D₁. In the meantime closure of push-button switch 200 completes a circuit through relay 201, the upper contacts of relay 202, conductor 203, upper contacts of relay 204 and conductor 205, contacts of relay 206 and conductor 207 to ground as previously described. The relay 201 will thus be energized to complete a shunt holding circuit around push-button 200 so that release of the same will not interrupt the circuit through conductor 198.

Rotation of switch arm 218 onto contact D₁ completes a circuit from conductor 198 to conductor 219 through the switch arm 218, contact D₁ to conductor 245 to the coil of door release solenoid 26 to release the lower door 10, Figs. 2 and 3, as previously described. Release of the lower door 10 permits gravity discharge of the first target from the target carrier 2. Release of the target by gravity allows the same to be blown rearward by the air stream causing the bridle B' to slide the connector C' off the guide 149 (Fig. 7) to engage the tow hook 152 and pull out the tow cable until the same is all unreeled.

Release of the door 10 causes actuation of switch 246 after the door has moved through an angle of fifteen degrees which completes a circuit from conductor 198 through the coil of relay 204 and conductor 247 to ground. Relay 204 upon being energized breaks the circuit through its normally closed upper contacts from conductor

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203 to conductor 205 causing holding relay 201 to become deenergized and thus deenergizing the system.

After the first target is in tow and it is desired to release the same to provide for target exchange the operation of target release is next in order and the circuit components of Fig. 12 effective therein are shown in Fig. 15. Referring to this figure the pilot again operates push button 200 which again illuminates signal lamp 208, energizes stepping relay 211 and holding relay 201. Stepping relay switch arm is moved onto an "R" switch contact causing current to flow from conductors 198 and 219 to conductor 225 which energizes relay 226 to close the normally open contacts 227 completing a power circuit through conductors 228 to energize the inverter (not shown) causing the same to deliver four-hundred-cycle alternating current to conductor 232.

When conductor 225 is energized current flows through the parallel connected conductor 229 and through the normally closed protective switch 231 through the coil of relay 230 causing the contacts of the same to complete the circuit from conductor 232 to the primary of high voltage transformer 234. High voltage output from the secondary of transformer 234 energizes the tow cable 150 to explosively rupture the frangible coupling C' as described with reference to Fig. 11 and causes the first tow target to be disconnected from the tow cable and dropped to the ground to be subsequently retrieved. After the inverter has built up full voltage supply to the primary of transformer 234 heater coil 236 heats the thermal switch 235 causing the same to close after a predetermined time interval of say five seconds as determined by the setting of the potentiometer 237 which causes the coil of relay 202 to become energized and breaking the holding circuit through the contacts thereof from holding relay 201 thus deenergizing the system as previously explained.

After release of the first target the pilot causes the cable to be reeled in which operation the circuit components of the wiring diagram, Fig. 12, such as illustrated in Fig. 16 become effective. After the release operation the next actuation of push button 200 causes the stepping relay 211 to move the switch arm 218 from the release or "R" contact to the succeeding "W" contact and at the same time establishes a holding circuit through holding relay 201 in the manner as previously described.

Current from conductor 198 flows through conductor 220 connected in parallel with the contacts "W" and by means of conductors 221 and 223 energizes relay to complete a circuit from bus bar 191 through winding motor 105 to ground. The motor 105 then actuates the reel 116 to wind in the tow cable 150 (Fig. 8).

When a predetermined amount of tow cable has been reeled the normally open footage switch 185 closes completing a circuit from conductor 221 through relay 206 to ground and causing the circuit to ground from holding relay 201 to be broken and thus deenergizing the system including relay 195 which when its contacts 193 and 194 open deenergizes motor 105.

The next actuation of push button 200 by the pilot energizes stepping relay 211 to move the switch arm 218 to the contact D₂ which energizes the door release solenoid 26a to permit opening of the lower door 10', Fig. 3, in exactly the same manner as in the discharge of the first target described above.

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The operations of target release and cable rewind next precede the release of the third target, Fig. 17, which is effected when the stepping relay moves the switch arm onto the contact D₃ which energizes conductor 270, upper contacts 273 of relay 272 and conductor 274 which energizes the door release solenoid 66 which drops the inner partition door 15, Fig. 2, and permits the target supported thereby to drop into contact with the outer door 10, Figs. 2 and 3. Movement of the partition 15 through an angle of fifteen degrees closes a switch 275 which connects conductor 270 to conductor 276 and energizes the coil of relay 272 causing the contact at 273 to be broken and conductor 270 connected to conductor 245 through the relay contacts. The door release solenoid 26 then is energized to release the outer door 10, Fig. 2, permitting the third target resting thereon to be discharged. Movement of the door 10 actuates the switch 246 which completes a circuit from conductor 198 through relay 204 causing the same to break the holding circuit from relay 201 contacts of relay 202 and conductors 203 and 205 to ground thus deenergizing the system.

After discharge of the third target and the subsequent operations of target release the fourth target is discharged in which door release solenoids 66a and 26a are sequentially operated in the same manner as above described with reference to discharge of the third target.

At any time when the tow cable is extended the same may be released by pressing the emergency push-button switch 240 which energizes the emergency cable release solenoid 175 to release the cable in the manner described above with respect to the wiring diagram, Fig. 12.

Although one embodiment of the invention has been illustrated and described variations thereof will be apparent to those skilled in the art as coming within the scope of the invention as defined in the appended claims.

I claim:

1. Apparatus for towing aerial targets from high speed aircraft comprising a streamlined container adapted to be suspended from the towing aircraft and having means for housing a plurality of aerial tow targets therein, releasable discharge doors on said container, a braked power driven reel positioned in the rear portion of said container and having a tow cable positioned thereon, a towing hook on said cable, a cable guide associated with said reel and having the tow cable passing therethrough, said guide having means for supporting a plurality of electrically releasable target coupling devices thereon each connected to the towing bridle of a respective tow target, and an electrical remote control system adapted for sequential actuation by the aircraft pilot to operate the discharge doors to discharge a target from said container into the air stream to thereby cause the associated coupling device to engage the tow hook and withdraw the towing cable against the braking resistance of the reel, to electrically actuate the coupling device to release the coupled tow target and to energize the reel driving mechanism to reel in the extended towing cable, said electrical control system being conditioned upon completion of each cycle of target discharge, release and cable reeling operations to be operative to repeat such cycles until all of the targets have been discharged and released.

2. The structure as claimed in claim 1, in which said power driven reel is provided with releasable

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means for connecting one end of the tow cable thereto, said releasable means including remotely controlled actuating means operative during rotation of the reel to disconnect the cable therefrom.

3. In a tow target system of the character described a target housing comprising a streamlined container having an opening in the bottom thereof for gravity discharge of targets therethrough, closure means normally closing said opening and provided with retracting means and latch means for maintaining said closure means in the closed position, internal hinged partitions in said housing serving to support tow targets resting thereon, individual latch means holding each of said partitions in target supporting position, electrical control means for the closure latch means and the respective partition latch means, said control means being sequentially operative to release said closure latch means to discharge a tow target initially resting thereon and to first actuate a respective partition latch means to drop a target resting thereon onto said closure means and thereafter to actuate the closure latch means to discharge the target from the container.

4. In a high speed aerial tow target system of the character described, a means for housing a plurality of aerial tow targets including an opening for the gravity discharge of targets therethrough, closure means for said opening, means for actuating said closure means to the open and closed position permitting selective discharge of targets, a power driven reel having a tow cable thereon, said cable having a tow hook at the end thereof, a guide having the tow cable passing therethrough, a plurality of electrically exploded frangible couplings positioned on said guide, each of said couplings being connected to the towing bridle of a respective target, each target upon discharge into the relatively moving air stream causing the coupling member associated therewith to pass off the guide and engage the hook on the tow line and means for electrically exploding a connected coupling to release the coupled target, said reel being subsequently energized for reeling in the tow cable for connecting a new target.

5. A tow target system as claimed in claim 4, including electrical circuits operative for energizing said closure actuating means, said explosive couplings and said reel, a selector switch operative to sequentially connect said circuits to a power source in a predetermined order and a control switch adapted for actuation by an occupant of the aircraft for actuating said selector switch.

6. The structure as claimed in claim 5 in which indicator means are provided actuated in unison with the selector switch to give a continuous indication of the operation last performed.

7. A system for high speed aerial towing of targets comprising means for housing a plurality of aerial tow targets, means for selectively and sequentially discharging said targets into the relatively moving air stream, a power driven reel operatively associated with said housing means and having a tow cable thereon adapted to be unreeled by aerodynamic drag force of a connected target and to be reeled in to effect target exchange, a towing hook on said cable, a guide means concentric with said cable, a plurality of electrically exploded frangible couplings mounted on said guide each connected to a respective tow target and adapted to be removed from said

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guide by drag of an associated target into coupling engagement with the tow cable hook and means for electrically energizing the tow cable to cause ignition and explosive disruption of a connected coupling to release a target being towed.

8. A carrier for aerial tow targets comprising a streamlined housing for housing a plurality of tow targets, a discharge opening in said housing, closure means for said discharge opening and having release means permitting said closure means to open due to the weight of a target resting thereon, hinged partitions in said housing serving as supports for respective targets, releasable latches for each partition permitting the partitions to drop so that individual targets may be dropped to rest on said closure means, means for actuating the closure release means, means for actuating the respective partition latches and means for interlocking said last two named means for sequential operation.

9. Apparatus for high speed aerial towing of targets comprising a means for housing a plurality of tow targets, a reel having a tow cable wound thereon and having braking means permitting the tow cable to be unreeled at a slow rate by tension load due to aerodynamic drag of

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a connected target, power means for driving the reel to wind in the cable, means for discharging the targets individually from said housing means, a coupling device connected to each target and adapted to automatically connect to the end of the towing cable upon discharge of the target into the air stream, each coupling device including an electrically ignited explosive release and means for electrically energizing said tow cable to effect explosive release of the coupling between a tow target and the tow cable.

10. The structure as claimed in claim 9, including a releasable connecting device between the tow cable and reel and means operable at will for actuating said device to release the cable when unwound from the drum and under tensile load.

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