SOME ASPECTS OF GLIDER TOW RELEASE PERFORMANCE

By R.G. Parker

A.R.L. , Australia

Presented at the XX OSTIV Congress, Benalla, Australia (1987)

Summary

Early in 1982, the Aeronautical Research Laboratories (ARL) were requested by the Airworthiness Branch of the Department of Aviation (DOA) to conduct performance tests on seven glider tow release mechanisms. The releases included new and used examples. The tests were based on Design Requirements relating to towing and launching of gliders and were developed to investigate the relationship between the force required to operate the release and the tow cable load applied.

A series of plotted characteristics clearly showing this relationship for each release is presented and discussed.

1. Introduction

During the decade following World War I, the launching of gliders by manual means, such as the rubber shock cord method, was generally superseded by techniques involving towing, eg automobile towing, winch launching and aero towing — the latter two methods being the most popular at present. Many designs of tow release mechanisms have resulted from this development, and all with the two common aims of transmitting towing forces from the tow cable to the glider over a range of tow cable angles, and the ability to release the cable easily when required. Although such international Design Requirements as British Civil Airworthiness Requirements (BCAR), Federal Aviation Authority (FAA), and Joint Airworthiness Requirements (JAR) are available for tow releases, there is little information on their operating characteristics and performance. However, an analytical study was made by Betts, Layton and Edwards(1) of a Schweizer tow plane release in 1971.

This situation prompted the Department of Aviation (DOA) in 1982, to request the assistance of the Aeronautical Research Laboratories (ARL) in assessing the performance of tow releases in terms of release operating force and tow load, particularly for recent designs and for releases whose mechanisms have been subjected to normal service wear. Seven glider tow releases were provided by DOA for testing. The type

Release No	Application	Reference Plane Relative to Direction of Flight	Release Condition	Tow Rings Used	Test Results
1	Tow aircraft	Parallel to release base	Badly wron hook, excessively stiff rubber	GFA* large ring	Release would require operating lever system to meet design requirements.
2	Tow aircraft	Cage normal to line of flight	New	GFA small ring	Release would require operating lever system to meet design requirements.
3	Winch launch	Mounting base normal to line of flight	Worn cage ring "Brinelled"	GFA small ring and 'Tost' small ring	Release body distorted under influence of in-line and side loads.
4	Aero tow and winch launch	Bottom of release parallel to line of flight	Used but good condition	GFA small ring and 'Tost' small ring	Mechanism self released under influence of inclined loads.
5	Aero tow	Cage normal to line of flight	Worn pivots and hook	GFA small ring	A 1.5 : 1 ratio lever system necessary to comply with design requirements.
6	Aero tow and winch launch	Cage 15° to line of flight	Used but good condition	GFA small ring and 'Tost' small ring	Complied with aero tow requirements. Self released in winch launch cases.
7	Aero tow and winch launch	Cage 15° to line of flight	Used but good condition	GFA small ring and 'Tost' small ring	Complied with aero tow cases. Self released in winch launch cases.

* Gliding Federation of Australia

TABLE 1. Summary of Releases Tested and Results

of operation and condition of each release is summarized in Table I, which includes the tow ring type used.

The purpose of these tests was not to compare the merits and demerits of the releases tested, but to obtain performance data for a number of typical tow releases at present in service. The information gained has been disseminated to the various authorities and where possible, the manufacturers involved, with the hope that it will assist in the future design, design approval, and performance assessment of glider tow release mechanisms.

2. Procedure

A test procedure based on the combined requirements of BCAR — Section E, FAA 43-13, and JAR-22, was devised to accommodate the following categories of release:

(a) towed aircraft (glider) releases;

(b) towing aircraft (tug) releases.

The main difference between the design requirements for these two types (summarized in Appendix I) is that the former should be capable of withstanding tow cable loads at wider angles from the line of flight, as shown in the following load cases and the aircraft reference diagram in Figure 1.

Load cases:

(a) Releases designed for towed aircraft (gliders);

(i) Aero tow

Load Case	Direction of Loading
1.	Line of flight
2.	30° to side of line of flight

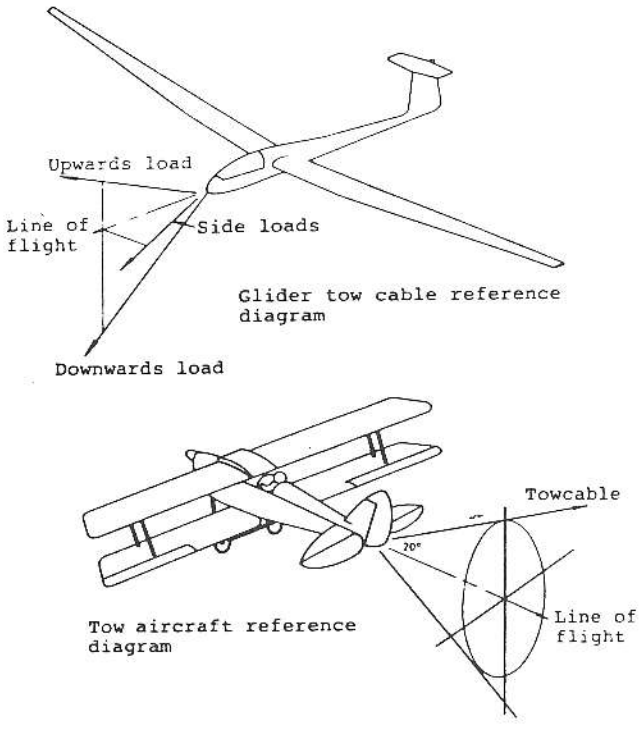

FIGURE 1-Towcable reference diagrams

3.	20° upward to line of flight
4.	40° downward to line of flight
5.	40° downward and 20° to side of line of flight
6.	20° upward and 20° to side of line of flight

(ii) Winch launch

Load Case	Direction of Loading
1.	Line of flight
2.	30° to side of line of flight
3.	75° downward to line of flight
4.	75° downward and 20° to side of line of flight

(b) Releases designed for installation in towing aircraft (tugs);

Load Case	Direction of Loading
1.	Line of flight
2.	20° to side of line of flight
3.	20° upward to line of flight
4.	20° downward to line of flight
5.	15° upward and 15° to side of line of flight
6.	15° downward and 15° to side of line of flight

Side load cases were introduced into the winch launch test procedure for better representation of service conditions than is required by existing Design Requirements.

Each release was mounted in a jig and placed in the ARL Tate-Emergy universal testing machine (Figure 2). The jig was so designed that each release could be mounted at the correct installed angle in relation to the direction of the load applied by the two cable. Tow cable loads were applied to the release in 1000 N (225 lbf) increments up to a maximum load of 7500 N (1685 lbf).

At each 1000 N (225 lbf) increment a spring balance was used to measure the release-lever force required to release the tow cable.

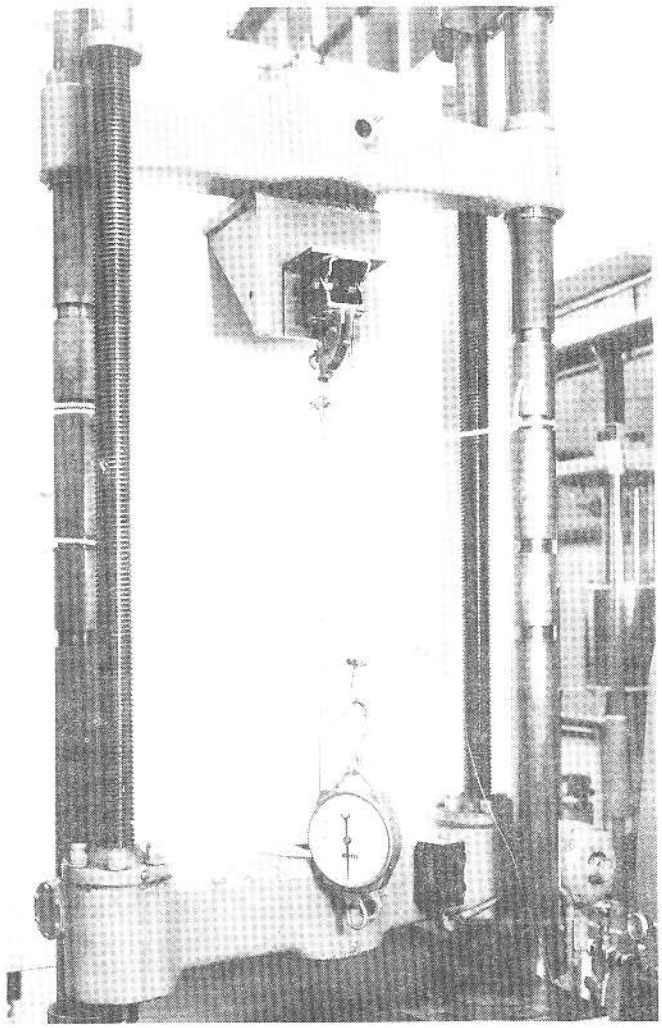

FIGURE 2-Glider release mounted in Tate-Emergy test machine.

3. Results

3.1 Release Number 1:

General Description: This release was designed and manufactured for use by towing aircraft and is illustrated in Figure 3.

The mechanism consists of a swinging hook and retaining latch assembly. It was attached, by a weld, to a mounting foot and employed a rubber block to act as a combined spring mechanism and stop for the swing hook.

The hook had a maximum working load of 5,340 N (1200 lbf) stamped on its side and was not loaded beyond this value.

Condition: The worn condition of the hook suggested it had experienced considerable service, including evidence of high towing ring bearing loads (refer to Figure 3, point B). The rubber block had become extremely hard, thus making it impossible to latch the hook in its correct locking position. The block was cut back to alleviate this problem.

Results: The results indicate (Figure 11) that the release was capable of taking the specified 5,340 N (1200 lbf) tow cable load in all the prescribed directions. The maximum release-lever force of 390 N* (88 lbf) implies that a leverage of 3:1 would be required to satisfy BCAR — Section E (cockpit release handle force not to exceed 134 N (30 lbf).

3.2 Release Number 2:

General Description: The release was manufactured in Australia and was designed to be used by towing aircraft. The body of the release was fabricated from welded steel plate, as shown in Figure 4.

Condition: This release was new.

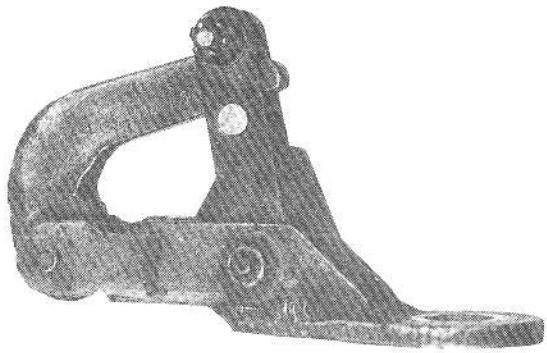

FIGURE 3-Release number 1.

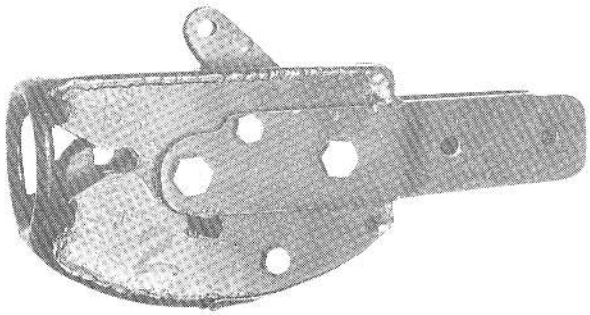

FIGURE 4-Release number 2.

Results: The release satisfactorily withstood all the loads in the directions specified for tug releases and the 7500 N (1685 lbf) maximum load. The maximum release lever force recorded was 605 N (136 lbf) and would require a lever ratio of 4.55:1 to satisfy BCAR — Section E, refer to Figure 12.

3.3 Release Number 3:

General Description: This glider release, Figure 5, was manufactured for winch launch applications. It is normally located on the bottom of the fuselage near the center of gravity and (apart from the hook which was a steel forging) was fabricated from welded steel plate.

Condition: The release had a great deal of wear around the hook and cage areas.

Results: Structural distortion of the release occurred when the maximum load was applied 30° sideways. Serious distortion of the release mounting feet was also observed during case 1. Figure 6 shows the permanent distortion which remained after the load was removed. The maximum release lever force, for the load case which produced distortion, was 1200 N (270 lbf) maximum. The test results are shown in Figure 13. It was observed that the release operating force varied up to 25% under a given tow cable side load depending on the orientation of the tow rings with the release mechanism jaws.

3.4 Release Number 4:

General Description: This release was manufactured for use by gliders in either aero tow or winch launch applications.

It was fabricated from welded steel plate and, as indicated in Figure 7, employed two guide lugs instead of the more commonly used cage.

Condition: Although this release had experienced service the general condition was good.

Results: This release did not comply with BCAR — Section E for either the aero tow or winch launch applications.

The release operating force was 187 N (42 lbf) maximum which was considerably lower than the three previous releases, Figures 14 and 15.

The tests were limited by the tendency of the release to allow the rings to twist off the hook when the tow cable was angled to the line of flight. The release did not meet the aero tow case 3 (20° upward load), case 4 (40° downward load) and the winch launch criterion of 75° down load.

3.5 Release Number 5:

General Description: This release was manufactured specifically to be mounted in the nose of gliders. It was constructed from welded steel plate and employed a fixed ring cage. Refer to Figure 8.

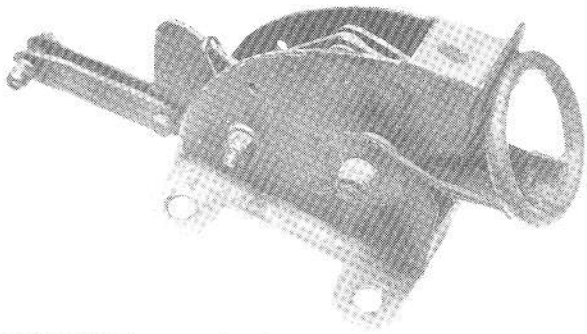

FIGURE 5-Release number 3.

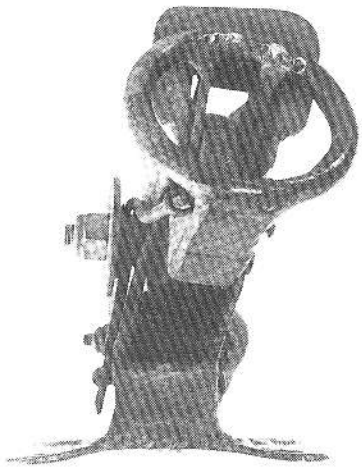

FIGURE 6-Release number 3 showing distorted body.

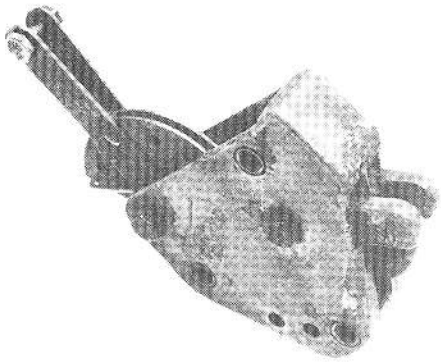

FIGURE 7-Release number 4.

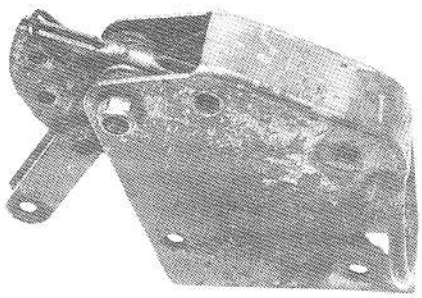

FIGURE 8-Release number 5.

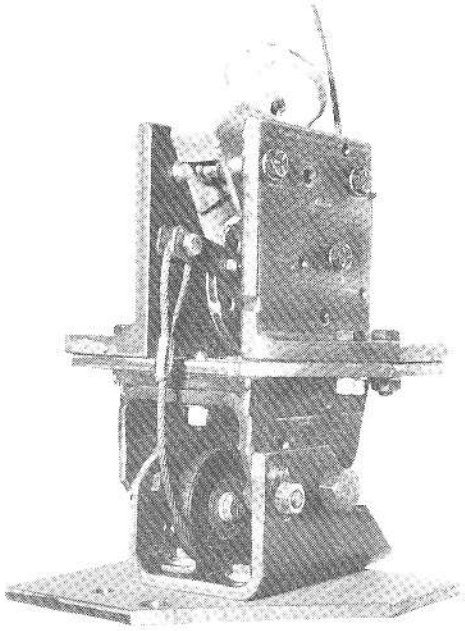

FIGURE 9-Release number 6 mounted in testing fixture.

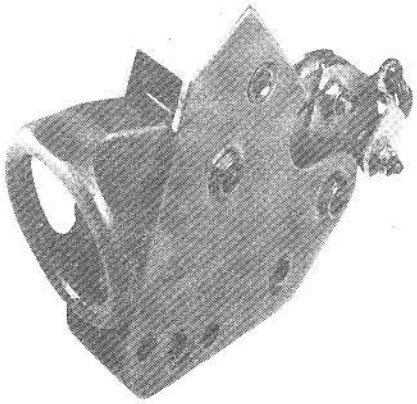

FIGURE 10-Release number 7.

Condition: The mechanism of this release, showed signs of considerable wear, but it was classed as being still serviceable.

Results: This release achieved all the glider release tests and required a maximum release force of 210 N (47 lbf), Figure 16. This suggests that a cockpit lever ratio of approximately 1.5:1 would be required for it to conform to the relevant BCAR.

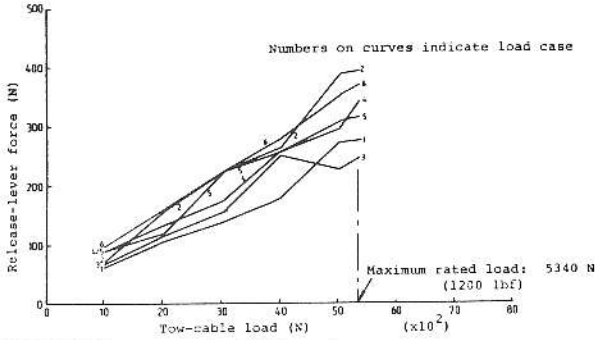

FIGURE 11-Release number 1/Tug release

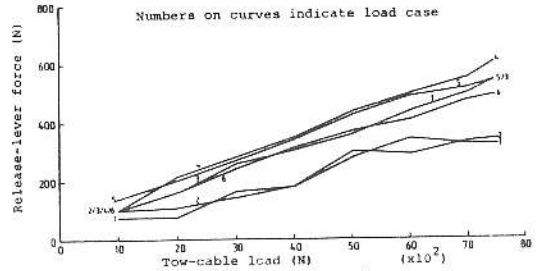

FIGURE 12-Release number 2/Tug release

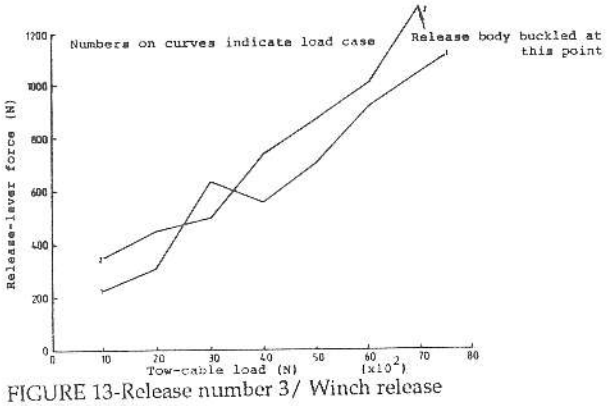

FIGURE 13-Release number 3/ Winch release

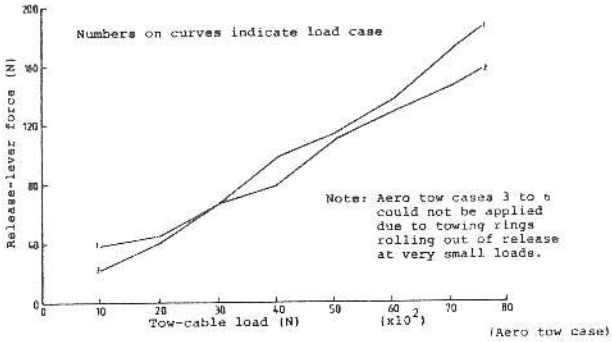

FIGURE 14-Release number 4/Aerotow-Winch release

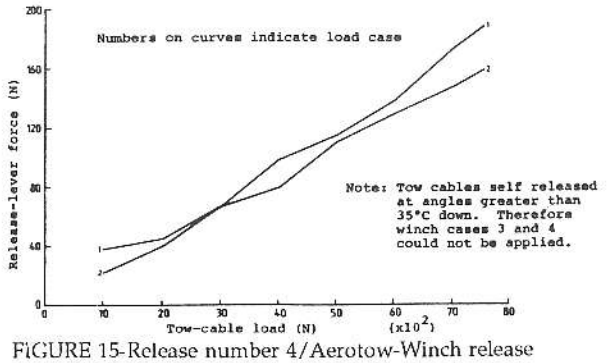

FIGURE 15-Release number 4/Aerotow-Winch release

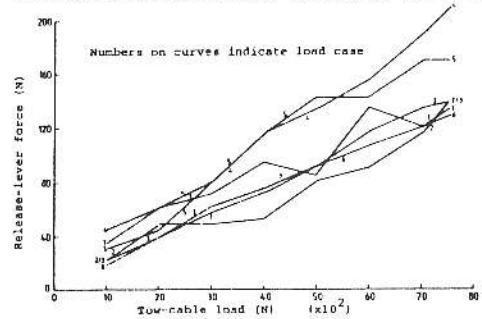

FIGURE 16-Release number 5/Aerotow"Nose" release

3.6 Release Number 6:

General Description: This release can be used for either aero tow or winch launch operations. The manufacturer has recommended that it can be used for gliders not exceeding 750 kg.

The body of the release was fabricated from welded steel plate, similar to release number 5, except that it was fitted with a spring loaded muzzle cage and an "overcentre" adjusting screw. It is shown fitted into the testing fixture in Figure 9.

Condition: The release had been used, but was still in good, serviceable condition.

Results: This release was successful in all the aero tow load cases, but did not satisfy the winch launch cases, due to self releasing under 75° down load conditions.

The maximum release lever force of 250 N (56 lbf) as shown in Figures 17 and 18 was compatible with releases 4 and 5.

3.7 Release Number 7:

General Description: This release was manufactured primarily for use in gliders, and is suitable for either aero tow or winch launch operations, Figure 10. The construction was different from release No. 6 in that it had an investment cast body.

Condition: The release had been in service, but was in good condition.

Results: This release succeeded in the aero tow load tests, but not in the winch launch tests for reasons similar to those for release number 6. It exhibited the lowest release force of all releases tested. The release force — Independent of cable load — was 102 N (23 lbf) maximum, see Figures 19 and 20.

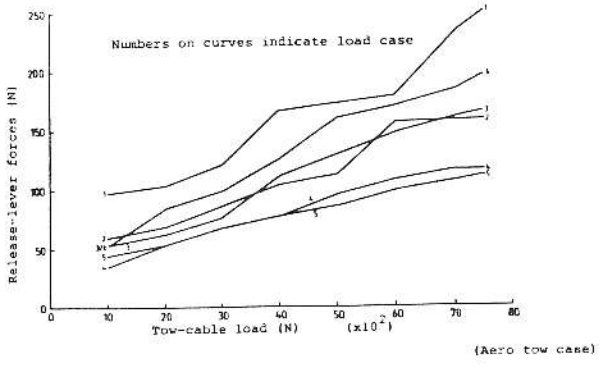

FIGURE 17-Release number 6/Aerotow-Winch release

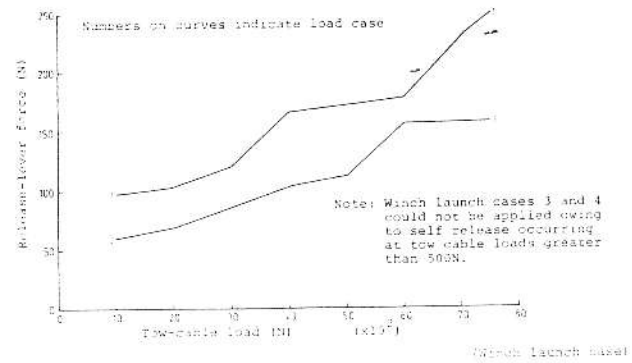

FIGURE 18-Release number 6/Aerotow-Winch release

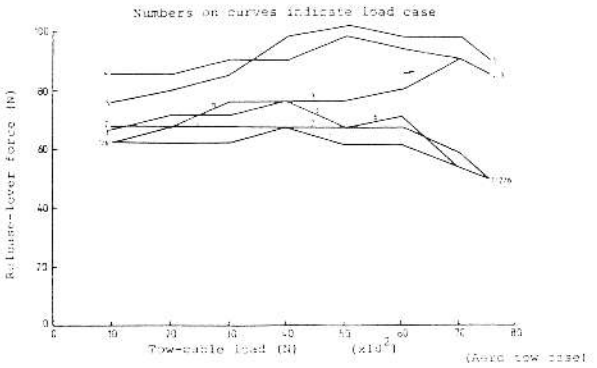

FIGURE 19-Release number 7/Aerotow-Winch release

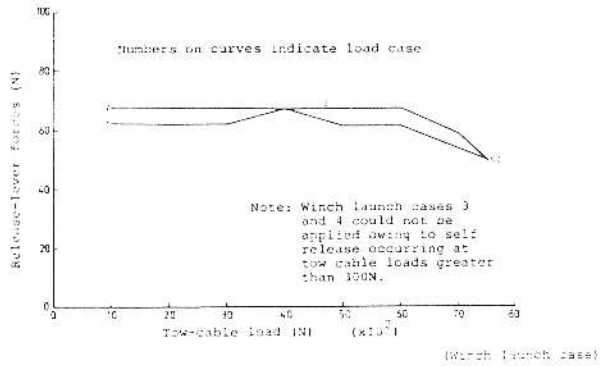

FIGURE 20-Release number 7/Aerotow-Winch release

4. Conclusions and Discussion

(a) Both releases tested under the tug criteria, ie release number 1 and release number 2, passed the tests, but would require cockpit lever ratios of up to 4.5:1 to satisfy BCAR section E.

(b) Release number 3 would not sustain winch side load case 2 without additional side support. Also, it would require strengthened mounting feet to comply with design requirements.

(c) Releases 4, 6 and 7 did not satisfy the winch launch criteria because of the tendency for each release mechanism to "self release" when the simulated towing load was inclined to the line of flight.

(d) Releases 5, 6 and 7 performed satisfactorily under the aero tow criteria. However, release number 4 would not tolerate side loading without releasing prematurely. (It is understood that side angle plates are fitted in some installations to alleviate this problem).

With the exception of release number 3, which required a maximum operating force in excess of 1110 N (250 lbf), none of the releases tested required excessive operating forces, although a lever system would be required for all releases, except number 4 and 7. However, the number of releases from the sample which failed to transmit maximum towing loads, as a result of self releasing was significant, and was considered to be partly the result of inadequate maintenance and adjustment data.

While working on this project the author formed the opinion that the inherent ruggedness and mechanical reliability of tow release mechanisms in general, plus the lack of maintenance and testing data, have combined to produce a "fit them and forget them" operating atitude. It is believed that this

situation could be improved if consideration was given to:

(a) The assessment of all existing design requirements with the aim of producing one comprehensive international design and performance standard.

(b) the provision (by manufacturers) of adequate installation data and performance characteristics of each release mechanism.

(c) the development and promulgation of suitable maintenance schedules and service testing procedures by controlling authorities.

5. Reference

(1) Betts, W.J.; Layton, G.P., 1971 Tow plane hook design and operational tests; *Technical Soaring* No. 1, Vol. 1, Soaring Society of America, Inc.

*At a tow-cable load of 5340 N not 7,500 N.

APPENDIX 1

SUMMARY OF GLIDER TOW RELEASE REQUIREMENTS

The requirements for glider tow releases can be categorized into two groups as follows:

Group	Description	Design Requirements
1	Glider releases relevant to towing aircraft-tugs.	FAA 43-13 Part 2
2	Glider releases relevant to towed aircraft-gliders.	FAA 43-13 Part 2, JAR-22, BCAR-Section E.

Summarizing the requirements for glider tow releases:

SECTION 1: Towing aircraft releases (Tug)

(a) FAA Advisory Circular 43.13 Part 2 specifies that the static test of the release mechanism must illustrate that it is capable of withstanding a load twice the maximum all-up weight (AUW) of the glider, acting rearward within a symmetric cone of 20 degrees about the line of flight of the aircraft.

(b) BCAR-Section E did not specify any release requirements. (It is not applicable to towing aircraft-Editor.)

SECTION 2: Towed aircraft releases (Glider)

(a) FAA Advisory Circular 43.13 Part 2 recommendations for gliders state that the release must be capable of with standing a load twice the maximum AUW of the glider, or 900 lbf, whichever is greater. This load to be applied in the following directions.
- Line of flight.
- Forward and upward 30 degrees from line of flight.
- Forward and downward 75 degrees from line of flight.
- Forward and sideways 30 degrees from line of flight (refer to Figure 1.)

(b) JAR-22 for gliders specifies that the release must be capable of withstanding 1.2 Qnom where Qnom is assumed to be the greater of:
- the rated ultimate strength of the towing cable.
- 1.3 times the glider maximum AUW.
- 5,000 N (1,125 lbf).

The direction of loading is:

i. Aero tow
- Line of flight.
- Forward and upwards 20 degrees from line of flight.
- Forward and downwards 40 degrees from line of flight.
- Forward and sideways 30 degrees from line of flight.

ii. Winch launch
- Forward and downward at an angle ranging from 0 degrees to 75 degrees from line of flight.

Two additional requirements of JAR-22 relate to the release handle force and displacement. They are:

i. release handle force must not exceed 200 N (45 lbf).

ii. The range of travel of the release mechanism in the cockpit must not exceed 120mm (including free travel).

(c) BCAR-Section E for gliders specifies that the glider release must meet the following conditions:

i. The release must be capable of withstanding surge loads under aero tow of a least the breaking strength of the tow cable, where the recommended minimum cable strength must exceed 1,000 lbf.

Under winch loads this value is increased by a factor of 1.2 or to the load required to balance the total pitching moment of the glider, whichever is less.

ii. The release-handle force must not exceed 133N (30 lbf).

The direction of loading is:

i. Aero tow:
- Line of flight.
- Forward and upwards 20 degrees from line of flight.
- Forward and downwards 40 degrees from line of flight.
- Forward and sideways 25 degrees from line of flight.

ii. Winch launch:
-Forward and downward at an angle ranging from 0 degrees to 75 degrees from line of flight.