

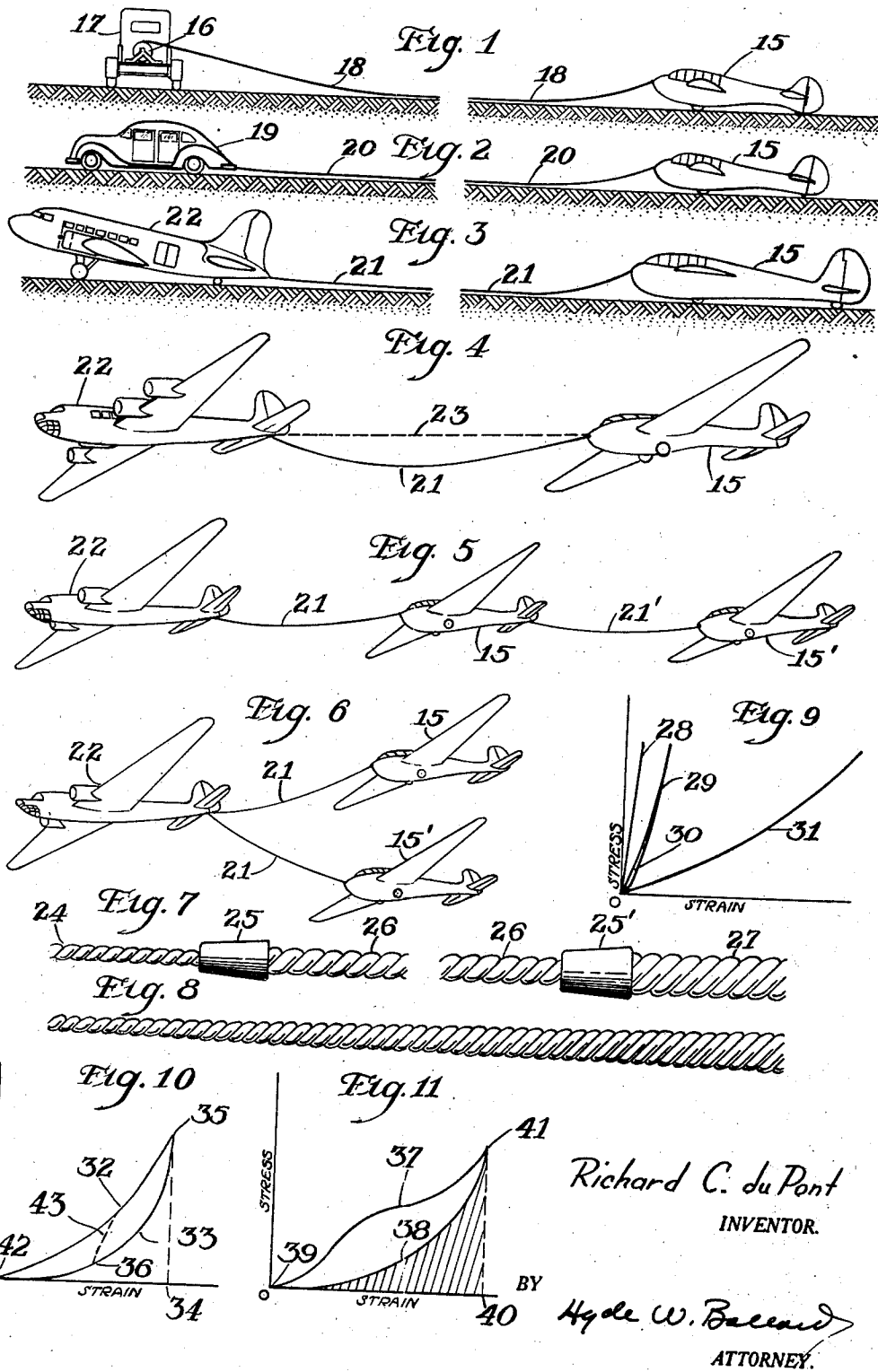
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SHOCK ABSORBING AERIAL TOWLINE

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SHOCK ABSORBING AERIAL TOWLINE

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My invention relates in general to launching and towing of aircraft and more particularly to the launching and towing of gliders.

One method of launching a glider heretofore used is to connect a towing airplane and a glider by a tow line of hemp or steel or of some other substantially non-yielding material of fixed length while the tow plane and glider are both resting on the ground, the glider being disposed behind the tow plane with the line substantially taut. The tow plane is then taxied down the runway, pulling the glider with it until such ground speed is attained as to enable the glider to fly. Usually, but not always, the glider attains flying speed first and after suitable altitude is reached, the glider pilot maneuvers the glider to slacken the line and reduce the load on the tow plane after which the tow plane gains sufficient flying speed to take off. When the tow plane reaches safe flying speed and altitude, the glider pilot maneuvers the glider to cause the line again to become taut, and the glider is towed through the air by the tow plane. The tow plane tows the glider to the desired height and distance depending on the particular operation undertaken. Similar methods have also been used to launch two or more gliders by connecting them either individually, or one behind the other, to the tow plane.

After both the tow plane and glider are at a safe altitude, it may be desired to maneuver the glider to some particular position with respect to the tow plane, for example either above it or below it, for a particular operation. Or it may be desired to cast off a glider so that it may proceed as a free glider. Or, the operation may consist in just ordinary towing of the glider or gliders for a considerable distance as, for example, in the case in transferring freight or troops.

Other well known methods of glider launching heretofore used are: the winch tow, in which the hemp or steel tow line is rapidly wound on the drum of a power-driven winch; and the automobile tow, in which the hemp or steel tow line is attached to an accelerating automobile. In these cases also, when sufficient altitude has been attained, the glider pilot may disconnect the tow line as he sees fit.

Heretofore it has been of extreme importance that no sudden jerk be placed upon the tow line, not only while the glider is being towed in the air, but before it takes off. During the launching operation, should a glider strike a slight obstruction, mudhole, or other soft spot on the field before it gets into the air, a broken tow line almost

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invariably results. In addition rough air or the sudden impact of the slipstream from the towing plane, if one is used, may impose excessively high loads on the tow line after the glider is in the air. In any event, the launching, maneuvering and towing operations subject a tow line to severe tension and shock causing frequent breaking of the tow line.

The tow lines heretofore used were usually made of vegetable fiber, such as manila or hemp, or else were made of steel cable. These materials have little or no elongation, neither have they any appreciable damping characteristics. Therefore, they have little or no shock absorbing ability and are subject to continuous breakage even though they may be many times stronger than needed for use under constant loads. To overcome these difficulties, various expedients have heretofore been proposed. For example, mechanical take-up devices and hydraulic shock absorbing devices have been proposed to protect these comparatively non-yielding lines. These devices have proven, for the most part, to be entirely impractical.

Rubberized shock cord has also been proposed. Such material, while having adequate elongation, has even less effective damping or energy absorbing characteristics than steel or hemp line. These materials all have the disadvantage of immediately transmitting or substantially returning all the force imparted to them, causing undesirable shock on the line and on the equipment. Rubberized shock cord is particularly bad because it behaves somewhat as a giant slingshot causing the glider to overshoot and otherwise subjecting the glider to uncontrollable forces.

The object of the present invention is to solve these problems in a simple and effective manner, by using a tow line having characteristics which prevent breakage of the tow line or the structure to which it is attached.

It has been found that certain synthetic materials, such as nylon, when properly fabricated, have certain characteristics which make them ideal for aerial shock absorbing purposes. These materials have high percentage elongation, as high as 30% and considerably more in some cases. Further, these materials have certain characteristics when the line is stretched or loaded and have entirely different characteristics when the tension is released or the line unloaded. In general, contrary to most materials, they have the characteristic of transmitting a considerably less average force than the loading force required for stretching the material. These materials have

energy absorbing characteristics which dissipate much of the energy required to stretch the material—in some cases as much as 60% is absorbed by the line.

The property of absorbing energy is sometimes referred to as hysteresis and the effect of this property in slowing up the return of the line to normal length is sometimes referred to as long elastic memory. It will be understood that the amount of hysteresis and long elastic memory are relative, being large as compared to such materials as hemp, steel and rubberized cord heretofore used, but small enough to cause return to normal length within the time of a second or so, so that the material will be in readiness to absorb a further shock. In other words, the elasticity of the material is high, that is, its ability to recover normal length after tension is reduced.

In most cases a successful aerial tow line according to the invention can be made by using a simple one-piece twisted or braided rope of the proper material and having the proper diameter and length. In other cases it may be desirable to make up a composite line by serially connecting ropes of different diameters of the same material or ropes of different material having somewhat different characteristics. The same desirable result can be obtained by manufacturing a tapered rope of gradually increasing diameter.

Various other features and advantages of the invention will be apparent from the following description and from an inspection of the accompanying drawing.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawing forming a part hereof, in which:

Figure 1 represents diagrammatically winch launching of a glider;

Figure 2 represents diagrammatically automobile tow launching of a glider;

Figure 3 represents diagrammatically airplane tow launching of a glider;

Figure 4 shows the airplane and glider of Figure 3 in towing position after the glider has been launched, and it illustrates diagrammatically the position of the tow line under various conditions of stress;

Figure 5 represents diagrammatically a plane towing a plurality of gliders in tandem;

Figure 6 represents diagrammatically a plane towing a plurality of gliders using the conventional fan tow;

Figure 7 illustrates a composite tow line made of sections of line having different diameters;

Figure 8 illustrates a tapered tow line;

Figure 9 illustrates stress strain curves of non-shock absorbing tow line materials;

Figure 10 is a curve showing force applied to the tow line plotted as a function of elongation of a material such as nylon; and

Figure 11 is a curve similar to Figure 10 but of a different material.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit.

Like reference characters denote like parts in the several figures of the drawing.

In the drawing accompanying and forming part of this specification, certain specific disclosure of the invention is made for purposes of explanation, but it will be understood that the details may be modified in various respects without departure from the broad aspect of the invention.

Referring now to the drawing, the winch tow of Figure 1 comprises the conventional power-driven winch 16 mounted upon a stationary truck 17. The glider 15 to be launched is shown resting on the ground. The shock absorbing tow line 18 connects with the nose of the glider and is wound on the winch 16, as will be understood by those skilled in the art.

In Figure 2 showing the automobile tow, the shock absorbing tow line 20 is of fixed length and connects the glider 15 to be launched with an automobile 19. Both automobile and glider are stationary on the field ready for launching.

In Figure 3 the tow plane is indicated by 22 and the glider by 15, both stationary and resting on the runway, with the tow line 21 connecting the two aircraft. In all cases, the tow line may be fastened to the glider and in Figure 3 the tow line may be fastened to the tow plane by a conventional release mechanism (not shown) for severing or releasing the line for emergency or other purposes.

According to the invention, the tow lines 18, 20 and 21 are twisted or braided ropes made from materials having the peculiarly beneficial characteristics discussed more at length below. Nylon is the most suitable material known at the present time but certain other plastics referred to below will also perform satisfactorily under certain conditions. The material of which the tow line is composed should have a sufficiently high tensile strength so that its weight per unit of length is not excessive. It should have high percentage elongation as compared to ropes of steel or vegetable fiber materials, for example, hemp and manila; and high hysteresis or energy absorption as compared to rubber. The effect of this latter property has been referred to as long elastic memory. Furthermore, the energy absorbed per unit of length must be sufficiently high to keep the diameter or length of tow line required in the given operation within practical working limits. The tow line material should also have sufficiently rapid recovery to permit absorbing the shock of a successive impact within a second or at the most a few seconds. In other words, the tow line material should have the property of substantially completely recovering its original length when the load is completely removed, that is, it should have excellent elasticity. Nylon and the other materials discussed below, when properly pre-worked, have these advantageous properties. The pre-working is explained more at length hereinafter.

Before explaining the action of the tow line according to the invention in actual towing operation, an explanation of its characteristics will be given in connection with Figure 10 which shows a stress-strain curve illustrating the behavior of a tow line material such as nylon. This figure shows tension stress applied to the tow rope plotted as a function of strain or elongation of the tow rope. It will be noted that the curve is made up of an upper line 32 which may be called the loading curve and a lower line 33 which may be called the unloading curve.

For purposes of explaining the operation of the invention, the rope material will be put

perior qualities of the line, it is not necessary to observe the same precaution in eliminating the original slackness as with conventional lines such as a vegetable fiber rope or steel cable.

In Figure 1 the winch 16 is suitably connected to the motor in the truck 17 and at the proper instant it may be caused to reel in the tow line 18 thus pulling the glider down the runway. After a comparatively short distance the glider is airborne. When the glider is well in the air, the winch operator slows down or stops entirely the reeling action, and the glider pilot may then cast off the tow line at his convenience.

The technique of Figures 2 and 3 requires a longer runway than that of Figure 1. In Figure 2 the automobile 19 pulls the glider 15 rapidly down the runway by tow line 20. Tow line 20 differs from tow line 18 only in that it may be considerably shorter due to the fact that it is not reeled on a drum. As soon as the glider has attained sufficient speed and altitude, the pilot likewise releases the tow line.

In Figure 3 the tow plane 22 taxis down the runway pulling the glider 15 behind it by tow line 21. Tow line 21 is composed of the same materials as are tow lines 18 and 20, the only difference being their respective lengths and method of attachment to the towing device.

In one form of airplane tow launching technique the glider attains flying speed before the towing plane whereupon it leaves the ground while the tow plane continues to taxi. The glider pilot then manipulates the glider to slacken the tow line 21, partially taking the load off the tow plane thus enabling the tow plane to take off with less difficulty. After the tow plane has reached safe elevation, the glider pilot maneuvers the glider to place the glider in the proper position with respect to the tow plane depending on the particular operation or maneuver. Once in the air, the glider may take a position above the tow plane or below it depending on the maneuver and depending also on whether or not other gliders are connected to the same tow plane.

As stated above, the tow line is subjected to severe shocks, while launching the gliders, while maneuvering the gliders and also during ordinary aerial towing. In the towing of gliders, shock may be caused by necessary maneuvering, and by air conditions entirely out of the control of the pilots. Bumpy air, gusts of wind and cross currents may alternately slacken the tow line and place it under considerable tension.

Considering the simple situation of a tow plane in flight towing a single glider in flight, the operation of the shock-absorbing line is as follows: Assume that air conditions cause the line to slacken to the position indicated by the position of the tow line 21 in Figure 4, removing all stress therefrom and that this condition is immediately followed by a condition placing the line under maximum stress, as shown at 23 in Figure 4. This means that while the condition of the line is changing from slack to taut, the plane and glider are moving at relatively different speeds. As soon as the line becomes taut, the tow plane resumes its towing function. Since the line must transmit the accelerating force, it stretches, its high percentage elongation providing time in which to accelerate the glider to the speed of the tow plane, thus reducing the rate of acceleration and the force exerted on the line.

As soon as the glider becomes accelerated to the speed of the plane and the accelerating force

is removed from the line, the reduced restoring force exerted by the tow line 21 delays the return of the line to its original length, thus preventing the glider from overaccelerating or overshooting which would cause the line to become unduly slack. Thus the peculiar action of the shock-absorbing tow line prevents a recurrence of a condition which would subject the line to additional shock.

It will be understood that the length of the tow line and the properties thereof will vary with each particular installation. For purposes of explanation of the invention, it will be assumed that the tow line in Figure 4 is of $\frac{3}{8}$ inch twisted nylon, is 500 feet in length at no load, has a breaking strength of 2500 pounds, and a usable strength of 80% of the breaking strength, i. e. a usable strength of 2000 pounds. It will be assumed that the tow line has a 30% elongation corresponding to the usable strength of 2000 pounds. Such a line under stress of 2000 pounds will have a 150 foot elongation and will stretch to a length of 650 feet. It will be assumed further that the tension on the tow line through still air with no surges will be about 10% of the breaking stress of the line, or say, about 250 pounds.

A maximum safe working load of 80% of breaking strength has been arbitrarily selected in order to provide a sufficient factor of safety in actual operation. Obviously, the energy absorbing and elongation characteristics are not limited to loads below this value.

Referring now again to Figure 10 in which it may be assumed that the peak 35 of the loading curve represents approximately 80% of the breaking strength of the tow line which may be for example 2500 pounds. Point 36 represents the normal towing load on a line of this strength. This will be ordinarily between 10% and 15% of the breaking strength of the line or about 200 pounds, in the present illustration.

Suppose now, for example, a surge occurs raising the load on the tow line from 200 pounds to 2000 pounds, the loading curve will correspond to the dotted line 43 and will follow the loading curve 32 up to the point 35, i. e. 2000 pounds. If now the tension is decreased the unloading curve will coincide with curve 33 until the normal towing load 36 is reached.

A second surge may occur at any point along the unloading curve 33 and in fact a series of surges all in higher or lower loading ranges may take place. Likewise, the load may be reduced to zero depending on conditions encountered.

The characteristic of energy absorption is always present, being represented by the area between the loading and unloading curves of the particular cycle corresponding to the particular change in loading conditions.

The tow line material should have a maximum usable elongation of at least ten per cent from unloaded condition to maximum working load of eighty per cent of breaking stress. The elongation may also run as high as thirty per cent, and in some cases much higher, so long as the material exhibits the proper energy absorption properties. The tow line material should have sufficient hysteresis in the working load range to give a minimum energy absorption of twenty per cent when put through the loading and unloading cycle from zero load to eighty per cent of breaking stress in two seconds. The energy absorbing properties may run considerably higher than this figure so long as the material has the other desirable properties such as sufficient elongation

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through a loading-unloading cycle. With zero tension the pre-stretched rope has zero elongation. This is represented by the zero point of the curve. As the tension increases, the rope lengthens a corresponding amount following the upper curve 32. The peak 35 of the loading curve 32 may represent a tension somewhat below the breaking stress of the rope. Upon tension being reduced from the point 35, the rope shortens a correspondingly smaller amount. In other words, the unloading curve 33 drops rapidly with decrease in tension, showing that the restoring force, exerted by the rope tending to return it to normal length, is considerably less than the force required to stretch the rope.

It will be noted that the shock-absorbing rope, upon being stretched, behaves somewhat as a spring, although not a spring of linear characteristics. As the tension is relaxed, the rope behaves as if the spring had incorporated therein a hydraulic dashpot retarding the return to normal length. Moreover, each individual unit of length of the rope behaves in this manner. The rope in returning to normal length may be said to act like a long spring having a separate dashpot associated with each unit length. In other words, the damping force is distributed throughout the length of the rope. As nearly as can be determined at the present time, the reason for this peculiar behavior is due to the internal molecular structure of the material. Regardless of theory, the restoring force exerted by the line is definitely less on the average than the stretching force for the various elongations and the line therefore absorbs a relatively large amount of energy.

The property of a rope exerting less stress when decreasing in length than when increasing its length, has been referred to as hysteresis. Although many materials have hysteresis to a slight extent, a significant property of applicant's tow line is the amount of hysteresis and the shape of the unloading curve, providing in effect a slowing up of the return of the line and its load from elongated position to normal length.

In order to afford a more complete understanding of this characteristic, a comparison with stress-strain curves of non-shock absorbing materials formerly used will prove helpful. Figure 9 illustrates typical curves of such materials. Curve 28 represents a steel cable having substantially no hysteresis and slight elongation. Curve 29 represents vegetable fiber ropes in which there is a barely perceptible amount of hysteresis which is indicated at 30 by the area between the loading and unloading curves and only slightly more elongation than steel. Curve 31 represents rubber which has relatively great elongation with little or no hysteresis or energy absorption.

As heretofore stated, all the materials whose characteristics are illustrated in Figure 9 have the disadvantage of substantially immediately returning all of the force stored up in the line by stretching, which causes undesirable shock on the line and on the equipment. The rubber line has the further disadvantage of behaving somewhat as a giant slingshot because of its increased elongation, causing the glider to overshoot and otherwise subjecting the glider to uncontrollable forces. It is therefore apparent that the proper shock absorbing material for a tow line must have both comparatively large elongation and comparatively high hysteresis and must exhibit these characteristics over the useful load range.

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In addition to having a line of the proper material, the line must also have the proper length and diameter so that the shocks imposed thereon will cause the material to operate in the proper part of the curve or loading range. A material giving a curve which does not rise to too much of a peak and has a gradual slope indicates proper elongation characteristics. A curve which gives sufficient elongation at low loads and very little additional elongation at higher loads, would be unsatisfactory for towing purposes at the higher loads. The best curve would be one which rises gradually and does not describe a peak at higher loads but actually flattens out somewhat and has an unloading curve which drops away from the loading curve at higher loads but not vertically. This gives the effect of maximum area between curves in the higher loading ranges and also sufficient elongation to provide some resilience in these ranges.

Figure 11 illustrates the stress-strain curve of a material such as rubber hydrochloride. The loading curve 37 tends to flatten out before peaking at 41. This has the advantage of providing a larger area between the loading curve 37 and the unloading curve 38. This rubber hydrochloride, while having a more advantageously shaped curve for certain purposes, lacks the tensile strength of nylon and has other undesirable properties which make it inferior to nylon for towing purposes.

An idea of the amount of energy dissipated will be apparent from Figure 11. Graphically, the area represented by 39, 37, 41 and 40 represents the total energy imparted to the line. The shaded area 39, 38, 41 and 40 represents the energy returned by the line. Therefore, the difference in these areas, namely, 39, 37, 41 and 38 represents the energy dissipated or absorbed by the tow line. It will therefore be understood that the greater the area between the loading curve 37 and the unloading curve 38, occurring within the load range being used, the more energy is absorbed with consequent greater dampening of shock. The explanation of amount of energy absorption also applies to Figure 10.

In order to approach a mathematical evaluation of energy absorbed, assume that a sample of tow line, say 10 inches long, is rapidly loaded and unloaded to 80% of its breaking strength. If the loading time is one second and unloading time one second, the stress-strain diagram of such a test will be represented by Figure 10. Since the area between the loading and unloading curves represents the energy absorbed, the percentage of absorbed energy is found by dividing the total area—42, 32, 35, 34 by the area between the curves—42, 32, 35, 33. The per cent of energy absorbed of the material represented by Figure 10 is roughly 50% which is typical of nylon. Other materials suitable for tow line purposes may have as low as 20% energy absorption and as high as 70 or 80%. It will be understood that the maximum limit is relatively unimportant provided there is sufficient elongation and residual energy to restore the tow line to substantially its original length so that subsequent shocks may be absorbed.

Referring now to Figures 1-4, the operation of my invention in actual launching and towing is as follows: A suitable length of shock absorbing line is laid out on the ground between the glider and the winch, automobile or tow plane, as the case may be. This line should be free of any unnecessary slackness although, due to the su-

under stress and ability to return to original length when unloaded within a reasonably short time to place the material in condition for handling a successive shock.

The filaments of certain plastics, such as nylon, when first formed from solution or melt have the peculiar characteristic of being capable of being stretched to many times their original length without exhibiting any substantial tendency to return when tension is released. When subjected to sufficient cold working, the filaments acquire an excellent elasticity, that is, ability to return to original length after stretching. For this reason, before making the filaments into rope, it is desirable that they be sufficiently cold drawn to the point where they exhibit such excellent elasticity. Commercial nylon is totally cold drawn before being sold on the market.

When a new synthetic rope is first placed in service and subjected to several loadings of say 80% breaking strength, a small amount (about 2 or 3%) of permanent elongation takes place.

This may be caused by the individual filaments of the yarn not being sufficiently cold worked to gain good elasticity after delivery from the spinners which spin the yarn. Or, it may be caused by the process of twisting or braiding the yarns into rope, in which event pre-stretching helps adjust the individual yarns of the rope into their final stable positions. Or, this unstable condition may be caused by both reasons.

After the rope has attained its full permanent set, it will return to original length after further stretching. The above ranges of values are intended to apply to lines which have been pre-worked sufficiently to become truly elastic and to make their elongation and hysteresis properties substantially uniform with successive loading and unloading cycles.

In certain cases in order to obtain the proper operation at different loads on the line it is desirable to use a composite line, as shown in Figure 7. In this figure the line is shown made up of three sections 24, 26 and 27 serially connected. It will be understood, however, that the line may be made up of two sections and also four or more, depending upon the characteristics desired. The sections 24, 26 and 27 have different characteristics and are connected by conventional rope couplings 25 and 25'. The sections may vary in material, or diameter, or length, or in various combinations of these characteristics.

Considering, for example, the situation where all sections are of the same material, nylon, section 24 may be the smallest diameter, section 26 the intermediate diameter, and section 27 the largest diameter. All of these sections may be of equal lengths or they may be of different length. The working strength of such a line will, of course, be limited by the tensile strength of the weakest section, which in this case would be the smallest section 24, but this construction permits working each section at different parts of the stress-strain curve.

For example, at low stresses the action of the weakest section 24 may be predominant. As the stress reaches a higher value, section 24 may tend to peak up, that is, lose its elongation characteristics. Above such a stress, section 26 will begin to predominate since this section will be working at a lower part of the stress-strain curve. Similarly, at tensions where both sections 24 and 26 peak up, and lose their ability to stretch readily, section 27 will be working at a desirable part of the stress-strain curve. Thus such a composition

rope would behave at all stresses corresponding to the lower part of the stress-strain curve.

It is obvious that the same results of a composite line can be obtained with the use of a tapered line such as shown in Figure 8. Here the range of the use of a tapered rope will permit a shorter overall length of tow line, but the cost of manufacture may be greater.

Referring now to Figure 5, the plain or composite tow rope according to the invention is particularly useful with glider trains, where a tow plane is towing a plurality of gliders, one behind the other, similar to railway cars. In Figure 5 the tow plane is indicated by 22, the gliders being indicated by 15, 15', etc. The tow plane 22 is connected to the first glider by tow line 21. The glider 15 is connected to glider 15' by tow line 21' and so on. Here, generally, the tow line 21 will be heavier than the tow line 21', the size of the line between successive gliders decreasing in diameter. Here, due to the action and reaction of each aircraft on all other aircraft in the chain, conditions causing shock on the tow lines may be particularly acute. The property of the tow line, according to the invention, of exerting greater stress upon elongation than upon return to normal length is particularly advantageous here in absorbing shock and preventing breakage of the tow lines.

Referring now to Figure 6, the tow plane 22 is shown towing two gliders 15 and 15' by separate tow lines 21, this being referred to as the fan tow. It will be understood that additional gliders may be connected by additional tow lines directly to the tow plane 22. Due to the action and reaction of the several gliders and of the tow plane on each other caused by maneuvering or air conditions beyond the control of the several pilots, the shock absorbing properties of a line according to the invention are especially useful here in easing shock and preventing breakage of the tow lines.

It will be understood that my invention can be practiced with lighter-than-air craft as well as with heavier-than-air craft, particularly in the case of aerial towing operations which require maximum shock absorbing qualities in the tow line.

Although nylon has been given for purposes of illustration as constituting the best all round tow line material known at the present time, the tow line or any section thereof may be made up of other materials having similar properties, such as rubber hydrochloride, vinyl type plastics, particularly vinyl chloride, vinylidene chloride and some cellulose derivatives. Nylon is a well known product manufactured and sold by E. I. du Pont de Nemours. Nylon is known as a synthetic linear condensation polyamide capable of being drawn into pliable strong fibers shown by characteristic X-ray pattern orientation along the fiber axis. Rubber hydrochloride is sold under the trade name "Laminite," manufactured by Andrews-Alderfer Processing Company. Vinyl chloride is sold under the trade name of "Colonial V Plastic Type II," manufactured by Colonial Alloys Company. Vinylidene chloride is known as Saran and is manufactured by the Dow Chemical Company.

While certain novel features of the invention have been disclosed herein, and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

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Having thus described my invention, I claim:

1. In a system for changing the velocity of an object, an object subject to motion, a body with respect to which said object has relative motion, a tapered synthetic plastic line gradually increasing in diameter from one part to another part, said line having the characteristics of high tensile strength, relatively great percentage elongation with long elastic memory, whereby the different parts of said line throughout its length act along different parts of the loading-unloading curves when the line is subjected to sudden pull, thereby obtaining maximum energy dissipation over a wide loading range.

2. In an air towing system, a towing device, a towed aircraft, a tow line connecting said device and said craft, said line having the characteristics of high tensile strength, high elasticity, at least ten per cent recoverable elongation from no load to full load; dissipating at least twenty per cent of the energy impressed thereon corresponding to said elongation, in a loading time of one second and unloading time of one second, whereby said line absorbs shock due to sudden pull imposed thereon without substantial rebound.

3. Apparatus according to claim 2 in which the tow line is composed of nylon fibers.

4. In an air launching system, a winch, a glider to be launched, a launching line releasably attached to said glider, adapted to be wound on said winch, power means for winding said launching line on said winch, said launching line having at least ten per cent elongation and twenty per cent hysteresis whereby said line absorbs shock without substantial rebound.

5. Apparatus according to claim 4 in which the launching line is composed of nylon fibers.

6. In an air launching system, a power propelled surface vehicle, a glider to be launched, a launching line releasably attached to said glider at one end and attached to said vehicle at the other, said line having at least ten per cent elongation and twenty per cent hysteresis whereby said line absorbs shock without substantial rebound.

7. Apparatus according to claim 6 in which the launching line is composed of nylon fibers.

8. In an air towing system, a towing device, a

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towed aircraft, a tow line connecting said device and said craft, said line having the characteristics of high tensile strength, high elasticity, at least ten per cent elongation from zero stress to eighty per cent of breaking stress, absorbing at least twenty per cent of the energy impressed thereon corresponding to said elongation, said energy absorption being measured by dividing the area between loading and unloading curves by the total area under the loading curve, said curves being formed by plotting tensional stress as a function of elongation between zero stress and eighty per cent of breaking stress when the line is loaded and unloaded in a time of two seconds.

9. Apparatus according to claim 8 in which the tow line is composed of nylon fibers.

10. A shock absorbing line for towing aircraft which when pre-stretched and loaded to eighty per cent of its breaking strength in one second has an elongation of not less than ten per cent of its original length and when immediately unloaded in one second has an area between the loading and unloading curves of not less than twenty per cent of the area between the loading curve and its projection on the elongation axis.

11. Apparatus according to claim 10 in which the line is composed of nylon fibers.

12. A shock absorbing aerial tow line for launching and towing aircraft in flight constructed of synthetic fibers having the characteristic of dissipating the energy corresponding to at least twenty per cent of their breaking strength, whereby a substantial portion of the energy imparted to said line is dissipated without being transmitted through the line from one craft to another due to sudden changes in velocity of the craft.

13. In a towing system, a towing device, a towed object, and synthetic plastic connecting means between said towing device and said towed object, said connecting means having the characteristic of at least ten per cent inherent elongation whereby at least twenty per cent of the energy imparted to said connecting means is dissipated.

14. Apparatus according to claim 13 in which the connecting means is composed of nylon fibers.

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