Dec. 8, 1964 B. I. LEEFER 3,160,289

MISSILE TRANSPORTER ERECTOR

Filed Feb. 18, 1963

3 Sheets-Sheet 1

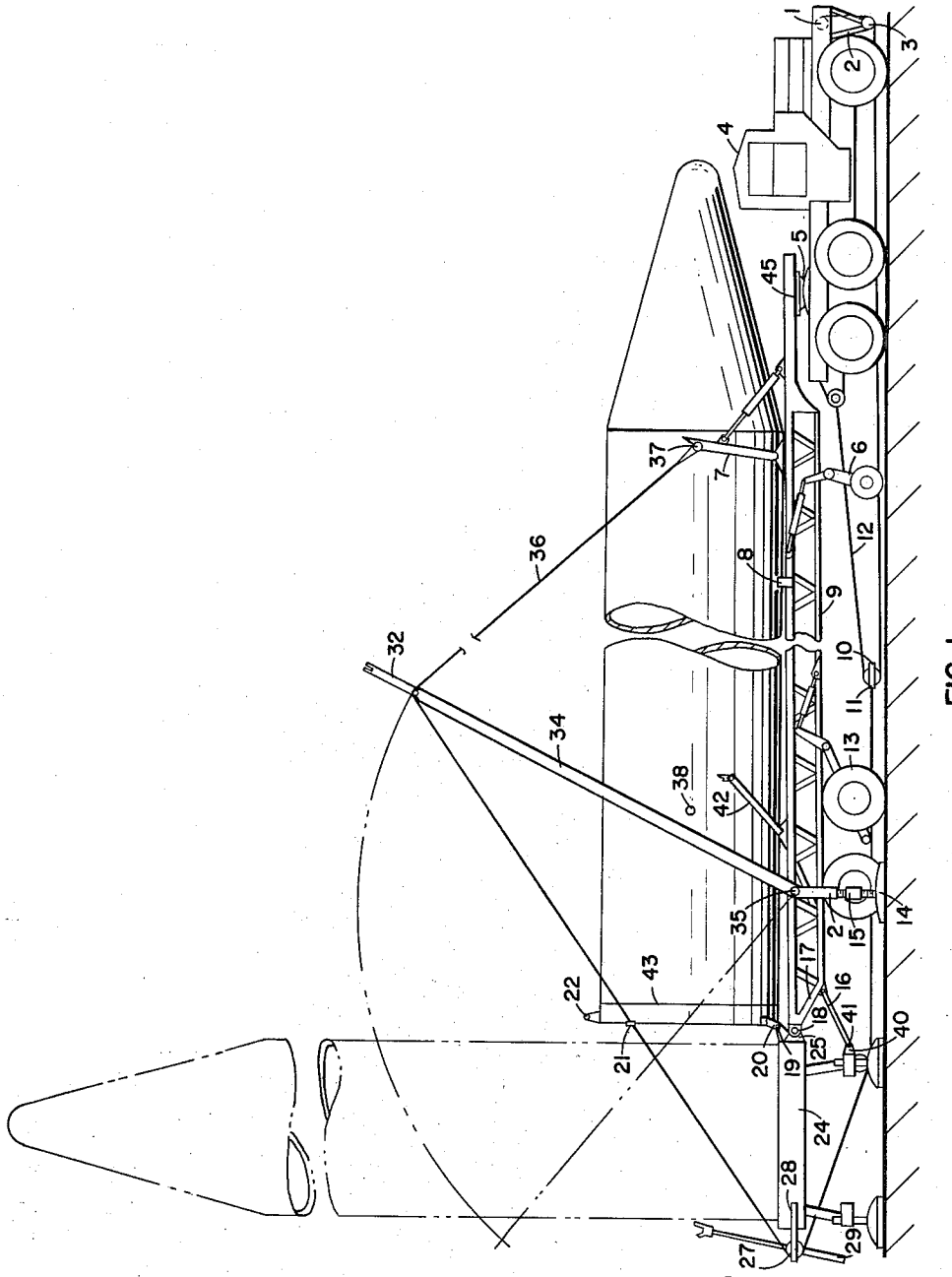


FIG. 1

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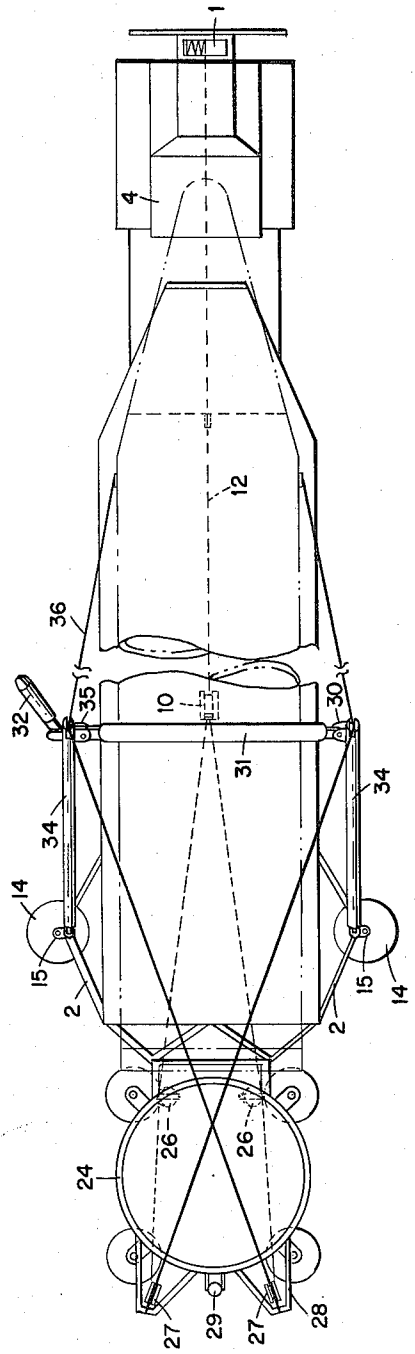


FIG. 2

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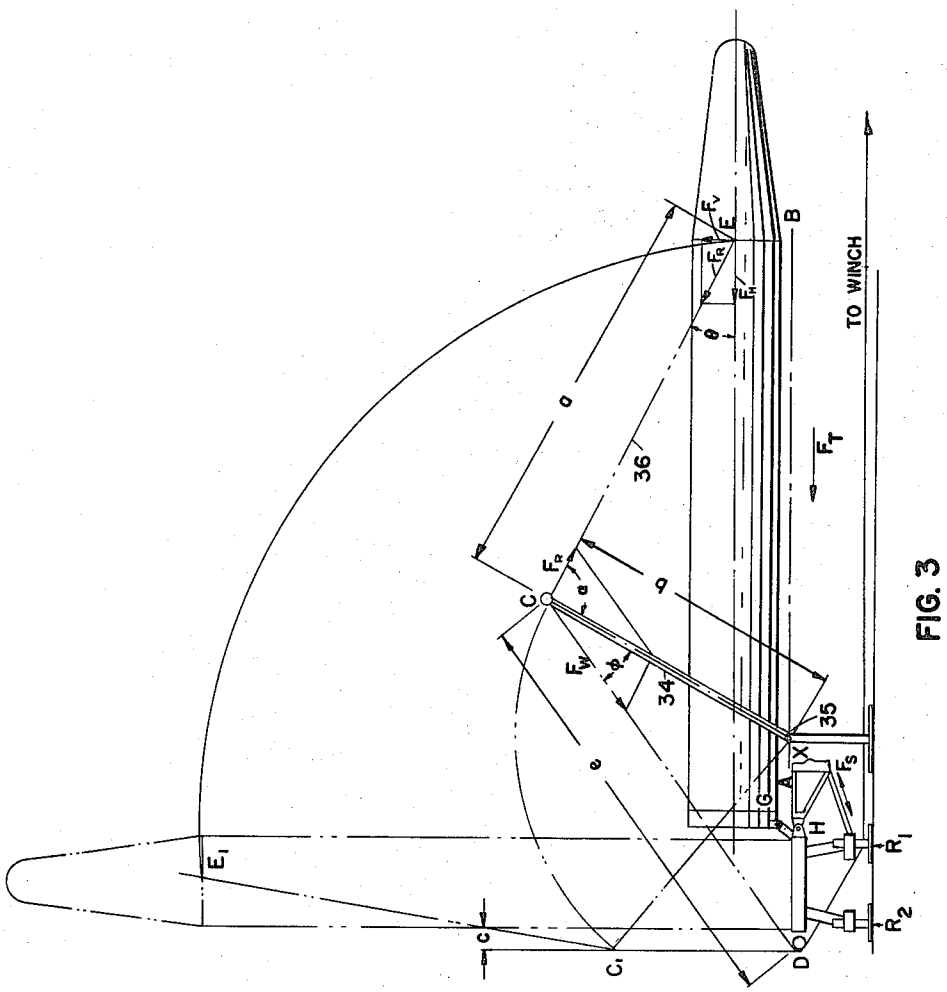


FIG. 3

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MISSILE TRANSPORTER ERECTOR

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6 Claims. (Cl. 214—1)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to a system for transporting and erecting a self-contained lightweight transporter-erector for use with large missiles. In missiles of this type, lifting points or bolts are usually designed and provided on the missile structure.

The system to be described is directly applicable to the JUPITER, a missile developed by the U.S. Army. However, a system based on the same principles could be used for any other missile of that structural type. An extension of the principles involved could be adapted to non-self supporting missiles, if desired, by applying the erecting forces to a frame-like structure capable of withstanding the loads. The frame, together with the missile, could then be erected, and the frame lowered after being disengaged from the missile.

In addition, although the JUPITER system herein described employs a separate launcher, a system could easily be used where the launcher is an integral part of the transporter-erector. Actually, when this JUPITER system is rigged for erecting, the transporter and launcher are connected in such a manner that they are, for all purposes, a single mechanical and structural entity. The system described is adaptable to, and designed around, existing equipment now in use, using standard Army equipment insofar as practical, and requiring a minimum of modification of that equipment.

In the past, it has been necessary to utilize a great deal of equipment for the erection of large missiles. For example, a separate winch truck which carried a vast assortment of frames, cables, fittings and accessories was formerly required to raise a missle to a launching position. Of course, a great deal of time and manpower is required to erect a missile when utilizing this conventional type erector system.

One object of this system is to provide a highly mobile missile transporting device.

Another object is to provide a self-contained erection system which will operate rapidly and with a minimum of manpower.

Still another object is to provide an erector system which is capable of raising a large missile with a minimum sized power unit.

The system to be described eliminates the winch truck and its equipment and reduces the manpower and set-up time to a very small fraction of that now required. It utilizes a tractor and a trailer, with a small amount of additional equipment and minor changes to existing equipment, as the erecting medium. There are no extraneous vehicles needed for the erection of the missile since the tractor and trailer are required at the firing site.

This system can easily erect a missile in 15 minutes from the time of arrivel at the site, using four men, with practically no handwork, against a minimum time of 45 minutes, for the previous system, which required a small crane as well as the use of about 10 men and much labor.

The foregoing and other objects and advantages of the present invention will become more fully apparent from the following detailed description of the exemplifying embodying apparatus shown in the accompanying drawings in which:

FIGURE 1 is an elevation of the system used to erect the missile;

FIGURE 2 is a plan view of the system in the same position as indicated in FIGURE 1; and

FIGURE 3 is a view similar to that of FIGURE 1 but illustrating force diagrams of the lifting apparatus.

Referring now to FIGURES 1 and 2, the missile is carried on a transporter which includes a tractor 4 and a trailer 9. Tractor 4 represents the automotive unit and source of power while trailer 9 supports the missile. A pair of rear steering wheels 13 are controllable from a station at the rear (not shown). A retractable jack 6, located near the forward portion of the trailer, is utilized for initial raising of trailer 9 relative to the tractor. Provision is made for two heavy adjustable struts 16, one on each side and at the rear of the transporter. An adjustable support arm 7 is mounted on each side of the forward portion of trailer 9. These support arms engage erecting bolts 37 which are attached to the forward portion of the missile. A support arm 42 is mounted on each side of the rear portion of trailer 9 for engagement with missile bolts 38. The adjustable arms can be operated together, or individually, as a forward set or a rear set to raise or lower the end portions of the missile as desired. Wheels 13 are individually or simultaneously adjustable, to give rotational adjustment to the transporter so that it can be leveled transversely. Jack 6 is the same, except that it need not be synchronized with the rear wheels. In addition, the transporter is equipped with a pair of removable and hinged outriggers 14 which contain jacks 15. The outriggers can be folded flat against the sides of the transporter for transporting where clearances permit, or they may be removed completely and carried elsewhere where road or railway clearances do not permit the additional width. On top of the outrigger-jack combination are hinged a pair of tubular columns 34, which are pivoted at 35. A pair of saddles 8 at the forward end of the trailer support the columns when the transporter erector is traveling. A cross bar 31 (see FIGURE 2) is hinged at the top of one column 34 and engages a remotely releasable latch at the top end of the column 34 on the opposite side of the trailer, The bar has an arm 32 for raising and lowering it from a station on the ground. The bar may be carried extended collinearly with one of the columns, or can be removed for storage elsewhere.

Before initiating erection the nose of the missile must be raised to a predetermined height above the trailer so as to lighten the initial load on the erecting system. This height is attained by raising arms 7 to their uppermost position, and obtaining the rest of the height with jack 6 before inserting adapter 5. Another solution would be to mount 5th wheel 45 on a jack arrangement, so that the transporter could be raised while remaining connected to it.

Tractor 4 provides motive power for towing trailer and missile, and power for operating the winch during erection. A pivoted sheave 3 mounted on the tractor can be folded up for travel. Sheave 3 serves to guide winch cable 12 under the tractor and transporter.

Launch pad 24 is provided with a hydraulic snubber assembly 29 which controls the missile erection rate after the missile center of gravity passes over the hinge point. The launch pad is also provided with two removable brackets 28 and attendant swivel snatch blocks 27. Two snatch blocks 26 (FIGURE 2) are connected to the forward legs of launch pad 24 for guiding the lift cables.

To provide a rigid pivot assembly, an auxiliary ring 43 is equipped with hinges 20 which mate with hinges provided on the launch pad. Hooks 21 are mounted on either side of ring 43 to keep V-sling 36 clear of accessories and to assist in the initial column lift. Snubber lug

22 is mounted on the auxiliary ring for engagement with the hydraulic snubber assembly.

During erection the launch pad would be emplaced before connection with the trailer assembly. When the pad is emplaced the transporter is backed to the pad, with the rear wheels steered and controlled at the rear station (not shown). The adjustable missile support arms 7 and 42 are then actuated to raise the missile to its maximum height. The transporter is guided to engage the hinges 20 for insertion of hinge pins 19. The rear portion of the trailer can then be lowered to engage bumper connection plates 25 for insertion of pins 18. The adjustable struts 16 are lowered and adjusted to enable them to be hooked to pad eyes 40 with pins 41. The jacks 15 are then lowered to contact the ground firmly. The rear missile support arms 42 can be disengaged at this time if desired. It should be noted that the lower the missile nose, the greater the erecting loads imposed initially.

Prior to this time, folding bracket assembly 2 with its pivoted sheave 3 have been swung into operating position and winch cable 12 rigged as shown.

When the winch is started columns 34 rise together with cross bar 31 extended from one of them. When the tops of the columns are above the top of the missile the cross bar is dropped and latched in the other column.

At this point, the system is ready for final erection in one or two minutes, and may serve as a standby.

When the center of gravity of the missile passes over pivot 19 the snubber 29 engages lug 22 and permits ring 43 to descend gradually to its final position on the pad. Slings 36 are then used to return the columns to their cradles with the winch paying out and restraining the columns. The transporter is then disconnected and removed thus completing the erection.

The design of the erection equipment components, in order to be most efficient, economical, and lightweight, should proceed in a particular fashion, hereinafter described.

Referring now to FIGURE 3, the location of E, the missile erecting point, is fixed and determined by the design of the missile. The sheave at D is also fixed within fairly close limits by the launcher configuration and should be as far to the rear as practical. The location of pivot 35, denoted by X, is important and the object of most of the calculations. Its position largely determines the magnitude of the erecting forces required.

The first determination is to establish the vertical hoisting force F_V required to erect the missile. This is done by taking moments about the hinge point of the missile at G considering the weight and center of gravity location of the missile and the position of the erecting point E. Then the limiting load F_H which imposes a compressive stress on the missile is determined. Obviously, the loads on both sides of the missile enter into this figure. Utilizing an appropriate factor of safety for both values, they are resolved to establish the resultant required and permissible force F_R which also determines the angle θ and the line of action of slings 36 which lead to the top of the column 34 at point C. The length a between point E and columns 34 is fixed and does not vary during erection, although the angle θ between the sling and the missile centerline will change during erection.

The exact length a and the length of column 34, the latter of which should be kept to a minimum, is determined as follows: Angle α, in the interest of obtaining the minimum length of 34, is a right angle. Point X, at the lower end of 34, falls on the line AB which is an arbitrary line parallel to the top of the transporter. This line would generally be at about the level of the upper rail of the transporter, and is not too critical.

The position of the erecting point E in the fully erected position E_1 must now be determined. A vertical line is placed a distance c to the left of the left surface of the fully erected missile. The distance c must be no less than that required to allow the crossbar 31 to clear the missile when it is fully erected. Obviously, the length of E_1C_1 is equal to a, regardless of its position. Consequently, the length b of columns 34 is determined to satisfy the condition that the columns be perpendicular to EC with the missile horizontal and reach from X to C_1 with the missile erected. This locates X and gives a definite length to the slings and columns.

All forces and loadings are at a maximum when the missile is horizontal. As the missile rises, these forces decrease because of the change in the angle θ and ϕ, and the reduction in the moment arm of the missile center of gravity about its pivot G. R_1 and R_2 vary in magnitude and direction but can act only in compression between the launcher feet and the ground since they are not staked down. When R_1 and R_2 act as shown, F_S is zero. When R_1 goes to zero and beyond, F_S comes into play putting that number into compression. When R_2 goes to zero and beyond, F_S is reversed putting the member into tension. At least one of R_1 or R_2 will be in compression at all times. They cannot go to zero or try to act in tension simultaneously.

The horizontal component of F_T is taken through H, and resists the horizontal component resulting from F_W around sheave D.

When the center of gravity of the missile passes over G the missile becomes self-erecting and is restrained from falling violently upon the launcher by snubber 29.

The above outlined procedure gives the loadings for minimum sizes of the structural members and wire ropes required, and yields their basic dimensions.

Although the preferred form of the embodying apparatus has been described in considerable detail in fully disclosing a practical application of the invention, it is to be understood that the modified structures shown and various other modifications of the apparatus may be utilized to advantage without departing from the spirit and scope of the invention as defined in the subjoined claims.

The principles of this invention having now been fully explained in connection with the foregoing description of illustrative embodying apparatus, I hereby claim as my invention:

1. A missile transporter erector comprising: a tractor having a winch; a trailer attached thereto; a launching pad attached to the rear of said trailer; a pair of movable columns each having one end pivotally connected to said trailer at a rear portion thereof, the distal end of each of said columns being free to swing in a vertical plane; cable means extending from said winch beneath said tractor and trailer; sling means attached at one end to said cable means; said sling means extending to the rear of said launching pad over said columns and adapted to be attached to the forward portion of a missile.

2. In combination a missile and a transporter erector for said missile, said combination comprising: a tractor; a trailer attached to said tractor; said missile being horizontally positioned upon said trailer and having a base portion, a nose portion and an erector bolt adjacent said nose portion; launch pad means rigidly attached to the rear of said trailer; an auxiliary ring pivotally attached to said launching pad and rigidly attached to the base of said missile; a pair of outriggers, one of said outriggers being mounted on each side of said trailer; a pair of columns, each of said columns having an end thereof attached to each of said outriggers, said columns extending generally upwardly; a winch attached to said tractor; cable means attached to said winch and extending beneath said trailer; sling means attached to said cable means, said sling means extending rearwardly of said launch pad, upwardly to the distal end of said columns and downwardly to the erector bolt of said missile.

3. A device as set forth in claim 2 wherein a cross bar is pivotally attached to the distal end of one of said columns and detachably connected to the distal end of the other of said columns, one end of said cross bar having

an actuating means for raising and lowering of said cross bar.

4. A device as set forth in claim 2 wherein a snubber means is mounted on the transporter erector for controlling the ascent of said missile during the final stages of erection.

5. A device as set forth in claim 2 wherein means are provided for raising or lowering the forward portion of said trailer.

6. A device as set forth in claim 5 wherein means are provided for raising or lowering the rear portion of said trailer.

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