Feb. 25, 1930. H. V. THADEN 1,748,500

MOORING OF AIRSHIPS

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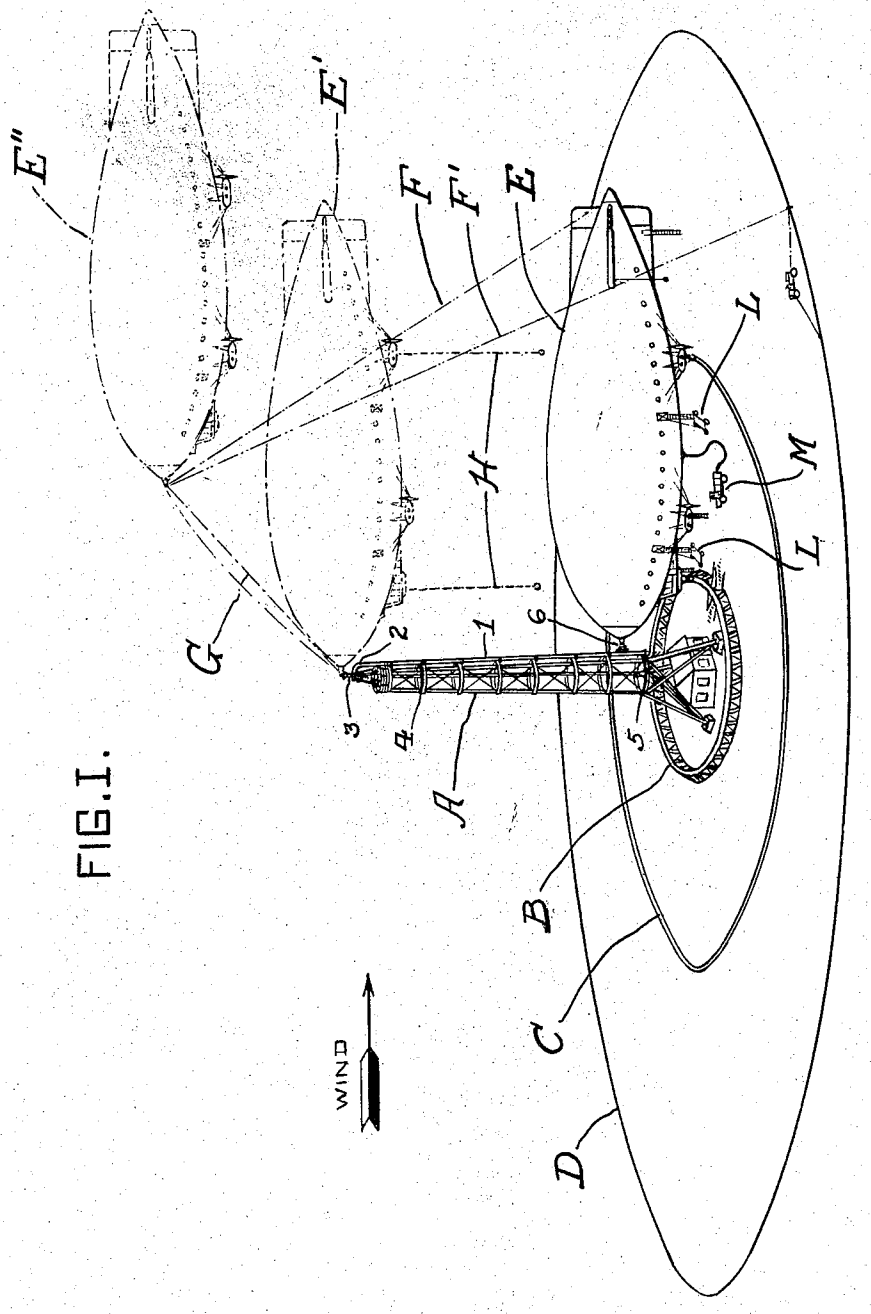


FIG. I.

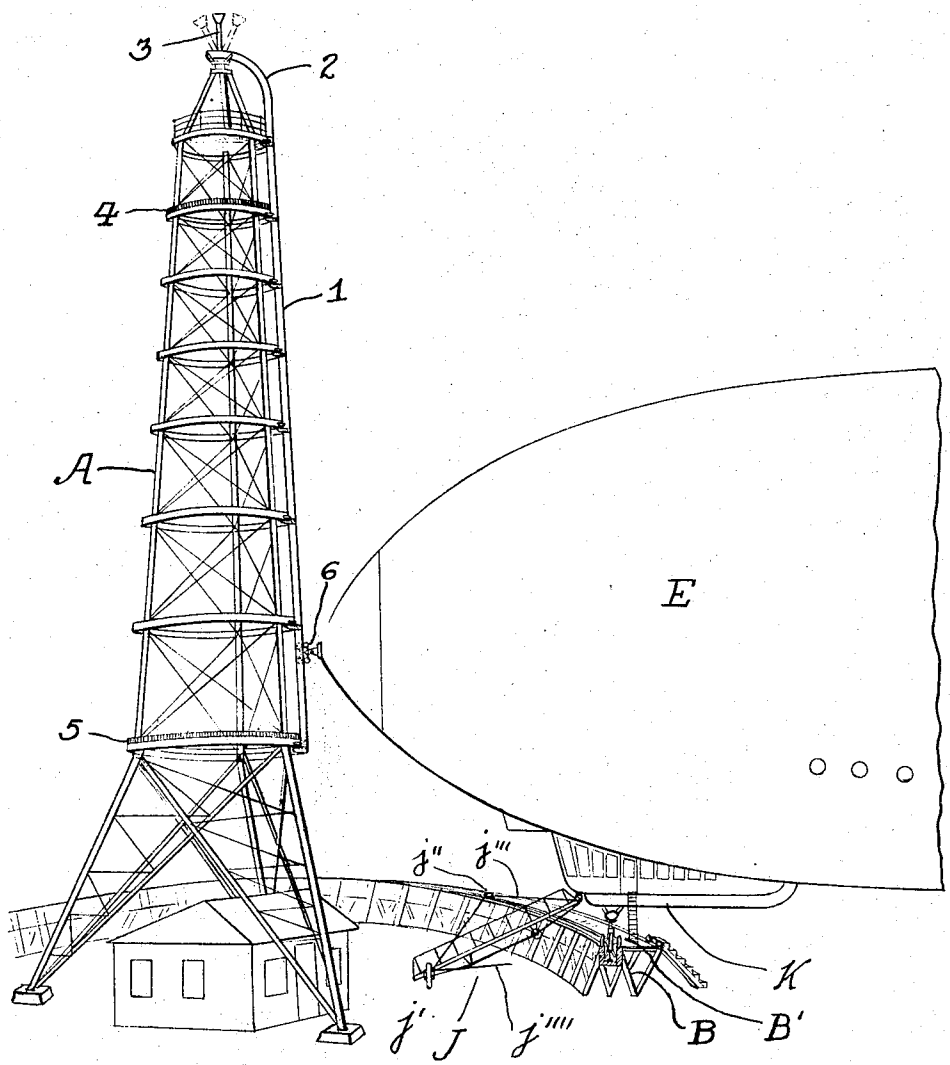
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FIG. II.



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FIG. III.

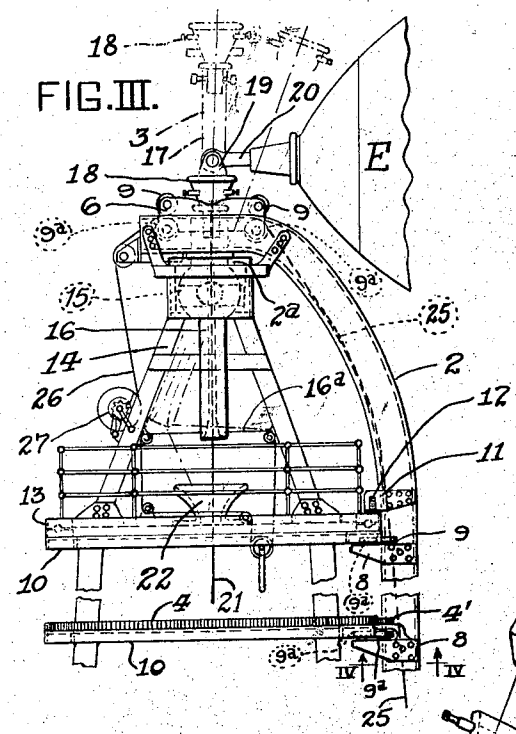


FIG. IV a.

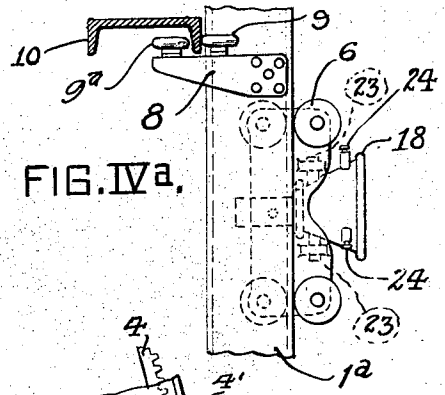
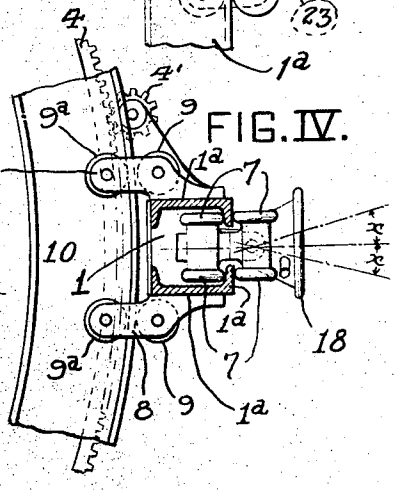


FIG. IV.



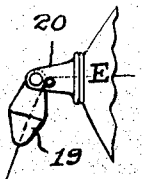


FIG. V.

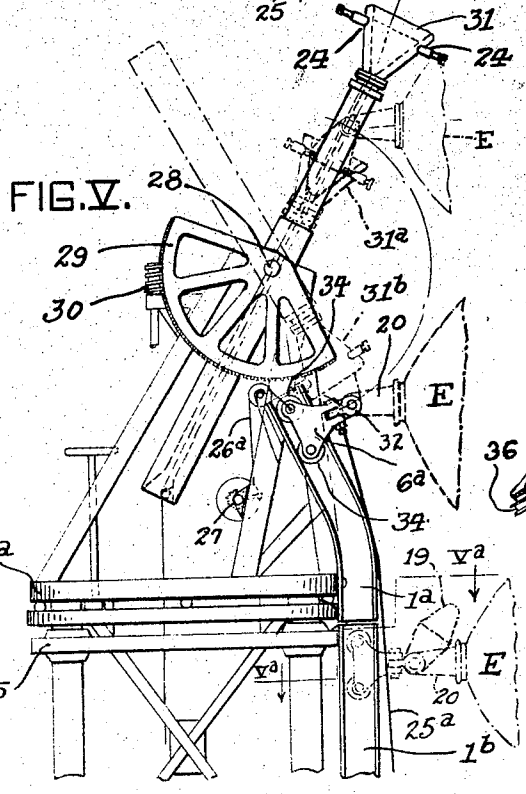
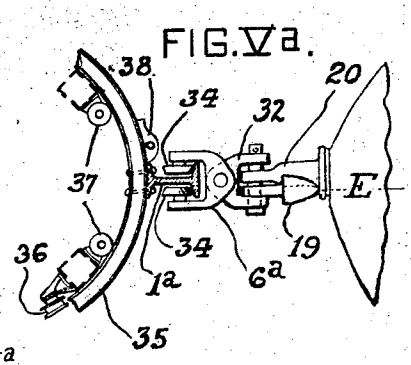


FIG. V a.



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FIG. VI.

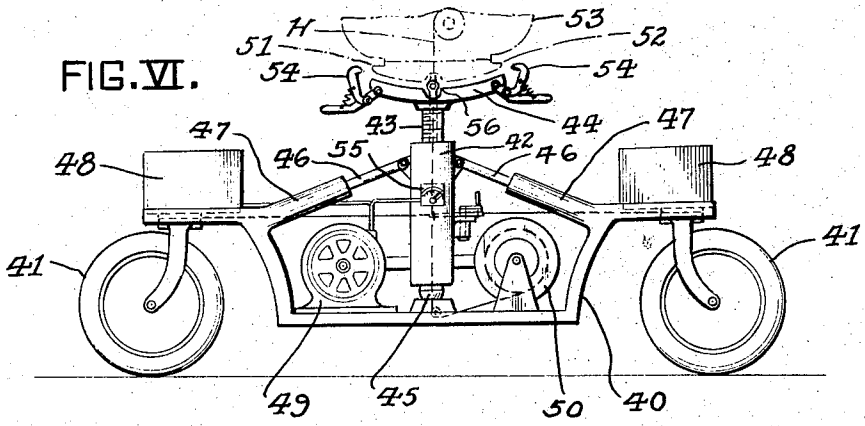


FIG. VI a.

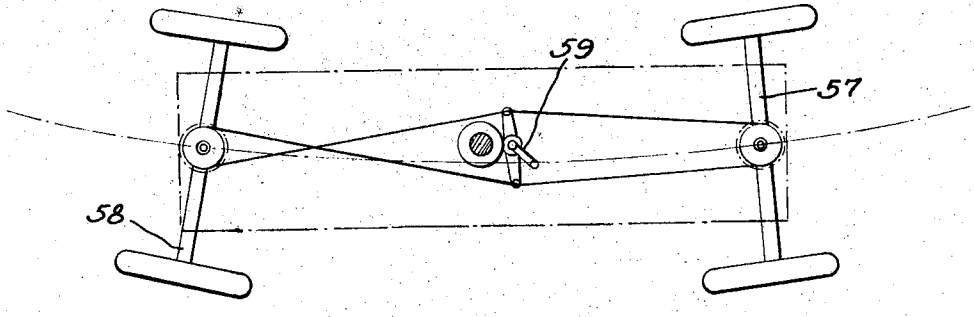


FIG. VII.

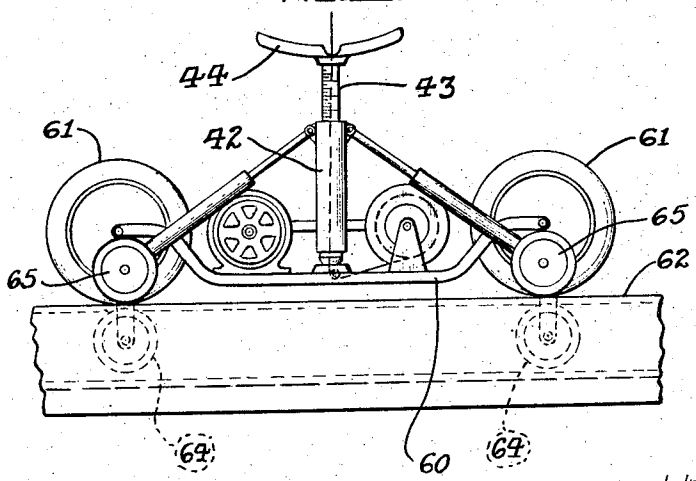
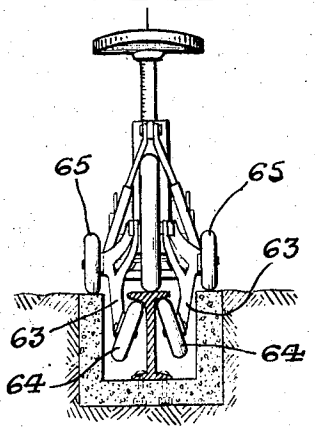


FIG. VII a.



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UNITED STATES PATENT OFFICE

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MOORING OF AIRSHIPS

Application filed January 22, 1924. Serial No. 687,689.

The subject-matter hereof relates to inventions in methods of mooring airships sometimes referred to as dirigibles, and the apparatus or mooring gear for improved methods of mooring. Among the objects are the provision of means to hold an airship at rest for the purpose of unloading and loading, inspection or minor overhauling in ways more convenient, safer and more expeditious than the methods of mooring heretofore known, to accomplish any of these objects with apparatus and equipment better suited to withstand the conditions of strain; and in general to moor ships in a manner that will protect the ship from damage or accident due to ground wind conditions, and in general to greatly facilitate the handling of airships for commercial use, both at landing and for departure from stations or terminals.

Heretofore mooring masts or mooring towers have been built carrying mooring gear adapted to dock the ship by the nose, which involved hoisting supplies or passengers to the mooring mast top with arrangements for access from the tower-head to the nose or bow of the ship. Such methods involve difficulties owing to the sensitive buoyancy of an airship, so that the regulation of trim of the ship is difficult, and air-current conditions add to the troubles of preventing the stern of the ship from rise or fall even though the nose be secured, while the movement of occupants and goods through the bow involves a constant variation in ballast difficult and complicated to compensate when having access only through the bow of the ship. Though it has been suggested to hold down a ship's hull when moored, by the nose, such practice does not prevent the danger of damage or complete ruin of the ship by a down-gust and deficient trim, nor does it facilitate the discharge and charging of the ship, nor provide for all of the necessary manipulation and handling of a ship when moored for the purpose of meeting practical commercial or military conditions. Such prior methods also involve the difficulties of snow loads and to a lesser extent the added weight due to rain and mist, as well as the diurnal variations of atmospheric and heat conditions. All of these and many other short-comings of mooring methods and apparatus have now become well-known, and the inventions herein set forth aim to meet in a practical way all of such difficulties and secure added advantages, which will be evident from the description of construction and operation hereinafter set forth.

The general features of this invention involve a method whereby an airship is brought to a mast preferably at or near its head, secured by mooring gear which permits the mooring block or attachment to be lowered, and with this suitable means whereby the entire ship may be pulled down, under control, with the bow mooring moving down, with the final securing of the ship to the ground by means permitting its rotation around a point at or adjacent its nose or prow where it is most advantageously held against wind pressure, but still permitted to freely swing-by-the-wind. It also involves in conjunction with the mooring system, means for access to any number of desired parts of the ship, and apparatus for the handling of goods, passengers, supplies and ballast from any point throughout the length of the ship, and making available such apparatus as can be readily moved when the ship swings, and also apparatus that will swing automatically with the ship without interrupting or deranging the process of loading or unloading.

The apparatus or gear for the practice of this method, involves a suitable tower amply braced internally when having clear sides from the top to near the bottom. The tower is made of sufficient height to bring a ship to dock by the nose, but the mast or tower-head equipment requires only the gear desirable for pulling in the ship and not apparatus for loading or carrying supplies. From the top of the tower a substantially vertical guide rail is supported on the side of the tower in a way permitting it to freely swing around the tower. At the top this guide is connected with the pull-in gear, such as the usual mooring ram, and has suitable means to then couple the ship to a traveling mooring block engaging the vertical guide and adapted to be pulled down while retaining its engagement

with the mooring guide, thus holding the ship's bow firm in the wind. The vertical guide may be a continuous rail with engaging traveling block or trolley, or may be in sections so that when the ship is moored to the ground the bow coupling block can swing around the mast near its base with only a section of the vertical rail moving. Suitable pull-down and up-pull cable connections control the movement of the bow mooring block, while two or more pull-down cables dropped from the ship are handled by ground trucks or cars which either have sufficient weight or which are restrained on suitable circular rails concentric with the arc of movement of the bow mooring block. Such mooring trucks or cars are arranged with suitable mooring-plates or saddles to engage means preferably below bumper-bags either on the bottom of well trussed parts of the bottom of the ship, or the bottom of gondolas or power cars, but such interconnection between ship and the movable ground gear is made positive to the extent that the ground gear will prevent downward load deflection and also resist the lift strain of the ship, and the apparatus is organized to measure the load as well as the lift. Thus the ground mooring gear provides means for measuring at all times the trim of the ship, while still permitting the ship to swing by the wind while suitably restrained at its nose to resist the head wind.

It will thus be seen that the mooring method and the mooring gear provide for advantageously bringing an airship to ground where it is accessible throughout its length, holding it to the ground to resist wind conditions when moored, measuring and indicating vertical trim at all times, and thereby permitting the adjustment of ballast and the adjustment of load, particularly facilitating the handling of the unloading and loading of passengers and goods involving the varying weight at different parts of the ship, without any danger of vertical swing of the ship's hull around its nose coupling.

While many variations may be made in the apparatus, and modifications in the method of handling, a particular example of the method and examples of the different apparatus and gear are shown in the accompanying drawings, in which:

Fig. I is a perspective view of a mast with three stages of ship approaching mooring and moored.

Fig. II is a side view of mast with adjacent mooring structure and bow of a ship moored thereto.

Fig. III is a side elevation of mooring masthead.

Fig. IV is a fragmentary view in section on line IV—IV of Fig. III.

Fig. IV^a is a fragmentary view in elevation of a point of attachment of the retaining guide with coupling carriage.

Fig. V is an elevation of a modified form of masthead and ram, showing in dotted lines successive positions of coupling and associated parts.

Fig. V^a is a fragmentary horizontal section of ship showing nose coupling attached to the form of pull-down carriage and guide shown in Fig. V.

Fig. VI is a side elevation of a ground truck for pull-down and trim of a weighted castering type.

Fig. VI^a is a diagrammatic plan of a steered ground truck.

Fig. VII is a side elevation of a monorail load and trim truck.

Fig. VII^a is an end elevation of the truck in Fig. VII showing flush rail and adjacent ground support.

In the particular embodiment of the inventions illustrated in the accompanying drawings, the mooring mast A has a circular rail B a short distance from its base. As shown the rail is supported on a trestle, with passages under the rail to permit access to the mast base and a concentric platform B′, which may be in sections and may be movable to rotate around the mast with the ships. Such constructions are accommodated to irregular ground and may be built over buildings, or a flush ground rail may be used. At a larger radius concentric with the mast centre is a path or a flush rail C, and at a still greater radius ground marks D on a circle establish mooring wire positions, and may have a plurality of flush ground pedestals suitably arranged and designated, and with belaying means for cable or snatch-block.

The method of mooring is illustrated by an airship shown dotted in position E″, with yaw lines F—F′ attached to the ship's nose and at points on the ground on the circle D with tower bow line G. In ship position E′, the bow line has hauled in the ship so that the nose has engaged the masthead coupling, and pull-down lines H—H have been lowered. In the final or moored position ship E has been lowered to the ground with its nose coupling hitched to the mast lowering guide, and its pilot car bumper is engaged and made fast to a trim car on the trestle rail, while one or more aft gondolas or cars have registered with and been secured to a ground truck or trucks. The moored ship is then accessible for running up the gangplank J to the cabin K. Wheels j at the ground end allow for lateral movement of the gangplank in order to follow the ship's swing while trolleys j'', one on either side of the gangplank, with outrigger struts j''' and lines j'''' assure proper movement with the ship.

When so moored the entire lower side of the ship becomes accessible for unloading or loading, adjustment of ballast for trim, and any required inspection or overhauling,

which may be accomplished by gangways on low-lying ship hulls, and in any others, even the largest, by ladder trucks L, pumping-wagons M, and any number of drop ladders, bos'n chairs, or lines from hatches, from the cars, or any suitable connections on the ship. All such means of access from the ground to the ship involves apparatus which inherently may swing with the ship or will roll on the ground with the swing of the ship, or is readily mobile to perform its functions at any part of the landing field as the ship swings and without interfering with it.

The essential mooring equipment for such method as above set forth, is shown in the accompanying drawings in a particular embodiment of design and construction in which the tower A is a fixed strong structure with a spreading base, and sufficient strength to withstand the predetermined lateral strain of ship attached at its top. From its top to, say, within twenty-five feet of the bottom a guide-rail 1 is supported to move on an element of the tower around the outside. Near the top of this guide-rail a curved section 2 leads adjacent to the mooring ram 3. Fixed to the tower are gears 4 and 5, while a pinion 4', and a similar one at the bottom, are secured to the vertical lowering rail 1, and these two pinions are interconnected to turn together, so that any swinging of the guide-rail 1 around the tower will be the same at top and bottom, thereby keeping the guide-rail substantially on an element of the tower and assuring its free rotating movement about the mast.

A carriage 6 provides for attachment of the nose-coupling of the ship, and is formed with trolley and guide wheels 7—7 engaging the flanges of the lowering guide channels 1^a—1^a. These channels have brackets 8—8, with wheels 9—9^a engaging a flange of channels, as 10, to hold the guide-rail to the mast or mooring tower and transmit horizontal strain due to tug of the ship, to the mast's fixed structure. Brackets 11 with weight-carrying wheels 12, may be disposed at suitable intervals to carry the weight of the guide-rail and permit free lateral rotation around the mast. The masthead in this form comprises a platform 13 with a structural tripod 14 having a gimbal bearing permitting inclination in all directions, supporting a hydraulic ram cylinder 16, into which a plunger 17 recedes and may be held by a spring but is preferably hydraulically operated by any suitable hydraulic connections and pump mounted on the masthead. The top, curved section 2 of guide-rail 1, has a central bearing 2^a positioning it at the ram but allowing it to rotate about the tripod. The mooring ram plunger 17 has a female coupling 18 detachably secured, and a male coupling block 19 forms the swivel connection with the nose coupling 20 of the ship when the bow line is housed. A central hole extends through the ram plunger 17 registering with a sleeve in the ram cylinder 16, to accommodate the pull-in cable 21 which may pass through a guide 22 in the platform 13, and down to a power house at the bottom of the mast, or the pull-in line may be handled by a winch on the masthead platform. For centering the ram suitable gear 16^a, such as cable, pulleys and compensating means, may be used.

The mooring ram is allowed to swivel to the desired degree during operation, as shown in dotted lines Figs. II and III, and when the nose coupling block 19 is housed in the ram cup 18, the plunger is retrieved, the ram brought into a vertical position, and the cup 18 brought into engagement with the pull-down carriage 6 where suitable pins 23 provide for fixed engagement with carriage 6, whereupon the female coupling 18 is detached from the plunger 17, thereby leaving the ship's nose secured solely to the pull-down carriage 6 when the clamps 24—24 are engaged with the coupling block 19.

The ship so attached is now ready to be lowered, and the nose lowering is accomplished by the haul-down cable 25 attached to the carriage 6 and carried to the bottom of the haul-down rail 1 where it may be operated by a suitable winch, or may be reeved back to the top of the guide-rail 1, and other suitable sheaves may be attached to the other end of the lowering carriage 6, with an intermediate operating winch under proper control. As shown in Fig. III, a haul-up cable 26 is operated by a winch 27 on the masthead.

A modified form of mooring ram and masthead is shown in Figs. V and V^a, in which the mooring ram is mounted on a bearing with pivots 28, to swing through a much larger arc but in one plane. The ram tripod or support and the haul-down rail 1^a are permanently secured together and rotate on top of the mast structure, as on a top ring 13^a, on suitable hold-down bearings. In this form the vertical swing of the mooring ram is controlled by a sector 29 actuated by a worm 30. When the nose coupling of the ship has been secured by the male member 19 and fixed by clamps 24 into the cone 31, the ram is retrieved preferably by hydraulic operation taking the position 31^a. Thereupon the pull-in line is slacked away, and the sector 29 rotated bringing the ram cone into position 31^b and carrying with it the nose coupling 20 so that it registers with a coupling bracket 32 attached to the carriage 6^a. The nose fitting 20 is then coupled to the bracket 32, and male coupling 19 released from ram cone 31, and the cable may be disconnected leaving the ship riding at the haul-down carriage 6^a. This carriage is at the top end of a haul-down rail 1^a, which in

this form is an I-beam secured rigidly to the masthead swiveling platform and its superstructure supporting the ram. When so designed the rail top is preferably a short separate section rigidly secured and moving with the top turret, to be brought into register with the lower portion of the rail when desired. Guide wheels 34—34 permit free movement of the carriage 6^a down and up the guide-rail 1^a. A haul-down wire 25^a is provided with an up-haul cable 26^a with suitable winch. Below the swiveling masthead the I-beam or rail 1^a terminates adjacent to a further section of haul-down rail 1^b which is rigidly attached to a circular ring 35 carried on wheels 36—37, which permit the rail supporting frame 35 to completely rotate around the mast structure with the rail sections. At one point in the ring 35 is a pin block 38 adapted to receive a pin from the adjacent end of the guide-rail I-beam or its support, so that adjacent sections of the pull-down rail may be locked in registered position. Below the pull-down rail section 1^b are a plurality of similar sections, each section being supported by rigid attachment to circular rings each mounted on bearings permitting free rotation about the tower. This permits the swiveling of the masthead mooring gear alone, during the approach of the ship, and only requires the registration of the pull-down guide-rail sections when actually lowering or raising the ship. When in ground-moored position the ship's nose coupling and pull-down carriage 6^a will engage only one section of the rail, depending upon the size of the ship and the height of the nose above the ground,—and when remaining moored to the ground only one section of retaining rail need be free to revolve about the mast, thereby leaving all the upper sections and the masthead entirely free and stationary. Under these conditions it may in emergency be even possible to operate the masthead mooring ram and gear to haul in a second ship to the same mast for temporary mooring at the masthead, without interfering with the movable nose mooring or the ship on the ground.

Besides the nose mooring, when the ship is brought to ground it is secured at two or more points to ground gear, one form of which is shown in Fig. VI consisting of a heavy ground truck with chassis 40 having four caster wheels 41, permitting the truck to move in any direction, and a plunger cylinder 42 containing springs supporting a plunger rod 43 carrying a mooring-plate 44. The plunger is supported on a universal joint 45 at the bottom and lateral cushioning rods 46 held in sleeves 47 against springs tending to keep the cylinder 42 in the central position, but permitting a reasonable amount of movement in all directions to accommodate lateral strain of the ship in any direction and also to provide for the chassis movement during the castering action of the wheels. On this truck are mounted preferably heavy batteries 48, driving a motor 49 to operate a winch 50, while the winch wire is reeved through the bottom bearing of the plunger 42 and through the plunger rod 43 to the top surface of the mooring-plate 44, so that its free end may be coupled with a pull-down line H lowered from a ship's gondola and preferably through an opening in a ship's mooring-plate 51 shown dotted, with ledges 52 below a buffer-bag 53, so arranged that quick-release clamps, such as shown at 54, will engage a permanent part of the ship and hold it when moored securely to the mooring-plate 44 of the ground truck. Such toggle clamps 54 provide for a tight hold and a quick-release by the operator on the truck throwing out the lower arm as shown, or effected by remote control.

A pressure indicator 55 is located in conjunction with the plunger 42 and registers both the downward pressure on the mooring-plate, as well as the lift of the ship straining at the couplings attaching it to the mooring-plate. The lift or load where the truck is attached to the ship is thereby accurately measured at all times, and any suitable means for communication and indication may be carried from each truck to the control station for coordinate action by the landing officer. The ram bar 43 may also be calibrated so that the amplitude of up-and-down movement against the springs in the ram indicates or checks the readings by instrument.

Mooring trucks may have liberal chassis and equipment weight, with winch and motor equipment and even driving equipment, and may also be weighted down additionally when required, by water or other ballast. When the ship is landed and the mooring-plate clamps set, the pull-down wire on the truck may be disconnected at a suitably provided coupling 56 available through a recess in the landing plate, and thereafter the ship will be free for release held solely by the clamps 54.

Instead of castering wheels, suitable four-wheel steering construction may be used where the operation of the truck for maneuvering about the field if desired, in which case axles 57—58 are controlled by suitable steering gear diagrammatically shown for illustration, with a single central steering means in proximity to the control means for actuating the winch so that the apparatus becomes a one-man truck for several functions. The chassis will, furthermore, be provided with suitable anchor cables and guide sheaves so that the winch may be used for pulling in the yaw wires, as shown in Fig. 1. Such heavy trucks will be used on a smooth mooring field surface accurately leveled so that the swing of the ship will keep the several moor-

ing cars in the same plane and prevent undue load strains on the ship.

Where it is convenient to use a circular mooring rail concentric with the tower, such may be on a trestle as when close to the tower, but if at a considerable radius unless run over buildings or irregular terrain, it is preferably a depressed rail flush with a mooring field so as to leave the field useful for landing of other aircraft and for ground transport. Such a mooring truck is shown in Figs. VII and VII[a], in which the chassis 60, carries a landing-plate with plunger and ram, spring-held in horizontal directions and articulated for lateral swing to a limited degree, and with motor and winch, all generally as in the landing truck above described. In such monorail landing car one track wheels 61—61 ride on the top of I-beam 62 and brackets 63—63 carrying under-running wheels 64—64 engaging the underside of the top flanges of the I-beam 62, in order to resist the up-thrust due to the lift of the ship. Lateral wheels 65—65 ride on smooth lateral ways which are flush with the ground in the case of the depressed track, but which may be enlarged so as to engage any suitable lateral ways to act as outriggers and properly support the mooring car laterally. With such rail mooring cars the lift is resisted by the rail and weighting is not necessary as in the case of the mooring truck.

To more fully appreciate the importance of the inventions herein set forth, it will be understood that when an airship is moored to the top of a mooring mast in the now conventional way, it is subject to the alternating sunshine and shade as in partly cloudy weather, the differences in day and night temperature and the effect of rain. Also where there is liability of snow, the excessive weight, particularly wet snow near the ground, makes it very difficult, if not impossible to cope with the question of trimming the ship to prevent it from canting up at a dangerous angle or dropping down and striking the ground. In emergency it even becomes necessary with such bow mooring at a mast-head, to cast off and seek safe altitudes or air conditions, but with unpreparedness of machinery or crew, quite likely when moored at station, departure would be impractical and might mean loss of the ship. Furthermore, when moored in the now conventional way at the top of a mast, as, for example, one hundred feet high, all cargo, supplies and passengers are carried to the top of the mast, which at best is slow for handling and requires very skillful and careful management in order to keep the ship in trim even under most favorable conditions.

By my method, contact with the approaching ship is made with the mast wire or haul-in cable, and preferably two yaw wires. The ground handling of the iaw wires is by apparatus such as winch trucks, which later serve as ground trucks for "floating" ground mooring points of the ship. Having brought the ship's nose to the mast, the particular and important advantages of my method involve the apparatus suitable to connect the ship to a vertically movable restraining block or carriage adapted to permit the nose mooring point to be moved down with the entire ship, being drawn down or lowered until predetermined points on the bottom of the ship are accessible from the ground, and then securing the ship to the ground by apparatus hereinbefore described in detail.

The hauling-down wires are coupled with lines from mooring cars or trucks below readily "floated" into proper position, and suitably adjusting ballast and up-strain keeps the pull wires taut, thereby preventing danger from vertical gusts during the mooring operation. As soon as the bottom mooring engages the ground truck saddles and is made secure, quick connections for water ballast can be made to pump from a roving tank car on the ground, and immediately adjust for loading on the ground trucks, so that with the nose moored to a swiveling mast rail or guide rail section, the only unrestrained movement is the swing with the wind, and the floating ground trucks and mast connection accommodate the swing perfectly, and without interference with the further operations, which are the essential reasons for the mooring of the ship, namely, the disembarking of goods or passengers and replenishing of supplies and ballast, and then reloading.

The power cars will then be accessible from the ground by ladders or portable steps adapted to move with the swing of the ship or readily maneuver. All of the direct connections with the ground may be conveniently removed clear of the swing of the ship when the latter remains at its mooring during the night or at times when heavy or varying winds make it unnecessary or undesirable to load or unload. The rear control, such as the elevators and rudders and their gear, will be within convenient reach by ladders or hoists, and with staging for overhauling and repair or inspection. For trim control ballast can be fed through the nose or bow, thus concentrating all the operations for equilibrium close to the mast where supplies and power house provide for handling with the minimum of movement even though the wind should box the compass.

Thus when the ship has been brought to the mast, and lowered to the ground, with the ground mooring gear secured, ballast connection can be immediately made and served under direction of the land officer as the passengers disembark, and accurately regulated to compensate for the lift while unloading goods, and also later on when loading or shipping supplies. Throughout these opera-

tions suitable telephone connection with each ground mooring gear supplies the important, if not the essential information regarding the lift or load and the exact degree at each ground contact of the ship, and ballast or trimming of cargo and supplies can be regulated to meet conditions in order to avoid any undue vertical strains in the ship's structure. Being close to the ground it will, of course, provide for most convenient emergency addition of buoyant gas, or replenishing loss, and in any event providing for the conditions desired for the next flight.

When leaving such a mooring station, the ground mooring apparatus with its load and lift measuring and indicating devices, makes it possible to trim ship to a level keel, or any degree of excess of bow or stern lift found desirable at the moment for departure. After removal of all gangways, steps, ladders or ballast connection, the quick-release devices on the ground mooring gear can be thrown out instantly, thereby releasing the ship from all connection except the nose coupling. The nose coupling carriage is then run up the mast with the rise of the ship clear of the ground to any desired degree, and at or near the top of the mast, the nose coupling is released, and the ship floats free with the wind, or in still weather rises clear of the mast and is ready for its flight. Some of the propellers can be backed in still weather to put a strain on the mast connection, to still further assure its riding clear of the mast. Under certain conditions, the pull-down ropes from the ground trucks may be payed out to ease the ship to its elevated position, still keeping control for horizontal trim, and with suitable means of regulation for measuring the pull, and the ends of the wires then released, and the cables pulled back into the ship and stowed ready for the next landing.

The ground mooring equipment may be varied in character and extent, and many modifications both in character and the number of ground gear may be used, and their exact design will embody in the details such automotive construction and hoist and indicating and communication apparatus, as are best suited for the purpose. It is therefore not necessary to show and describe many details of construction, but the illustrations of the ground mooring truck and monorail car, shown for example, will suffice to make clear the important features of invention, and indicate any development and improvement in apparatus which may be desired for any particular station equipment. It will be noted, however, that the ground mooring truck with its equipment will have ample weight to resist the proportion of lift that may be concentrated at its point of attachment to the ship, and the structure will be of ample strength to carry the maximum load. The cushioning springs will have a suitable amplitude of motion both under load and lift and will be properly calibrated, and the load or pull-measuring apparatus will be embodied with suitable indicators, in a reliable way and properly protected for the character of service, and will have such lighting and telephone communication connections as to meet all the requirements, as heretofore indicated, or that may prove advantageous for the best handling of the mooring and releasing, as well as the holding of the ship at station for any short or long period. In the case of the monorail truck weight is not necessary, and the chassis or running gear will be designed to float freely and permit the obvious lateral strain to be suitably accommodated, but without affecting the proper registering of the load and lift of the ship at the point of attachment. Quick-release dogs or other suitable devices will be embodied. The landing-plates on the ground mooring gear will preferably be standardized, and a standard form of bottom engaging plate will be adopted for all ships, so they may at any time use this method of mooring at any station or airport. While the weight on the smooth surface trucks may be designed to meet the conditions of the smallest ships, additional weights may be added so that the same trucks can be used when larger ships are berthed. Should it be found desirable to restrain the ship when moored from rolling without removing ballast to provide suitable lift, cables may be run from the hull sides to points on the circle of motion of the ground truck, and secured to movable carriages spaced from the trim truck by suitable outriggers; or with some constructions of ships vertical struts may be run from the ground or ground cars to the hull bilges, or any suitable engaging means on one side, or both, if desired.

In certain cases modified ground gear will prove of great importance. This is in the use of airships in cold weather or for northern exploration or service. Where freezing weather is encountered the ground trucks may be equipped with runners or placed on skids readily movable on the ice or on the snow. In such case, a circular track or tracks on the mooring field may be flooded and frozen, thereby providing an admirable floating support for the ground gear, and particularly because such an ice track can be most readily provided with a perfectly level surface. Where mooring is needed only under such climatic conditions, the sled form of mooring gear and ice rings may be provided in a much simplified form, and easily and quickly made with economy.

The mast-head constructions heretofore described in detail may be modified in many ways. The mooring ram per se, may be used in the form now generally known, and likewise the known forms of couplings may serve in the combination of other structural fea-

tures involved in these inventions. It is preferred, however, to use a ram under hydraulic control, and thereby readily provide for the retrieving of the plunger at will by the attendant, and under perfect control. Such hydraulic manipulation provides sure means of nesting the mooring line cone in its cup and securing the cup to the haul-down car, and thereafter detaching the cup or female member from the ram plunger in the case of the form shown in Fig. III. The same advantages apply to the case of the modified mast-head gear shown in Fig. V for the housing and securing of the cone, and in addition it facilitates the operation of bringing the cone-pin into registry and thereupon linking-up the nose connection with the pull-down car or trolley.

Ample motor equipment may be carried on the mast-head for all the required manipulation of the ram and to operate and control the movement of the pull-down carriage. The swing of the ram to any necessary lateral angle it will be seen is permitted. With all, the only requirements at mast-head are for the coupling and lowering of the ship's nose or bow connection, thereby entirely eliminating the size and strength of mast upper work that would otherwise be necessary in the now common practice of hauling goods, crew and passengers to the top with elevators or hoists, or requiring pipe lines for the feeding of supplies or ballast. For access to the ship's bow, a limited amount of equipment and apparatus may, of course, be embodied as in any of the known forms of design. In any event the mast top or ram swivel to permit the ram to operate in all directions throughout the circle, but a complete gimbaled ram support becomes unnecessary, and a pivot on one horizontal axis simplifies the design in this part, with the complete rotation of the mast top and the adjacent lowering guide rail providing for the necessary movement around the compass.

As it is well understood that airships of the future will be of large and larger sizes, the mooring masts of nearly two hundred feet would have to be built higher for the former methods of mooring, but even large or expanded sizes of masts may be greatly avoided when it becomes only necessary, as in the case of these inventions, to temporarily haul-in to the mast-head, because the danger of rise or fall of the stern will be eliminated as soon as the ship is lowered to earth and secured by the ground mooring equipment.

All of the features herein set forth relating to the method and also to the apparatus shown and described in one form, will, it is understood, be subject to many variations, and particularly in size and detail as well as arrangement.

While many embodiments or adaptations of these inventions might be mentioned, one of particular interest involves the provision for the mooring of airships over buildings. Using this method the trestle B, in any modified form, or girders or trusses may be constructed over buildings thereby leaving the ground area available for other useful purposes. In cities, such rigid rail supports may be constructed over the roofs of existing buildings even of varying heights. Thus a mooring station on buildings would be possible with only sufficient space for the mooring mast and a small adjacent area, while the ground gear for holding the ship down and supporting its load, involving complete control of trim, would be taken care of by two or more circular tracks supported over the buildings and spanning any gaps between or over streets. Adjacent the trestle tracks, platforms, as shown in Fig. I, would provide for handling goods and passengers and accessibility to the ship for station work. Such circular platform may also be supported on tracks to revolve with the ship, keeping passengers or goods always in convenient position for access to the ship, and with frequent steps or other means of access to the movable platform at points around the track, convenient particularly in the case of the smaller radius track close to the mast.

Such an adaptation of the invention would solve the problem of providing an airship station in a most desirable location in cities for commercial purposes, because it provides for the complete support and control of ship at station, thus entirely avoiding the very serious contingency of the ship sinking by the stern, which is the great danger in other methods of mooring to a masthead.

The invention in its many forms provides for the various power equipment and gear for berthing and mooring, being handled at the base, on ground, or on ground tracks, besides facilitating the loading and unloading and the inspection of the entire ship. It makes possible the entire mooring and berthing control of airships being subject to ground command observation, and with ample freedom of movement for personnel, both in the landing as well as departure of ships from station, and all duties required in connection with the ship when at station. Departure from many parts of the ship can be made quickly in emergency, and a crew can be shipped far quicker by boarding at any number of points with the crew each going direct to quarters, instead of as heretofore the restricted boarding by a single bow hatch accessible only by elevator at great height.

Besides the many advantages with respect to the handling of the ship and everything connected with the operation of airships at station, it will be noted that the element of safety to crew as well as passengers, is an outstanding and vital advance in the art.

It will be understood that my invention is

not confined to the particular embodiments herein specifically described or shown in the accompanying drawings, but that various modifications and much engineering detail will be involved in the specific practice of my invention at each station or for stations at various locations and subject to varying conditions, but without departing from the spirit of my invention,—and what I claim and desire to secure by Letters Patent is:

1. A mooring station for airships having a central mast interiorly rigidly braced and without external guy wires, mast-head landing wire and coupling apparatus adapted to swing around the axis of the mast, a vertical restraining guide held a fixed distance from the axis of the mast and cooperating with the mast-head gear and adapted to swing around the outside of the tower with horizontal strain-resisting connections therewith, and a carriage to hold said coupling apparatus against the guide in all positions of elevation.

2. An airship mooring station comprising a rigid mast, ship's bow coupling connections supported on and a fixed distance from the axis of said mast, a rotatable coupling guide-rail secured to the outside of the mast by means permitting it to swing freely around the same with an attached ship, a ground support carriage carried on a circular rail around said mast and a second ground gear having means for attachment to the ship's bottom adapted to swing around the mast, a plurality of means positioned in a circle around said mast at greater radius adapted for attachment of yaw lines, a mobile ground gear having self-contained equipment to manipulate yaw lines or pull-down lines from a ship.

3. A mooring mast comprising an internally trussed structure from its top to near its bottom, a vertical guide secured a fixed distance from the axis of the mast by means permitting it to rotate around the outside of the mast, a mooring line coupling engaging by slidable means said guide and means to control vertical movement thereof, and a swiveling mast-head-cable-handling apparatus cooperating with the upper end of the guide.

4. Mooring equipment for an airship comprising a structure having a mooring block or coupling supported to freely swing around said structure adapted for controlled vertical movement and resisting the horizontal pull of the ship at all points of elevation to hold said mooring block at fixed radial distances from the axis of the mast, a freely mobile ground truck unconstrained to move in all directions adapted to engage the bottom of the ship, to be secured thereto and embodying means to resist and measure load or lift of said ship in a vertical direction.

5. Ground gear for airship mooring comprising a bow mooring pivotal connection, means to restrain the ship's position a predetermined distance from the ground and permit free swinging of the ship around said bow mooring, a gangplank or the like having a ground support permitting free swinging around said bow mooring, and detachable connections with the ship to move the gangplank or the like with the swing of the ship.

6. Ground gear for airship mooring comprising a bow mooring pivotal connection, means to restrain the ship's position a predetermined distance from the ground and permit free swinging of the ship around said bow mooring, means providing access for passengers and goods from the ground to the ship having ground support for the weight of said means and permitting free floating with the ship around the bow mooring.

7. Mooring equipment for airships comprising a mooring ram having a mooring line plunger and coupling means, hydraulic equipment to house said plunger, means for rotating the ram in a vertical plane around a horizontal axis, a vertical coupling guide supported in fixed relation to said ram, and means for alternately shifting the ship coupling from the ram to the vertical guide for independent manipulation of the coupling either in the ram or for movement on the guide.

8. A mooring station for airships comprising a mooring mast, means for bow connection of a ship adapted to be lowered and raised on said mast and revolve about the same, a level circular rail about the axis of said mast having fixed supports and a platform adjacent to and concentric with said rail, means for access thereto from surrounding structures or ground and providing accessibility to adjacent parts of a ship moored to said rail.

9. A mooring mast for airships comprising a rigid tower, a rigid rail held by strain-resisting means a fixed distance from the axis of the tower by supports permitting it to swing completely around the tower, a mooring carriage adapted to slide the full length vertically on said rail without interference with the rail supports, an inwardly curved upper portion to said rail intersecting the axis of the mast, whereby the mooring carriage may slide into axial position at the top for the reception of the ship's nose coupling and may slide down the rail with the ship's nose coupling axis substantially horizontal.

In testimony whereof, I have signed my name to this application this 16 day of January, 1924.

HERBERT V. THADEN.