

March 11, 1958

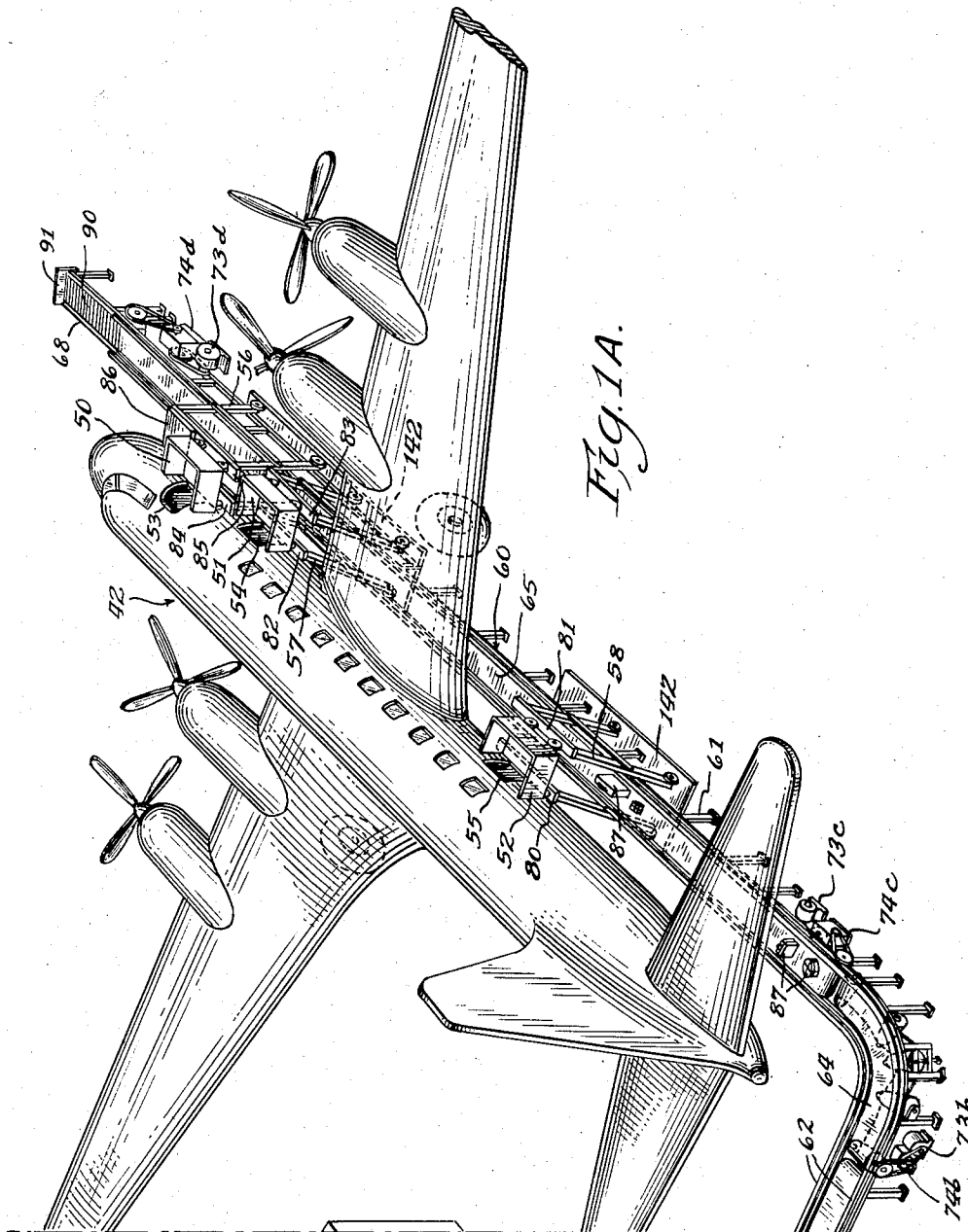
E. J. RENNER ET AL

2,826,319

AIR CARGO HANDLING APPARATUS

Filed Oct. 10, 1955

19 Sheets-Sheet 1



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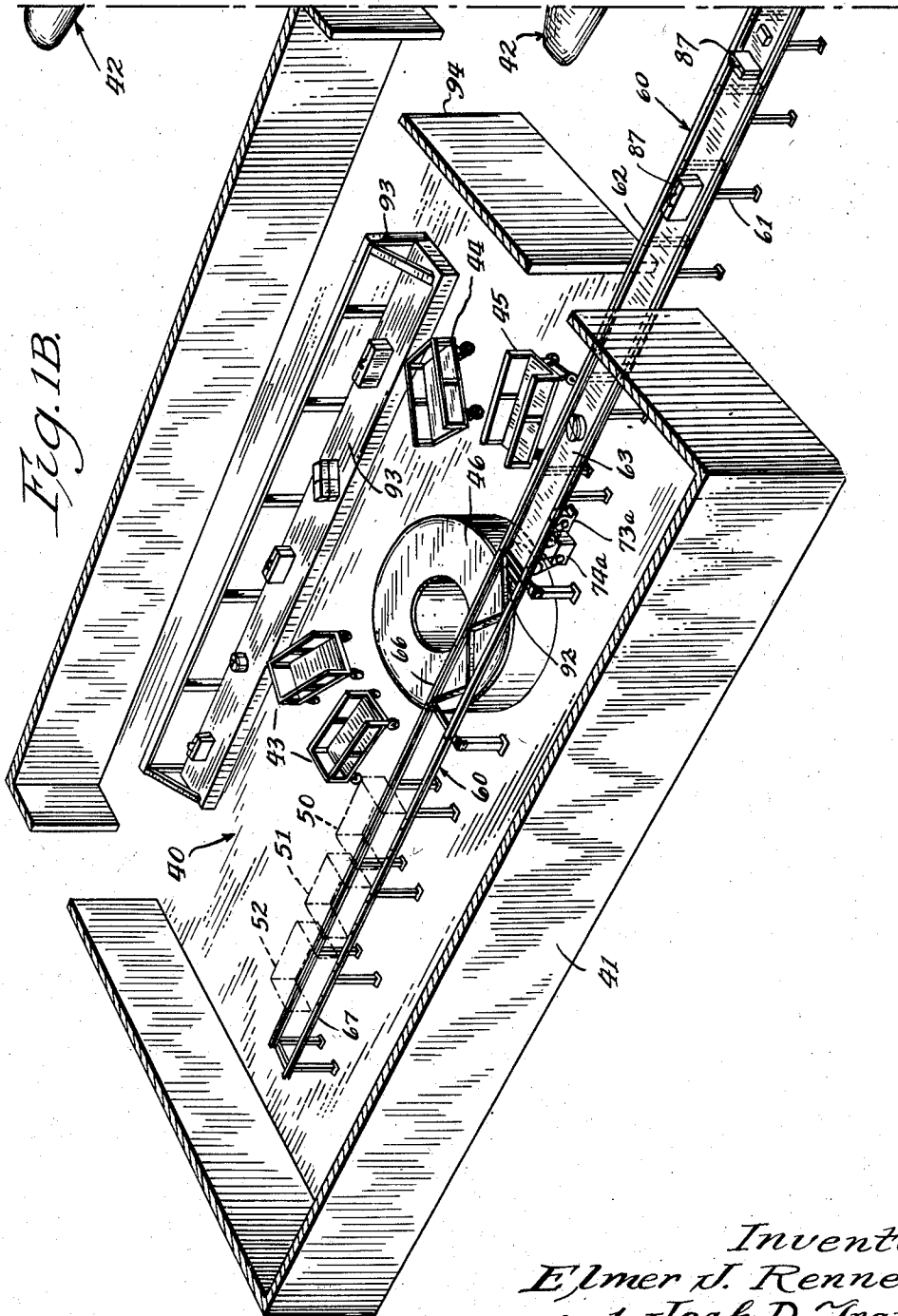
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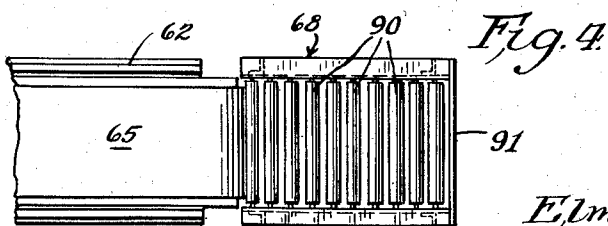
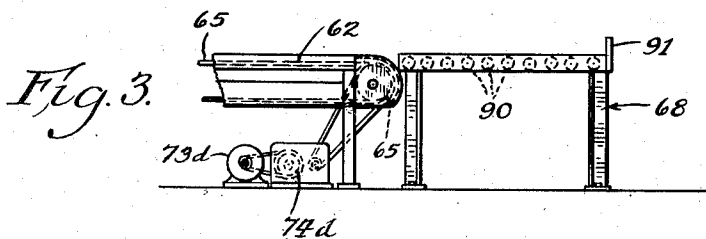
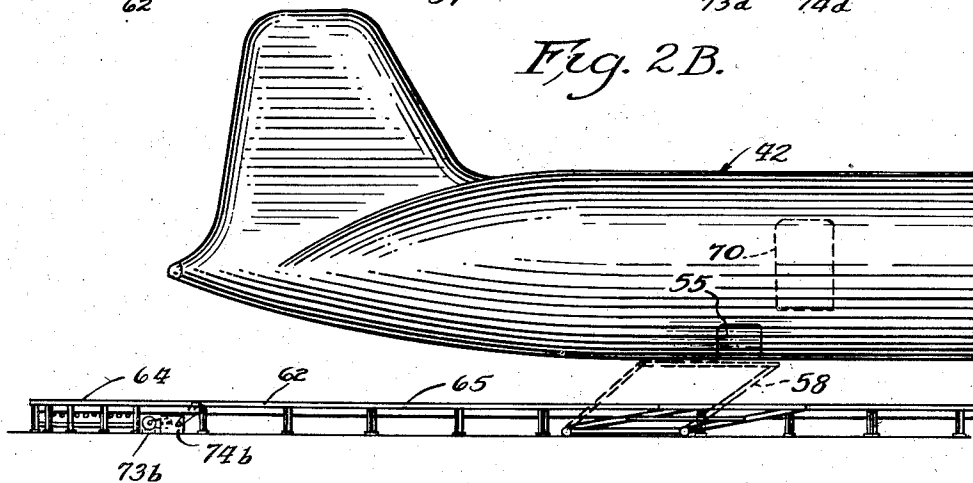
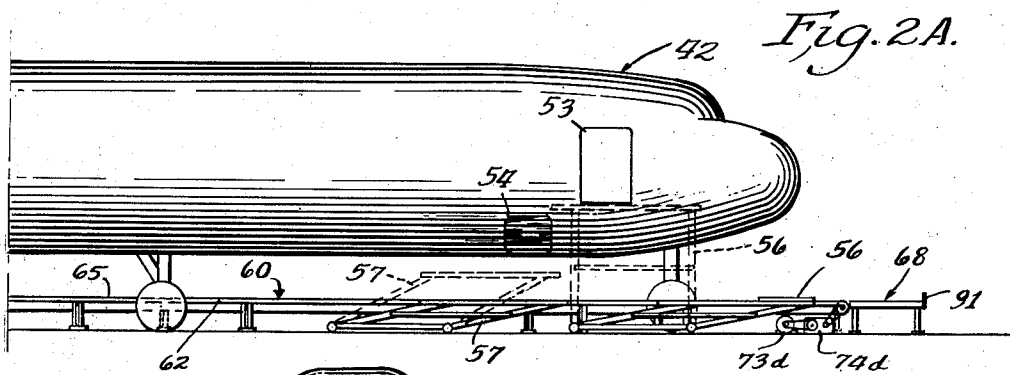
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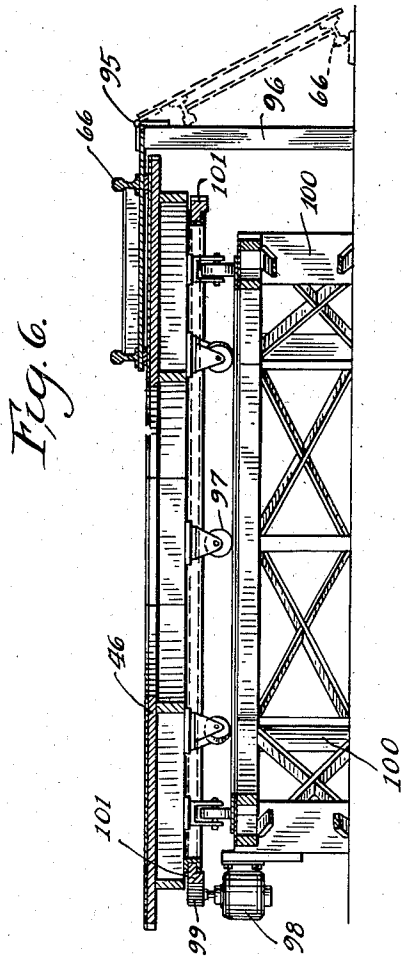


Fig. 6.

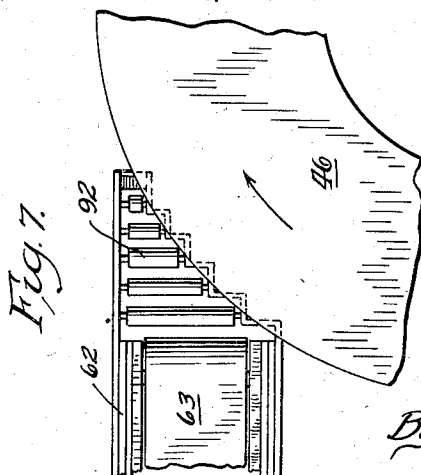


Fig. 7.

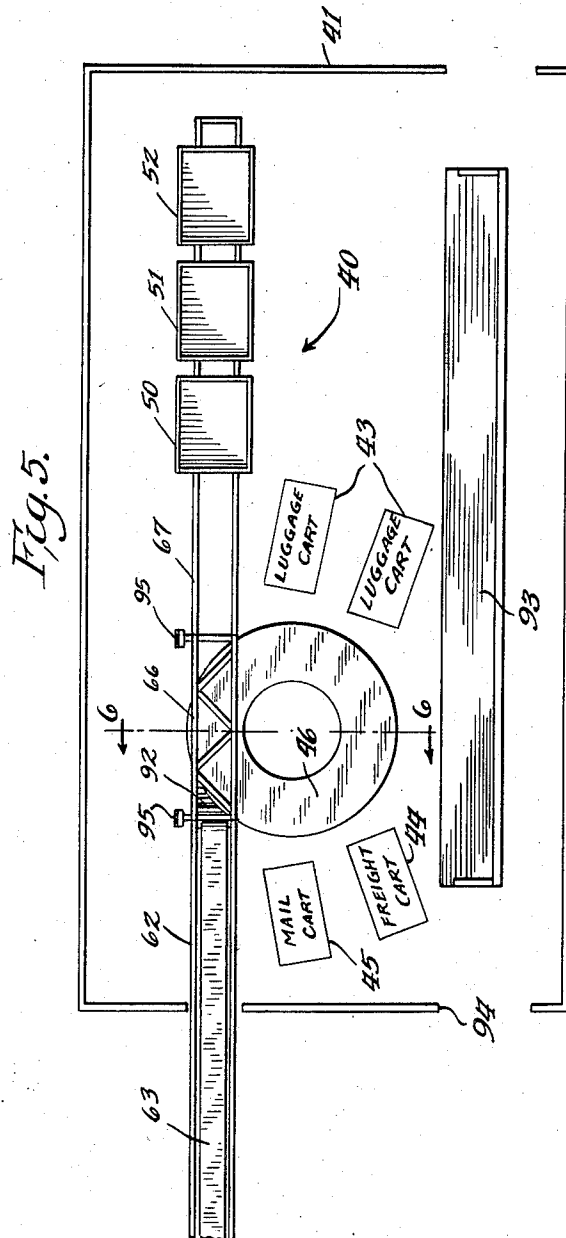


Fig. 5.

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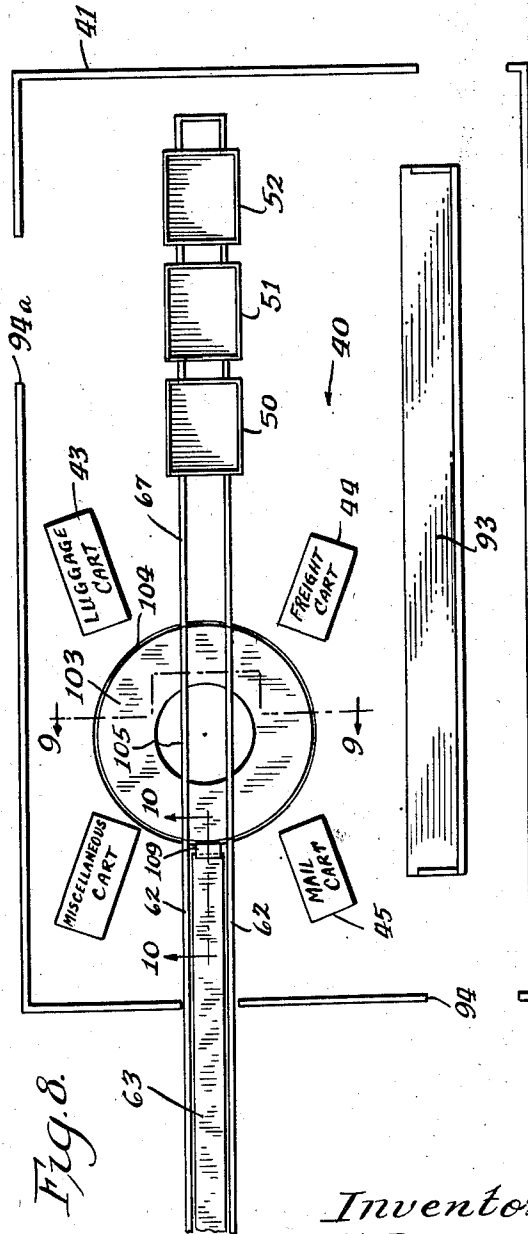
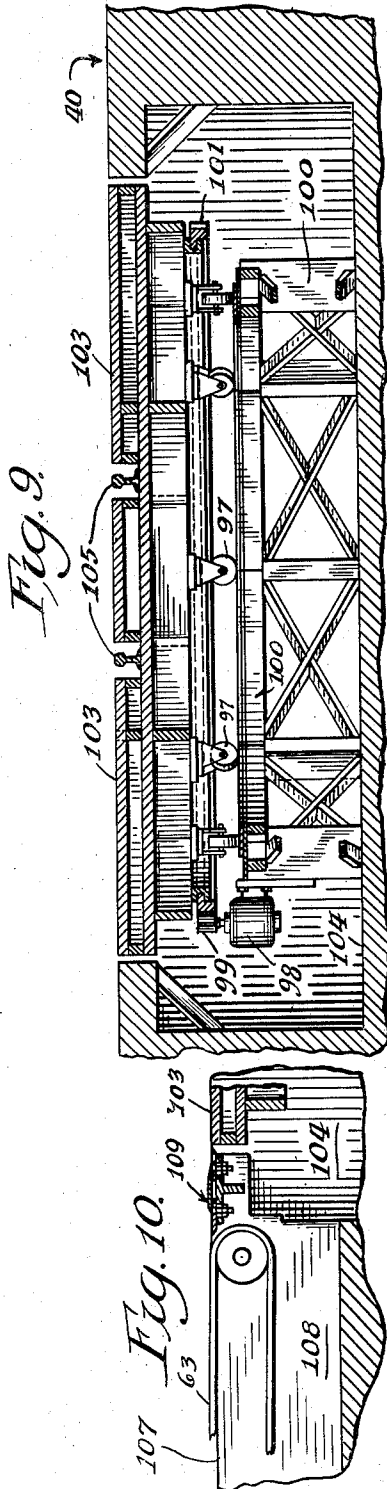
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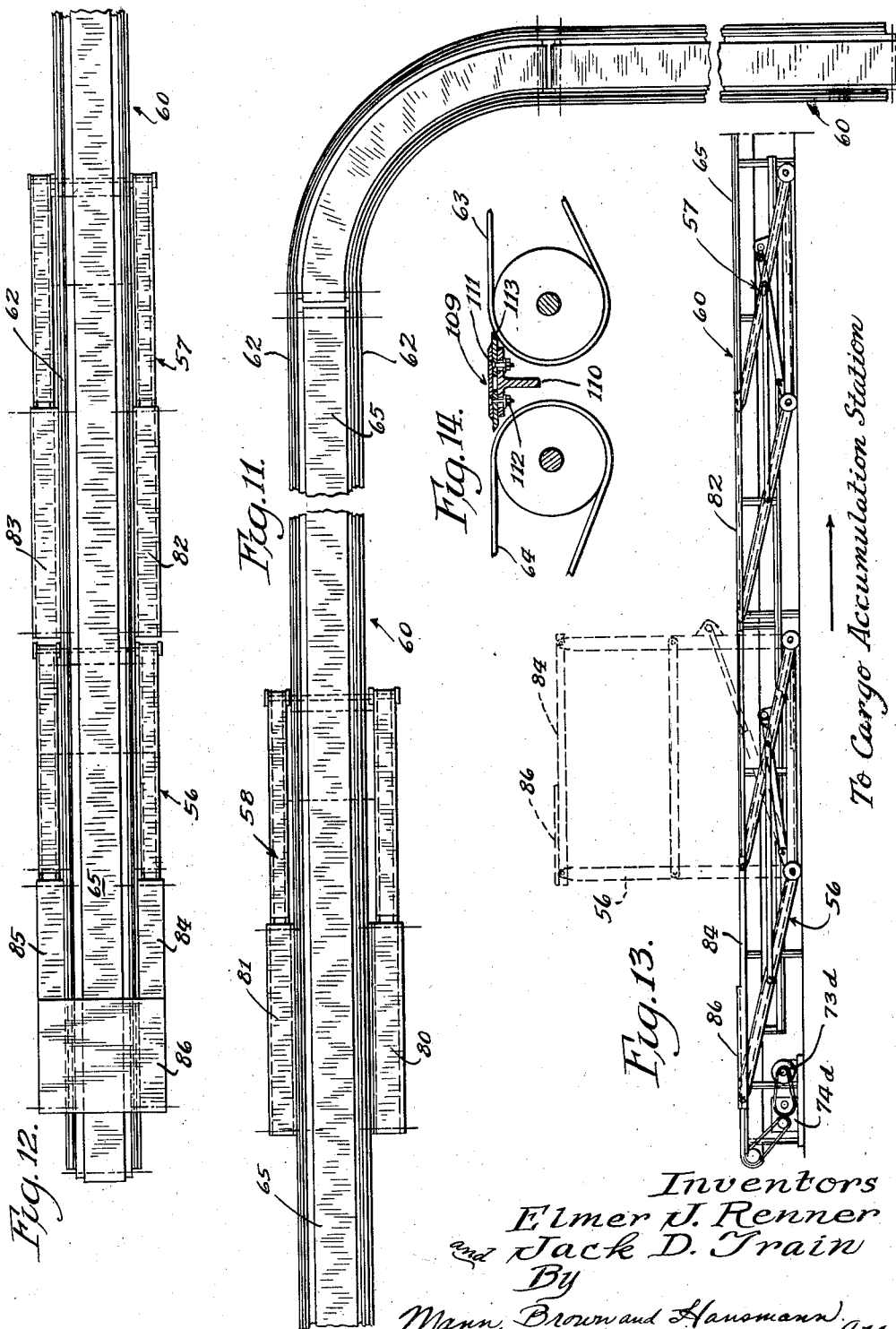
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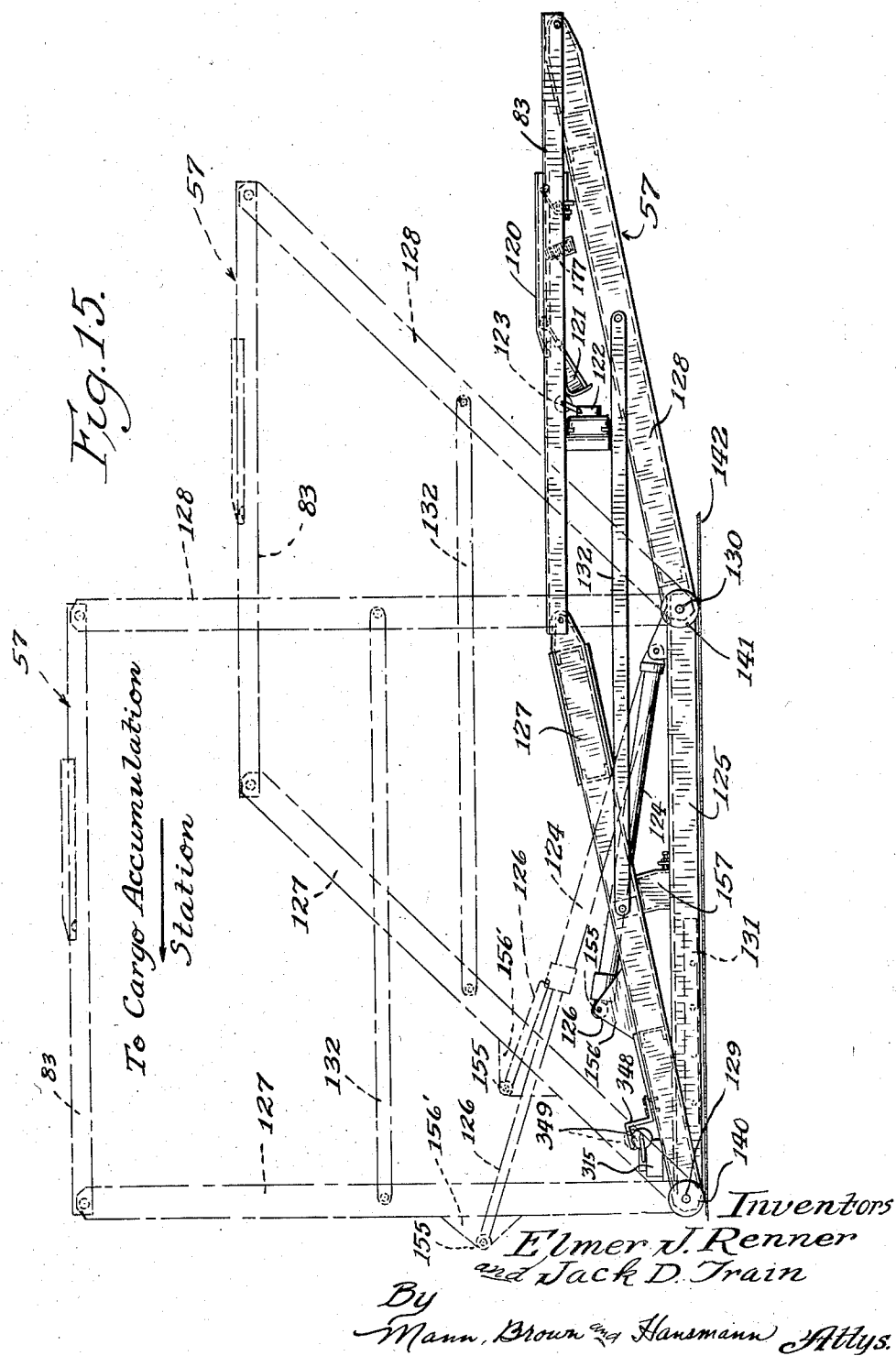
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Fig. 16.

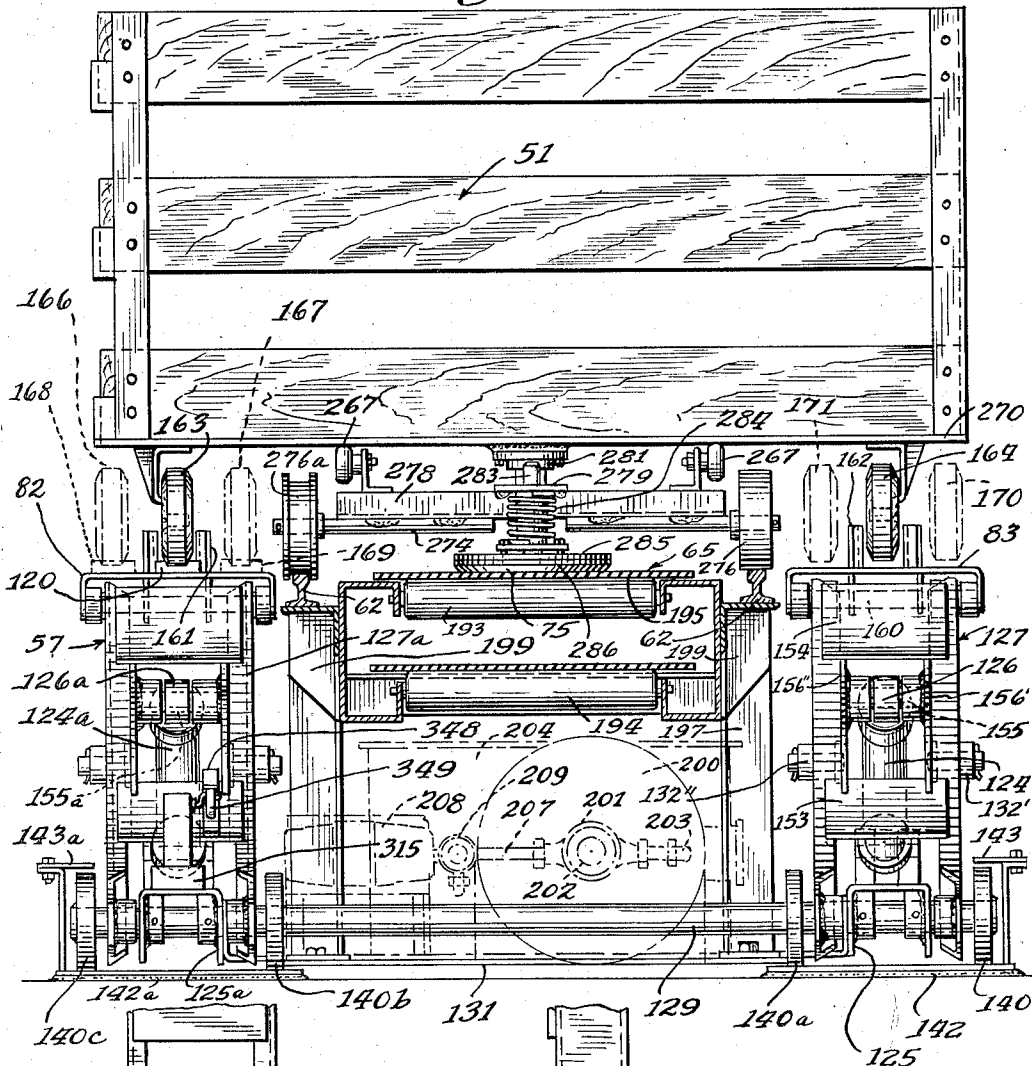


Fig. 17.

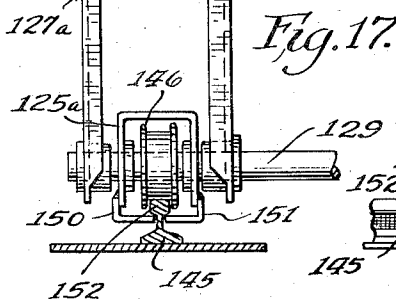
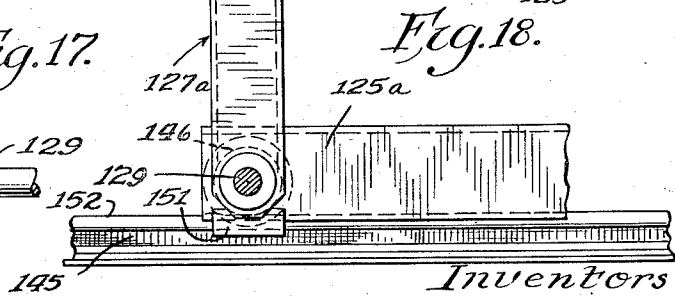


Fig. 18.



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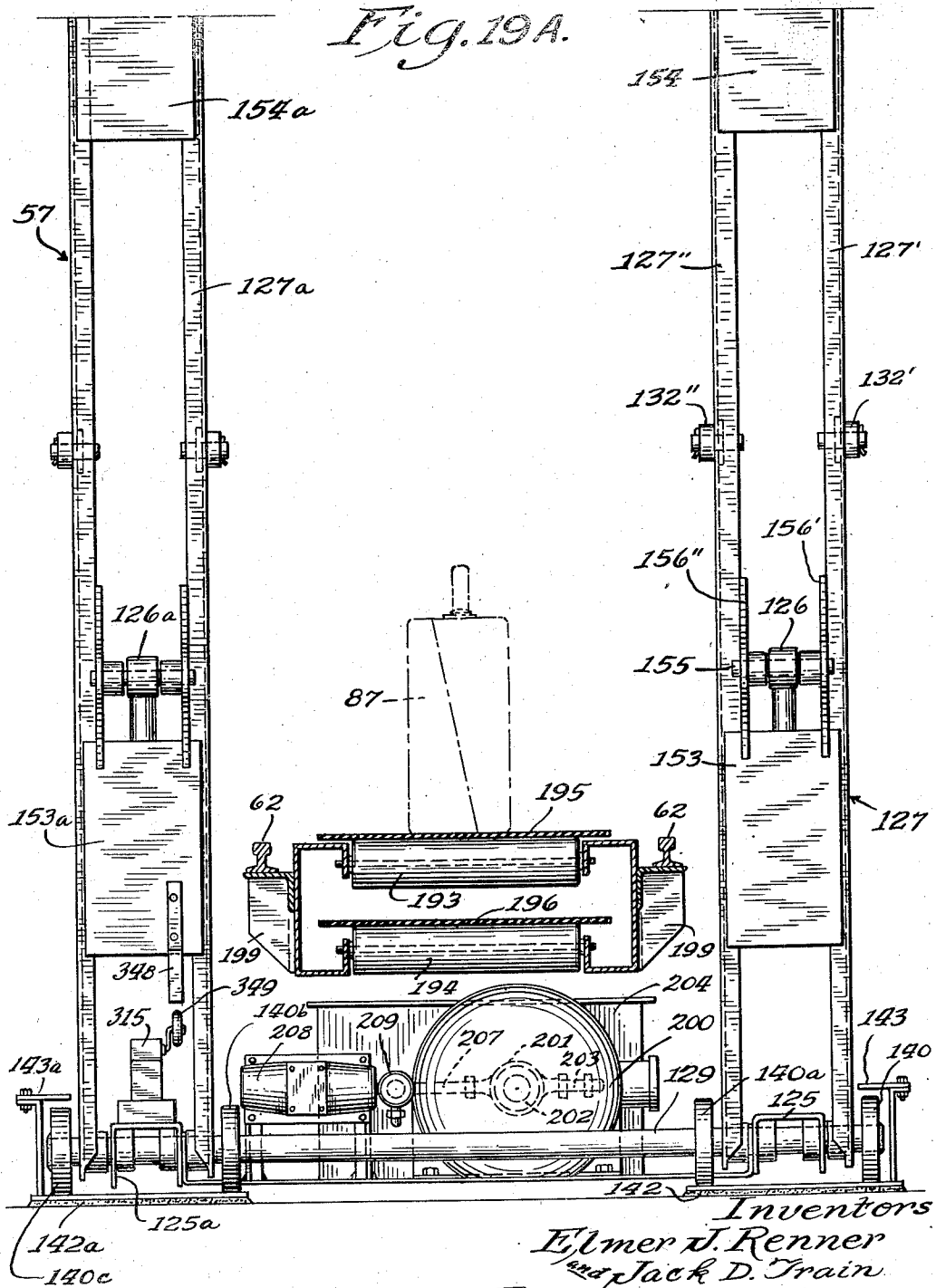
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Fig. 19 B.

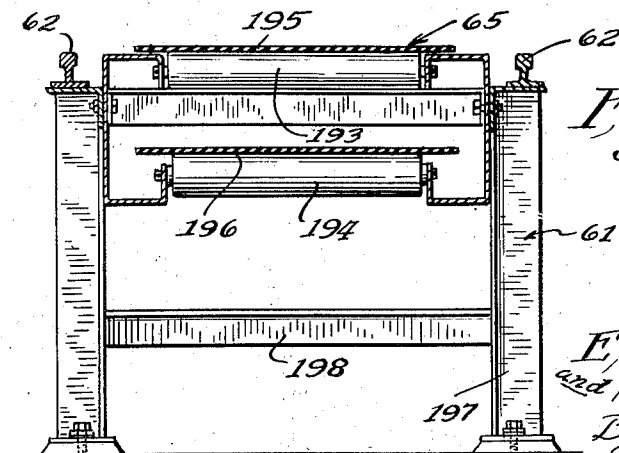
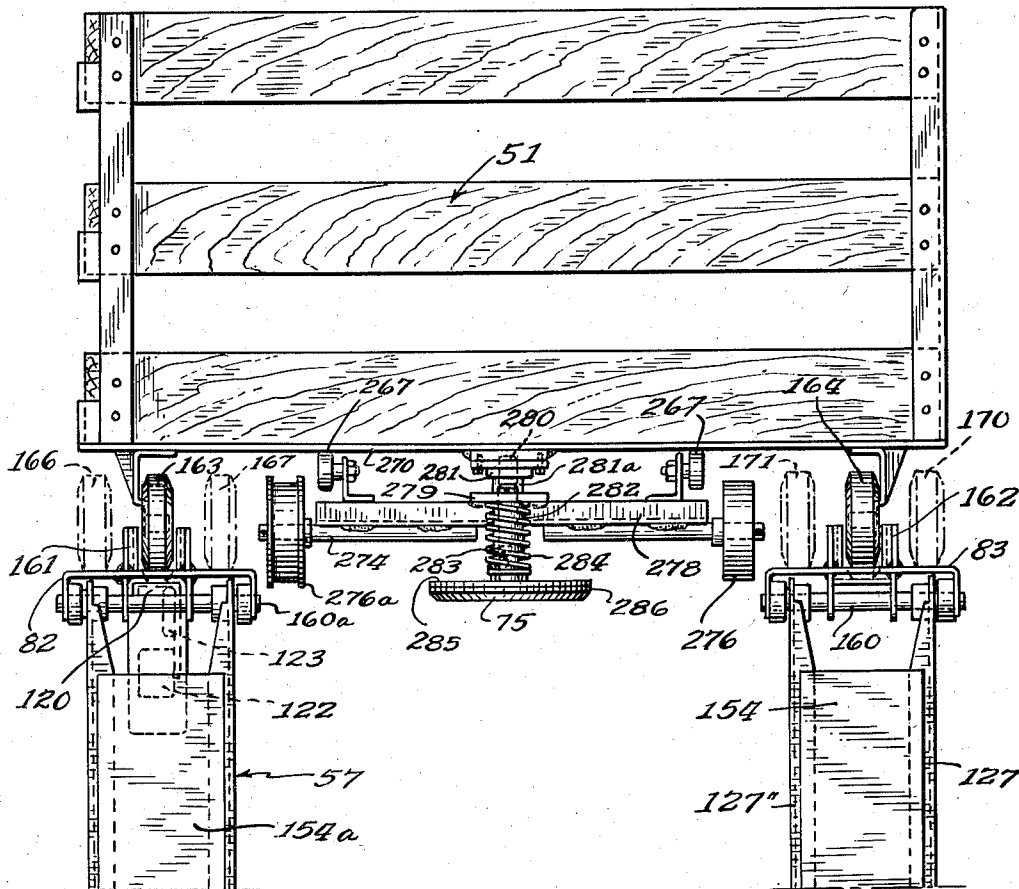


Fig. 20.

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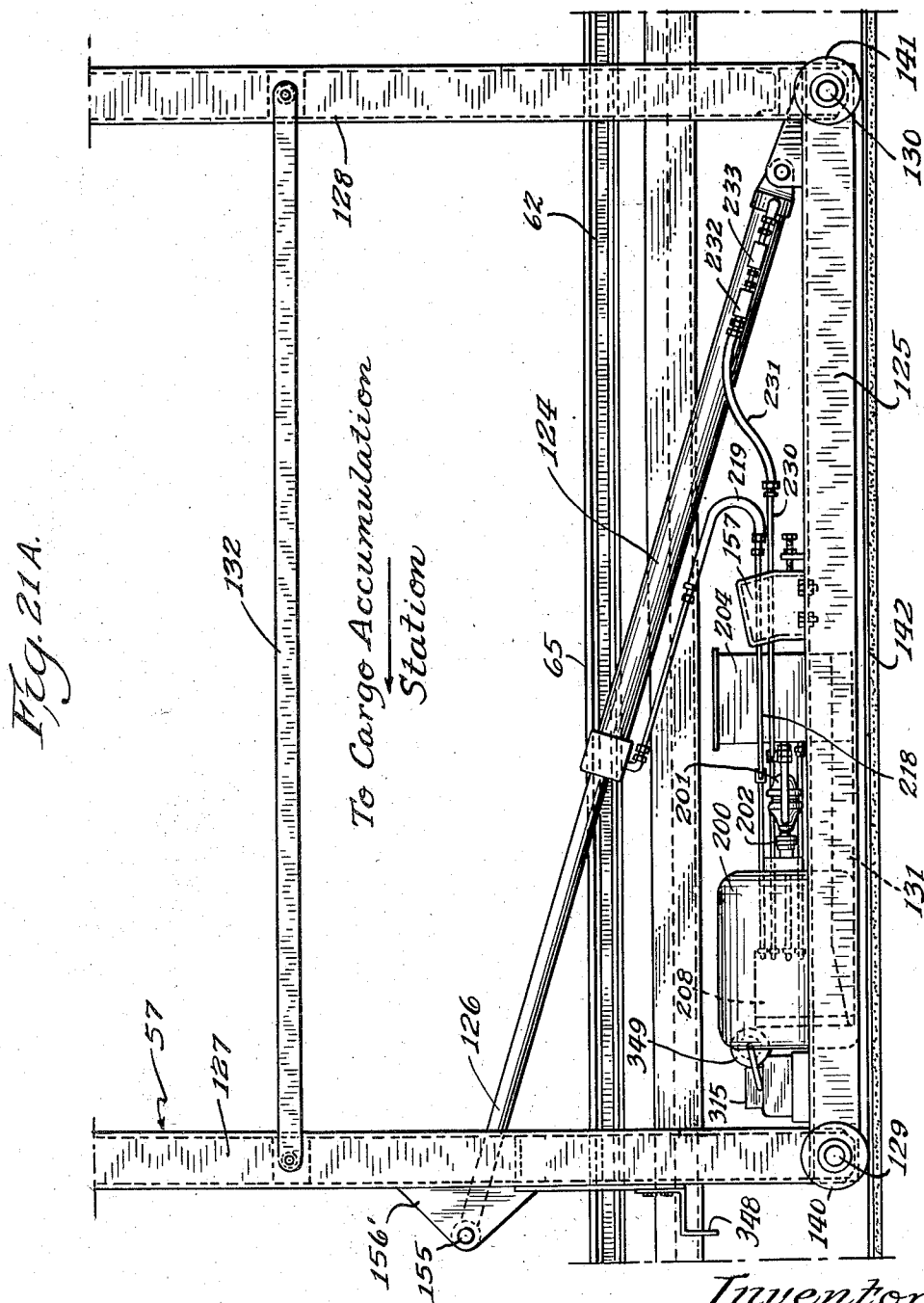
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AIR CARGO HANDLING APPARATUS

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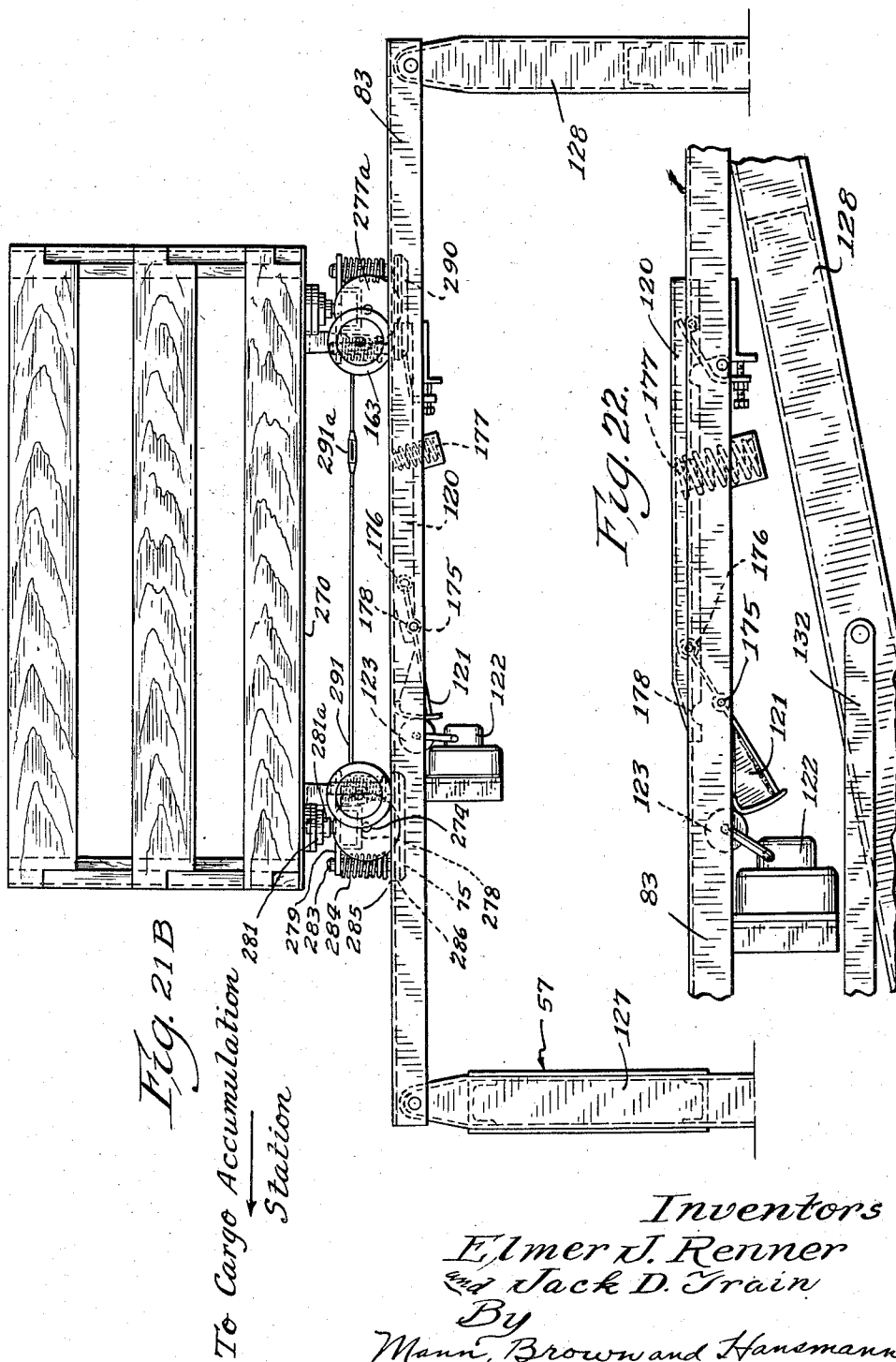
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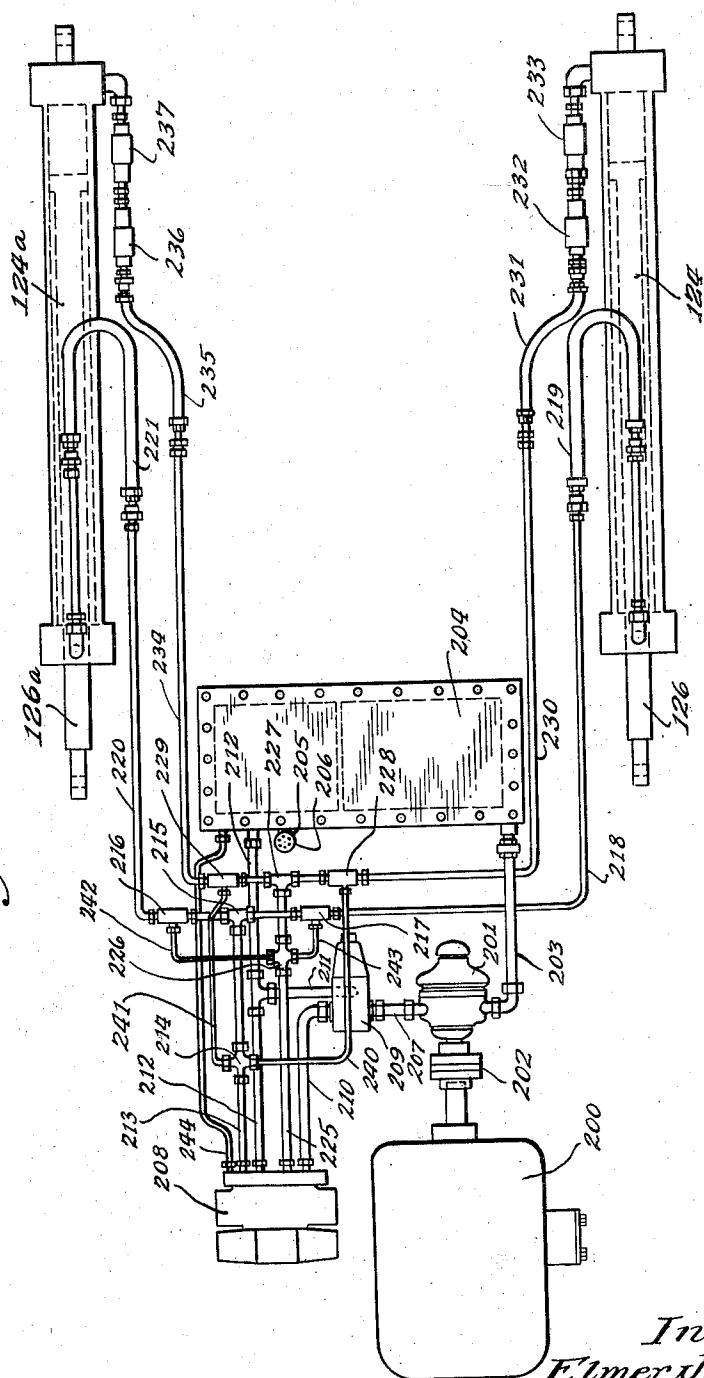
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Fig. 27.



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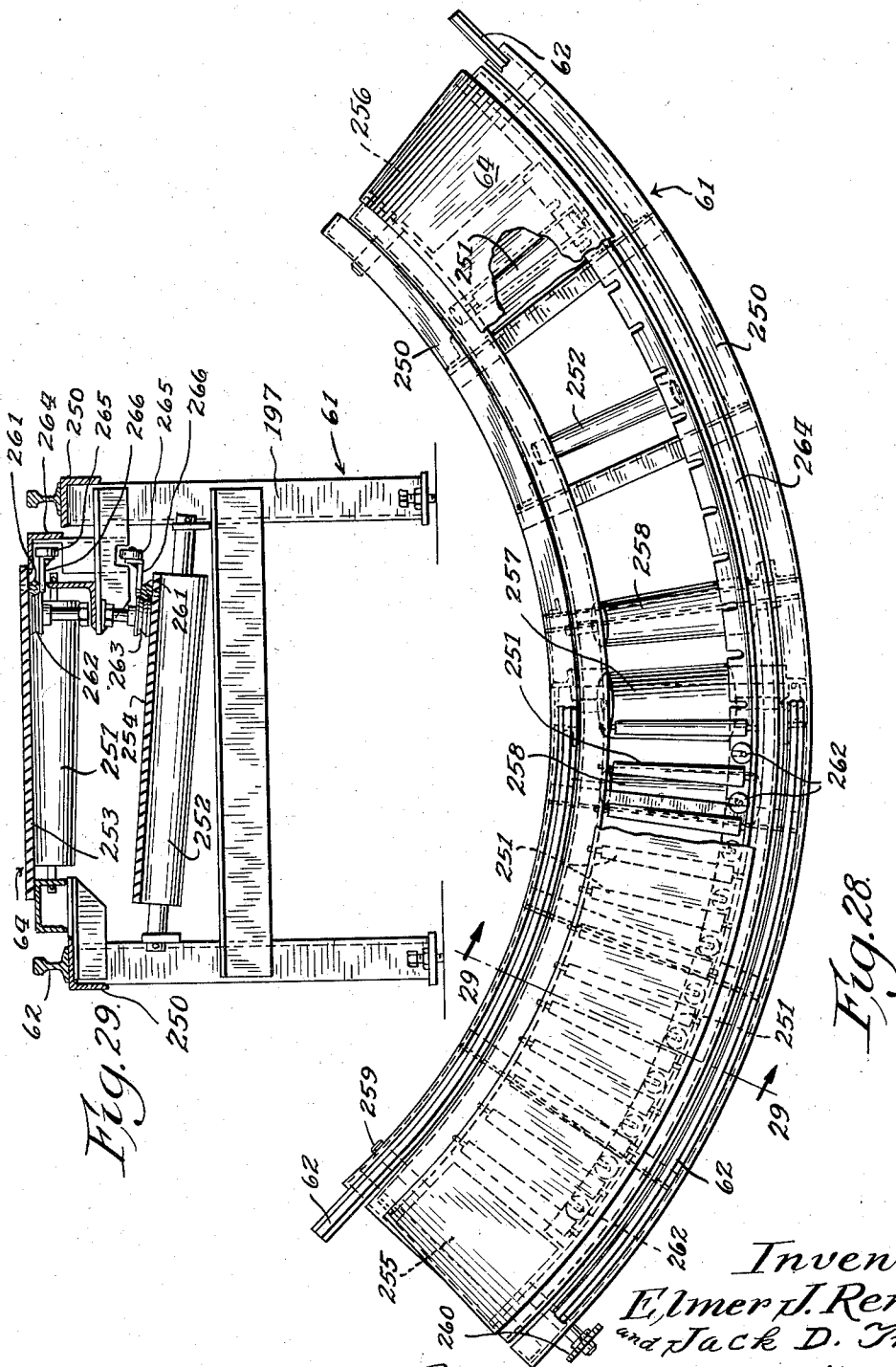


Fig. 28

Fig. 29

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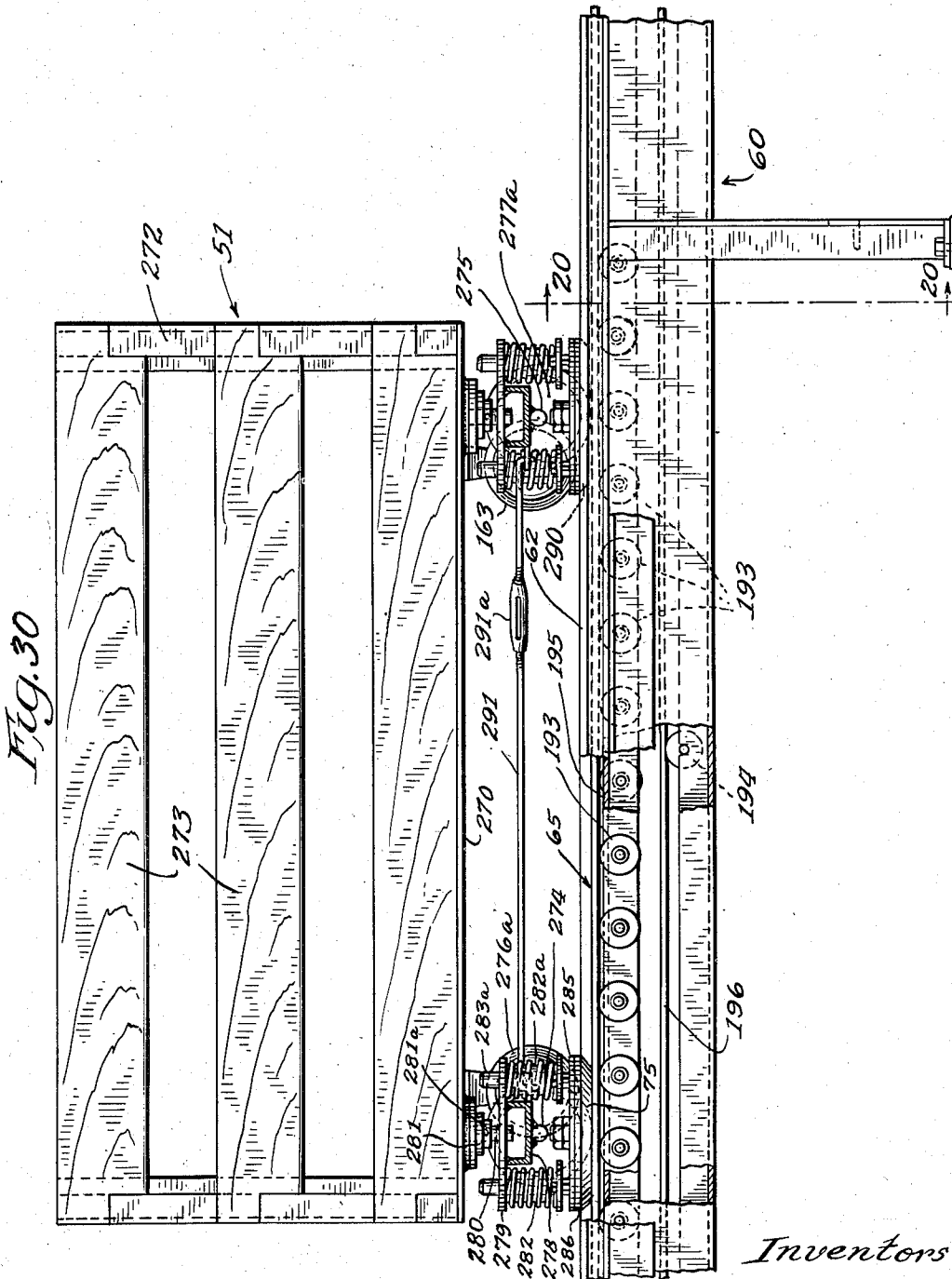
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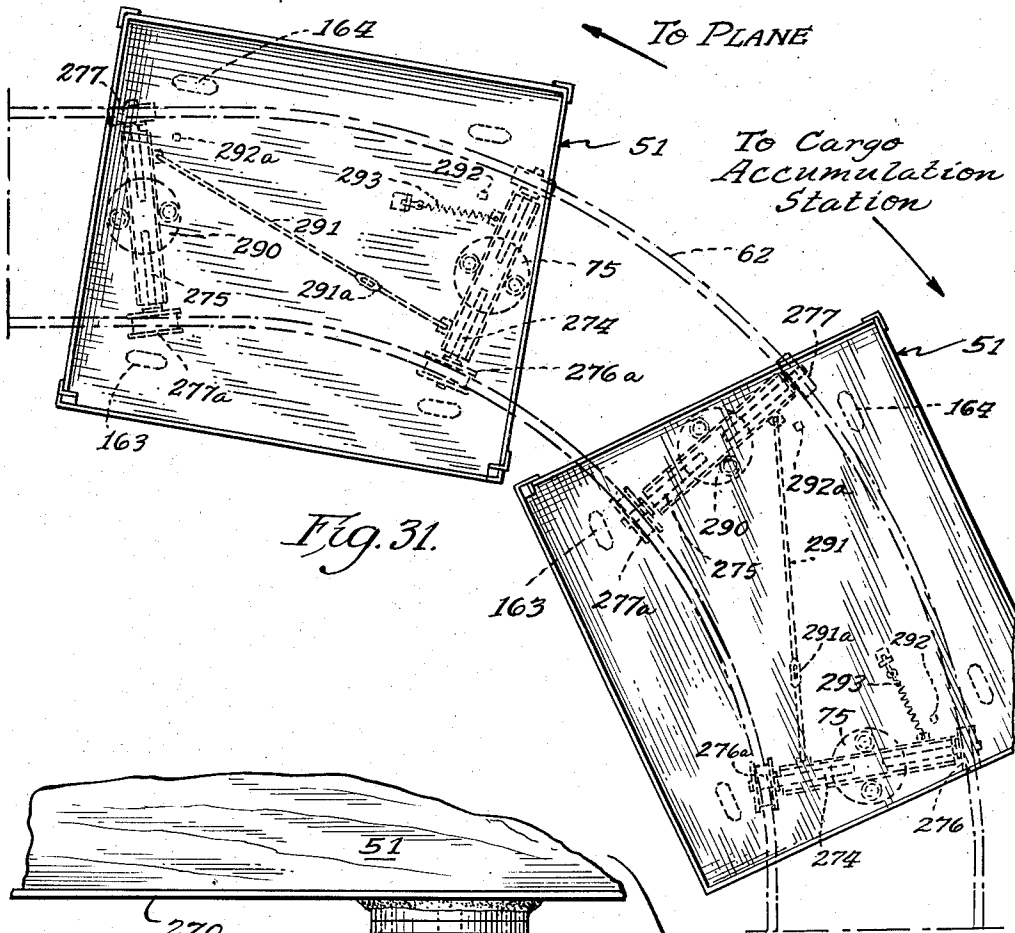


Fig. 31.

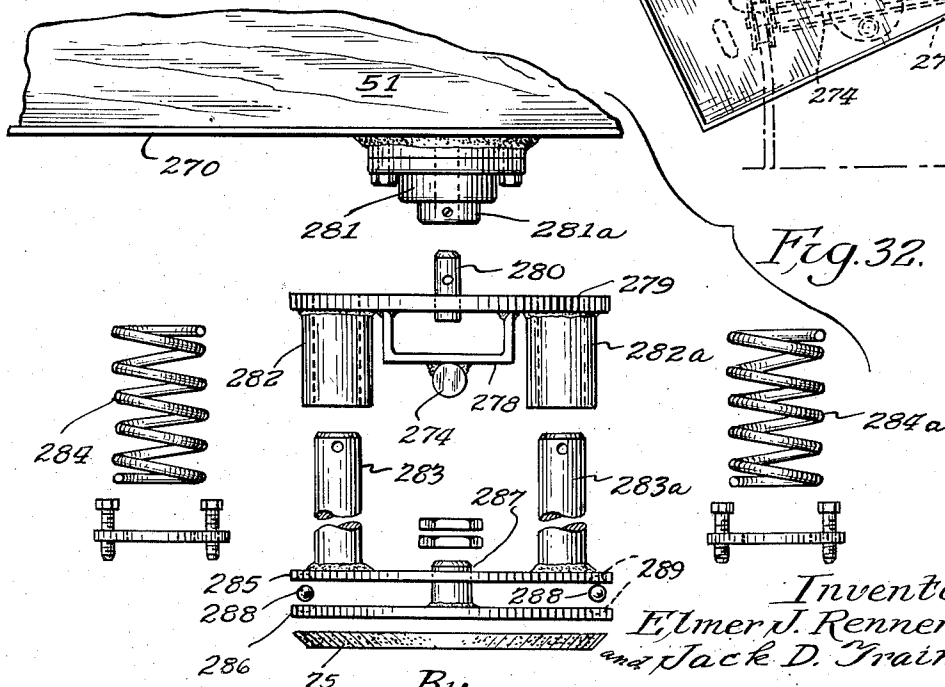


Fig. 32.

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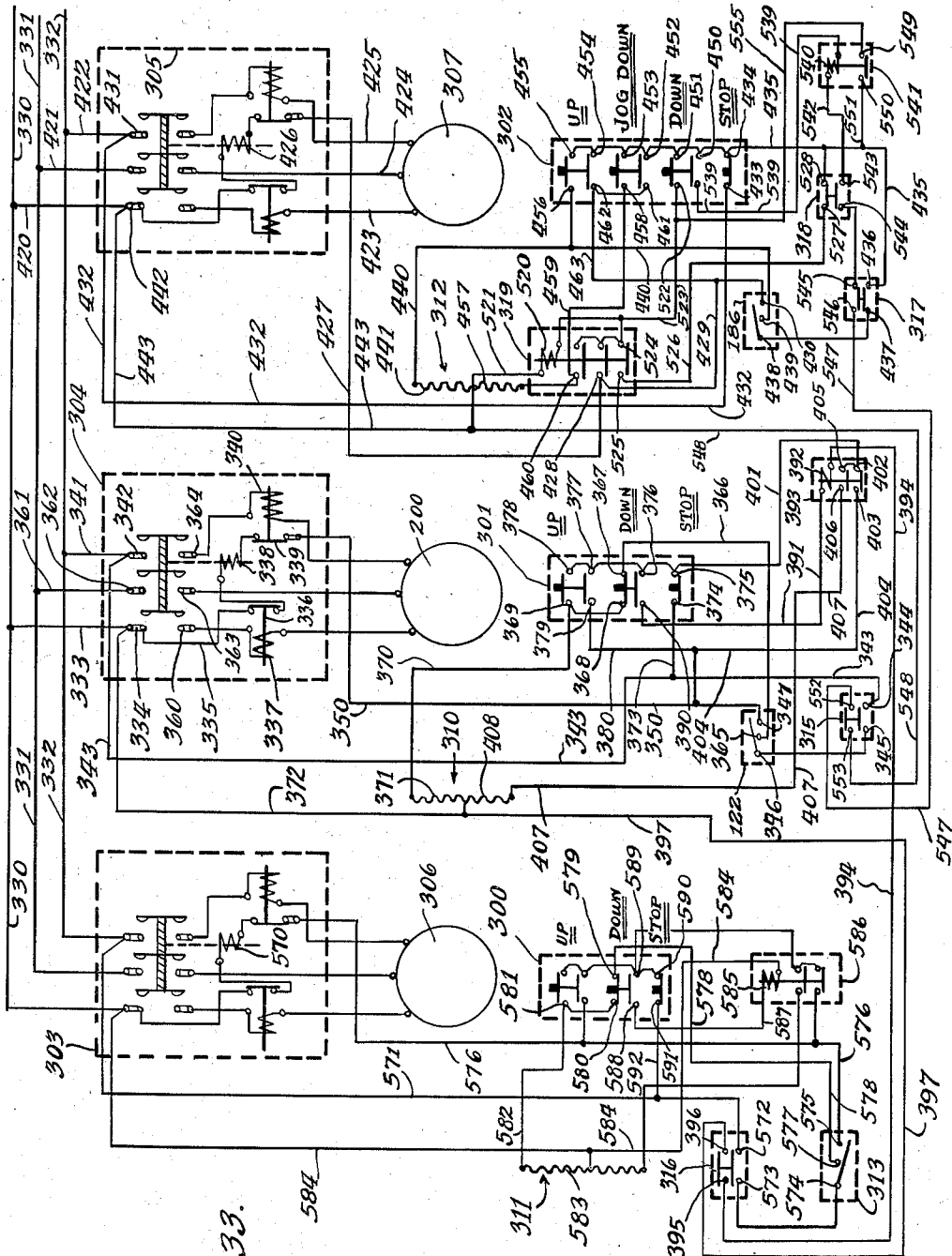


Fig. 33.

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AIR CARGO HANDLING APPARATUS

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Application October 10, 1955, Serial No. 539,335

12 Claims. (Cl. 214—89)

This invention relates to apparatus for loading and unloading airplanes and other vehicles.

The method commonly used for loading passenger baggage and other cargo on airplanes is to accumulate the cargo at a cargo receiving station, load the cargo there upon one or more carts, haul the carts to the plane by means of a small tractor, disconnect the tractor, and transfer the cargo by hand from the carts standing upon the ground into the cargo holds of the plane. In some cases an inclined conveyor is used to reach the cargo holds located in higher positions in the plane. When the cargo has all been loaded in the plane, the empty carts are removed and returned to the cargo accumulation station. The method is simply reversed for unloading the plane.

Another known method for loading an airplane is to load the cargo upon fork lift trucks and drive the loaded trucks into position near the cargo holds into which the cargo is to be transferred, where the lifting mechanism of the truck raises the cargo into position for such transfer. Again, the method is reversed for unloading the airplane.

As is well known, both these methods are cumbersome and slow. This is particularly annoying to passengers who have travelled hundreds of miles very quickly, and then forced to wait possibly 20 minutes or more before receiving their luggage which is being unloaded from the plane. The exasperation often-times produced by such experiences in otherwise satisfied passengers has made the need for a more efficient cargo handling method a compelling one. However, despite many efforts made to devise alternative methods and apparatus, no satisfactory substitute has been found prior to this invention.

Another disadvantage in the use of conventional equipment, besides the inefficiency of loading and unloading a particular plane, is the fact that simultaneous operation of several such mobile pieces of equipment may cause a traffic snarl which slows up not only the servicing of the plane being unloaded, but also various unloading, and servicing operations of the other planes in the airport.

Furthermore, using fork lift trucks, tractor borne inclined conveyors, or tractor drawn baggage carts, creates a serious risk of damage to the passengers' baggage, to the plane itself, and to other mobile equipment used in cargo handling operations, as well as the risk of personal injury to baggage-handling personnel and passengers. Experience has shown that plane damage alone caused by the mobile equipment is of alarming proportions.

The method and apparatus of this invention avoid all these disadvantages. Both loading and unloading of airplanes carried out according to this invention are fast and inexpensive. Moving all cargo along a predetermined path—in the preferred embodiment by means of an endless conveyor belt—avoids the necessity of having mobile trucks, with their attendant traffic and safety problems.

This invention is intended for use with a special form

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of airplane towing mechanism which is adapted to tow the airplane rearwardly into an exact predetermined position with respect to a relatively fixed cargo conveyor for cooperation therewith. The towing equipment is no part of the present invention, and need not here be described. All that is required is that the airplane be accurately positioned with respect to the cargo conveyor system, and this of course could be accomplished in any number of ways.

The apparatus of this invention includes one or more cargo pallets which are loaded at a loading station and then moved along a predetermined path to a cargo hold of the airplane, where each pallet is hoisted into the air into a position from which the cargo it carries may be conveniently transferred into a cargo hold of the plane. The pallet is preferably propelled between the pallet loading station and the cargo hold of the plane by means of an endless conveyor belt, and as the pallet arrives at the hoist it automatically trips a switch which causes the hoist to raise the pallet off the conveyor belt.

In the method of this invention, the loaded cargo pallets are moved along a predetermined path to a position near a selected cargo hold of the plane. Upon arrival at the cargo hold, the pallet is raised to a predetermined height and the cargo transferred from the pallet into the cargo hold.

This invention will be described by reference to the embodiment of the apparatus shown in the accompanying drawings. In the drawings:

Figures 1A and 1B give a diagrammatic perspective view of one embodiment of the apparatus of this invention;

Figures 2A and 2B give a diagrammatic side elevation of the same embodiment;

Figure 3 is a side elevation of one feature of the embodiment;

Figure 4 is a plan view of the same feature;

Figure 5 is a plan view of one embodiment of the cargo accumulation and pallet loading station;

Figure 6 is a sectional view of the turntable at said station, the view being taken along line 6—6 in Figure 5;

Figure 7 is an enlarged plan view of one feature shown in Figure 5;

Figure 8 is a plan view of an alternative arrangement for a cargo accumulating and pallet loading station;

Figure 9 is a sectional view of the turntable at that station taken along line 9—9 in Figure 8;

Figure 10 is an enlarged sectional view taken along line 10—10 in Figure 8;

Figure 11 is a plan view of the middle portion of the embodiment of this invention shown in Figures 1A and 1B;

Figure 12 is a plan view of the outer end of the embodiment of this invention shown in Figures 1A and 1B;

Figure 13 is a side elevation of the structure shown in Figure 12;

Figure 14 is a sectional view of a seal lip used between adjacent sections of the conveyor belt shown in Figure 11;

Figure 15 is a side elevation of the hoist, shown in various positions, which is employed at the inner and middle plane loading stations in the embodiment of this invention shown in Figures 1A and 1B;

Figure 16 is an end view of the hoist and cargo pallet comprising one embodiment of the cargo elevator of this invention;

Figure 17 is an end view of a hold-down device employed with said embodiment;

Figure 18 is a side elevation of the same device;

Figures 19A and 19B show an end elevation of the embodiment of Figure 16 when the hoist is in its elevated position;

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Figure 20 is a sectional view taken along line 20—20 of Figure 30 showing the belt conveyor structure of the system shown in Figures 1A and 1B;

Figures 21A and 21B give a side elevation of the same embodiment as shown in Figures 19A and 19B;

Figure 22 is a fragmentary side elevation of the hoist switch of the same embodiment;

Figure 23 is a plan view of the embodiment shown in Figure 21B;

Figure 24 is a fragmentary end elevation showing the switch tripping means of the hoist employed at the outermost plane loading station in the embodiment of the invention shown in Figures 1A and 1B;

Figure 25 is a plan view of the same hoist;

Figure 26 is a fragmentary side elevation of the same hoist with a pallet shown in phantom upon it;

Figure 27 is a plan view of the hydraulic system of the hoist shown in Figure 16;

Figure 28 is a plan view partly broken away of the curved section of the conveyor belt which is included in the embodiment of Figures 1A and 1B;

Figure 29 is a cross sectional view taken along line 29—29 in Figure 28;

Figure 30 is a side elevation of the cargo pallet of the embodiment of Figures 1A and 1B, the pallet being shown riding upon the endless conveyor belt;

Figure 31 is a plan view of two cargo pallets upon a curved section of the conveyor belt;

Figure 32 is an exploded detail view of the traction plate on the bottom side of the pallet of Figure 30; and

Figure 33 is a schematic diagram of the electrical circuits for actuating the hydraulic systems of the cargo hoists of the system shown in Figures 1A and 1B, including an interlock circuit that connects the electrical circuits of the hoists in that system.

General description.—Figures 1A and 1B give in diagrammatic perspective a general showing of how the method and apparatus of this invention may be employed for loading and unloading a passenger airplane. The plane which is shown in position for loading is an example of the type of plane with which this invention is most useful, for it is a large, modern passenger plane with three cargo holds. This invention may be adapted for use as well with airplanes having a wide range of size and type of construction.

The view shown in Figures 1A and 1B is from the rear and off to one side of the plane which is in position for loading. When the two figures are considered together, they provide a view of the entire system of air cargo handling from the point at which baggage and other cargo are accumulated for loading on the plane, to the stations at which the various pieces of cargo are transferred into the cargo holds of the plane. When the two figures are placed side by side, the cargo accumulation station is seen at the left and the plane being loaded is at the right.

Cargo accumulation station 40 is enclosed in a building 41 of conventional construction. Passengers preparing to board plane 42 deposit their luggage at a ticket counter (not shown), from which it may be moved to cargo accumulation station 40 by hand truck, endless conveyor belt, or other suitable means. Carts 43, for instance, may be used for this purpose.

Cart 44 may be employed to bring to the cargo accumulation station air freight of various kinds. Cart 45 may be employed to bring to the cargo accumulation station mail which is to be transported on plane 42. Carts 44 and 45 are shown in Figure 1B positioned arbitrarily about station 40; when not in use, these carts may stand in any convenient area within building 41.

Rotating turntable 46 is located at the approximate center of cargo accumulation station 40, with an area surrounding it where carts 43, 44 and 45 may be positioned when used for bringing air cargo to the cargo ac-

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cumulation station. In the view shown in Figures 1A and 1B, the air cargo loading and unloading apparatus of this invention is shown in the condition it occupies during the loading operation.

In particular, the apparatus is shown in the condition it occupies after most of the air cargo has been loaded on the plane. Cargo pallets 50, 51 and 52, as will be seen, have been propelled to their respective cargo holds of the plane. These are cargo holds 53, 54 and 55 respectively. There the pallets have been raised by hoists 56, 57 and 58 to a position in which they present the air cargo for easy transfer into the cargo holds.

The positions to which cargo pallets 50, 51 and 52 will return after their loads have been transferred to their respective cargo holds (and from which the loaded pallets originally began their journey to the plane) are shown in phantom on the side of turntable 46 which is away from the loading position of plane 42. The cargo pallets are moved from these positions to their loading and unloading positions at the cargo holds by endless conveyor 60. Conveyor 60 comprises frame 61 carrying a pair of tracks 62 and endless conveyor belts 63, 64 and 65.

Section 66 of tracks 62 is arranged so that it may provide a route across turntable 46 or may be swung back away from turntable 46, as desired. Air cargo pallets 50, 51 and 52 begin their journeys from an adjacent section 67 of tracks 62. From there they may be propelled across track section 66, passing over turntable 46 and then onto the main section of tracks 62 leading from the air cargo accumulation station towards the plane to be loaded.

Endless conveyor 60 follows a predetermined path from cargo accumulation station 40 to the general vicinity of the cargo holds of plane 42. In the embodiment shown, the predetermined path runs from the cargo accumulation station towards the plane at an angle of approximately 90° to the longitudinal axis of the plane. When conveyor 60 reaches the vicinity of the rear end of the plane, it curves more or less sharply to make a right angle turn and proceed along the side of the plane in which the cargo holds are located and within a predetermined distance from those holds. It extends forward a short distance beyond the forwardmost hold of the plane. Adjacent its outermost end is positioned stop table 68. Obviously, the particular routing of the conveyor to and from the plane may be altered according to airport plan.

The apparatus or system thus generally described may be used to achieve very rapid, safe and reliable loading and unloading of large passenger airplanes. A plane having a capacity of 58 passengers, for example, has been emptied of passengers and an equivalent load of mail, baggage, express and freight in approximately four minutes by use of the apparatus and method of this invention.

Cargo accumulation and loading.—Passengers planning to board plane 42 may deposit their luggage at the appropriate ticket counter (not shown) and proceed from there directly to passenger entrance 70 (shown in phantom in Figure 2B) of plane 42. The passenger entrance is generally on the side of the plane opposite cargo holds 53, 54 and 55.

The passenger luggage may be brought by carts 43 or other suitable means to air cargo accumulation station 40, and there placed piece by piece in cargo pallets 50, 51 and 52 as the pallets stand upon track section 67 of conveyor 60. Air freight and air mail may also be brought to cargo accumulation station 40 for loading on the pallets in the same way. Carts 44 and 45 may be used to transport this cargo to station 40.

By a means to be explained in more detail below, the order in which pallets 50, 51 and 52 are arranged upon track section 67 is always maintained the same. For this reason, pallet 50 will always be first to leave cargo

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accumulation station 40 and will, therefore, always be available for the forwardmost cargo hold 53 of plane 42. Likewise, pallets 51 and 52 will always proceed to cargo holds 54 and 55, respectively.

This fact produces one of the important advantages of this invention, which reduces significantly the time required for loading air cargo upon airplane 42 and also the unloading time required at the other end of the flight. For convenience and efficiency, air cargo has customarily been classified according to type (e. g. passenger luggage, freight, express, and air mail) and according to destination. The cargo has then been placed in particular cargo holds of the plane, and also in particular locations within the individual cargo hold. This makes it possible to handle the same type of cargo in generally the same way upon all flights, and also permits a minimum of dislocation of the stored cargo when the plane is being partially unloaded at an intermediate flight point.

With the method and apparatus of this invention, it is only necessary to place in cargo pallet 50 as it stands in the cargo accumulation station all the air cargo which it is desired to transfer to cargo hold 53 at the outermost end of conveyor 60 near the nose of the plane. Similarly, cargo intended for cargo hold 54 is placed on pallet 51, and cargo intended for hold 55 is placed on pallet 52. If desired, a further refinement may be introduced when loading the pallets by placing upon each pallet first those items of air cargo which are desired to be removed last for transfer to the hold in which they will be stored for flight.

Another advantage of this invention is that the weight distribution of the cargo load upon the pallets may be so controlled that when the cargo is transferred from the pallets to the plane, the proper weight distribution is achieved automatically within the holds.

Predetermined path to airplane.—Another important advantage of this invention stems from the economical and orderly use of space which is made possible by employing a predetermined path from air cargo accumulation station 40 to the airplane.

Cargo pallets 50, 51 and 52 will never interfere with each other, since they are always moved to and from plane 42 in a fixed order. Likewise, the cargo pallets will never interfere with any other cargo pallets employed for loading and unloading other airplanes which are brought to other stations of the same airport, for the path followed by pallets 50, 51 and 52 is always along a predetermined course.

Moving cargo pallets 50, 51 and 52 will never cause damage to the airplane or to the passengers, again because these pallets follow a predetermined path in going to and from the plane. Similarly, there is substantially no risk of personal injury to the other personnel who are servicing the plane by activities such as filling it with gas or oil, and who with the commonly used mobile tractors or fork lift trucks would have to keep a constant look-out to be certain to avoid harm at a busy airport.

Endless conveyor belts 63, 64 and 65 are driven by motors 73a, 73b, 73c and 73d. These motors are connected to the drive rollers of each of the endless belts through speed reducers 74a, 74b, 74c and 74d, respectively.

Operation of conveyor belts 63, 64 and 65—driven in the way just described—is reversible. During loading of plane 42, the top portion of each belt moves in the direction from cargo accumulation station 40 toward the airplane. During the unloading operation, the upper portions of the belts move in the opposite direction.

Each of cargo pallets 50, 51 and 52 is provided with a spring-loaded traction plate 75 (shown in Figure 16 and other figures) by means of which the moving belt of conveyor 60 may engage the pallet in order to move it to or from plane 42 as desired. After pallet 50, for example, is loaded as it stands upon track section 67, the pallet is moved manually or otherwise across track section 66 over turntable 46, and from there onto the section of

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tracks 62 leading towards airplane 42. As pallet 50 is moved onto this section of tracks 62, moving conveyor belt 63 engages spring loaded traction plate 75 depending from the bottom of the pallet, and moves the pallet along the tracks toward plane 42.

When pallet 50 reaches curved conveyor belt 64, it simply continues to roll along tracks 62 while the frictional engagement of the traction device depending from its bottom side is transferred from conveyor belt 63 to curved conveyor belt 64. After the pallet has rounded the curve and is ready to start along the predetermined path parallel to the longitudinal axis of plane 42, the frictional engagement with depending traction plate 75 is again transferred from one belt to another, this time from curved conveyor belt 64 to conveyor belt 65.

When the empty cargo pallets are to be returned from the plane loading stations at cargo holds 53, 54 and 55 back to cargo accumulation station 40, they are propelled in the same way by the endless conveyor belts 65, 64 and 63 (in that order) by reversing the direction of motors 73.

Automatic operation of hoists.—Hoist 58 includes elevating platforms 80 and 81, one on either side of conveyor 60. Likewise, hoist 57 includes elevating platforms 82 and 83 on either side of conveyor 60. Before the hoists are elevated, these platforms are positioned substantially flush with conveyor tracks 62. (This can perhaps best be seen from Figures 11 through 13 and Figure 16.) Thus, as cargo pallet 50 is propelled alongside plane 42 towards cargo hold 53, no obstruction to its passage is presented by either hoist 58 or 57.

Hoist 56 also has two elevating platforms 84 and 85 on either side of conveyor 60. However, in addition to these two platforms hoist 56 is provided with personnel platform 86, which extends across above conveyor 60 from one side of the hoist to the other.

When pallet 50 reaches hoist 56 and moves over the hoist in a position to be raised, the pallet automatically trips a switch (shown in Figure 22 and other figures) which then actuates the hydraulic lifting mechanism of the hoist to a limited extent. Pallet 50 is thereby automatically raised by hoist 56 to a predetermined height. In the embodiment shown this may be a foot or somewhat more above the position occupied by the pallet when it arrives at the plane loading station, and therefore about one foot above conveyor belt 65.

Cargo pallet 50 is then moved up to within reach of cargo hold 53, by manual operation of a switch controlling further operation of the hydraulic lift mechanism of hoist 56. The position occupied by pallet 50 for convenient transfer of its load into cargo hold 53 may be seen in Figures 1A and 2A.

In a similar manner, pallet 51 is moved from cargo accumulation station 40 onto endless conveyor belt 63 and is propelled by belts 63, 64 and 65 to the vicinity of cargo hold 54. As pallet 51 reaches hoist 57, which is in the position shown in Figures 12 and 13, it is moved over elevating platforms 82 and 83 to the point where the pallet triggers the automatic control switch of the hydraulic lift system of this hoist. This automatically raises pallet 51 a predetermined distance above conveyor belt 65, substantially as shown in Figure 2A. From here pallet 51 may be raised still farther, if desired, by manual operation of a control switch.

Pallet 52 is moved from cargo accumulation station 40 to the vicinity of cargo hold 55 of plane 42 in the same way, where it trips a switch and is then automatically raised by hoist 58 to a predetermined height. Once again, it may be raised farther, by manual operation of a control switch, to within convenient distance of the cargo hold, as shown in Figures 1A and 2B.

Selective actuation of the switches operating hoists 56, 57 and 58 is carried out automatically by pallets 50, 51 and 52, respectively, so that no hoist is ever elevated by any pallet other than the one associated with the

plane loading station at which the hoist in question is located. Pallet 50 actuates only hoist 56, and never hoist 57 or 58. Pallet 51 actuates only hoist 57, and never hoist 58. Hoist 58 is actuated by the arrival of pallet 52.

Loading cargo by individual pieces.—The method and apparatus of this invention may be used to accumulate at station 40 the major part of the air cargo which is to be loaded on plane 42, and then to move that cargo in the manner described to the respective cargo holds into which it is desired to load it. This will make it possible to load the major part of the air cargo onto plane 42 by the time most of the passengers have boarded the plane.

In the embodiment shown, individual pieces of luggage which are received at cargo accumulation station 40 after the cargo pallets have already been moved out to the plane may also be handled quickly and conveniently. After pallets 50, 51 and 52 have been moved across track section 66 above turntable 46, section 66 is folded back out of the way to remove obstructions to items of cargo placed upon the top of revolving turntable 46. In the embodiment shown, during the loading of plane 42, turntable 46 preferably revolves in a counterclockwise direction seen from above. As items of luggage or other air cargo approach the point of juncture between conveyor 60 and table 46, they may be easily transferred from the table onto moving conveyor belt 63.

As seen from Figures 1A and 1B, individual items of luggage 87 may thus be transported from cargo accumulation station 40 out to cargo holds 53, 54 and 55 of plane 42 in much the same manner as the cargo pallets have already been propelled. When the individual items of cargo reach the appropriate cargo hold, they may be removed from conveyor belt 65 by the cargo handling personnel and lifted up to the cargo hold.

As already explained, pallets 52, 51 and 50 are automatically raised about a foot or more above conveyor belt 65 when the pallets trip the hoist switch of their respective hoists. This leaves sufficient clearance for the individual items of air cargo to pass beneath the elevated pallets on conveyor belt 65, even if the pallets have not been moved by manual operation of the hoist switch to a position closer to the more elevated cargo holds such as holds 53 and 54. Figure 19A shows how individual pieces of luggage 87 may be carried on conveyor belt 65 beneath the raised hoists at the plane loading stations.

If it is desired to send individual pieces of cargo on conveyor 60 before cargo pallets 50, 51 and 52 have been moved out to the plane, this is of course also possible.

If the attention of the cargo handling personnel is directed elsewhere when individual items of cargo arrive at the intended cargo hold on conveyor belt 65, the arrival of the item may go unnoticed and it would then pass beyond the proper cargo hold. In order to avoid damage to the cargo if this overrunning by individual items occurs at the forwardmost end of conveyor 60, stop table 68 is provided immediately adjacent the outer end of the conveyor.

As better seen from Figures 3 and 4, stop table 68 is provided with a series of freely revolving rollers 90 positioned at right angles to the direction of movement of the cargo items as they come to the end of conveyor belt 65. The roller which is closest to the end of belt 65 is positioned near enough to the belt that any but the smallest items of luggage or other cargo carried to the end of belt 65 will slide smoothly onto stop table 68. If the inertia of the pieces carries them to the end of the stop table, upright board 91 will block further movement.

Unloading operation.—The apparatus and method of this invention may be used with the same speed and convenience for unloading cargo from the airplane after it has reached its destination. As mentioned above, a complete unloading of passenger luggage, freight, express, and air mail from a 58 passenger airplane has been completed

in only four minutes using the apparatus and method of this invention.

Generally speaking, cargo pallets 50, 51 and 52 are not employed in the unloading operation. It has been found ordinarily to be a quicker method to remove individual items of air cargo from cargo holds 53, 54 and 55 and place them directly upon conveyor belt 65.

Belt 65 and the other conveyor belts 63 and 64 are operated in the opposite direction during the unloading process from the direction in which they moved during loading. Reversible drive motors 73 are started and reversed in direction by use of manually operated switches (not shown).

When unloading air cargo by individual items, section 66 of track 62 which overhangs turntable 50 is folded back out of the way. As the individual pieces of cargo moving on conveyor belt 63 approach turntable 46, they slide off the belt and onto the turntable. Fully automatic transfer from the moving conveyor belt to the rotating turntable is achieved by use of rollers 92, which are described in more detail below.

In the unloading operation carried out with the embodiment shown in Figures 1A and 1B, turntable 46 rotates in a clockwise direction as seen from above. Thus, as the individual pieces of cargo pass from conveyor belt 63 onto table 46 they are moved away from belt 63 to make room for additional items of cargo. The items upon the table are carried around to convenient removal points depending upon the type of cargo. If desired, this may be at carts 43, 44 or 45, or it may be at baggage claim platform 93.

With the method and apparatus of this invention, it has been found that all passenger luggage may be removed from a plane and made available at baggage claim platform 93 practically as soon as the passengers have disembarked from the plane and have walked into terminal building 41 through doorway 94 to claim their baggage. The air freight and air mail cargo can be removed in a similarly expeditious way.

The net result is not only that valuable time is saved for disembarking passengers, but the airplane can be very quickly readied to receive additional luggage, freight or airmail in preparation for another flight. The over all operation of the airport is thus rendered very much more efficient.

Turntable.—Figure 5 gives a diagrammatic plan view of the cargo accumulation station 40 shown in Figure 1B. Turntable 46 is located so that tracks 62 are extended over one segment of the table, by means of track section 66, and then beyond the table, by means of track section 67. Conveyor belt 63 is disposed so that its end is located adjacent turntable 46. Rollers 92 fill the gap between the end of conveyor belt 63 and turntable 46. The rollers are shown diagrammatically in Figure 5. They are best seen in the enlarged fragmentary view given in Figure 7.

Baggage claim platform 93 and doorway 94 have the same location in Figure 5 as in Figure 1B, with platform 93 conveniently located in relation to both turntable 46 and doorway 94.

Pallets 50, 51 and 52 are shown standing upon track section 67 in a position in which they may be conveniently filled with luggage. The luggage may have been brought to cargo accumulation station 40 by, for example, carts 43. Carts 44 and 45 are also shown in Figure 5 in positions they might occupy after having been used to bring air freight and air mail, respectively, from some other part of the airport to cargo accumulation station 40.

Turntable 46 is indicated in Figure 7 as rotating in a clockwise direction when seen from above. Air cargo is brought to turntable 46 by means of conveyor belt 63 (from the left in Figures 5 and 7) and is permitted to slide from conveyor belt 63 onto rollers 92 and from there to turntable 46. If the items of air cargo are large enough, the rear end of the item will be subject to frictional forces from conveyor belt 63 while the front end

rolls smoothly across rollers 92 and from there to turntable 46. If the item is smaller, it may remain upon rollers 92 until another item of air cargo comes along conveyor belt 63 to push the first item off the rollers and onto turntable 46.

In Figure 7, track section 66 have been swung back so that it is out of the way of any items of air cargo which ride upon turntable 46 as it rotates. Items of air cargo are carried around by rotating table 46 from the vicinity of conveyor belt 63 and rollers 92 into various positions from which they may be conveniently removed from turntable 46, depending upon the nature of the item of air cargo and the arrangements that are made for distribution of air cargo at the airport after it has been removed from incoming planes.

Figure 6 shows how track section 66 may be conveniently positioned across the top of turntable 46 when it is desired to move cargo pallets 50, 51 and 52 from the station at which they are loaded (as shown in Figure 5) into position for being propelled by endless conveyor belt 63. Track section 66 may be very easily swung back out of the way by means of hinges 95 carried by support posts 96, whenever desired. Then, when empty cargo pallets 50, 51 and 52 return from the loading operation at plane 42, track section 66 may again be swung up into place across turntable 46.

Figure 6, which is a sectional view taken along line 6—6 in Figure 5, shows the general structure of turntable 46. Table 46 rotates upon wheels 97. It is driven by reversible motor 98 acting through pinion 99, the motor being attached to supporting framework 100 upon which wheels 97 ride. Pinion 99 engages rack 101 which is attached to the outer edge of turntable 46.

Figure 8 shows an alternative arrangement of the turntable within cargo accumulation station 40. Turntable 103 shown in that figure is located in a pit 104 which is depressed sufficiently that the upper surface of turntable 103 is flush with the floor level in station 40. This can best be seen in the cross sectional view given in Figure 9, which is a view taken along line 9—9 in Figure 8.

Track section 105 is an extension of tracks 62 across turntable 103, and track section 67 extends beyond the turntable. Track sections 105 and 67, like turntable 103, are positioned so as to be flush with the floor level of station 40.

The ends of tracks 62 which abut turntable 103 are likewise at floor level. The same is true of the end of conveyor belt 63. Tracks 62 and belt 63 rise with a very gradual incline as they leave turntable 103. The gradual slope of conveyor belt 63 is best seen from Figure 10, in comparison to the horizontal line 107. Figure 10 is a fragmentary sectional view taken along the line 10—10 in Figure 8. As shown in Figure 10, trench 108 extends from pit 104 underneath conveyor belt 63 to accommodate the framework of the conveyor structure upon which belt 63 is supported.

Sealing lip 109, shown diagrammatically in Figure 8 and in cross section in Figure 10, closes the gap between turntable 103 and the end of conveyor belt 63. Items brought to turntable 103 upon conveyor belt 63 will slide across sealing lip 109 in the same fashion as they do across rollers 92 in the embodiment shown in Figure 5. In the embodiment of Figure 8, turntable 103 may be rotated in either clockwise or counterclockwise direction, as desired, during the unloading operation.

One of the principal advantages of having turntable 105 flush with the floor level of cargo accumulation station 40 is that it reduces the amount of work that the baggage handlers must perform. As turntable 103 rotates, the items of cargo may be conveniently slid off onto the floor of cargo accumulation station 40 at the desired point around the table. Luggage may be removed at one point, freight at another, and mail at another. If desired, baggage claim platform 93 may be employed.

On the other hand, luggage may be piled into cart 43 and pulled through door 94a to another part of the airport.

As shown in Figure 8, the axis of conveyor belt 63 passes directly through the center of circular turntable 103. Likewise, track section 105 is located in the center of the table.

Cargo pallets 50, 51 and 52 are shown in Figure 8 in the positions they occupy while they are being filled with cargo before being sent out with loads by means of conveyor belt 63 towards the plane to be loaded. When the loaded pallets are to be pushed across turntable 103 (or when the unloaded pallets are returned from the plane to cargo accumulation station 40), turntable 103 must be positioned so that track section 105 is indexed with tracks 62 and 67. Reversible motor 98 may be employed for the purpose of aligning turntable 103 and track section 105 in the proper position.

Conveyor belt.—In the embodiment shown in Figures 1A and 1B, conveyor 60 extends toward plane 42, from cargo accumulation station 40, to a point somewhere in the vicinity of the tail of the plane. There the conveyor follows a curved path so as to change by 90 degrees the course followed by items carried by the conveyor.

As seen in Figure 11, conveyor belt 63 leading from station 40 abuts curved conveyor belt 64, which in turn leads into conveyor belt 65. The latter belt runs along the side of plane 42 to the nose of the plane and a little bit beyond. As already explained above, plane 42 has been moved back into loading position with cargo holds 53, 54 and 55 only a very short distance from the positions which cargo pallets 50, 51 and 52 will occupy when they are raised by hoists 56, 57 and 58, respectively.

Belts 63 and 65 are broken away in Figures 11 and 12 to indicate that the length of the conveyor 60 may be whatever is desirable in view of the types and sizes of airplanes with which the cargo handling apparatus of this invention will be used. Cargo leaves cargo accumulation station 40 at the lower right hand corner of Figure 11, moves up to curved conveyor belt 64, then to the left across the figure. It continues moving across from right to left in Figure 12. In Figures 11 and 12, hoists 56, 57 and 58 are shown in the position they may take for use with the type of airplane shown in Figure 1A.

Figure 14 shows a sealing lip 109 similar in construction to that already shown in Figure 10. The function of sealing lip 109 is to provide a closure of the gap between conveyor belts 63 and 64, for example, or between belts 64 and 65. The lips are omitted from Figure 11 for clarity.

Sealing lip 109 consists of T-shaped structural member 110 to which upper plate 111 is bolted by means of countersunk bolts 112. Member 110 and plate 111 grasp between them a pair of adjusting plates 113, formed of a resilient material such as rubber, one extending on each side towards the adjacent conveyor belt. The outer edges of adjusting plates 113 are bevelled so that the plates may be brought very close to conveyor belts 63, 64 or 65, as the case may be, to leave a very small open space between sealing lip 109 and the conveyor belts. The leading and trailing edges of cover plate 111 are also bevelled so that a minimum of obstruction is presented to items which are moving from the end of one conveyor belt across sealing lip 109 to the opposite belt.

Cargo hoist.—Figure 13 gives a side elevation of conveyor 60 at the outer end near the nose of plane 42. Cargo pallets arriving at this end of the conveyor from cargo accumulation station 40 approach from the right in Figure 13. Cargo hoists 57 and 56 are shown in solid line in the positions they occupy as cargo pallet 50, for example, is propelled toward cargo hold 53 by conveyor belt 65.

As cargo pallet 50 passes over cargo hoist 57, the hoist is permitted to remain in the down position shown in Figure 13, since pallet 50 is not designed to trip the hoist

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mechanism which causes elevating members 82 and 83 of hoist 57 to be raised. When pallet 50 reaches hoist 56, however, it does trip the switch which is adapted to cause hoist 56 to raise elevating members 84 and 85, together with personnel platform 86. Cargo hoist 56 is moved in this manner from the down or collapsed position shown in Figure 13 in solid line up into the elevated position shown in the same figure in dotted line.

Figure 15 shows more detail of cargo hoist 57. The hoist is shown in a down or collapsed position in solid line. It is shown in broken line in an intermediate position to which it may be raised by actuation of the elevating mechanism, and also in broken line in its uppermost position after it has been fully elevated.

The elevating member of cargo hoist 57 which is seen in Figure 15 is member 83. The cargo pallet 51 which is associated with hoist 57 approaches from the left in Figure 15. Pallet 51 is adapted to depress cam bar 120 as it passes over elevating member 83. When cam bar 120 is depressed, this operates cam lever 121, which in turn closes normally open hoist switch 122. Depression of cam bar 120 pushes down the upper end of cam lever 121. As the cam is pivoted by rotatable attachment to elevating member 83, the lower end of the cam is caused to rise and push against wheel 123 of hoist switch 122.

Hoist switch 122 is connected in the electrical circuit of the motor that drives the hydraulic pump for cargo hoist 57. The pump is connected to hydraulic ram 124 on one side of cargo hoist 57, and to ram 124a (shown in Figure 16) on the opposite side of the hoist. Ram 124 is rotatably attached at its bottom end to base member 125 of cargo hoist 57. Piston 126 extends from the upper end of hydraulic ram 124, and is rotatably attached at its upper end to upright member 127 of hoist 57, located at the rear end of the hoist. In the same way, the bottom end of ram 124a and top end of piston 126a are rotatably attached to base member 125a and upright member 127a, respectively, on the other side of the hoist.

Upright 127 at one end of hoist 57 and upright 128 at the other are pivoted at their lower ends about axles 129 and 130, respectively. These axles are journaled at one end in base member 125, seen in Figure 15. Axles 129 and 130 extend across to the opposite side of hoist 57, where they are journaled in base member 125a and carry pivoted members 127a and 128a, all corresponding to the similarly numbered members which are seen in Figure 15.

Platform 131 also extends from one side of cargo hoist 57 to the other, serving both to carry the major part of the hydraulic system of the hoist (as explained below) and also to help provide rigidity between base members 125 and 125a on opposite sides of the hoist.

Elevating member 83 is supported by uprights 127 and 128, to which it is rotatably attached at either end. Elevating member 82, on the opposite side of cargo hoist 57, is similarly supported by uprights 127a and 128a. Cross bars 132 and 132a, respectively, reinforce uprights 127 and 128 on one side of the hoist and uprights 127a and 128a on the other. The cross bars are rotatably attached at each end to the uprights they reinforce.

The framework of cargo hoist 57 that results from this arrangement of members has the appearance when in its most elevated position of a box frame riding upon two wheel-bearing axles, the frame having no cross pieces at the top, and a wide platform cross member at one end of the bottom. The box frame is collapsible in the direction of the end of the hoist at which hydraulic rams 124 and 124a are rotatably attached to base members 125 and 125a.

At all stages of collapse of this box frame and later return of the frame to the upright position, the frame maintains (by means described below) its parallelepiped shape. The result is that elevating members 82 and 83 sweep through the same arc on both sides of cargo hoist 57, maintaining at all times their parallel relation and their equal heights above the ground.

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When hoist switch 122 is closed, the hydraulic pump of hydraulic rams 124 and 124a is caused to operate. This forces pistons 126 and 126a to be moved out of the cylinder of rams 124 and 124a. As seen from the intermediate broken line position of cargo hoist 57 shown in Figure 15, pushing piston 126 out of the cylinder of ram 124 forces upright 127 to rotate about axle 129 at its bottom end. As upright 127 rises from the collapsed position, cross bar 132 and elevating member 83 pull up in the same way upright member 128 at the other end of elevating member 83.

As piston 126 is pushed farther out of the cylinder of ram 124 by continued operation of the hydraulic pump of the system, uprights 127 and 128 continue to approach the vertical position until elevating member 83 has reached its highest position, which is shown in broken line in Figure 15. At the same time, elevating member 82 is moved up into the same relative position on the other side of the hoist.

The final part of the rise of cargo hoist 57 is produced, as stated above, by manual operation of a switch. When the hoist has reached its extreme elevated position, the manual switch is no longer actuated and no additional hydraulic pressure is applied. Since the hydraulic system is fluid tight, the position taken by the hoist is a stable one. In fact, hoist 57 will remain elevated at any elevated position it comes to rest in when actuation of the manual switch ceases. The positions to which hoists 56, 57 and 58 are raised depends upon the height of cargo holds 53, 54 and 55 which are being serviced by the hoists. Figures 2A and 2B give an example of different heights to which the three hoists may be raised.

Cargo hoist 57 is shown in Figure 15 as being carried on wheels adapted to ride upon plate 142, and corresponding plate 142a on the other side of the hoist. Within predetermined limits, cargo hoist 57 may be moved toward the nose of the plane or toward the tail of the plane, as desired. This provides additional flexibility in the use of the apparatus of this invention, for it permits forward and rearward adjustment to be made in the position of cargo hoist 57 depending upon the location of cargo hold 54 in the plane which is being loaded or unloaded.

As best seen from Figure 16, rear wheel 140 is supplemented in the embodiment shown by other wheels 140a, 140b and 140c, all carried upon axle 129. Similarly, wheel 141 seen in Figure 15 is supplemented by wheels 141a, 141b and 141c, all carried by axle 130.

The center of gravity of cargo hoist 57 shifts markedly when upright members 127 and 128 collapse from the vertical position to a near horizontal position and return to the vertical. This shift is made even more marked by addition of the weight of pallet 51 and the cargo it carries when these are raised or lowered upon elevating members 82 and 83. The pallet and its cargo tend to tip hoist 57 forward over front axle 130, raising wheels 140 off the ground at the rear end of the hoist.

One factor opposing the tendency of hoist 57 to tip forward when loaded is the placement of the motor pump and hydraulic mechanism which operate hoist 57. These are for the most part supported upon platform 131 at the rear end of hoist 57. The weight of this equipment helps to counterbalance the shift in center of gravity as the pallet and load are lowered, or as they are first caused to be raised, by elevating members 82 and 83.

Another means of opposing this shift in the center of gravity of the loaded cargo hoist is to place a counterweight of concrete or similar heavy material upon platform 131 at the rear end of hoist 57.

Still another means of counteracting the shift in center of gravity of hoist 57 is to provide a hold-down device which will operate to keep wheels 140, 140a, 140b and 140c from being lifted very far, if at all, off plates 142 and 142a. Such a hold-down device is seen in Figure 16, where bracket 143 is connected to plate 142 at its bottom end and overhangs wheel 140 at the top. Bracket 143

extends along conveyor 60 for the same distance it is desired to move hoist 57 to accommodate different locations of cargo holds of airplanes with which the hoist is used. A similar hold-down device 143a is provided on the opposite side of cargo hoist 57 to help hold down wheels 140c. (Hold-down device 143 has been omitted for clarity from Figures 15 and 21A.)

The cargo hoist of this invention may be designed to ride upon rails 145 as shown in Figures 17 and 18 rather than upon plate 142. In this embodiment, there is a pair of flanged wheels 146 on each side of cargo hoist 57. The wheel shown in Figures 17 and 18 is at the left rear end of hoist 57. It occupies, in other words, the same relative position with respect to the cargo hoist as the wheels 140b and 140c shown in Figure 16.

In this embodiment, base member 125a has welded to it angles 150 and 151, which together form a hold-down device which will counteract the upsetting tendency described above. Angles 150 and 151 embrace flange 152 at the top of rail 145 upon which wheels 146 ride. Grasping the bottom part of flange 152 on both sides, angles 150 and 151 keep base member 125a and therefore axle 129 and wheel 146 all in their operative positions, with the wheel riding upon track 145.

Figures 16, 19A and B, 21A and B, and 22 show in more detail how cargo hoist 57 raises cargo pallet 51 into its elevated position. From these figures can be seen the movement by which hydraulic rams 124 and 124a force pistons 126 and 126a into an extended position, thus elevating upright members 127 and 127a until the latter are in a vertical position. As seen from Figures 21A and 21B, in this position cross bar 132 and elevating member 83 are horizontal. Elevating members 82 and 83 are both raised, as seen in Figures 19A and 19B, to their extreme upper position, and they have carried with them cargo pallet 51.

Upright 127 is comprised of two channel members 127' and 127'' which face each other and are connected by a wide plate 153 at their bottom ends and a second wide plate 154 at their top ends. Members 127' and 127'' each have a hole at the bottom end through which axle 129 passes. Thus the upright member forms a yoke through which the axle for wheels 140, 140a, 140b and 140c passes.

The upper end of hydraulic piston 126 is rotatably attached to upright member 127 by means of rod 155 which is journaled in housings 156' and 156'' attached to uprights 127' and 127'', respectively. Horizontal members 132' and 132'' are rotatably attached to uprights 127' and 127'', respectively, at the rear end of hoist 57 and to the corresponding upright members at the front end of the hoist.

Elevating member 83 is connected at the top of upright 127 through a construction somewhat similar to the connection of the same upright to axle 129 at the bottom of the hoist. Elevating member 83 is a wide channel member which rides with its open portion facing downward, so that the sides of the channel overlap the top of upright 127. The top of upright 127 is formed in a yoke somewhat like that at the bottom of the upright. Connecting rod 160 provides a means of rotatably attaching the yoke so formed to the side walls of the channel comprising elevating member 83.

The same type of construction is used for the other three upright members and elevating member 82. The upright members all have a relatively large transverse dimension in comparison to their height. This gives them a degree of stability in a transverse direction which is especially important in a cargo hoist which is used to elevate loads having the weight of cargo pallet 51 and the cargo it carries.

When cargo hoist 57 is in its down or collapsed position with upright members 82 and 83 at a height just flush with tracks 62 and conveyor belt 65, the frame of the hoist has not yet been swung down to the very lowest

position it could possibly assume. Hydraulic rams 124 and 124a tend to keep uprights 127 and 127a at the desired angle to the horizontal, after additional hydraulic pressure is no longer applied to move hoist 57 down to its bottom position. Stop 157, shown in Figure 15, provides an additional, mechanical means of keeping upright 127 at the proper angle when hoist 57 is in its down position. Stop 157a, on the other side of the hoist, does the same for upright 127a. The stops, located about midway between the ends of hoist 57, are carried by base members 125 and 125a, respectively.

Hoist switch.—As shown in Figures 16 and 19B, elevating members 82 and 83 carry guide chutes 161 and 162, respectively. These have been omitted for clarity from Figure 21B.

The guide chutes on hoist 57 are located in the middle of the elevating members. Guide chute 161 operates to guide cam roller 163 directly to cam bar 120 as cargo pallet 51 rolls upon elevating members 82 and 83 while cargo hoist 57 is in its down or collapsed position. Guide chute 162 keeps guide roller 164 in the proper transverse position so that cam roller 163 will maintain its correct transverse position for tripping cam bar 120. Cam roller 163 and guide roller 164 are both at the front end of cargo pallet 51. Similar rollers are located in the same positions at the rear of the cargo pallet, but have been omitted for clarity from Figures 16 and 19B.

From Figure 16 it is seen that cam rollers 166 and 167 (shown in phantom) may be carried at the front end of other cargo pallets in positions from which they will selectively actuate other cam bars 168 and 169 located on cargo hoists 56 and 58, respectively. Similarly, guide rollers 170 and 171 may be located in corresponding positions on the other side of cargo pallets 50 and 52, respectively.

Figure 22 shows the position occupied by cam bar 120 as cam roller 163 approaches it when cargo pallet 51 is moved along conveyor 60 by conveyor belt 65. In this position, elevating member 82 is substantially flush horizontally with the top surface of conveyor belt 65. As seen, upright 128 lies in a collapsed position with horizontal member 132 and elevating member 82 depressed accordingly.

Cam lever 121 rotates about fulcrum 175 which is attached to elevating member 82. The bottom end of cam lever 121 presses against switch wheel 123, which is adapted to actuate hoist switch 122. The upper end of cam lever 121 is rotatably attached to cam bar 120 by means of hinge 176. Cam bar 120 is supported in its uppermost position by coil spring 177, the bottom end of which is secured to elevating member 82. When cam bar 120 is in this position, switch wheel 123 of hoist switch 122 is in contact with the bottom end of cam lever 121, but is not pressed by lever 121 enough to close normally open limit switch 122.

When cam roller 163 depresses cam bar 120 against the urging of spring 177, the cam bar moves down to the point where notch 178 in the bar rests against fulcrum 175. This causes the bottom end of cam lever 121 to be raised. As the bottom end of cam lever 121 is raised, this pushes wheel 123 and causes the arm on which the wheel is borne to be rotated, thus actuating hoist switch 122.

Cam bar 120 is shown in Figure 16 in its uppermost position just before it will be struck by cam roller 163. Figures 19B and 21B show how cam roller 163 depresses cam bar 120 when the roller rides upon the bar.

Figure 23 shows in plan view how cargo pallet 51, upon approaching cargo hoist 57 from the direction of cargo accumulation station 49, will have its cam roller 163 and guide roller 164 directed in the correct paths by guide chutes 161 and 162, respectively. As cargo pallet 51 rides over elevating members 82 and 83, cam roller 163 trips cam bar 120, and actuates hoist switch 122 as explained above. This causes cargo hoist 57 to

raise pallet 51 into the position shown in plan in Figure 23.

Figures 24 through 26 are views of cargo hoist 56, which is at the outermost plane loading station of the system shown in Figure 1A. Figure 24 shows how guide roller 170 on cargo pallet 50 is guided along the correct path by guide chute 181 on elevating member 85 of cargo hoist 56. As shown in Figure 25, guide chute 182 occupies a corresponding position on elevating member 84 on the opposite side of hoist 56. Cam bar 168 on elevating member 84 of hoist 56 is of similar construction to cam bar 120 on hoist 57.

Personnel platform 86 is shown in Figure 25 as folded back on hinges 184 to be out of the way of cargo pallet 50 as it rides upon elevating members 84 and 85. When cargo hoist 56 is used without cargo pallet 50, personnel platform 86 may be folded over into the position shown in broken line in Figure 26 to increase the area of the platform by about one half.

Figure 26 shows how cam roller 166 of cargo pallet 50 rolls through guide chute 182 on elevating member 84 and from there onto cam bar 168. Depression of cam bar 168 actuates hoist switch 186, in the same manner as hoist switch 122 on cargo hoist 57 was actuated by cam roller 163 of cargo pallet 51. Upright members 187 and 188 of cargo hoist 56, and corresponding upright members 187a and 188a on the opposite side of the hoist, are then raised from the down or collapsed position toward the vertical position and this raises elevating members 84 and 85 with cargo pallet 50 upon them.

In the embodiment shown in Figures 21B and 22, the hoist switch mechanism is for clarity shown on elevating member 83 on the right side of hoist 57, rather than on the left side as in Figures 19B and 16. The hoist switch is shown on the left hand side of cargo hoist 56 in Figures 25 and 26. The hoist switch may in fact be located on either side of the cargo hoist, as desired. One advantage of locating the switch on the right hand elevating member (the elevating member which is farther from the plane being loaded or unloaded) is that in this position there is less chance of accidental actuation of the hoist switch by baggage handling personnel, one of whom might inadvertently step upon cam bar 120.

Consideration of Figures 16, 23 and 25 discloses how the cam rollers of the various cargo pallets 50, 51 and 52 selectively operate the hoist switch means of their associated cargo hoists. The elevating members of each cargo hoist are in effect divided into lanes: three each at hoists 57 and 58, and, for convenience, two lanes at hoist 56. The cam rollers at the front of each cargo pallet (and the corresponding rollers directly behind them) are located so that they are all at a characteristic distance from the longitudinal axis of the pallet for each of the three pallets. The rollers are so aligned that as their pallet is propelled over the elevating members of the cargo hoists the rollers for a given pallet will always pass through the same lane on those elevating members. The cam roller and the roller trailing it mounted on cargo pallet 50, for example, always ride in the outermost lane on the cargo hoists. The corresponding rollers on pallets 51 always ride in the middle lane on the cargo hoists. The same rollers on pallet 52 always ride in the innermost lane.

Since the cam bars on cargo hoists 58 and 57 are in the middle and innermost lanes, cargo pallet 50 passes over those hoists without having its cam roller 166 energize a hoist switch. It is not until pallet 50 reaches the outermost cargo hoist 57 that cam roller 166 finds cam bar 168 in its path. Similarly, pallet 51 passes over cargo hoist 58 without having its cam roller 163 strike the hoist switch of that hoist. However, when pallet 51 reaches cargo hoist 57, cam roller 163 depresses cam bar 120 and causes the hoist to raise its pallet. In the same manner, cam roller 167 will depress cam bar 169 as soon as it reaches cargo hoist 58.

When the cam bar of a cargo hoist is depressed and the

hoist lifts the cargo pallet off conveyor belt 65, the cam bar is permitted to be pushed down an appreciable distance below the top of the elevating member on which it is carried, as is shown in Figure 26 for cam bar 168 and elevating member 84. Simultaneously, as shown in Figures 24 and 25, guide roller 171 at the front of the opposite side of cargo pallet 50 is caused to roll down inclined trough 189 into level trough 190. As a result, the forward movement of cargo pallet 50 is continued, despite the breaking of frictional engagement between conveyor belt 65 and the pallet, until the pallet has moved into a position near the middle of the cargo hoist.

In Figure 26 cargo pallet 50 has not yet reached its position of forwardmost roll, as guide roller 170 has presumably not yet come to rest in level trough 190, as is the case in Figure 24. In Figure 23, cargo pallet 51 has come to rest in the position it occupies while being raised by hoist 57, with its guide wheel 164 having coasted down incline 191 into depressed trough 192.

Conveyor structure.—Figure 20 gives a cross sectional view of conveyor structure 61. The sectional view is taken along the line 20—20 in Figure 30. As will be seen from Figures 1A and 1B, line 20—20 might be indicated at one of many places (except the curved section of the conveyor) along the entire length of conveyor 60.

Framework 61 carries support rollers 193 and return rollers 194. The upper on conveying portion 195 of conveyor belt 65 rides upon support rollers 193. The lower or return portion 196 rides upon idler rollers 194. Framework 61 also carries tracks 62 on either side of the conveyor belt.

It has already been explained that cargo hoists 56, 57 and 58 may be moved limited distances along the axis of conveyor 60. Uprights 197 and cross bars 198 of conveyor framework 61 present limits upon the extent to which the cargo hoists may be so moved.

Since axles 129 and 130 and platform 131 of cargo hoist 57, for example, extend across from base member 125 to 125a, these three transverse members will all require clearance in order for the hoist to be moved any substantial distance. This may be best seen in Figures 15, 16 and 21A. With platform 131 and axle 130 straddling a particular upright 197 of conveyor structure 61 with one of them on either side of the upright, hoist 57 may be moved a certain distance forward and backward. This distance is increased by removing the lower portions of uprights 197 and the accompanying cross bar 198 in order to permit clearance underneath the remaining portions 199 of the upright. The clearance is best seen in Figures 16 and 19A, where it is seen that the hydraulic system carried by platform 131 is able to pass under return roller 194 and portions 199 of uprights 197.

Hydraulic system.—The hydraulic system by which cargo hoist 57 is operated is shown in plan view in Figure 27, in end-elevation in Figure 19A, and in side elevation in Figure 21A. The major part of the hydraulic system for hoist 57 is mounted on platform 131 which extends between base members 125 and 125a.

Referring now to Figure 27, electric motor 200 drives hydraulic pump 201 through flexible coupling 202. Input pipe 203 of pump 201 is connected with hydraulic oil reservoir 204. Reservoir 204 is filled with oil through pipe 205, provided with a breather cap 206.

Output pipe 207 of pump 201 is connected with 4-way valve 208 through relief valve 209 and connecting pipe 210. Relief valve 209 is connected through pipe 211 with return line 212 leading back to oil reservoir 204. The relief valve is adjusted for a predetermined maximum pressure. If the pressure in line 207 rises above this figure, sufficient oil is diverted through lines 211 and 212 back to the reservoir to reduce the pressure to the predetermined maximum.

Valve 208 is a 4-way valve of conventional type which connects input pipe 210 with return line 212 when no

hydraulic pressure is to be applied to hydraulic rams 124 and 124a, with output line 213 when pressure is to be applied to the top end of the ram, and with output line 225 when pressure is to be applied at the bottom end of the rams.

Line 213 leads from valve 208 to 4-way fitting 214 and from there to T-joint 215. T-joint 215 branches out on one side to check valve 216 and on the other to check valve 217. Line 218 leads from check valve 217 through flexible tubing 219 to the top side of the cylinder of hydraulic ram 124. Line 220 leads from check valve 216 in the same way through flexible tubing 221 to the top side of hydraulic ram 124a on the opposite side of cargo hoist 57.

Line 225 leads from valve 208 to 4-way fitting 226 and beyond that to T-joint 227. T-joint 227 is connected on one side to check valve 228 and on the other to check valve 229. Line 230 leads from check valve 228 through flexible tubing 231 to flow control valves 232 and 233, and then to the bottom side of the cylinder of hydraulic ram 124. Line 234 leads in the same way from check valve 229 through flexible tubing 235 to flow control valves 236 and 237, and from there to the bottom side of the cylinder of hydraulic ram 124a on the opposite side of cargo hoist 57.

Pilot lines 240 and 241 lead from 4-way fitting 214 to check valves 228 and 229, respectively. In the same way, pilot lines 242 and 243 lead from 4-way valve 226 to check valves 216 and 217, respectively. Each of the check valves 228, 229, 216 and 217 is of conventional construction. The valves are adapted to be actuated by hydraulic pressure from pilot line 240, 241, 242, and 243, respectively, without the flow of any fluid through the pilot lines into the check valves. The valves normally permit flow of fluid in one direction only, and when actuated by application of hydraulic pressure through the associated pilot line will permit oil flow only in the reverse direction.

Application of pressure through line 213, 4-way fitting 214 and pilot lines 240 and 241 causes check valves 228 and 229 to permit oil flow only in the direction away from rams 124 and 124a, respectively. This bars application of hydraulic pressure through those check valves to the bottom sides of hydraulic rams 124 and 124a.

Similarly, application of pressure through line 225, 4-way fitting 226 and pilot lines 242 and 243 causes check valves 216 and 217 to permit oil flow only away from rams 124a and 124, respectively. This bars application of fluid pressure to the top side of hydraulic rams 124 and 124a.

Bleed line 244 is the only other connection to 4-way valve 208. This line leads from valve 208 back to oil reservoir 204. It carries back to the reservoir any internal leakage of oil which may appear in valve 208.

Motor 200 of the hydraulic system is energized by means of the circuit shown in Figure 33 and described below in this specification. 4-way valve 208 is operated by a system of push buttons which are included in the same circuit.

When motor 200 drives pump 201, hydraulic pressure is applied either at the bottom or top ends of hydraulic rams 124 and 124a, depending upon the condition of valve 208. When 4-way valve 208 connects input line 210 with return line 212 leading to oil reservoir 204, pump 201 merely circulates oil through the system without applying any hydraulic pressure to rams 124 and 124a.

When input line 210 is connected through 4-way valve 208 with output line 225, valve 208 at the same time connects line 213 with return line 212. This applies hydraulic pressure to the bottom end of hydraulic ram 124 through T-joint 227, valve 228, line 230, flexible tubing 231, and flow control valves 232 and 233. At the same time, the upper end of hydraulic ram 124 is connected through flexible tubing 219, line 218, check valve 217, T-joint 215 and line 213 to 4-way valve 208 and

from there through return line 212 back to oil reservoir 204. Application of increased hydraulic pressure at the bottom end of ram 124, with all hydraulic pressure removed from the top end, forces piston 126 out of the cylinder of ram 124.

A similar application of hydraulic pressure at the bottom of hydraulic ram 124a and return of fluid from the top end of ram 124a back to reservoir 204 causes piston 126a to be forced out of the cylinder of that hydraulic ram.

When 4-way valve 208 connects input line 210 with output line 213 it also connects line 225 with return line 212. This produces the opposite result from that just described. Hydraulic pressure is then applied to the top end of hydraulic ram 124 through T-joint 215, check valve 217, line 218 and flexible tubing 219. At the same time, the pressure in output line 213 acts through 4-way coupling 214 and pilot line 240 to actuate check valve 228 to permit oil to flow from the bottom end of hydraulic ram 124 through flow control valves 232 and 233, flexible tubing 231, line 230, T-joint 227, line 225 and return line 212 back to oil reservoir 204. The application of hydraulic pressure at the top of ram 124 and flow of oil from the bottom of the ram back to the oil reservoir cause piston 126 to be forced back into the cylinder of hydraulic ram 124. At the same time, a similar result occurs on the opposite side of hoist 57 with hydraulic ram 124a.

It is essential that elevating members 82 and 83 of cargo hoist 57 rise and fall at the same rate, in order to keep those two members always at the same height. Otherwise cargo pallet 51 would be tipped sidewise in one direction or the other, and might damage plane 42 or in extreme cases might fall off the hoist and damage the baggage or the personnel handling the baggage. Uniform rate of rise and fall of elevating members 82 and 83 is produced by keeping equal the rates at which pistons 126 and 126a are extended from and forced back into the cylinders of hydraulic rams 124 and 124a, respectively. The control of the rates of movement of pistons 126 and 126a is accomplished by use of flow control valves 232, 233, 236 and 237.

Each of the four valves 232, 233, 236 and 237 permits a free flow of oil in one direction and regulates accurately the maximum rate at which oil may flow through the valve in the opposite direction. Valves 232 and 233 are arranged so that the direction in which flow control valve 232 controls the maximum volume of oil that may pass through it in a given time, and the direction in which valve 233 has the same effect, are opposite to each other. The result is that the volume of oil passing through flow control valves 232 and 233—and thus through the cylinder of hydraulic ram 124—in either direction during a given period never rises above a predetermined maximum amount. Generally the maximum permitted rate of flow is the same in both directions, but the essential thing is that in a given direction the maximum possible rate of flow is always equal for the two rams on opposite sides of the hoist.

In the hydraulic system shown, pump 201 has an output rate greater than the combined rates of maximum flow in a particular direction permitted by flow control valves 232 and 233 on one side of cargo hoist 57 and flow control valves 236 and 237, connected with hydraulic ram 124a, on the opposite side of the hoist. Valves 236 and 237 have the same characteristics as valves 232 and 233, respectively. Thus the rate of flow to hydraulic rams 124 and 124a is always the maximum permitted by the flow control valves, and is always the same for corresponding ends of rams 124 and 124a.

Pistons 126 and 126a occupy the same relative positions in rams 124 and 124a when cargo hoist 57 is in its down or collapsed position. In this position the upper end of each piston is at the same height as the upper end of the other piston. The performance charac-

teristics of each hydraulic ram and its piston are also the same. As a result, flow of equal amounts of fluid under pressure into the bottom ends of rams 124 and 124a to extend pistons 126 and 126a will extend the pistons so that their upper ends are always at the same height. This keeps upright members 127 and 127a and the rest of the frames which support elevating members 83 and 82, respectively, in the same relative positions at all times while the elevating members are being raised.

For the same reasons, elevating members 82 and 83 are maintained at the same height as they are lowered when pistons 126 and 126a are forced back into the cylinders of rams 124 and 124a, respectively, by flow of equal amounts of fluid under pressure at the top ends of the two rams.

Curved conveyor section.—The curved section of conveyor 60 in which endless conveyor belt 64 operates is shown in Figure 28. Conveyor structure 61 includes circular guide members 250. Tracks 62 rest upon members 250, with conveyor belt 64 riding between them.

As shown in Figure 29, uprights 197 carry a group of frustum-shaped support rollers 251 and a group of frustum-shaped idler rollers 252. The upper or conveying portion 253 of belt 64, upon which cargo is carried, rides upon rollers 251. The lower or return portion 254 of belt 64 rides upon idler rollers 252. The idler rollers are positioned at a suitable distance below the support rollers.

Support rollers 251, as shown in dotted line in Figure 28, are spaced relatively closely together. Idler rollers 252, on the other hand, are spaced more widely. Conveyor belt 64 is broken away in the right central portion of Figure 28, thereby disclosing in solid line a support roller 251 and an idler roller 252.

Rollers 251 and 252 are disposed radially about the center of curvature of the curved conveyor, which in Figure 28 lies above the curved section shown. The larger ends of these frustum-shaped support rollers 251 and idler rollers 252 are, as is seen, directed radially outward from the center of curvature of the conveyor.

Drive roller 255 is positioned at one end of the curved conveyor and terminal roller 256 at the other end. These rollers, like rollers 252 and 253, are frustum-shaped. However, they are considerably larger in diameter than the support and idler rollers.

Take-up roller 257 is positioned below idler rollers 252, and near the center of the curved conveyor. Large idler rollers 258 flank take-up roller 257 on either side, at about the same height as roller 257. Take-up roller 257 and large idler rollers 258 have their larger ends directed radially outward, and inclined downward.

The return or lower part 254 of endless conveyor belt 64 is arranged to pass over one idler roller 258, under take-up roller 257, and again over idler roller 258 on the opposite side of the take-up roller. The vertical position of take-up roller 257 may be adjusted by moving the bearings in which the axle of the roller is journaled upward and downward, by means not shown. As take-up roller 257 is moved upward and downward, this decreases and increases the tension that is placed upon the entire looped belt 64. In addition, if the belt stretches or contracts during various conditions of use, the tension on the belt can be maintained at substantially the same amount at all times.

Axle 259 of drive roller 255 carries gear 260 which is driven by a chain drive (shown in Figure 1A) from gear reducer 74b and motor 73b.

Conveyor belt 64 is fabricated of a flexible material such as rubber covered fabric transmission belting, or any other suitable material which provides the necessary flexibility and strength. The strength required will depend upon the length of conveyor belt 64, the sharpness of the curved path of the conveyor, and the tension which must be placed upon the belt to cause it to rotate under given loading conditions.

As shown in Figure 29, tensioning strip 261 is carried

on the inner surface of looped conveyor belt 64 near the outer periphery of the belt. Tensioning strip 261 extends downward from top portion 253 of conveyor belt 64 and upward from bottom portion 254 of the belt. The inner edge of the strip has an inverted V-shape.

Upper tensioning wheels 262 are rotatably mounted on conveyor structure 61 just below the bottom of upper or conveying portion 253 of the conveyor belt, and just inside tensioning strip 261. Tensioning wheels 262 are flanged so as to fit snugly against the inner edge of tensioning strip 261.

Lower tensioning wheels 263 are rotatably mounted on conveyor structure 61, just above the inner surface of bottom or return portion 254 of conveyor belt 64, and just inside tensioning strip 261. Lower tensioning wheels 263 are also flanged to fit snugly against tensioning strip 261.

As shown in Figure 28, upper tensioning wheels 262 are spaced at frequent intervals around the outer edge of conveyor belt 64. Lower tensioning wheels 263 are similarly spaced. In this position, tensioning wheels 262 and 263 cooperate with tensioning strip 261 to tend to keep conveyor belt 64 in its normal operative position as it is rotated by drive roller 255.

Tensioning channel 264 is also arranged about the outer part of upper portion 253 of conveyor belt 64. The top of tensioning channel 264 is, in the embodiment shown, below the upper or conveying surface of the conveyor belt. Leveling wheels 265 are rotatably mounted on extension arms 266 carried at intervals by tensioning strip 261. Leveling wheels 265 are positioned to ride against the lower surface of tensioning channel 264, if the outer edge of upper portion 253 of the conveyor belt starts to buckle up, in order to hold the belt down in its normal operative position.

Cargo pallet.—In Figure 30, cargo pallet 51 is shown being propelled by conveyor belt 65 along a section of conveyor 60 which may be, for example, alongside plane 42. Upper or conveying portion 195 of the conveyor belt rides upon support rollers 193. Lower or return portion 196 of the belt rides upon idler rollers 194.

The superstructure or body of cargo pallet 51 is comprised of base 270, uprights 271 and 272 on one side, uprights 271a and 272a on the other, and horizontal panels 273 extending around the pallet and supported by the uprights. Horizontal panels 273 on the side of the pallet next to the airplane are preferably removable, as indicated in Figure 1A, for convenience in loading and unloading the pallet. Base 270 carries rear axle 274 and front axle 275 upon which are mounted rear wheels 276 and 276a, and front wheels 277 and 277a, respectively. Wheels 276 and 277, on the right side of cargo pallet 51 as seen in Figure 30, are omitted for clarity in that drawing. Axles 274 and 275 are pivotally mounted on the bottom side of base 270 by a means shown in greater detail in Figure 32.

In Figure 32, the various parts of the apparatus by which axle 274 and traction plate 75 are suspended from the base of cargo pallet 51 are shown in an exploded side view. Axle 274 is welded to channel 278, which is in turn attached to upper plate 279. Plate 279 carries shaft 280 rising vertically above it. Bearing 281, with rotatable member 281a, is attached to base 270 of the cargo pallet, and vertical shaft 280 is connected to rotatable member 281a by a bolt or cotter pin passing through corresponding holes in the two members. This arrangement permits axle 274 to be rotated, in the horizontal plane, with respect to the longitudinal axis of the cargo pallet.

Traction plate 75 is also arranged to rotate in the horizontal plane with respect to axle 274. Vertical cylinders 282 and 282a are welded to the bottom side of plate 279, one near the leading edge of the plate and one near the trailing edge. Pistons 283 and 283a are slideably engaged in cylinders 282 and 282a, respectively,

with coil springs 284 and 284a arranged about the outside of the cylinders. The springs press against plate 279 at their upper ends. At their bottom ends, the springs press against circular piston plate 285, to which are welded the bottom ends of pistons 283 and 283a. When compressed, springs 284 and 284a continuously urge piston plate 285 downward from upper plate 279. This provides the spring loading for traction plate 75. Traction plate 75 is carried by circular backing plate 286, which is rotatably connected to piston plate 285 by means of traction plate shaft 287. Ball bearings 288 are confined between piston plate 285 and backing plate 286, riding within channels 289 in those plates. Channels 289 are aligned with each other vertically and are concentric with circular plates 285 and 286 themselves.

When assembled, these parts have the appearance shown in Figure 30 in side elevation and in Figure 19B in end elevation. As seen, the arrangement of parts provides a traction plate 75 which is continuously urged by coil springs 284 and 284a against conveyor belt 65 while cargo pallet 51 rides with its wheels 276, 276a, 277 and 277a upon tracks 62. At the same time, the arrangement of parts is such that when cargo pallet 51 is raised by hoist 57 so that the frictional engagement between traction plate 75 and conveyor belt 65 is broken, plate 75 hangs suspended in midair from base 270.

Because shaft 280 and member 281a are rotatable in bearing casing 281, axle 274 (split at the center as seen in Figure 19B to accommodate the traction plate assembly) can rotate in a horizontal plane carrying with it wheels 276 and 276a. As seen in Figure 19B, wheel 276a is flanged, for a purpose to be explained below. Small rollers 267 are rotatably mounted above axle 274 at either end upon brackets attached to channel 278, to provide an additional support between axle 274 and base member 270 when the axle rotates with respect to cargo pallet 51.

As shown in Figure 19B, cargo pallet 51 carries near its left front corner cam roller 163 and near its right front corner guide roller 164. The purpose of rollers 163 and 164 has been explained above in connection with the discussion of the hoist switch for cargo hoist 57. Corresponding rollers are positioned at the rear of the pallet.

Traction plate 290 is suspended from the front axle assembly of cargo pallet 51 in a manner similar to the suspension of traction plate 75 at the rear of the pallet. When cargo pallet 51 moves along tracks 62 in a straight portion of conveyor 60, it is propelled by frictional engagement between the upper surface of conveyor belt 65 and the bottom surface of traction plates 75 and 290, which are urged by their loading springs against the surface of the belt.

In the embodiment shown, pallet 51 must be propelled not only along a straight section of rails 62 where straight conveyor belts such as 63 and 65 operate, but it must also be propelled across the gap between one endless conveyor belt and an adjacent endless conveyor belt, and must in addition be propelled around the curve of conveyor belt 64. Figure 11 shows the two gaps and the curved section of conveyor 60 which occur along the path of cargo pallet 51 as it is propelled from cargo accumulation station 40 out to hoist 57.

Referring again to Figure 30, it is seen that leading traction plate 290 may be pushed out over the gap between adjacent conveyor belts without breaking the frictional engagement between spring loaded traction plate 75 and the upper surface of the conveyor belt. If cargo pallet 51 is passing from conveyor belt 63 to 64, for example, the continued frictional engagement of plate 75 with belt 63 will push the pallet along rails 62 until spring loaded traction plate 290 attains a firm frictional engagement with the upper surface of conveyor belt 64. The frictional engagement between plate 290 and belt 64 will continue to propel cargo pallet 51 in a forward

direction, even when traction plate 75 has momentarily broken its frictional engagement with conveyor belt 63. As cargo pallet 51 proceeds forward, spring loaded traction plate 75 again attains frictional engagement with a conveyor belt, this time belt 64. Cargo pallet 51 is propelled across the gap between conveyor belts 64 and 65 in the same manner.

As cargo pallet 51 is propelled around the curve by conveyor belt 64, rotatable axles 275 and 274 are free to turn to permit the body of the pallet to turn at a different rate than the axles. This is necessary because with the sharp curvature of the curved section of conveyor 60 there is a significant difference in the direction in which cargo pallet 51 faces while on the curve and the directions in which the leading and trailing axles face.

To assure that leading axle 275 will tend to face in the proper direction to turn around the curve when cargo pallet 51 passes from conveyor belt 63 onto conveyor belt 64, inner wheel 277a of the cargo pallet is flanged. When cargo pallet 51 leaves the straight section of tracks 62 which flank conveyor belt 63, and enters upon the curved section of the tracks flanking curved conveyor belt 64, inner pallet wheel 277a is caused to drag somewhat by the frictional resistance between the wheel flanges and the track. This helps turn axle 275 counterclockwise as seen in the lower right hand corner of Figure 31 to go around the curve. Wheel 277 at the outer end of axle 275 is not flanged, and so it simply follows along the outer track of the pair of tracks 62.

As shown in Figure 23, the outer end of axle 275 is rotatably connected to rigid bar 291, which in turn is rotatably attached at its other end to the inner end of axle 274. This is also seen in Figure 31. As the inner end of axle 275 is caused to drag by the flanges on wheel 277a and the outer end of axle 275 is thus forced forward, rod 291 pulls the inner end of trailing axle 274 forward and this in turn pushes the outer end of axle 274 back. This places both leading axle 275 and trailing axle 274 in proper position for carrying cargo pallet 51 around the curve.

As will be seen from Figure 31, axles 274 and 275 are turned in a similar fashion when cargo pallet 51 moves around the curve in the opposite direction. When pallet 51 moves in a clockwise direction as seen in Figure 31, flanged wheel 276a drags somewhat, outer wheel 277 on axle 275 is forced backward by action of rod 291, and flanged wheel 277a is pushed forward somewhat. Both axles 274 and 275 are then facing in the proper direction to make the turn around the curve in the conveyor belt.

As cargo pallet 51 is just entering or leaving the curved section of tracks 62, the direction in which traction plate 75 or 290 faces may be different from the direction of both the pallet and the rotatable axles. This occurs because (as shown at the upper left hand side of Figure 31) the automatic turning of axles 274 and 275 to accommodate for the curve in tracks 62 takes place simultaneously. As axle 274 first enters upon the curve while pallet 51 is moving toward cargo accumulation center 40, for example, axle 274 turns with the curve, and so does traction plate 75. At the rear end of the pallet, however, axle 275 is caused by the automatic operation of rod 291 to turn prematurely. Axle 275 is already positioned for the curve, while that end of the pallet still rides upon the straight section of tracks 62. Rotation of traction plate 290 upon ball bearings 288 continues the traction plate in its same frictional engagement with conveyor belt 65, rather than forcing the plate to skew around upon the belt when axle 275 is turned as just described.

When cargo pallet 51 is lifted off tracks 62 by hoist 57, as shown in Figure 23, axles 274 and 275 must be kept at right angles to the longitudinal axis of the pallet in order that the wheels carried by those axles will be in proper position for riding upon tracks 62 when the pallet is returned to its position upon the tracks. Stops 292 and 292a are attached to base member 270 in posi-

tions which will bring axles 274 and 275 at 90° to the axis of the pallet when the axles are pressed against the stops. Coil spring 293 is connected at one end to base member 270 and at the other to the end of axle 274 opposite that at which rod 291 is attached. The tension of spring 293 pulls the end of rotatable axle 274 to which it is attached toward the center of the pallet, and against stop 292. This brings axle 274 into position at 90° to the axis of the pallet. The end of axle 274 opposite stop 292 is automatically pulled away from the center of the pallet by action of spring 293, and the action of rod 291 at the same time automatically pulls the diagonally opposite end of axle 275 against stop 292a. Axles 274 and 275 are by this means automatically kept properly positioned while cargo pallet 51 is lifted off tracks 62. Coupling 291a is provided to adjust the length of rigid rod 291 whenever necessary to keep axle 275 parallel to axle 274 when the latter is pulled snugly against stop 292.

Electrical circuit for actuating hydraulic system of hoists.—Figure 33 gives a diagram of the electrical circuit by means of which the hydraulic systems of cargo hoists 56, 57 and 58 are actuated. It also includes a circuit diagram of the electrical interlock system by means of which each cargo pallet 50, 51 and 52 is prevented from leaving its respective station at plane 42 to go back to cargo accumulation station 40 unless every other cargo pallet between the pallet in question and station 40 has already started back toward the cargo accumulation station.

In Figure 33, push button switch 300 is used for manual raising and lowering of cargo hoist 58. Similar switches 301 and 302 are used for manual operation of hoists 57 and 56, respectively. (As pointed out above, cargo hoist 56 occupies the outermost position near the nose of plane 42, hoist 57 occupies the middle position, and hoist 58 occupies the innermost position nearest cargo accumulation station 40.) Electrically operated relays 303, 304 and 305 are employed in the circuits through which power is applied to run the electric motors of the hydraulic systems of hoists 58, 57 and 56, respectively. Three-phase electrical motor 200 is the motor carried, in the manner shown in Figures 16, 19A, 21A and 27, upon platform 131 of cargo hoist 57. Similar motors 306 and 307 are the drive means for the hydraulic pumps of cargo hoists 58 and 56, respectively.

Solenoid 310 operates 4-way valve 208 (shown in Figure 27) of the hydraulic system for cargo hoist 57. Solenoids 311 and 312 perform a similar function in the hydraulic systems of cargo hoists 58 and 56, respectively.

Limit switch 122 is the hoist switch of cargo hoist 57. Limit switches 133 and 136 are the hoist switches for cargo hoists 58 and 56, respectively. Limit switch 315 is carried upon base member 125 of cargo hoist 57, as shown in Figure 21A. Limit switch 316 is carried in a similar position upon cargo hoist 58. Limit switch 317 on cargo hoist 56 corresponds to switches 315 and 316, and limit switch 318 is an additional switch employed because of the extra manual control on that hoist for bringing it down only part way when desired.

Other components of the circuit shown in Figure 33 will be identified as the circuit is described.

Closing of a manually operated switch (not shown) applies three-phase alternating voltage to power lines 330, 331 and 332, to supply the electrical power for the hydraulic systems of cargo hoists 56, 57 and 58. As cargo hoist 57 is the hoist which is most completely shown and described in this specification, operation of the hydraulic system of that hoist will be discussed first. As has been explained above, the elevating mechanism of hoist 57 is actuated only by cargo pallet 51. In this description, therefore, cargo pallet 50 is considered already to have passed beyond cargo hoist 57.

The voltage on power line 330 is applied to one side of solenoid 338 of relay 304 through line 333, contact

334 of relay 304, lead 335, and overload switch 336, which is normally held closed by heater coil 337. The other side of solenoid 338 is connected to a second overload switch 339, which is normally held closed by heater coil 340.

The voltage on power line 332 is applied to terminal 344 of limit switch 315 through line 341, contact 342 of relay 304, and lead 343. When switch 315 is closed, terminal 344 is connected with its opposite terminal 345, which in turn is connected with terminal 346 of limit switch 122.

Limit switch 315, as shown in Figure 21A, is normally biased open. However, when bracket 348 mounted on upright 127 of cargo hoist 57 swings downward while the hoist is being lowered into its collapsed position, the bracket reaches a predetermined height at which it strikes switch wheel 349 and closes limit switch 315. In the embodiment shown, this occurs when elevating members 82 and 83 of cargo hoist 57 have reached a point in their descent which is about a foot, or slightly more, above conveyor belt 65. Whenever upright 127 and bracket 348 are in this position or lower, the switch member connecting terminals 344 and 345 of limit switch 315 is held closed. Thus switch 315 is always closed whenever cargo hoist 57 is in its down position, as when it is awaiting arrival of its associated cargo pallet.

When hoist switch 122 is closed by arrival of cargo pallet 51 at the hoist, this connects terminal 346 of the switch to opposite terminal 347. Terminal 347 is connected through line 350 to overload switch 339 and solenoid 338. Thus, so long as limit switch 315 is closed, the closing of hoist switch 122 places the potential difference between power lines 332 and 330 across solenoid 338.

Energizing of coil 338 closes all the contacts in relay 304. As a result, voltage is applied to three-phase electrical motor 200 from power line 330 through lead 333, contacts 334 and 360 of relay 304, and heater coil 337. At the same time, voltage is applied to the motor from power line 331 through lead 361 and terminals 362 and 363 of relay 304. Similarly, voltage is applied from power line 332 through lead 341, terminals 342 and 364 of relay 304, and heater coil 340. Arrival of cargo pallet 51 at cargo hoist 57 thus starts motor 200.

If during operation of the hydraulic system an overload is ever imposed upon motor 200 through either heater coil 337 or 340, the overloaded heater coil will open overload switch 336 or 339, respectively. Current will immediately cease to flow through solenoid 338, relay 304 will open, and operation of motor 200 and the hydraulic system will cease.

The closing of hoist switch 122 not only applies a potential difference across solenoid 338, but in addition across coil 371 of solenoid 310 of 4-way valve 208. As has been pointed out above, terminal 346 of hoist switch 122 is connected with power line 332 whenever switch 315 is closed. Closing switch 122 connects terminal 346 with contact 365 of the same switch. Contact 365 is connected with one side of coil 371 through line 366, contacts 367, 368 and 369 of push button switch 301, and line 370. The other side of coil 371 is connected through line 372 with terminal 334 of relay 304 and from there through line 333 to power line 330.

Application of this voltage to coil 371 of solenoid 310 places 4-way valve 208 in condition to cause hydraulic pressure from pump 201 to be applied (in the manner explained above) through the hydraulic system of cargo hoist 57 to the bottom end of hydraulic rams 124 and 124a. As a result, cargo hoist 57 raises cargo pallet 51 off conveyor belt 65.

The automatic raising of cargo pallet 51 continues until the pallet reaches the predetermined height at which bracket 348 releases switch wheel 349 and permits limit switch 315 to resume its normal open position. Opening switch 315 breaks the connection between power line

332 and contact 346 of switch 122, so removes the potential difference from solenoid 371 of relay 310. This permits 4-way valve 208 to return to its normal condition, in which input pipe 210 is connected through the valve to return pipe 212 leading to oil reservoir 204. No additional hydraulic pressure is applied thereafter to the bottom of rams 124 and 124a, and thus the raising of the cargo pallet is automatically stopped.

At this juncture cargo hoist 57, with cargo pallet 51 upon it, will have been raised to about the height shown in Figure 2A. With cargo holds located at about the height shown for holds 54 and 55 in Figures 2A and 2B, it is desirable to raise the cargo pallet still higher toward the hold. With a cargo hold located at about the height shown for hold 53 in Fig. 2A, the cargo hoist will generally be elevated practically to its full extension.

Additional raising of the cargo hoist and the cargo pallet above the height to which they rise automatically is accomplished by manual operation of push button switch 301. Power line 332 is connected through lead 341, terminal 342 of relay 304, line 343, and lead 373 to terminal 374 of switch 301. So long as the "Stop" button is not pressed, terminal 374 is connected with terminal 375, which in turn is connected with terminals 376, 377 and 378 of relay 301. If the "Up" button is pressed, a connection is made between terminals 378 and 369 of relay 301, and one side of coil 371 of solenoid 310 of 4-way valve 208 is thereby connected with power line 332. Since the other side of coil 371 is connected with power line 330 by means previously described, pressing the "Up" button energizes coil 371 and places 4-way valve 208 in condition to permit application of hydraulic pressure to the bottom end of hydraulic rams 124 and 124a.

Pushing the "Up" button also establishes a connection between terminals 377 and 379 of switch 301. Leads 380 and 350 connect terminal 379 with solenoid 338 of relay 304. This imposes the potential difference between power line 332 and power line 330 across solenoid 338, and actuates relay 304. Actuating relay 304 closes all the contacts of that relay and applies three-phase alternating voltage to motor 200. Thus, pushing the "Up" button of switch 301 energizes motor 200 simultaneously with the actuation of 4-way valve 208.

As a result, hydraulic pressure is applied to the bottom side of rams 124 and 124a of cargo hoist 57, and elevating members 82 and 83 of the hoist are caused to rise. This raises cargo pallet 51. Hoist 57 continues to raise cargo pallet 51 so long as the "Up" button is held closed by the operator. As soon as the pallet has been raised to the desired height, the operator releases the "Up" button and the two circuits through solenoid 338 of relay 304 and coil 371 of relay 310 are broken. The operation of motor 200 immediately stops, and 4-way valve 208 returns to its neutral condition.

After all the cargo has been transferred from cargo pallet 51 into cargo hold 54 of plane 42, the operator may lower cargo hoist 57 manually (if the interlock circuit described below does not prevent this) to drop cargo pallet 51 into a position where traction plates 75 and 290 resume their frictional engagement with conveyor belt 65 and the pallet is propelled back on tracks 62 toward cargo accumulation center 40.

Pressing the "Down" button breaks the connection between terminals 367 and 368 of switch 301, and also connects terminals 376 and 390 of the same switch. Terminal 390 is connected through lead 391 to solenoid 392 of timer 393. Timer 393 may be a conventional type which is adjustable to provide the desired period of electrical contact between its terminals. The time selected should be long enough to permit cargo hoist 57 to lower cargo pallet 51 from the highest possible position of that pallet to a point where frictional engagement is established with conveyor belt 65 and the cargo pallet has been rolled off elevating members 82 and 83 onto track 62.

During this period, timer 393 acts to keep the hydraulic system of cargo hoist 57 continuously operative to drive the hoist down and hold it down despite the fact that— from the time hoist 57 descends to the height at which limit switch 315 is closed until a short time after conveyor belt 65 establishes contact with traction plates 75 and 290 and the pallet first starts to move off the hoist— both hoist switch 122 (because cam roller 163 continues to depress cam bar 120) and limit switch 315 are closed. Ordinarily, of course, when switch 122 is closed while limit switch 315 is also closed, cargo hoist 57 automatically raises pallet 51 into the air.

As already explained, when the "Stop" button is not pressed, terminal 375 of switch 301 is connected to power line 332 through contact 374 of relay 301, lines 373 and 343, terminal 342 of relay 304, and line 341. Terminal 375 is connected with terminal 376 of the same switch, and, as pointed out above, when the "Down" button is pressed the latter terminal is connected with one side of solenoid 392 of timer 393. The other side of the solenoid is connected by line 394 to terminal 395 of limit switch 316 associated with cargo hoist 58. This provides an interlock circuit between hoists 57 and 58, as will be explained in more detail below. When limit switch 316 is closed, terminals 395 and 396 of that switch are connected. Terminal 396 is connected through lines 397 and 372, terminal 334 of relay 304, and line 333 to power line 330. It is seen that when the "Down" button is pressed the potential difference between power lines 332 and 330 is impressed across solenoid 392 of timer 393, thus closing the contacts of the timer.

Terminal 375 of push button switch 301 is connected through lead 401 with terminal 402 of timer 393. With the contacts of the timer closed, terminal 402 is connected with terminal 403 and through lines 404 and 350 to one side of solenoid 338 of relay 304. Since the other side of solenoid 338 is connected with power line 330, relay 304 is energized and motor 200 is started.

At the same time, 4-way valve 208 is actuated to cause hydraulic pressure to be applied to the top end of the cylinders of rams 124 and 124a. Terminal 402 of timer 393 is connected with terminal 405. So long as the contacts of timer 393 remain closed, terminal 405 is connected with terminal 406 of the timer. Lead 407 connects terminal 406 to one side of coil 408 of solenoid 310. Voltage from power line 330 is applied to the other side of coil 408 through line 333, terminal 334 of relay 304, and line 372. The energizing of coil 408 activates 4-way valve 208.

As long as timer 393 remains closed, voltage is supplied across motor 200 and coil 408, and cargo hoist 57 proceeds downward to its collapsed position, where it is held by the hydraulic system of the hoist. Of course, if the "Stop" button of push button switch 301 is pressed, this will break the circuits which apply the voltage of power line 332 to solenoid 338 and to coil 408 of solenoid 301. This will stop operation of hydraulic rams 124 and 124a. Then, to start the hoist down again, the "Stop" button must be released and the "Down" button pressed.

The operation of cargo hoist 56, at the outermost plane loading station near the nose of plane 42, is similar to that of cargo hoist 57, but with some additions because of the special conditions at that plane loading station. Relay 305 of cargo hoist 56, for example, is the same in construction and operation as relay 304 of hoist 57, with power from power lines 330, 331 and 332 being applied to relay 305 through lines 420, 421 and 422, respectively. Lines 423, 424 and 425 connect the other side of relay 305 to three-phase electrical motor 307.

Alternating voltage from power line 330 is applied through line 420 to one side of solenoid 426 of relay 305 in series with other elements similar to those contained in relay 304. Alternating voltage from power line 332 is applied through line 422, terminal 431 of relay 305 and line 432 to terminal 433 of push button switch 302. So

long as the "Stop" button of switch 302 is not pressed, terminal 433 is connected with terminal 434. Terminal 434 is connected by lead 435 to terminal 436 of limit switch 317. With limit switch 317 closed, terminal 436 is connected with terminal 437 of switch 317. Terminal 437 is connected with terminal 438 of hoist switch 186. When hoist switch 186 is closed by the arrival of cargo pallet 50 at cargo hoist 56, terminal 438 is connected with terminal 430. This puts the voltage of power line 332 on the other side of solenoid 426—through lead 429, terminal 428 of relay 319, and lead 427—and closes relay 305, causing motor 307 to be energized.

Closing hoist switch 186 also connects terminal 438 with contact 439 of that switch. This applies the voltage of power line 332 through line 440 to one side of coil 441 of solenoid 312. The alternating voltage of power line 330 is applied to the other side of coil 441 through line 420, terminal 442 of relay 305, and line 443. This actuates the 4-way valve of the hydraulic system of cargo hoist 56 to cause hydraulic pressure to be applied at the bottom end of the hydraulic rams of that hoist.

Thus the arrival of cargo pallet 50, and the resulting closing of hoist switch 186, automatically cause elevating members 84 and 85 of cargo hoist 56 to be raised. Elevating members 84 and 85 carry pallet 50 upward with it. The automatic elevation of cargo pallet 50 continues until limit switch 317 opens at a predetermined height, in the same manner as limit switch 315 of cargo hoist 57 opened after cargo pallet 51 had been raised to a predetermined height. Further raising of cargo pallet 50 is accomplished manually by use of the push buttons of switch 302.

While the "Up" button of switch 302 is pressed (assuming that the "Stop" button is not pushed), alternating voltage from power line 332 is applied through closed hoist switch 186, in a manner to be explained, to one side of coil 441 and also to one side of solenoid 426 of relay 305. This actuates the 4-way valve of the hydraulic system of hoist 56 and energizes motor 307. As a result, hoist 56 raises cargo pallet 50 to the desired height, at which point the "Up" button is released.

Voltage from power line 332 is applied through line 422, contact 431 of relay 305, and line 432 to terminal 433 of push button switch 302. With the "Stop" button not pressed, terminals 433 and 434 of switch 302 are connected. The latter terminal is connected to terminals 450 through 455 on one side of switch 302. While the "Up" button is pressed, terminal 455 is connected with terminal 456 on the other side of the switch. Terminal 456 is connected through line 440 to one side of coil 441. The same alternating voltage from power line 332 is applied from terminal 456 through the other branch of lead 440 to terminals 439 and 430 of hoist switch 186. From there it is applied through line 429, terminal 428 of relay 319, and line 427 to solenoid 426 of relay 305.

For the majority of airplanes the forwardmost cargo hold 53 is located considerably higher than the other two holds, 54 and 55. This is shown in Figures 1A and 2A. For this reason, it is more difficult to raise hoist 56 accurately to the desired height upon the first try by the operator. If the "Up" button is pressed too long, cargo hoist 56 will rise too far and it will be necessary to bring it back down to the desired position with respect to cargo hold 53. A "Down" button of the type used in the circuit of cargo hoist 57 would not be suitable for this because of its connection with a timer, which assures that once started down the hoist will continue moving down and remain in its collapsed position for a predetermined interval of time. The "Jog down" button is added to cargo hoist 56 to provide the necessary selective control which the operator needs for accurate positioning of the elevated hoist.

The circuit in which the "Jog down" button is connected includes no timer, and the circuit is thus effective only while the "Jog down" button is pressed by the operator. Thus, simply by pushing the button the desired length of time, the operator may control accurately how far down

elevating members 84 and 85 of cargo hoist 56 are brought before they are stopped in position for loading or unloading of cargo pallet 50. If the operator—because of the difficulty of estimating the height of cargo pallet 50 from the ground when cargo hoist 56 is raised to substantially its full height—makes an error and brings the pallet back down too far, this can easily be corrected by his pushing the "Up" button once again.

Voltage from power line 330 is applied to one side of coil 457 of solenoid 312 through line 420, terminal 442 of relay 305, and line 443. So long as the "Jog down" button is pressed (and the "Stop" button is not pressed), voltage from power line 332 is applied to the other side of coil 457 through line 422, terminal 431 of relay 305, line 432, terminals 433, 434, 450 through 453, and 458 of push button switch 302, lead 459, and terminal 460 of relay 319. This energizes solenoid 312 which actuates the 4-way valve in the hydraulic system of cargo hoist 56 to put it in condition to cause hydraulic pressure to be applied at the top of the hydraulic rams of hoist 56.

With the "Jog down" button pressed (and the "Stop" button not pressed), the voltage of power line 332 which is applied to terminal 452 of push button switch 302 is also applied, through terminals 461 and 462 of switch 302, leads 463 and 429, terminal 428 of relay 319, and lead 427, to one side of solenoid 426 of relay 305. This energizes motor 307.

When cargo pallet 50 has been unloaded by transferring its load of cargo into hold 53, it may be desirable to bring the cargo pallet down part way toward conveyor belt 65 to await the time when pallets 51 and 52 will have been started back toward cargo accumulation station 40 and thus the track will be clear for pallet 50 to leave plane 42 and return to station 40. Holding relay 319 and limit switch 318 are employed in the circuits by which this is accomplished.

Voltage from power line 330 is applied to one side of solenoid 520 of holding relay 319 through line 420, terminal 442 of relay 305, and lines 443 and 521. When the "Down" button is pressed, voltage from power line 332, which is present at terminal 451 of push button switch 302, is communicated to terminal 522 of switch 302 and from there by lead 523 to the other side of solenoid 520 of holding relay 319.

As soon as the contacts of relay 319 are closed by this energizing of solenoid 520, holding contacts 524 and 525 provide a parallel connection through which the voltage of power line 332 is applied to lead 523 and thus to solenoid 520. Holding contacts 524 and 525 are connected by lead 526 to normally closed terminals 527 and 528 of limit switch 318. Terminal 528 is connected through lead 435 with terminal 434 of push button switch 302. It is seen that so long as terminals 527 and 528 of limit switch 318 are closed and the "Stop" button of switch 302 is not pressed, holding contacts 524 and 525 are in communication with power line 332.

With holding relay 319 energized, the operator may release the "Down" button and cargo hoist 56 will nonetheless continue to move downward. Voltage from power line 332 is applied, as already explained above, to terminal 524 of holding relay 319. With the contacts of relay 319 closed, terminal 524 is connected with terminal 428 of that relay and thus to one side of solenoid 426 of relay 305. At the same time, terminal 524 of relay 319 is connected with terminal 460 of the same relay. The latter terminal is connected with coil 457 of solenoid 312. Energizing solenoid 426 and coil 457 starts motor 307 and simultaneously actuates the 4-way valve in the hydraulic system of cargo hoist 56 to cause the hoist to move down.

Limit switch 317 is positioned on cargo hoist 56 in a manner similar to limit switch 315 on hoist 57. Limit switch 318 is attached to cargo hoist 56 in somewhat the same manner, but is positioned so as to be actuated at a second predetermined height which is above the predetermined height at which limit switch 317 is actuated. When cargo hoist 56 has dropped to the point

at which switch 318 is actuated, normally closed terminals 527 and 528 are disconnected and consequently voltage from power line 332 is no longer applied at terminal 524 of holding relay 319. Motor 307 and the 4-way hydraulic valve are thus no longer energized. Cargo hoist 56 stops its descent at this point.

As will be explained below, the separate circuits for cargo 56, 57 and 58 are interlocked to prevent any hoist from lowering its associated cargo pallet, unless the next pallet between that hoist and cargo accumulation station 40 has already been lowered to within a predetermined distance of conveyor belt 65 to start its journey back toward station 40. As soon as this condition prevails at the outermost plane loading station where cargo hoist 56 has dropped pallet 50 to the predetermined height at which limit switch 318 was actuated, pressing the "Down" button of switch 302 will cause hoist 56 to continue its downward movement and pallet 50 will come into frictional engagement with moving endless conveyor belt 65.

Voltage from power line 332 is applied (so long as the "Stop" button is not pressed) to terminal 450 of push button switch 302. With the "Down" button closed, this voltage is transmitted to the other side of switch 302 and from there by lead 539 to solenoid 540 of timer 541. The opposite side of solenoid 541 is connected by lead 542 to terminal 543 of limit switch 318. Normally open terminals 543 and 544 of switch 318 have been closed by actuation of limit switch 318. Normally closed terminals 545 and 546 of limit switch 317 have not yet been opened by the descent of cargo hoist 56, since switch 317, as explained above, is located below switch 318. Lead 547 connects terminal 546 with the interlock circuit of cargo hoist 57 and lead 548 provides a return. Lead 548 connects with lead 443, terminal 442 of relay 305, line 420, and power line 330. Thus the potential difference between power lines 332 and 330 is placed across solenoid 540 of timer 541.

As long as contacts 549 and 550 of timer 541 are held closed (and the "Stop" button is not pushed) the voltage of power line 332 which is applied at terminals 433 and 434 of push button switch 302 is applied also through leads 435 and 551, terminals 550 and 549 of timer 541, and leads 555 and 523 to solenoid 520 of holding relay 319. This energizes motor 307 and coil 457 of solenoid 312 of the 4-way hydraulic valve for hoist 56, as was the case when relay 319 was closed previously. Cargo hoist 56 therefore continues its descent and remains down, even though hoist switch 186 is kept closed by the presence of cargo pallet 50 until the pallet has been moved off the hoist.

Closing relay 319 does not bring holding contacts 524 and 525 into play at this juncture because terminals 527 and 528 of limit switch 318 have been opened earlier by the descent of hoist 56. Thus relay 319 continues actuated only so long as the contacts of timer 541 remain closed. When the timer opens, holding relay 319 is de-energized. The electrical system of cargo hoist 56 is then in condition to be actuated automatically by a subsequent arrival of cargo pallet 50 at the plane loading station of hoist 56, when the pallet has been loaded again at cargo accumulation station 40 and has returned from there with its new load.

The electrical circuit for operation of cargo hoist 58 corresponds to the circuit for hoist 57, which has already been described above in detail. Relay 303 for hoist 58 corresponds to relay 304 for hoist 57. Power from power lines 330, 331 and 332 is transmitted through relay 303, when solenoid 570 is energized to close the contacts of the relay, to be applied to three-phase electrical motor 306.

Solenoid 570 is energized by the closing of limit switch 316 (corresponding to limit switch 315 of cargo hoist 57) and hoist switch 313 (corresponding to switch 122 of cargo hoist 57). Voltage from power line 332 is applied through lead 571, terminals 572 and 573 of

limit switch 316, terminals 574 and 575 of hoist switch 313 and lead 576 to one side of solenoid 570 of relay 303. The other side of solenoid 570 is connected to power line 330 in a manner similar to the connection of solenoid 538 of relay 304 for cargo hoist 57.

Voltage from power line 332 is also applied at terminal 577 of hoist switch 313 when closing of the switch connects terminals 574 and 577. Lead 578 transmits this voltage to terminals 579, 580 and 581 of push button switch 300. Lead 582 applies the voltage to one side of coil 583 of solenoid 311 of the 4-way valve for the hydraulic system of cargo hoist 58. The other side of coil 583 is connected through lead 584 with power line 330.

Energizing of motor 306 and coil 583 in the manner described causes hoist 58 to raise cargo pallet 52 automatically to the predetermined height at which normally open limit switch 316 is permitted to open. Further raising of pallet 52 is accomplished by the manual operation of the "Up" button of switch 300, in the same manner as described for cargo hoist 57. Likewise, cargo hoist 58 is lowered in the same manner as was hoist 57 by operation of the "Down" push button and the resulting energizing of solenoid 585 of timer 586.

Controlled order of pallet movement.—It is important that no cargo pallet be lowered into frictional engagement with conveyor belt 65 until the next cargo pallet between it and cargo accumulation station 40 has been lowered into engagement with conveyor belt 65, on which it will ride back toward station 40. In the embodiment shown, cargo pallet 52 is always the first to return to the cargo accumulation station. It is followed by pallets 51 and 50 in that order. If this were not arranged, a cargo pallet returning to station 40 might collide with an intervening hoist which had not yet lowered its cargo pallet onto conveyor belt 65. Pallet 50, for example, might collide with cargo hoist 57, unless the hoist had already been lowered and had permitted cargo pallet 51 to roll off elevating members 82 and 83 onto tracks 62 to be propelled back to the cargo accumulation station.

The order in which cargo pallets 52, 51 and 50 return from plane 42 to cargo accumulation station 40 is controlled by an interlock system which connects the electrical circuits of the 3 cargo hoists with which the pallets are associated. In the interlock system, the energizing circuit of the timer of each cargo hoist is connected through the limit switch which is employed on each preceding cargo hoist to stop at a predetermined height the automatic raising of that cargo hoist and its associated pallet.

There is no interlock circuit which bars lowering of cargo pallet 52 by cargo hoist 58, as there is always a clear track between the plane loading station at which hoist 58 is located and cargo accumulation station 40. As is seen from Figure 33, one side of solenoid 585 of timer 586 is connected through lead 584 to power line 330. The other side of solenoid 585 is connected through lead 587 to terminal 588 of push button switch 300. Whenever the "Down" button of switch 300 is pressed, terminals 588 and 589 of the switch are connected. Terminal 589 is connected with terminal 590 of the same switch, and when the "Stop" button is not pressed terminals 590 and 591 are connected. Leads 592 and 571 connect terminal 591 with power line 332. Thus timer 586 is actuated whenever the "Down" button is pushed, and cargo hoist 58 immediately proceeds to lower cargo pallet 52 until the pallet establishes frictional contact with conveyor belt 65 and starts back toward cargo accumulation station 40.

Timer 393 of the electrical circuit of cargo hoist 57, however, cannot be actuated until cargo hoist 58 at the innermost plane loading station has been lowered to the predetermined height at which normally open limit switch 316 is closed. Until that time, pressing the "Down" but-

ton of push button switch 301 cannot energize motor 200 or coil 408 of solenoid 310 of 4-way valve 208. As already explained above, voltage from power line 332 is applied to one side of solenoid 392 of timer 393 whenever the "Down" button of switch 301 is pressed. The other side of solenoid 392 is connected with power line 330 through lead 394 and terminals 395 and 396 of limit switch 316, leads 397 and 372, terminal 334 of relay 304, and line 333. When terminals 395 and 396 are connected by the closing of limit switch 316, cargo hoist 57 can be moved downward. Before this happens, however, the hoist remains at its elevated position even if the "Down" button is pressed.

The electrical circuit which includes the "Jog down" button of push button switch 302 of cargo hoist 56 is not interlocked with the electrical circuits of the other hoists. Thus, pressing the "Jog down" button will bring elevating members 84 and 85 of hoist 56 down to the predetermined height at which limit switch 318 is actuated. At this point the circuit of the "Jog down" button is rendered ineffective.

The circuit of cargo hoist 56 which includes the "Down" button of push button switch 302, like the corresponding circuit of hoist 57, is interlocked with the electrical circuit of the cargo hoist which is the next hoist along the path to cargo accumulation station 40. When hoist 56 has been lowered to the point at which limit switch 318 has been actuated, terminals 543 and 544 of that switch are connected. As the hoist at this time is above the point where limit switch 317 will be actuated, terminals 545 and 546 of switch 317 are still closed. It is seen that one side of solenoid 540 of timer 541 is connected at this juncture, through lead 542, terminals 543 through 546, and lead 547, with terminal 552 of limit switch 315 of cargo hoist 57.

Until cargo hoist 57 has been lowered far enough to close limit switch 315, timer 541 of cargo hoist 56 can not be actuated because of normally open terminals 552 and 553 of switch 315. However, as soon as cargo hoist 57 is lowered far enough to close switch 315, terminals 552 and 553 are connected and a circuit is completed from there through leads 543 and 443, terminal 442 of relay 305, and line 420 back to power line 330. As already explained above, pressing the "Down" button of switch 302 places voltage from power line 332 on the other side of solenoid 540 of timer 541. Thus, when the "Down" button is pressed after cargo hoist 57 has closed limit switch 315, timer 541 of hoist 56 is actuated, and motor 397 and coil 457 are energized to cause cargo hoist 56 to be lowered into its collapsed or down position.

The interlock system just described assures that cargo pallets 52, 51 and 50 always return from plane 42 to cargo accumulation station 40 in the exact order just given. The pallets always stand upon track section 67 at station 40 in the order in which they arrive from the plane. Thus, when they leave track section 67 to be moved on out to plane 42 again, the pallets always move in the reverse order: pallet 50, 51, and then 52. This controlled order of cargo pallet movement makes possible the high degree of automatic operation that characterizes the preferred embodiment of this invention.

Although the present invention has been described by reference to the loading and unloading of airplanes, it is useful also in meeting similar loading and unloading problems for boats, busses, and the like. As used in the claims below, the term "vehicle" includes airplanes, boats, busses and any other transportation media for which cargo is accumulated at a single station before loading, and is redistributed from a single station after unloading.

The above detailed description of this invention has been given for clearness of understanding only. No unnecessary limitations should be understood therefrom, as modifications will be obvious to persons skilled in the art.

We claim:

1. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each of said pallets being adapted to be propelled between the pallet loading station and its associated plane loading station; endless reversible drive means adapted to propel each cargo pallet along a predetermined path between the pallet loading station and the plane loading station associated with said pallet; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station to a predetermined height above the position of the pallet after it arrives at said station and to lower it again from said predetermined height to said arrival position; control means for selectively actuating the hoist to raise or lower its associated pallet; and an interlock circuit connecting the control means of all said hoists, said circuit being adapted to prevent any hoist from lowering its associated pallet to a height at which said endless drive means is operative to propel said associated pallet unless every pallet between said associated pallet and the pallet loading station has already been lowered to said height for that pallet.

2. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; an accumulating station for individual pieces of air cargo; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each of said pallets being adapted to be propelled between the pallet loading station and its associated plane loading station; an endless, reversible conveyor belt adapted to propel each cargo pallet along a predetermined path between the pallet loading station and the plane loading station associated with said pallet, said belt being further adapted to carry individual pieces of air cargo between the accumulating station for such pieces and the plane loading stations; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position, said hoist including an elevating platform on each side of the conveyor belt, both said platforms being adapted to rise and fall at the same rate when carrying a cargo pallet, said hoist being further adapted whether in an elevated position or not to permit individual pieces of air cargo to be carried past it by the conveyor belt; and control means for selectively actuating the hoists to raise or lower its associated pallet.

3. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; an accumulating station for individual pieces of air cargo, including a turntable adapted to carry individual pieces of cargo while continuously rotating; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each of said pallets being adapted to be propelled between the pallet loading station and its associated plane loading station; endless reversible conveyor means adapted to propel each cargo pallet along a predetermined path between the pallet loading station and the plane loading station associated with said pallet, and also adapted to carry individual pieces of air cargo between the accumulating station for such pieces and the plane loading stations, a portion of said conveyor means being located adjacent said turntable so as to permit convenient transfer of individual pieces of cargo between said means and said table; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position, said hoist being further adapted whether in an elevated position or not to permit individual pieces of

air cargo to be carried past it by the conveyor means; and control means for selectively actuating the hoist to raise or lower its associated pallet.

4. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; an accumulating station for individual pieces of air cargo, including a turntable adapted to carry individual pieces of cargo while continuously rotating; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each of said pallets being adapted to be propelled between the pallet loading station and its associated plane loading station; endless reversible conveyor means adapted to propel each cargo pallet along a predetermined path between the pallet loading station and the plane loading station associated with said pallet, and also adapted to carry individual pieces of air cargo between the accumulating station for such pieces and the plane loading stations, a portion of said conveyor means being located adjacent said turntable so as to permit convenient transfer of individual pieces of luggage between said means and said table; routing means adapted to selectively permit said pallets to be propelled past said turntable and said individual pieces of cargo to be transferred between the turntable and said conveyor means; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position, said hoist being further adapted whether in an elevated position or not to permit individual pieces of air cargo to be carried past it by the conveyor means; and control means for selectively actuating the hoist to raise or lower its associated pallet.

5. The apparatus of claim 4 having a stop table located immediately adjacent the end of said endless conveyor means farthest from said accumulating station for individual pieces of air cargo, said stop table being adapted to present a very slight amount of friction towards movement of items onto the table from said conveyor means.

6. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each pallet having a wheel bearing front axle and rear axle, and each pallet carrying two spring loaded traction plates, one near the center of each axle; an endless reversible conveyor belt running between the pallet loading station and the plane loading stations; track means for supporting and guiding the wheels of the cargo pallets along a predetermined path between the pallet loading station and the plane loading stations, said track means being adapted to support each cargo pallet at such a height that the spring loaded traction plates are pressed against the conveyor belt to produce a frictional engagement between the plates and the conveyor belt sufficient to move the pallet along the track means; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station to a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position; and control means for selectively actuating the hoist to raise or lower its associated pallet.

7. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each pallet having a wheel bearing front axle and rear axle, and each pallet carrying two spring loaded traction plates, one near the center of each axle; and endless reversible conveyor belt running between the pallet loading station and the plane loading stations; track means for supporting and guiding the wheels of the cargo pallets along a

predetermined path between the pallet loading station and the plane loading stations, said track means being adapted to support each cargo pallet at such a height that the spring loaded traction plate is pressed against the conveyor belt to produce a frictional engagement between the plate and conveyor belt sufficient to move the pallet along the track means; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station to a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position, said hoist including an elevating platform on each side of the conveyor belt, both said platforms being adapted to rise and fall at the same rate when carrying a cargo pallet; a switch for each hoist, said switch being adapted to be actuated by the pallet associated with that particular plane loading station, and when actuated to energize its associated hoist to cause it to raise the pallet; and an interlock circuit connecting the switches for all said hoists, said circuit being adapted to prevent any hoist from lowering its associated pallet to a height at which the traction plates of said pallet are in frictional engagement with the conveyor belt unless every pallet intervening between said associated pallet and the pallet loading station has already been lowered to said height for that pallet.

8. Apparatus for rapid loading and unloading of air cargo which comprises: a cargo pallet loading station; an accumulating station for individual pieces of air cargo, including a turntable adapted to carry individual pieces of cargo while continuously rotating; at least one plane loading station; a cargo pallet associated with each of said plane loading stations, each pallet having a wheel bearing front axle and rear axle, and each pallet carrying two spring loaded traction plates, one near the center of each axle; an endless reversible conveyor belt running between the pallet loading station and the plane loading stations; track means for supporting and guiding the wheels of the cargo pallets along a predetermined path between the pallet loading station and the plane loading stations, said track means being adapted to support each cargo pallet at such a height that each spring loaded traction plate is pressed against the conveyor belt to produce a frictional engagement between the plate and conveyor belt sufficient to move the pallet along the track means, said conveyor belt also being adapted to carry individual pieces of air cargo between the accumulating station for such pieces and the plane loading stations, a portion of said conveyor means being located adjacent said turntable so as to permit convenient transfer of individual pieces of luggage between said means and said table; routing means adapted to selectively permit said pallets to be propelled past said turntable and said individual pieces of cargo to be transferred between the turntable and said conveyor means; a hoist at each plane loading station, said hoist being adapted to raise the pallet associated with said station to a predetermined height above the position occupied by the pallet upon its arrival at said station and to lower it again from said predetermined height to said arrival position, said hoist including an elevating platform on each side of the conveyor belt, both said platforms being adapted to rise and fall at the same rate when carrying a cargo pallet; a switch for each hoist, said switch being adapted to be actuated by the pallet associated with that particular plane loading station, and when actuated to energize its associated hoist to cause it to raise the pallet; and an interlock circuit connecting the switches for all said hoists, said circuit being adapted to prevent any hoist from lowering its associated pallet to a height at which the traction plates of said pallet are in frictional engagement with the conveyor belt unless every pallet intervening between said associated pallet and the pallet loading station has already been lowered to said height for that pallet.

9. Air cargo handling apparatus comprising a cargo accumulation station, a plurality of airplane loading and unloading stations, single lane reversible conveyor means extending between said accumulation station and said loading and unloading stations, pallets equivalent in number to said airplane loading and unloading stations carried by said conveyor means, hoist means positioned adjacent each airplane loading and unloading station, means for actuating only the hoist means furthest from said accumulation station upon engagement therewith by the pallet first to leave the accumulation station, and means for actuation of subsequent hoist means only by engagement therewith of the respective next successive pallets.

10. The apparatus set forth in claim 9 wherein said hoist means are movable longitudinally of said conveyor means.

11. The apparatus set forth in claim 9 wherein said hoist means automatically raise the respective pallets to a predetermined height above the position occupied by the pallet upon its arrival at the respective plane loading and unloading stations, said hoist means including means for further selectively raising the individual pallets.

12. The apparatus set forth in claim 9 including individual cargo piece stop table means positioned at the

end of said conveyor means positioned furthest from said accumulation stations, said hoist means automatically raising the respective pallets sufficiently high to permit passage of individual cargo items to said stop table means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,787,763	Rosenbrook	Jan. 6, 1931
1,971,339	Fitch	Aug. 28, 1934
2,096,958	Clerc	Oct. 26, 1937
2,338,348	Newman	Jan. 4, 1944
2,379,094	Maxon	June 26, 1945
2,404,195	Schlieben	July 16, 1946
2,470,696	Gonzalez et al.	May 17, 1949
2,487,613	Stone	Nov. 8, 1949
2,498,819	Noville	Feb. 28, 1950
2,503,210	O'Halloran	Apr. 4, 1950
2,623,626	Ditolla	Dec. 30, 1952
2,634,869	Hicks	Apr. 14, 1953
2,651,087	Fellows	Sept. 8, 1953

OTHER REFERENCES

Aero Digest Publication, Nov. 15, 1945.

U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,826,319

March 11, 1958

Elmer J. Renner et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 40, before "then" insert -- are --; column 2, line 58, for "seal" read -- sealing --; column 9, line 6, for "have" read -- has --; column 13, line 72, for "of collapsed" read -- or collapsed --; column 28, line 30, for "brong" read -- bring --; column 32, lines 21 and 22, for "assocoated" read -- associated --; line 50, for "hoists" read -- hoist --; column 33, line 72, for "and endless" read -- an endless --; same column 33, line 73, and column 34, line 73, for "betwen", each occurrence, read -- between --.

Signed and sealed this 6th day of May 1958.

(SEAL)

Attest:

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Commissioner of Patents