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IMPLEMENTATION OF DOWN-THE-HOLE DRILLING RIG TRAINING AID

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ABSTRACT

Mechanical equipment training aids has been used widely in the last few years due to the advancements in technology and also the fact that they allow drivers of all levels to acquire skills and experience to be prepared for real in-field emergencies with lower cost. This paper presents the implementation of a down-the-hole drilling rig training aid which is a one-to-one scale training aid of the “Titon 100R” drilling rig [1]. A comparison between the technical specifications of both the original equipment and the training aid is mentioned. Regarding the low cost training programs, the training aid has been tested and technically approved to be used as a training aid for the drivers of drilling rig especially those who do not have enough in-field work experience.

KEY WORDS

Construction Equipment, Training Aids, Terramechanics, Titon 100R Drilling Rig Equipment.

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INTRODUCTION

The dependency and need for heavy construction equipment for earthmoving, excavating, and lifting have grown with the size and complexity of construction projects in the last two centuries. Operating and mechanical principles for most types of equipment has not been basically changed as when they were evolved many years ago [2].

The use of training aids has been used in the construction equipment field for years to train drivers from all levels. With proper-scaled prototype of real equipment, the driver is able to acquire the in-field work experience necessary for him to deal with in-field emergencies with a cost effective solution [3, 4].

Generally, the importance of the training aids for the development of working process can be summarized in the following [3, 4]: (1) optimum utilization of human resources, where training helps in planning for the task which leads for optimizing the utilization of human resources leading to achieve the goals and accomplish the mission, (2) development of human resources, where practice helps to provide an opportunity and broad structure for the development of human resources' technical and behavioral skills in an organization, (3) development of skills of drivers where experience helps in increasing the skills of drivers at all levels.

To mention the many advantages of using the one to one scale training aids in training, items like learning, practice and cost should be discussed. On scale of beginners and considering learning how to drive such heavy equipment, future drivers teaching programs tend to get into cash problems as the cost of renting real equipment is extremely expensive. With the training aid a driver can get a thorough learning program at a fraction of the cost [5, 6].

When it comes to practice the choice of using an affordable training aid makes more sense especially for such expensive machines. For advanced level drivers and considering the development of their skills, nothing beats spending enough time of practice and experience in an environment looks like the real one. With the use of a training aid, drivers are able to get more work time and able to train in a wide variety of working environments without ever leaving the training workshop [5, 7]. Also a driver cannot be trained to be prepared for emergency situations in the field due to the risk involved so an indoor training aid is the closest way that can approach the real thing. By spending enough time using a realistic training aid the drivers will learn how to handle dangerous situations so if a problem does happen they will know how to respond properly.

A one-to-one scale training aid of the "Titon 100R" drilling rig is produced to fulfill the training program of the beginner drivers to gain experience that is necessary to help them to break through. The main systems of the training aid have been explained briefly in the next few sections of the paper as well as a comparison between the technical specifications of both the original equipment and the training aid, this is the key point of the paper.

IMPLEMENTATION METHODOLOGY

The design and development of heavy construction equipment are driven and evolves from the needs of the user market. Heavy construction equipment manufacturers are very responsive to market needs and feedback from users. Today it is assumed that if no equipment is available to perform a necessary task, it can be designed and built. However versatile Lattice boom crawler cranes that are equipped with augers for drilling holes attachments are very common on most types of drilling hole operations, down-the-hole drilling rig equipment proves more efficient to do the job either for its high maneuverability especially when working in hard to reach places or for the devotion of many accessories that increase the equipment productivity when taking the time factor into consideration [2, 8, 9].

Titon 100 is a mobile self-contained hydraulic crawler drill designed for blasthole drilling in the mining, quarry and construction industries. The drill is equipped with a fixed boom, manual pipe rack and a control panel on a swing-arm. The Titon 100 is designed for drilling 89 to 105 mm diameter holes using a 3" diameter hammer to depths of 39 meters when equipped with 76 mm drill pipes (3000 mm in length). To achieve the basic concept of developing a training aid good for use in drivers training program at a fraction of the cost, the design of the training aid, shown in Fig.1, is based on the specifications of the original equipment [1], yet with lower power in all features concerning the traction force, drilling power and the accessories. The training aid has been designed thoroughly according to the standard methods of design [10, 11] and taking into consideration the effect of the Egyptian soil on the tool [12, 13]. The design of the training aid in details is considered out of the scope of this paper, and instead a brief explanation of the outcome product is mentioned as will be discussed in the following sections of the paper.

TECHNICAL SPECIFICATIONS

The technical specification of the training aid is much as the same as that of the original equipment. A comparison between the main dimensions of the training aid and the main dimensions of the original equipment are mentioned in table.1, and the only difference is in the total height which is due to the fact that the boom of the training aid is shorter than that of the original equipment as shown in Fig. 1.

Table 1. Main Dimensions comparison.

Dimension	Training aid	Original equipment [1]
Total length [mm]	7200	7200
Width [mm]	2430	2430
Total height [mm]	2000	2900 (with dust collector)

The Undercarriage

Guided by the design of the original equipment, the undercarriage base of the training aid consists of a heavy-duty steel frame mounted on two track assemblies and a track oscillation shaft as shown in Fig.2. The independently (hydraulically)

oscillating tracks are fitted with chain linked single bar grouser plates and equipped with chain guides. Track chains are tensioned by a hydraulic grease cylinder on the idler wheel. The hydraulic motors are equipped with 3-stage planetary gears in the hub of the driving wheel achieving tractive force of about 58 kN on the first gear and about 39 kN on the second gear. An integrated, spring loaded, multiple disc safety brakes are used. A crosswise mounted power pack consisting of a diesel engine, hydraulic pumps and air compressor is mounted at the rear of the steel frame.

Power Train

The water-cooled, turbo charged, 4-cycle direct injected Deutz diesel engine which is used in the original equipment is substituted with a three phase 30 Kw DC electric motor, shown in Fig.3, is used to operate the 120 bar hydraulic pump that is used to actuate the two hydraulic motors in the track through a parallel connection hydraulic circuit [14] as shown in Fig.5.

Traditionally a reduction is needed as a final drive attached to each sprocket. This design achieves low noise level and offers long service intervals for efficient and environmentally friendly operation; the power train of the training aid is demonstrated in Fig 4.

The Superstructure

The superstructure is generally composed of two main parts (a) the cabinet (b) the rack and boom assembly which is considered as the main attachment. Both parts will be discussed briefly in the following subsections.

The Cabinet

The cabinet of the drilling rig training aid from inside is a little bit different from the cabinet of the original equipment. It is equipped with instruments that give the driver up-to-date information about the operation parameters to help him in his training program. The control panel indicators are provided with updated information from sensors which are attached to the actuators. The 24 V electric system features electric control panel for the main power source and drilling.

The drill is equipped with a reversing alarm and is fitted with two 12 V batteries. There are two safety-system shutdown for emergencies: (1) Emergency safety push button at the control panel to help the driver to shut down the system in case of emergency such as the existence of a human in the working zone of the equipment, (2) Emergency stop ripcord at the feed. The hydraulic system control levers are used to operate the hydraulic actuators and they are similar to the ones in the original equipment.

Main Attachments: Rack and Boom Assembly

The boom is attached to the undercarriage in a way that allows it to move freely in a plane through two hydraulic cylinders, as shown in Fig 6. The boom controls the rack's angle of inclination as well as its elevation, as shown in Fig. 7.

The hydraulic fixed boom is built of square steel profile. It is fitted with sliding ledges, a fork type boom head and a pivot cradle for the feed.

The role of the rack is to hold the drilling assembly which is simply constructed of the drilling tool and its driving DC motor which is attached to the rotation head cradle that moves linearly on the toothed rack using a DC motor.

The drill feed is a motor/chain type and the rotation head cradle slides on steel and plastic guides to reduce feed wear. However the rotation head in the real equipment is equipped with a 3-stage planetary gear and DanfossR hydraulic motor for attaining maximum torque, this system is not included in the training aid as it is not needed for beginners training programs.

The 40 bar hydraulic gear pump is powered through a motor-integrated gearbox and is used to actuate the boom control hydraulic cylinders through a parallel connection hydraulic circuit shown in Fig 8 [14]. Gear pumps are generally preferred because of their simple construction and easy maintenance with their low filtration requirements. The drill is equipped with a combined cooler; one section is for engine coolant and the other for hydraulic oil. Imitating the design of the original one, the cooler is constructed of robust steel pipes, which provide a large cooling surface efficient to do the job without any additional accessories as the training aid is not designed to operate in maximum power needed to drill productively in hard rocks.

AUXILIARY SYSTEMS AND ACCESSORIES

The original Titon 100 is equipped with a low noise screw type air compressor, an air receiver and a pneumatic control system 12 bar operating pressure. The compressor unit is an oil-injected, single stage rotary screw compressor consisting of two helical asymmetric rotors mounted on a rotor casing. The unit comes standard with a compressor control operated by an ON/OFF switch, which can be adjusted to decrease the air volume and pressure for efficient drill hole collaring.

Also the drill is equipped with an adjustable OE 200 lubrication device for flushing head, drill pipes and DTH hammer. Controls of the system are located on the operator's platform and can be controlled proportionally. The dry dust collector on the Titon 100 is equipped with a hydraulically driven suction fan. Dust filters are cleaned externally by adjustable air impulses during the pipe changing cycle. The dust collector fan does not need to be dismantled for filter change. Some other optional accessories are included in the standard basic unit of the original equipment such as; suction hood rubber, set of hose clamps, suction hose (to dust collector), air lock, hose clips, set of rollex hoses, spare parts manual, filter spanner, set of spray paints, fire extinguisher.

To achieve the cost effective design, many of the abovementioned accessories have not been included. However some of them may be taken into consideration to be included of the next version based on the evaluation results of the training program that can be linked to many factors two of which are the reality in training and safety

procedures. Therefore, the inclusion of some of these accessories as a development of the project can be seen as future work.

CONCLUSIONS

The construction industry will continue to use one-to-one scale training aids in the future to help drivers to get in field experience at a fraction of the cost. A one-to-one scale training aid of the “Titon 100R” drilling rig is produced to fulfill the training program of the beginner drivers to gain experience that is necessary to help them to break through. The main systems of the training aid have been explained briefly. A brief comparison between the technical specifications of both the original equipment and the training aid is mentioned. Regarding the low cost training programs, the Training aid has been technically approved to be used as a training aid for the drivers of drilling rig especially the beginners.

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Fig. 1. The drilling rig training aid (up) compared to the original equipment (down).

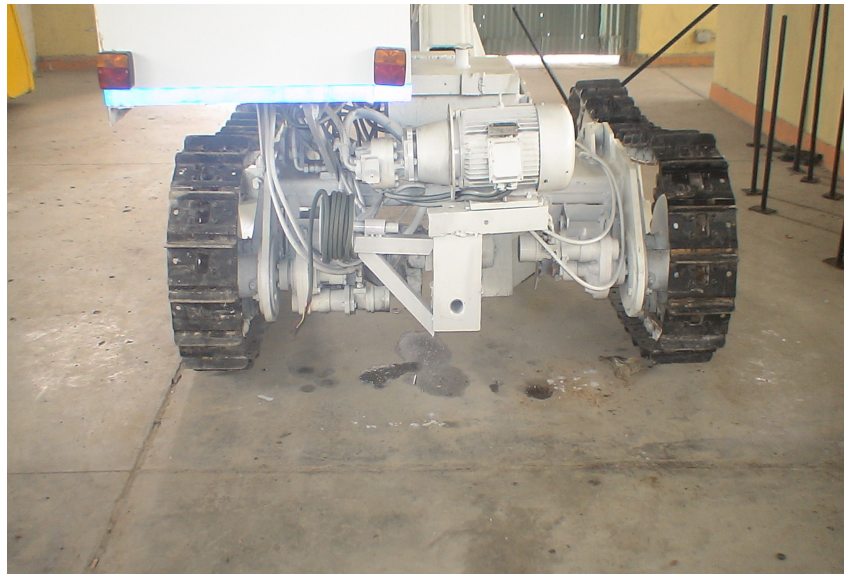


Fig. 2. The Undercarriage.



Fig. 3. The main power source.

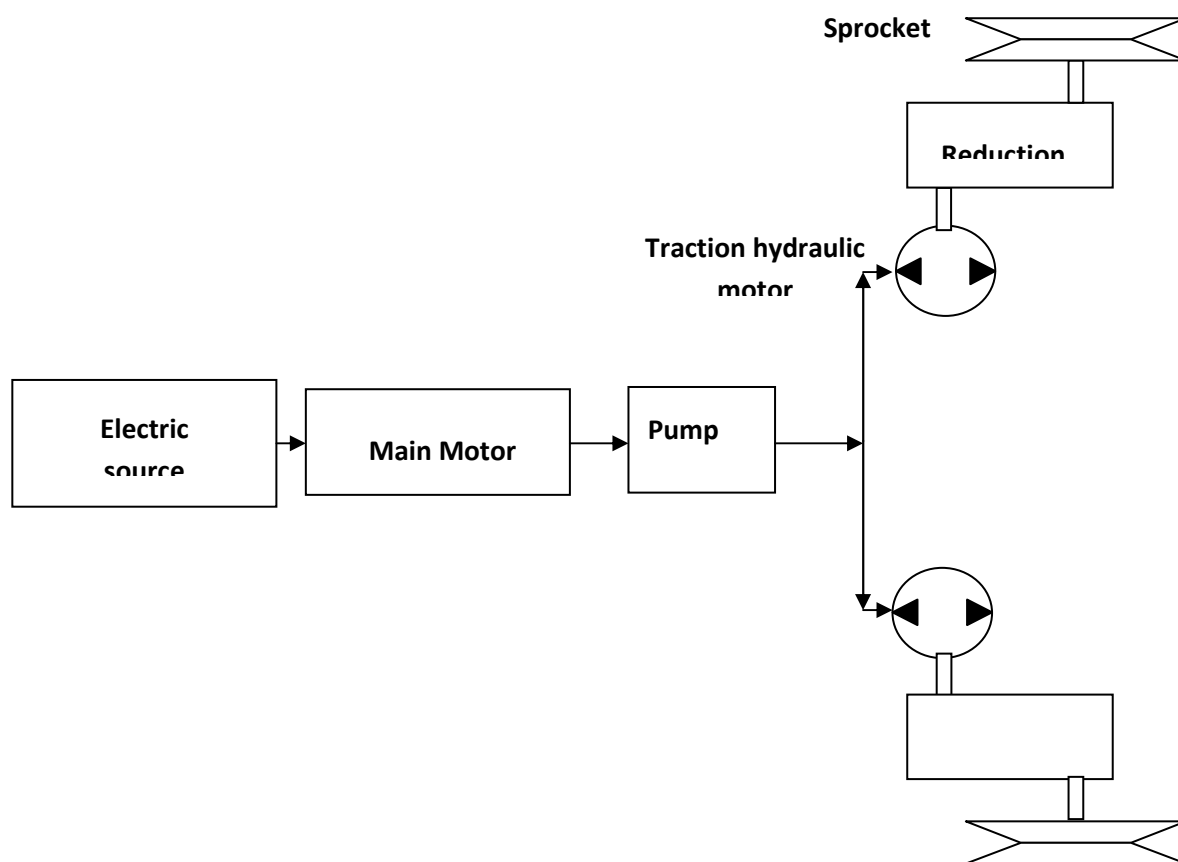


Fig. 4. Training aid power train.

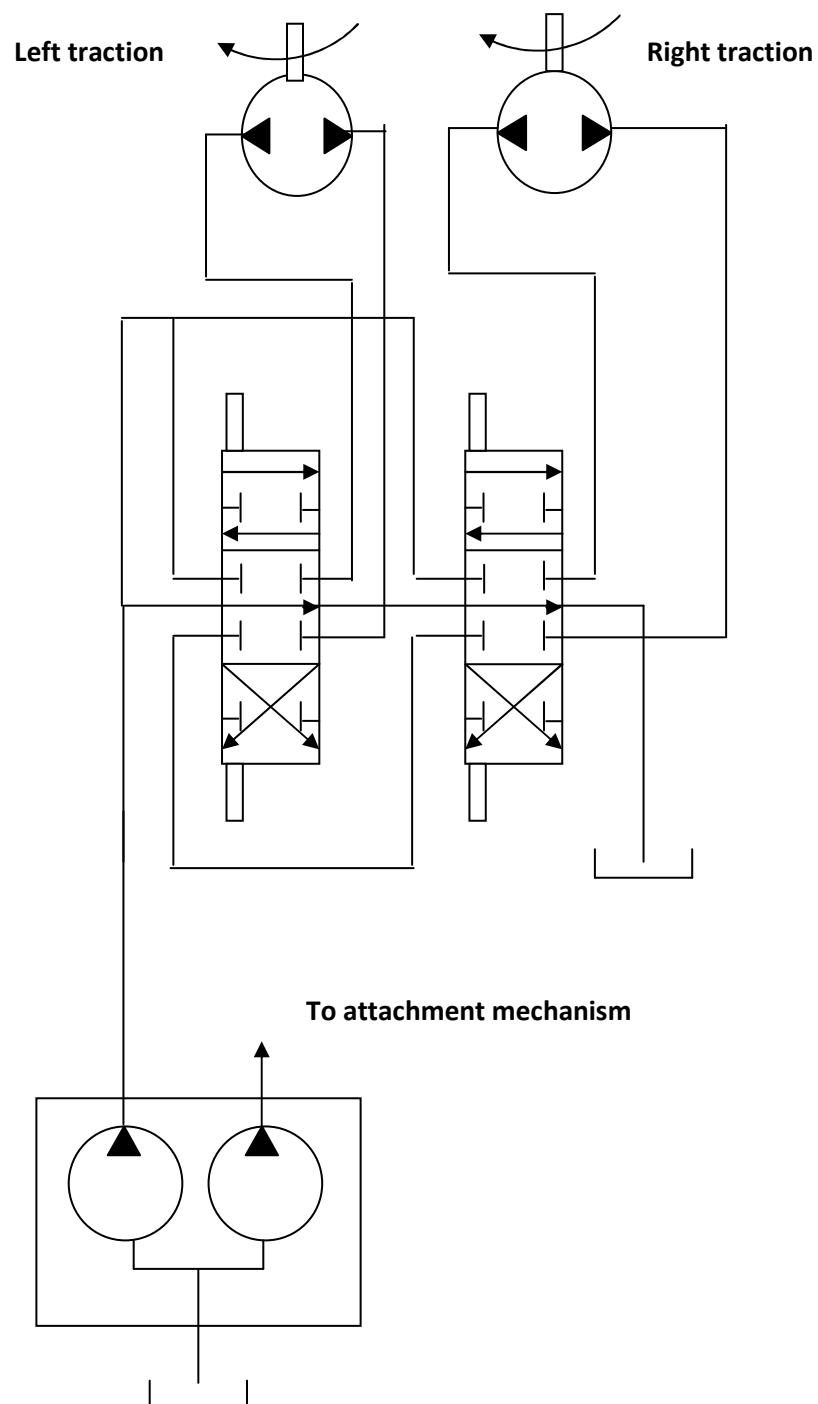


Fig. 5. Schematic drawing for the hydraulic circuit (traction mechanism) [14].

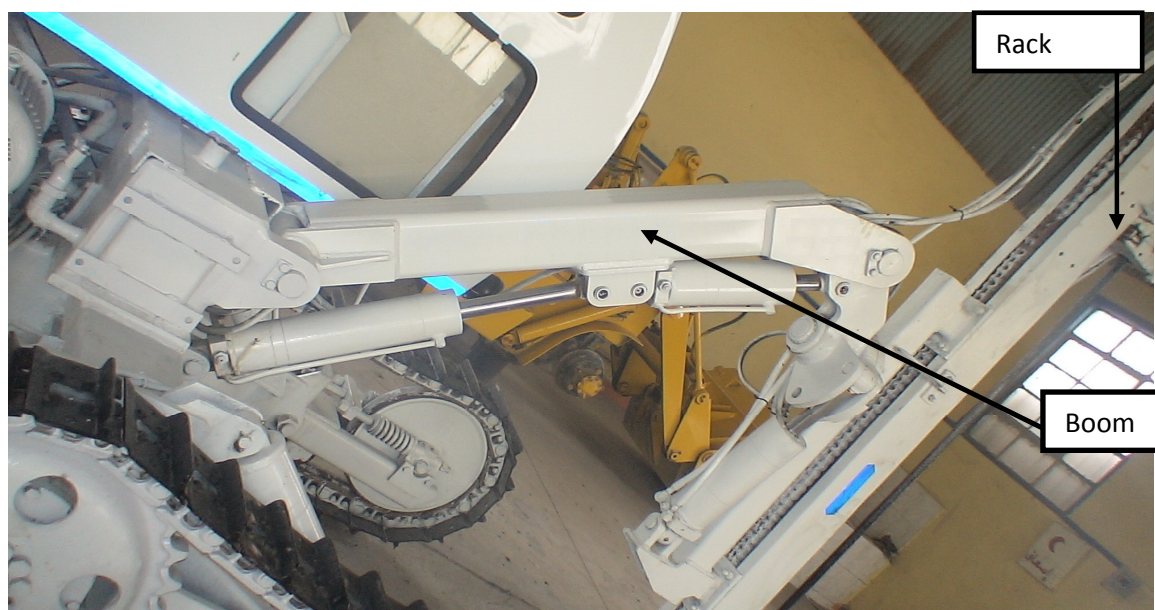


Fig. 6. Rack and boom assembly.

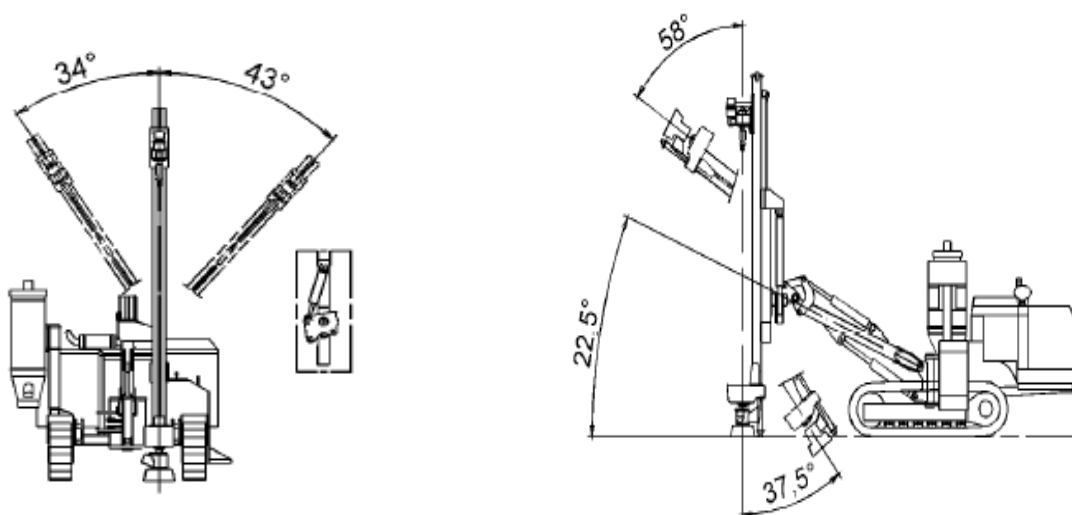


Fig. 7. Rack swiveling (left) and boom tilting (right) angles.

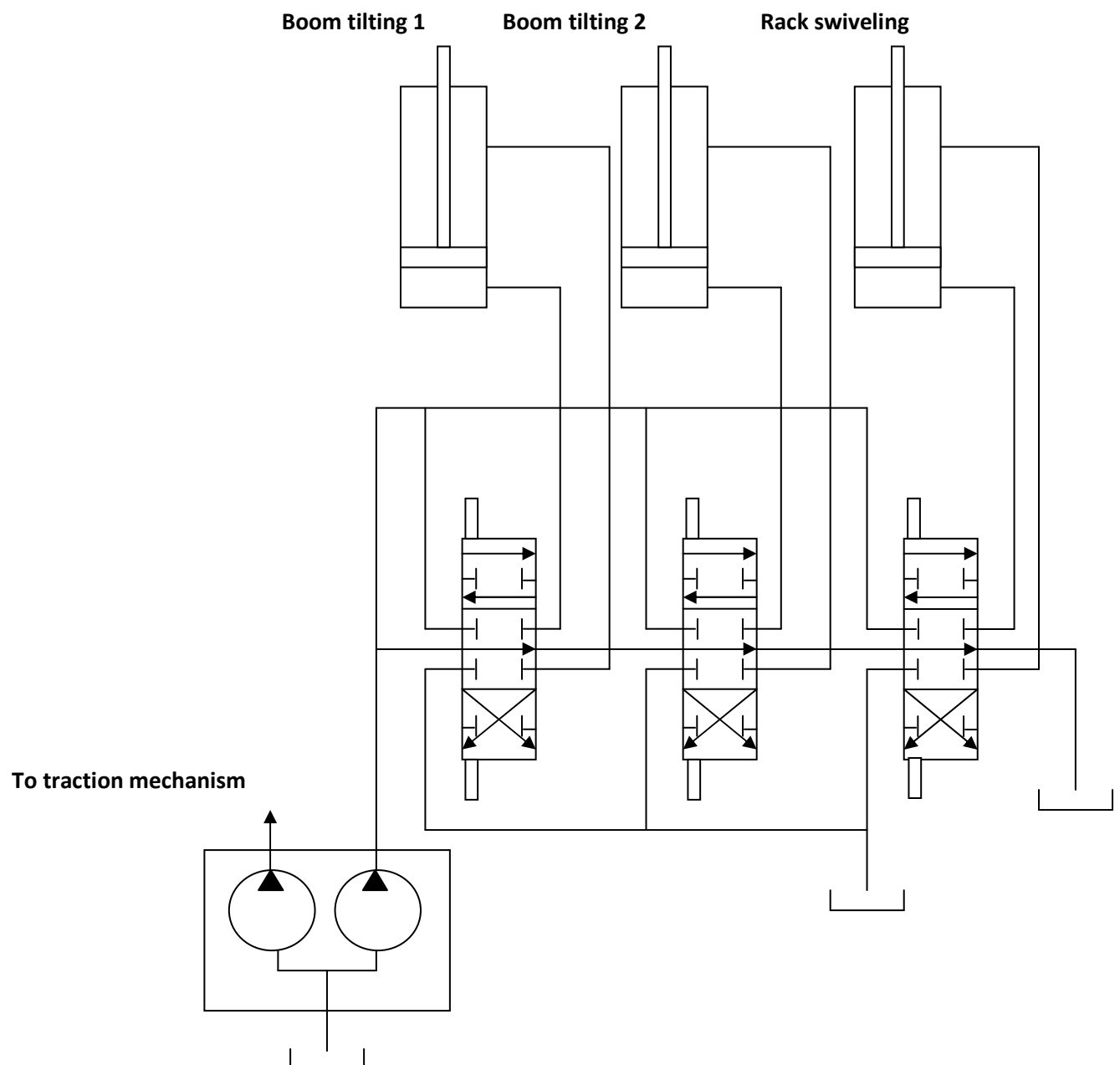


Fig. 8. Schematic for the training aid main attachment hydraulic control circuit [14].