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Design and Development of Mini Tractor Operated Installer and Retriever of Drip Line

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A B S T R A C T

The mini-tractor operated drip lateral installer and retriever was fabricated at department of farm machinery and power engineering, CAET, Junagadh agricultural university, Junagadh. A drip line installer and retriever were developed for small fields. One operator can install drip line on or just beneath the soil surface to precisely irrigate crops after planting and retrieve the drip line after irrigation is no longer needed for the season. The developed implement was operated by the mini-tractor using three-point hitch, it performs both the operations of installation and retrieval of drip line. The installer and retriever mainly consists of a main frame, drip line spool as well as spool supporting frame, press wheel, guiding wheel & shaft, transportation wheel, depth adjust mental wheel, chain & sprocket mechanism, pedestal block bearing, power transmission assembly were developed.

Introduction

Drip irrigation is the drop by drop application of water directly to roots. It has little or no water losses through conveyance and the on-farm irrigation efficiency of a properly designed and managed drip irrigation system can be as high as 90 per cent, compared with 35 to 40 per cent efficiency of surface method of irrigation (Narayanmoorthy, 1997). The area covered under drip irrigation systems has, the largest area under drip irrigation include Rajasthan 1.68 Mha, Maharashtra 1.27 Mha, Andhra Pradesh 1.16 Mha, Karnataka 0.85 Mha, Gujarat 0.83 Mha and Haryana 0.57 Mha. The area under drip irrigation has shown higher growth in recent years, growing at a CAGR (Compound annual growth rate) of 9.85 per cent in the 2012-2015 period, while sprinkler irrigation has grown a pace of 6.60 per cent in the same time period. Overall, the area under micro-irrigation has grown at a CAGR of 7.97 per cent in this time frame (Anon., 2016a).

In field, drip line requires various field operations such as installation and retrieval of drip line. Installation and retrieval by mechanical method as well as manual method were used. Farmers have been using manual

device for installation and retrieval operation, they were time consuming, laborious, boring, tedious and costly also. These operations need to be done carefully and skilfully to avoid the damages due to folding or twisting of tube during handling and to make the bundle suitable for proper storage. Therefore, the present study was carried out to developed and evaluates the performance of mini-tractor operated installer and retriever of the drip line with the following

Literature review

Zhu *et al.,* (2004) developed an implement is mounted to the tractor using a three-point hitch and performs both functions of installation and retrieval of drip tapes in one unit. During the installation process, drip tapes are placed in shallow trenches cut by the 5 cm wide chisel and are covered with soil by 6.5 cm wide pneumatic wheels. The depth of drip tapes can be adjusted from 0 to 5 cm beneath the soil surface.

During the drip tape retrieval process, drip tapes are distributed evenly across rotating spools while any water in the tapes is squeezed out. The retrieval speed is adjusted by changing the tractor PTO (Power Take Off) speed. To retrieve excess disposable drip tapes, a special spool was developed to quickly remove the tapes from the unit. No tools are needed for either installing or removing drip tape spools.

Mathematical models were developed to calculate drip tape length, retrieving time, and spool sizes.

Taley *et al.,* (2006) developed manual coiler and tested for its performance with 150m long segment of drip lateral in the field and reported that overall performance of machine good in terms of field capacity, field efficiency, and reduction in cost.

Materials and Methods

A drip line installer and retriever were designed and developed to combine install and retrieve operations of drip line in one pass to ensure timeliness in making bundles of drip line. The drip line installer and retriever machine consist of a main frame with installer as well as retriever frame, hydraulic motor, press wheel, guide wheel, support wheel, power transmission system to provides power for installing and retrieving attachment, framework and three-point linkage unit. The components of drip line installer and retriever were designed and fabricated based on the parameters like functional requirements, engineering and general considerations.

General consideration

It should be simple in design, safe in operation and power requirement be met with mini tractor. It should install and retrieve drip line faster than the existing traditional methods.

Assumptions considered in design

The assumptions made in the design of installer and retriever of drip line are as follow:

No draft was included for installer and retriever of drip line attachment because it is semi mounted. The implement being semi mounted type, the draft requirement was considered to be negligible.

The power consumption by the device is very low within the capacity of available mini tractor.

It should install or retrieve three row of dripline at a time.

It should be simple in fabrication and easy to manufacture using locally available materials.

All part can be easily assemble and dismantled for inspection and repair

Development of major functional components of drip line installer and retriever

The detailed design of the functional components and different mechanisms were carried out. The machine consists of a main frame with sub frames for installer as well as retriever, hydraulic pump, press wheel, guide wheel, support wheel, power transmission system to provides power to installing and retrieving attachment, framework and three-point linkage unit. The basic emphasis was given on simplicity of fabrication, use of locally available material and minimum cost of fabrication. Ease of assembling and dismantling for repairs and inspection were duly considered. The design of following components was taken up:

Main Frame
Spool
Press Wheel
Guide Wheel & shaft
Support Wheel
Depth Control Wheel (Fig. 1)

Main Frame

The main frame is meant for holding different components, which may be subjected to bending, tension, and vibrations. Two L-sections of 50 x 50 x 5 mm were welded together to form a square hallow pipe. This square hollow pipe was used to make square frame 1900 x 900 mm. This square frame used as a main frame for an according the components like sub frames, hydraulic pump, press wheel, guide wheel, transportation wheel, depth control wheel, power transmission system. The size of the fabricated frame is as shown in the Figure 2. Main frame is such that it can be divided into three parts. Two end parts can be brought in line or can be pushed back side of the center part as per the requirement i. e. operation in field or transportation. The length (1900 mm) of the central part of the frame is equal to the width of the tractor (1900 x 900 mm) whereas the two side parts are 950 x 900 mm each.

Spool

The spool (Fig. 3) consists of a shaft (450 mm x 650 mm) mounted on a spool supporting frame made from square pipe. The shaft is having fixed wheel of 900 mm on one side and a collapsible four bar attachment on the other side of the shaft. The shaft is mounted such that it acts as a cantilever having support of two bearing (6209, 45 x 85 x 19) on one side. The shaft is covered with baffle plates (4 plates, GI sheet, 3 mm thick, 650 mm x 20 mm) and a mechanism to contract or expanded as per the requirement. Spool is mounted on the main frame with help of spool supporting frame. The height of spool supporting frame is 550 mm from main frame. The dimension of the drip line is an important factor in designing the diameter and width of the spool. Considering the standard dimensions of new drip line, the dimensions of the spool are kept as. In which 300 mm is the diameter of spool, 200 mm is assumed as thickness of drip line bundle with 150 mm (50 mm freeboard + 100 mm passage) freeboard. A sprocket having 14 teeth mounted on the shaft of the pedicle block bearing for transmitting the power.

Press wheel

The press wheels were fabricated using MS hollow pipe of 250 mm diameter and 30 mm length having 3 mm thickness. Two circular plates of 3 mm thickness and 310 mm diameter were welded on each side of the hollow pipe as above. This creates a groove (Fig. 4) of 30 mm on each end. Three such wheels were fabricated. All the three wheels

were attached to the main frame. The brackets were fixed with bolts and nut such that they allowed the movement of threaded rod. Iron plate 500 mm ×30 mm ×5 mm was bent in C-shape, and a 10 mm hole was drilled at both ends, C shape iron plate and wheel were joined by means of nut and bolt (Fig. 4). Size of bolt used is 100 mm length and 10 mm diameter. Threaded iron rod having diameter 25 mm and length (350 mm) with two nuts for locking (Fig. 4). One end of threaded rod was welded on middle part of C-shape the other end was attached to remove moulded knob by means of a nut (Fig. 4).

A pipe having 30 mm diameter and 50 mm length was welded with L- shaped plate which is directly attached to main frame by means of nut and bolt. Iron rod was threaded throughout its length. The depth of press wheel can be adjusted by means of two nuts. Flexible PVC pipe of 350 mm diameter and 30 cm length was joined by means of welding with C-shaped iron plate with two extensions (Fig. 4). Press wheel is attached at rear side of the implement by nut-bolt (100 mm length and 10 mm diameter) such that it travels near the crop row. During installation of drip line, it passes through the groove of press wheel and a straight row of drip line is maintained through press wheel near the crop row.

Guide wheel and shaft

The lateral guiding wheel is a simple non-powered, freely rotating wheel mounted on a shaft called guiding wheel shaft. The guide wheels were fabricated using MS hollow pipe of 90 mm diameter, 30 mm length having 3 mm thickness (Fig. 5). Two circular plates of 3 mm thickness and 150 mm diameter were welded on each side of the hollow pipe as mentioned above. In center of circular plate, a hole of 30 mm diameter was drilled. This creates a groove (Fig. 6) of 30 mm on each end. Three such wheels were fabricated. All the three wheels were attached to the spool supporting frame. Guide wheel shaft has 15 mm diameter and 650 mm length, and length is selected according to length of spool. Two stoppers on shaft specifies the limits of movement of wheel on the shaft. The limit is adjusted by means of stopper as above. Shaft is welded to rectangular plate (70 x 50 mm). Rectangular plate is directly attached to spool supporting frame by means of nut-bolt (Fig. 7).

Fig.1 Developed machine

Fig.2 Detailed drawing of main frame

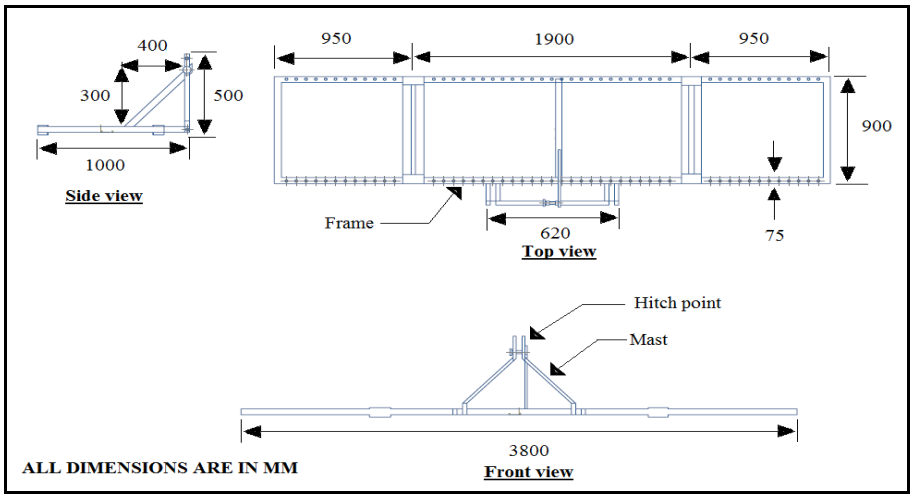

Fig.3 Fabricated view of spool

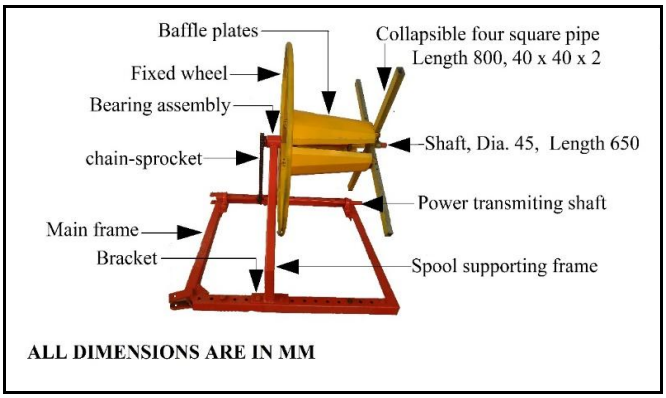

Fig.4 Detailed drawing of press wheel

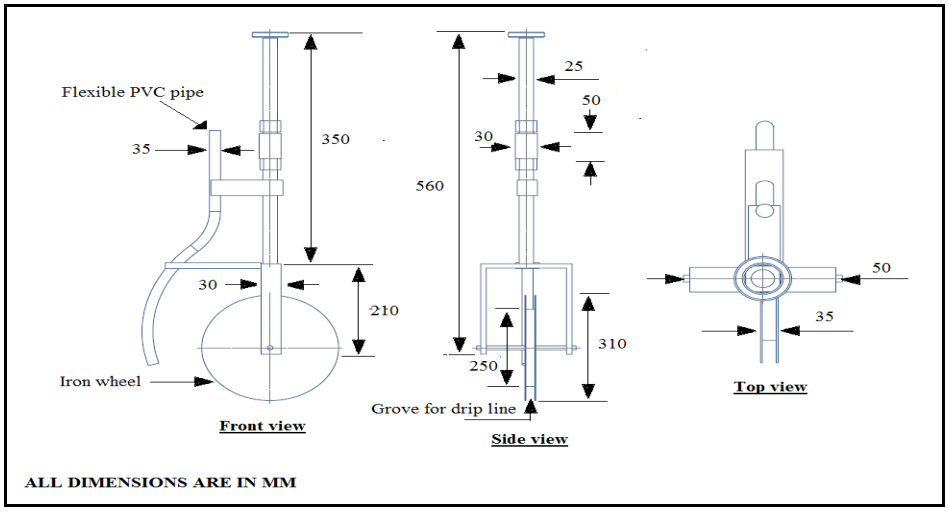

Fig.5 Fabricated view of press wheel

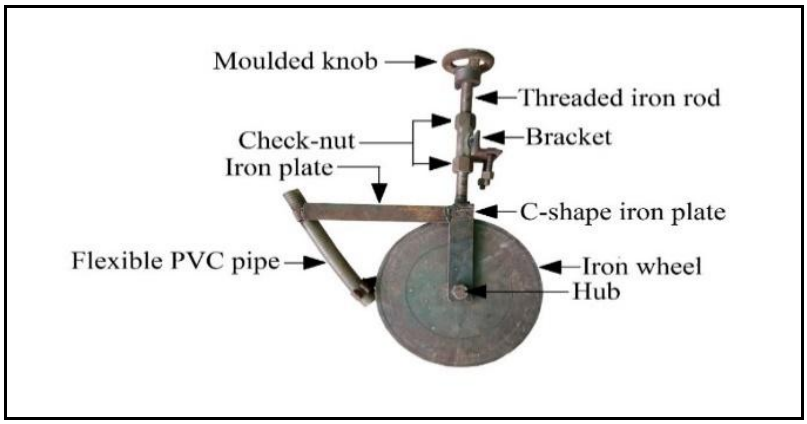

Fig.6 Detail dimension of guide wheel and shaft

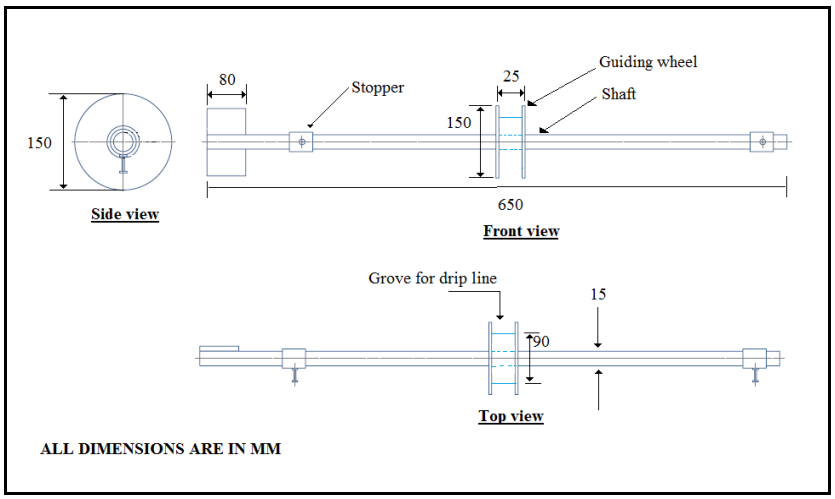

Fig.7 Fabricated view of guiding wheel and shaft

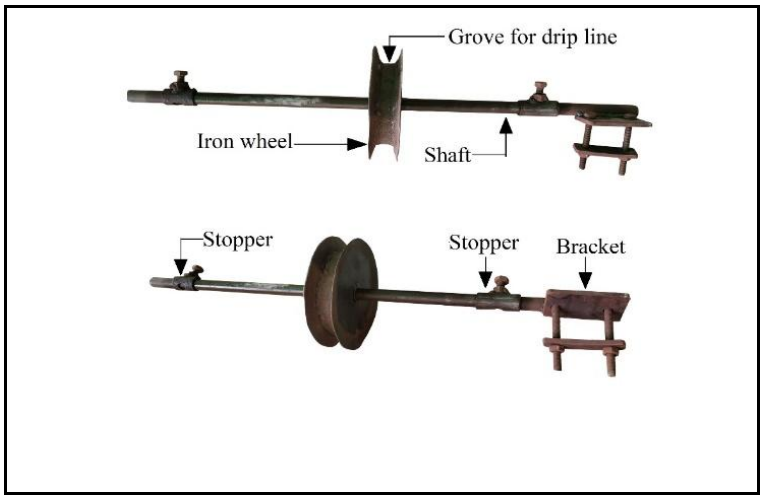

Fig.8 Detailed drawing of transportation wheel

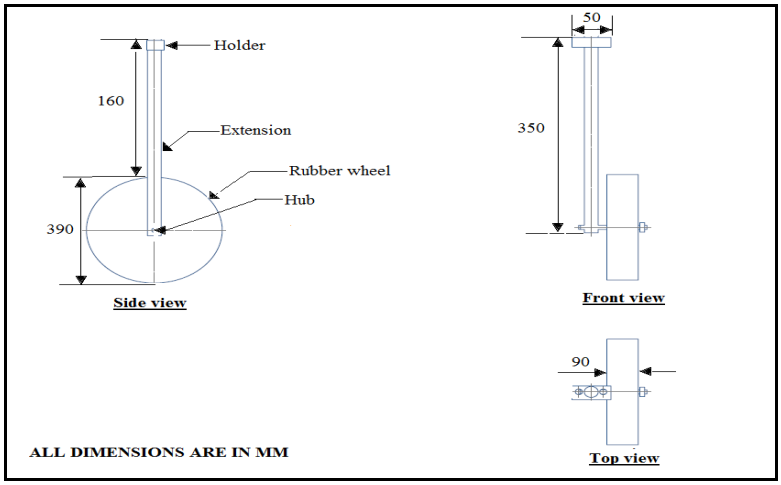

Fig.9 Fabricated view of transportation wheel

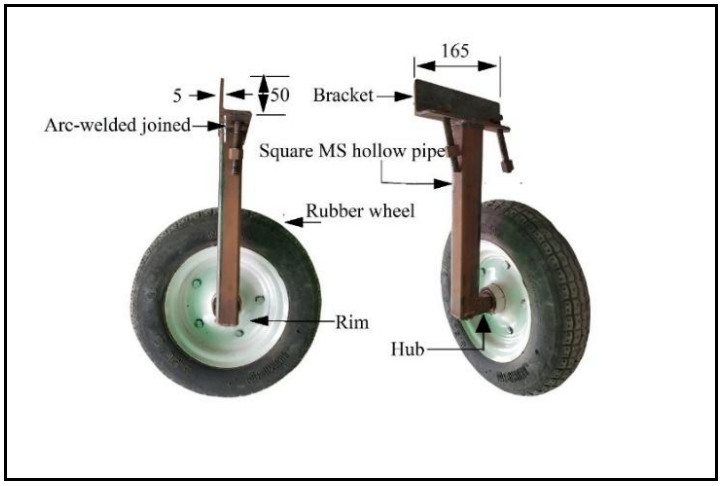

Fig.10 Detailed drawing of depth control wheel

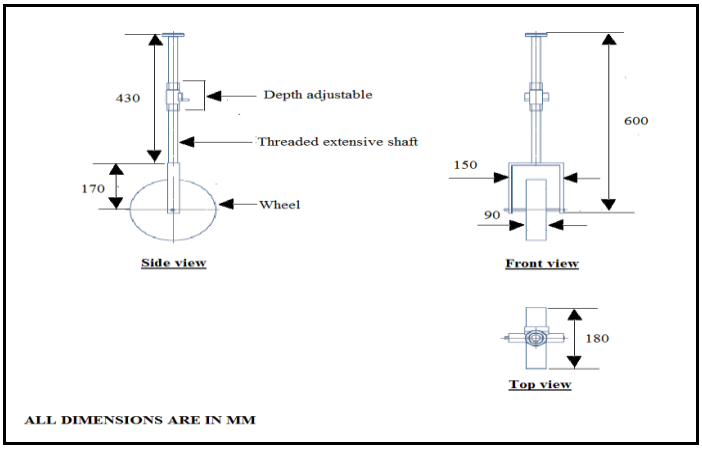

Fig.11 Febricated view of depth control wheel

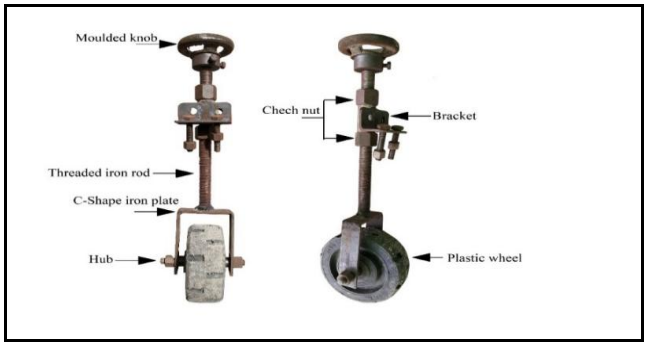

Fig.12 Power transmission unit of drip line installer and retriever

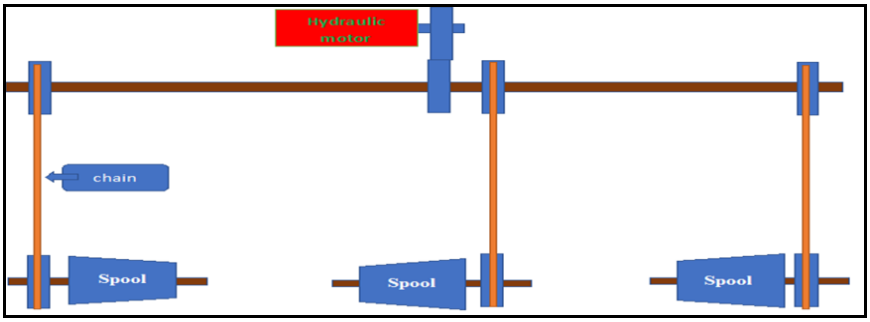

Fig.13 Developed device (a) & (b)

(a)

(b)

Table.1 Detailed specifications of installing and retrieving attachment to main frame

Sr.	Particulars	Specifications
1	**Name of implement**	**Installer and retriever of drip line**
2	**Type of hitch and its detail**	
	Linkage	3 – Point hitch system
	Power source	Hydraulic motor
3	**Overall Dimensions**	
	Length, mm	3800
	Width, mm	900
	Height, mm	1520
	Weight, kg	
4	**Frame**	
	Material of fabrication	Mild Steel (L – channel size: 65 mm × 65 mm × 6 mm) Three point hitch (75mm × 5mm)
	Length, mm	3800
	Width, mm	900
	Height, mm	500
5	**Transportation Wheel**	
	Material of fabrication	Rubber wheel with extension
	Diameter of wheel, mm	390
	Thickness of wheel, mm	90
	Length of extension, mm	350
	Diameter of handle wheel, mm	110
	Dimension of wheel holding plate, mm	165 X 50
	No. of transportation wheel	2
6	**Installer/Retriever**	
	Material of fabrication	Mild Steel
	Nos. of Installer / retriever on frame	3
	Height, mm	1000
	Diameter, mm	90
	Thickness, mm	55
	Spacing between Installer / retriever on frame, mm	1200
7	**Press wheel**	
	Material of fabrication	Mild Steel
	Length of extension of press wheel, mm	350
	Diameter of wheel, mm	330
	Diameter of wheel grove, mm	35
	Thickness of wheel plate, mm	3

	Diameter of wheel shaft, mm	25
	Width of groove on wheel	30
	Thickness of the disc, mm	28
	Diameter of PVC pipe, mm	35
	Length of PVC pipe, mm	300
	No. of Press wheel	3
8	**Guide wheel**	
	Material of fabrication	Mild Steel
	Length of guide wheel shaft, mm	65
	Diameter of guide wheel, mm	150
	Diameter of wheel grove, mm	1000
	Thickness of wheel plate, mm	3
	Diameter of wheel shaft, mm	15
	Depth of wheel groove, mm	5
	Length of holding plat, mm	50
	No. of guide wheel	3
9	**Power transmitting shaft**	
	Material of fabrication	Mild steel rod
	Length, mm	750
	Diameter, mm	45
10	**Chain and sprocket mechanism**	
	Type	Pintle chain
	Width, mm	10
	Length, mm	1624
	Thickness, mm	3
	Pitch, mm	16
	Velocity ratio	1 : 1
11	**Spur gear**	
	Material of fabrication	Cast iron
	Velocity ratio	1:2
12	**Pedestal block bearing**	
	Material of fabrication	Casting with press fitted bearing
	Diameter, mm	46
	Length, mm	35
	Height, mm	70

Transportation wheel

As the name suggest these wheels are meant for transportation. The base components consist of a rubber tire along with a rim (Fig. 8). This is once again attached with iron member through a bearing and nut and bolt. The iron member is made up of square MS hollow pipe 30 x 30 x 3 mm and having bosh over which the bearing is fitted. The length of iron member that line vertical is 350 mm (Fig. 8). A bracket to attach it with the main frame is made up of MS angle 50 x 50 mm and 165 mm length (Fig. 8). Two bolts along with nuts

are provided. The hole for same are made as show in Figure 8. Influence pressure of this rubber wheel was 50 kg/cm^2. It was supposed that the weight of the machine with full load is too high for efficient work. To reduce the work load of tractor two transport wheels were provided to the machine. The height of the machine from the ground was fixed. Maximum height facilitates easy transportation of the machine, work just like a tractor. On the field application the load is distributed between the hydraulic of the tractor and the two wheels which also reduce the effort of tractor.

Depth control wheel

The depth control wheel consists of a plastic wheel with threaded extension iron rod. The plastic wheel having 180 mm diameter and 90 mm width was readily available (Fig. 10), it was selected. All the two wheels were attached to the main frame. The brackets were fixed with bolts and nut such that they allowed the movement of threaded rod. Iron plate 490 mm ^{x}30 mm ^{x}5 mm was bent in C-shape, and a 20 mm hole was drilled at both ends, C shape iron plate and wheel were joined by means of nut and bolt (Fig. 10). Size of bolt used is 80 mm length and 25 mm diameter. Threaded iron rod having diameter 25 mm and length (350 mm) with two nuts for locking. One end of threaded rod was welded on middle part of C-shape the other end was attached to remove moulded knob by means of a nut (Fig. 10). A pipe having 30 mm diameter and 50 mm length was welded with L- shaped plate which is directly attached to main frame by means of nut and bolt (Fig. 10). Iron rod was threaded throughout its length. The depth of depth wheel can be adjusted by means of two nuts. Depth wheel is attached at front side with both ends of main frame of the implement by nut-bolt (100 mm length and 10 mm diameter). These wheels are provided to maintain the depth of laying down the lateral line a required level. The pair of wheels was having the adjustment for controlling the depth. It consisted of threaded iron rod which had provision of nut and bolt arrangement for controlling the depth of penetration of machine.

Power transmission unit of drip line installer and retriever

Power transmitted from hydraulic motor to main shaft through spur gear of 1:2 ratio. So that hydraulic motor transmits 17-45 rpm at different three levels, corresponding power transmission to main shaft was 35-89 rpm. Power transmission shaft is connected to spool by chain and sprocket transmission system, which transmits 35-90 rpm at 1:1 ratio. Power transmission system include hydro motor, spur gears, chain and sprocket and pedestal block bearing which is included in this section. Schematic diagram of power transmission is shown in Figure 11.

Fabricated installing and retrieving attachment to main frame

Design and developed installing and retrieving attachment to main frame, its design drawing and specifications of all units are shown in following Figure 8 (a &b) and Table 1 respectively.

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