DEVELOPMENT AND TESTING OF A COUNTERSINKING ATTACHMENT TO THE TRACTOR OPERATED POST - HOLE DIGGER

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled " **Development and Testing of a Countersinking Attachment to the Tractor Operated Post-hole Digger** " is a bonafide record of project work done by us and that this work has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title to us, of any other university or society.

Tavanur,
29th May 1996

Rajesh, G.K.

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Sindhu Bhaskar.

CERTIFICATE

Certified that this project report, entitled **"Development and Testing of a Countersinking Attachment to the Tractor Operated Post-hole Digger"** is a bonafide record of project work done jointly by Rajesh, G.K., Saju Varnan, A. and Sindhu Bhaskar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

29/5/96

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SYMBOLS AND ABBREVIATIONS

Agric.	-	Agriculture
AO x GB	-	Andaman ordinary x Gangabondham
cm	-	Centimetre(s)
D	-	diameter
dia	-	diameter
Dept.	-	Department
Engng	-	Engineering
et al.	-	and others
Fig	-	Figure(s)
FIM	-	Farm Implements and Machinery
FPME	-	Farm Power Machinery and Energy
g	-	gram(s)
ha	-	hectare
hp	-	horse power
hr	-	hour(s)
i.e.	-	that is
I.S.I	-	Indian Standard Institutions
J.	-	Journal
K.A.U.	-	Kerala Agricultural University
K.C.A.E.T.	-	Kelappaji College of Agricultural Engineering and Technology
kg	-	kilogram
kmph	-	kilometre per hour

L	-	Length
m	-	metre(s)
mc	-	moisture content
min	-	minute(s)
mm	-	millimetre
MS	-	Mild Steel
No.	-	Number(s)
Pp	-	Page
PTO	-	Power Take Off
rpm	-	revolutions per minute
Rs	-	rupees
s	-	second(s)
sec	-	second(s)
T.N.A.U.	-	Tamil Nadu Agricultural University
Viz.	-	namely
WCT x GB	-	West coast tall x Gangabondham
&	-	and
@	-	at the rate of
^{o}C	-	degree
/	-	per
%	-	percentage

CHAPTER - I

INTRODUCTION

The agricultural lands of our country are characterized by different types of soil, vegetation and relief conditions. The most wide spread type of soils are: black soils, alluvial soils, red soils and laterite soils. The other recognised soil includes forest and hill soils, peat and marshy soils.

Soil as a medium subjected to working parts of earthmoving machines is highly heterogenous in nature. It may contain coarse and fine gravel, different grades of sand, clay and colloidal particles and various organic materials. It has been established that the same soil may have different mechanical properties when different crops have been grown on it. Due to this it is very difficult to give an exact account of the mechanical properties of the soil. Therefore in agriculture, attention is devoted to the mechanical properties of the soil. However, to date the study of the physical and mechanical properties of the soil has not been properly correlated with the theory of technological processes and hence is out of touch with the problems of agricultural mechanics. This makes it difficult to establish the relationship between resistance of soil and its moisture content, adhesion, mechanical composition and other properties.

Agricultural production largely depends on the availability of power in farming operations. It has been established that the productivity of crops closely depends on the power used per unit area. In India the availability of power in farming sector is estimated as 0.55 hp/ha. According to World survey, power needed for improved agriculture has been established out as 0.8 hp/ha. For intensive farming, this figure should be at the order of 1 hp/ha and therefore it is needless to say that the availability of power in Indian agriculture should be enhanced significantly to cope up with demand for remunerative farming.

For any crop, the requirement of energy input more during the time of planting and obviously it will vary depending upon the crops being cultivated. Common tillage operations viz., ploughing, harrowing etc. for seasonal crops have already been mechanised to greater extent and for this purpose cost effective and established implements and machinery are available. However, perennial crops do require speciallised operations like digging and pitting at their time of planting. Almost all plantation crops are planted in pits where water table is sufficiently below the root zone depth.

Pitting is necessary to provide favourable conditions for the early establishment and growth of young plants. The size of pits depends upon the type of planting materials used and nature of the soil.

The normal technique of planting of tree seedling is to plant seedlings in the pits of size ranging from about 45 cm x 45 cm x 45 cm to about 90 cm x 90 cm x 90 cm. The size depends on site of plantation and root pattern. After planting, the soil is loosened around the plant and heaps are formed around the seedlings for the support, conserve moisture, seedlings are planted up to collar portion of the seedlings in the pits. In case of deep rooted plants like rubber, pits are made with size 90 cm x 90 cm x 90 cm. This is the present normal method of planting.

It has been found that the damage to rubber trees by winds like their uprooting can be prevented by a cheaper and quicker method of mechanised planting seedlings in what is called bore holes. Damage by wind is very grave and loss making problem faced by the rubber planters all over the world. A study of the cause of uprooting shows that mainly three reasons are responsible for it. Exorbitant height of tree, lack of strong soil wall to support the trunk of the tree and inability of tap root to develop proper anchorage. The second and third short coming are caused by the defective size of the conventional pits in which the ruber seedlings are planted. In the conventional pits the tap root is unable to penetrate deep in to hard soil and so it bends and grows in the lateral direction. This causes poor anchorage and it is the most important factor of the trees during heavy winds.

The introduction of new schemes sponsored by the Government and other agencies like Rubber Board has increased the motivation of tree sapling plantation in conical pits made in the soil at a required spacing. With the increase in tempo of tree planting work, the need for mechanised hole digger for planting tree seedlings is keenly felt.

In the conventional methods, the holes are dug with a spade, pick-axe etc. This method is not suitable for large scale and require much labour and time. By this method cost of operation is very high. To eliminate the hazards for human health and for timely planting of trees sapling in large scale immediately after the receipt of mechanised pit diggers are essential.

Though many types of mechanised tree hole diggers are available, a tractor operated tree hole digger is more effective, since it aids in easy transportation of the unit and reduces labour consumption. Separate prime mover is not needed since power can be taken from PTO of the tractor.

Hence a project on " Development and testing of a counter sinking attachment to the tractor operated post hole digger " is under taken with the following objectivs.

1. Development of a countersinking attachment to the post hole digger to dig holes for planting tree saplings.

2. Field evaluation of the various units and carrying out suitable modifications to eliminate the problems encountered during the field operations.

3. Performance evaluation of the unit in terms of field capacity, field efficiency etc.

CHAPTER II

REVIEW OF LITERATURE

In this chapter a brief review of previous work done on origin and development of auger and hole diggers have been presented.

2.1. Small scale equipments for earth moving

Small scale earthmoving equipments are manually operated. They consists of shovel, spade, pick-axe etc.

2.1.1. Shovels

The chief objective of a shovel is to move loose soil or similar material over short distances. The essential parts are the blade, the socket and the handle with grip. There are long handled and short handled shovels for moving material lying on the ground on both operated with both hand and one handled scoops. On long handled shovels the angle between the blade and handle is only slightly less than 180^{o}, where as this same angle on very short handled shovels is acute. In fact, these shovels much used in various parts of Africa and Far East (Hopfen, 1969).

Various types of shovel blades have been developed for different working condition. A good multipurpose shovel blade is concave and slighty pointed. Blades with a straight edge and rounded raised shoulders are particularly suitable for picking up material from smooth ground while the pointed ones are better on uneven ground. The handles and connections between blade are much the same as those used for spades.

2.1.2. Spade

German hoe or spade is an improved version of pick-axe which consists of one part of an axe and other part of 25 cm long and 12 cm broad tapering spade (Arya _et al_., 1990). With a hole in between for insertion of a handle. While operating first vertical cut of an axe is given and then about 20 cm deep horizontal cut is needed with the help of spade to form an inverted L shaped cut. Then the spade is rested on right thigh and moved up sideways to lift up soil in the order to form a gap in which a plant is inserted with the help of second hand. Thereafter the spade is withdrawn with a little sudden upward pull so as to allow soil to fill the gap and the soil is stamped properly by foot inorder to ensure proper soil compaction.

2.2. Earth moving machineries

Earth moving machinery comprise of machines which cut and extract earth, blast rocks, sand and other loose materials and then transfer them to a predetermined position and finally discharge the material on dumping points through dumpers, belt conveyors etc. A few machines of this category are used for road making and maintenance purposes. Earth moving machinery consists of different types of excavators and drilling machines.

2.2.1. Excavator

Excavators are classified according to the type of equipment, direction of movement of the working machine and capacity. Depending upon the type of working device excavators are classified as chain type, wheel type or with special purpose working tools. Depending upon the direction of movement of working tool excavators can be classified into longitudinal digging or transverse digging. In case of longitudinal digging excavators, the direction of movement of working tool coincides with direction of movement of excavator. In transverse digging excavators, the working tool moves perpendicular to the direction of movement of the excavator. Besides the above groups of excavators, there are swinging shovels where the working tool can be turned with respect to the excavator (Amithosh De, 1989).

2.2.2. Drilling machines

Drilling is performed inorder to blast the over burden, ore deposit, coal scams etc. so that the power required for excavators to extract the material becomes less. This reduces the wear and tear of the excavators, increases their life, reduces clearing time of material and decreases operating cost. Drilling holes are usually made in a zig-zag manner. The spacing between rows and column is of equal length. Certain empirical rules are followed for this spacing and depth of holes as indicated below (Amithosh De, 1989).

Drilling machines used in surface mining projects, construction works etc., can be classified into the following. Depending upon principle, depending upon type of hammer, depending upon power transmission.

Depending upon principle of working they are further classified into percussive type, rotory type and rotory percussive type.

2.2.2.1. Jack hammer mill - percussive type

Jack hammer mill is an example of percussive drilling type machine and is familiar equipment to mine workers and civil construction labourers. This is a hand held and unmounted drill used to bore vertically downward holes. It is capable of making drill holes upto a depth of 3 m with hole diameter generally between 25 and 37 mm.

2.2.2.2. Tercone rock roller bit - rotary type

In rotary drilling machine which are electrically driven in combination with pneumatic and hydraulic system. The drilling tool is a tercone rotary bit.

2.2.2.3. Button bit - rotary percussive type

These have cylinderical bodies with large diameter head on top and the stem is spline shaped. Rotational speed varies 10-25 rpm the hole diameter varies from 100-210 mm.

2.2.2.4. Pneumatically operated machine

This consists of an air motor, transmission system and chain drive. The motor is driven by compressed air, which drives the sprocket chain arrangement through gear box or a belt pulley system. The rotary head is spaced on a chain which reciprocates during the raising and lowering of the chain.

2.2.2.5. Hydraulically operated machine

This can be classified into two different types. By the use of hydraulic rams and by the use of hydraulic ram in combination with rope pulley arrangement.

2.2.2.6. Electrically operated machine in combination with hydraulic and pneumatic system

Rope pulley mechanism is an example of this type.

2.3. Augers

Auger is nothing but a boring tool having a centering point and one or two cutting edges which are radially alligned. This is an Archimedes screw for removing the material when it is advancing straight may or may not have a handle. It can be operated with two persons or by mechanical means such as power tillers, tractors and trucks.

2.3.1. Hand operated augers

Hand operated augers are driven by man power. It can be operated by one or two persons. Power augers are usually mounted on trucks, power tillers and tractors. The power to the auger unit is transmitted from the prime mover through a suitable transmission system. The capacity of this unit in digging holes is higher when compared to the manually operated hole diggers. Power augers have continuous flight with a hard metal cutting bit which brings the soil or soft rock to the surface as a spiral shaving. Auger drilling is particularly suitable for sand, gravel, clay and slate formations. It may be used in chalk, limestone, slate and similar soft rocks. The most important advantages of auger technique are high rate of penetration, large volume of material handled in short time and low noise level. Continuous flight augering is used for 63-350 mm bores.

According to type of flight augers can be classified into continuous flight, single flight and partial flight.

2.3.2. Continuous flight auger

It is having continuous flights and can be used for maximum depth of augering. The cut soil is coming through this flight.

2.3.3. Partial flight auger

In some augers a bit is used in which partial flight is incorporated.

Among these 3 types, continuous flight auger completely removes the soil from the hole. Hence continuous flight augers are used in places where scouring of the soil is of utmost importance.

Classification based on cutting head, augers are classified into finger type, fish type and carbide cutter head. The finger type cutter head is for cohesive and clay materials. The carbide cutter head is for hard pan and stiff deposits. Normally finger type cutter heads are used.

The classification of the augers based on the size of the auger is furnished in table 2.1.

Table. 2.1.

Classification of auger based on size

Sl.No.	Hole size mm	Flight OD mm	Auger ID mm
1	159	127	57
2	171	146	70
3	184	159	82
4	336	305	152

2.4. Post hole digger

Post hole diggers are augers, which are specially used for making holes for fence posting or banana planting. These are operated by mechanical power only. i.e. by means of tractors, power tillers and power engines.

Miel (1950) had developed a post hole digger. He used a separate engine as prime mover. It can be operated by a single man. As the total engine and gear box weights are directly over the auger. It is very fast digger.

Lines,R.A (1952) had developed a VENGAR equipped post hole digger which can be used for boring a concrete surface as well as for boring for nursery plantation and fencing. The special feature is the design and the setting of the teeth at the bottom end of the spiral ribbon of the auger. It is so equipped that it can bore through any concrete.

RONTHREADGATE (1952) had developed a home made post hole digger. For the geared head differential of an old model 'T' ford truck is used. For additional support the outer axle bearing are brought in and fitted to the differential housing and the spider and the wheel are welded up, to give positive drive. For the drive shaft, two levels and joint from an old truck are used. The raising and lowering of digger is effected by tractors hydraulic system and for the top stay rod is telescopic so that it is possible to set the machine to dig vertical holes on hill sides.

McDONALD (1952) had developed a post hole digger. He used an external hydraulic cylinder to raise and lower the auger through a toggle system. The auger is driven by PTO shaft by 'V' belts.

Two man post hole digger developed in America comprises a worm gear unit for high speed reduction and connection of gear head to the engine is through the 'V'belts.

SAMBATHRAJAN (1982) had developed a single man controlled trolly mounted post hole digger. The height of the digger can be adjusted by hand screw.

TNAU model (1985) auger digger as an attachment to power tiler is a front mounted unit and consists of a helical blade of 22.5 cm diameter. The power to the blade is transmitted from the power tiller engine pulley through 'V' belt transmission system. A rack and pinion arrangement with an auxillary handle is provided for depth control. The hole size is 22.5 cm diameter and 40 cm in depth.

KATHIRVELI et al. (1990) developed an auger digger as an attachment to power tiller. This auger unit can be mounted infront of power tiller and is simple to operate. It was developed to dig holes for planting tree seedlings in agro and social forestry programmes. The auger unit consists of a spiral auger actuated by rack and pinion arangement which enables the auger to move up and down with the help of a simple rotating hand wheel. The drive for the rotation of the auger is transmitted from the power tiller engine pulley through belt pulley and bevel gear transmission systems. With the help of bearings and fixtures the entire unit is fixed in a rectangular frame. During operations depth control is made using the hand wheel which is provided at the side of the unit. This unit dig holes of size 225 mm in diameter and a depth of 450 mm.

KUMAR,P. et al. (1990) had developed an engine operated portable tree hole digger. It consists of RT-35 engine of 1.7 hp with speed reduction unit bevel gear box assembly frame with handle, auger tips etc. The engine and gear box are aligned and mounted on the main frame. Two auger bits of sizes 100 mm and 150 mm in diameter can be fixed to the out put shaft of the gear box with the help of shear pins. The power from the engine to the auger for rotary motion is transmitted using chain and sprocket and bevel gear asembly. During operations, two persons are required for holding the whole unit at two ends of the frame. With this unit a hole of size 150 mm in diameter and a depth of 250 mm can be made.

Tractor operated post hole diggers are commercially available in our country. HOWARD made post hole diggers is used for digging holes of varied sizes and depth, for fencing, erection of marking stones, plantation of trees and

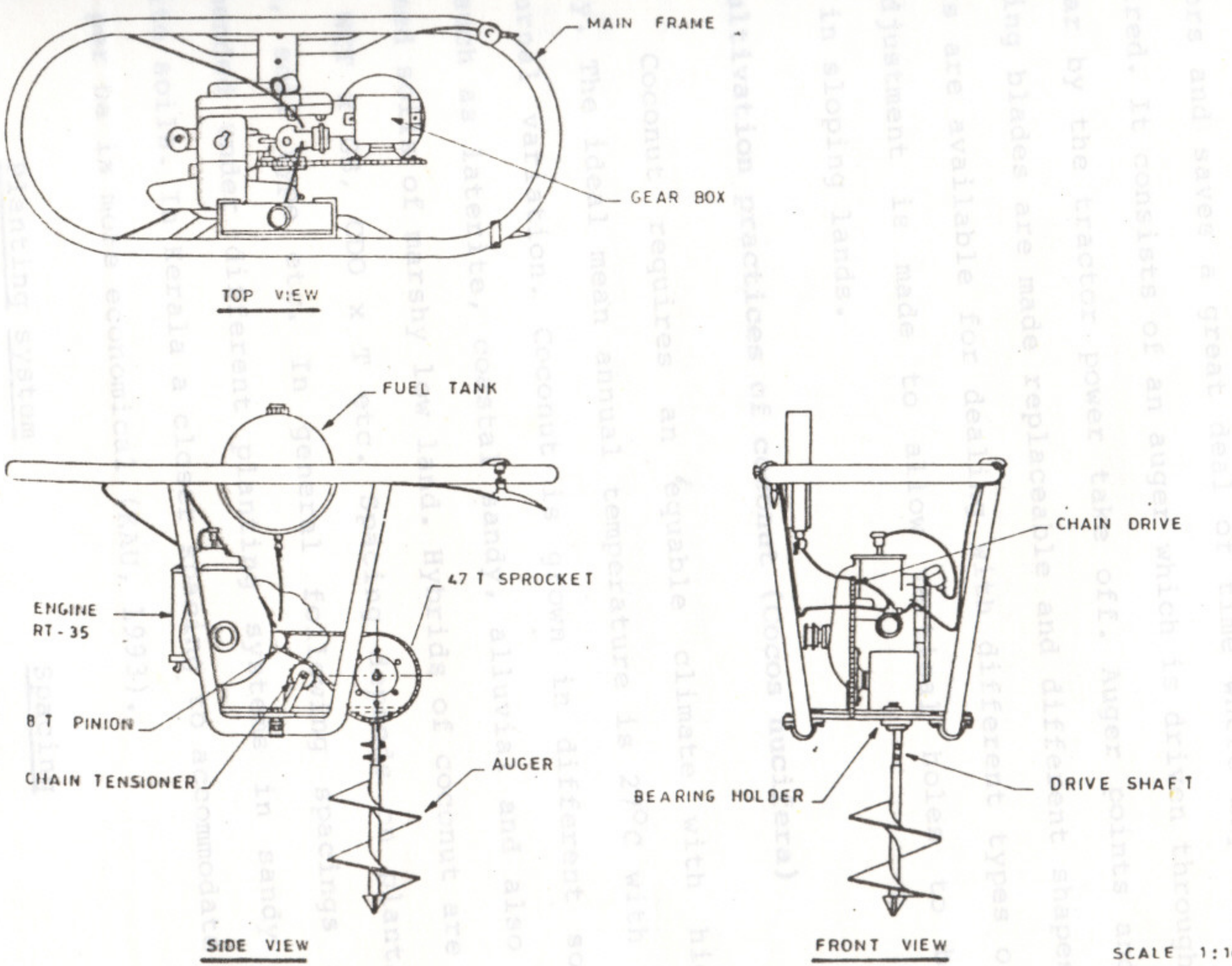


Fig 2.1. Power operated portable tree hole digger

saplings etc. It is an attachment to the hydraulic power lift of tractors and saves a great deal of time where may holes are required. It consists of an auger which is driven through bevel gear by the tractor power take off. Auger points and the leading blades are made replaceable and different shapes of points are available for dealing with different types of soil. Adjustment is made to allow vertical holes to be drilled in sloping lands.

2.5. Cultivation practices of coconut (Cocos nucifera)

Coconut requires an equable climate with high humidity. The ideal mean annual temperature is 27°C with 5-7°C diurnal variation. Coconut is grown in different soil types such as laterite, coastal sandy, alluvial and also in reclaimed soils of marshy low land. Hybrids of coconut are AO x GB, WCT x GB, CDO x T etc. Spacing depends on planting system, soil type etc. In general following spacings are recommended under different planting systems in sandy and laterite soils. In Kerala a closer spacing to accommodate 250 palms per ha is more economical (KAU, 1993).

Planting system	Spacing
Triangular	7.6 m
Square	7.6 - 9 m
Single hedge	5 m in the rows 9 m between rows
Double hedge	5 x 5 m in rows 9 m between pairs of rows

2.6. Cultivation practices of rubber (Hevea brasciliensis)

Rubber can be grown from almost sea level upto an altitude of 500 m in areas receiving a well distributed annual rainfall of not less than 200 cm and a warm humid equable climate (21^{o} to $35^{o}C$). These are grown in laterite and lateritic soils. Well drained and red loam soils are also suitable for rubber cultivation. The varieties of rubber are RRII-105, RRII-300, RRII-203 etc. The planting density recommended is 420 to 445 plants per ha in case of buddings or plants proposed to be field budded and 445 to 520 plants per ha in case of seedlings. The standard pits recommended are of 90 cm x 90 cm or 75 cm x 75 cm (KAU, 1993).

CHAPTER III

MATERIALS AND METHODS

In this chapter, the selection of prime mover, the power transmission system to the tractor operated post-hole digger, its fabrication details and the methods to find the performance of the unit are discussed.

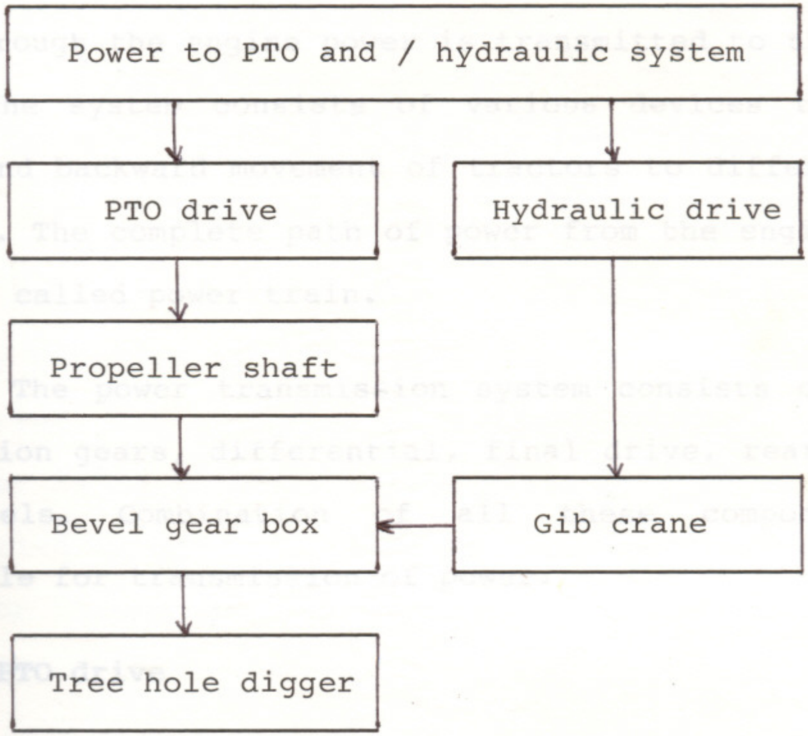
3.1. Selection of prime mover

The tractor is chosen for attaching a tree-hole digger to fulfil the following requirement.

The hole digger unit is to be designed as a portable unit. The unit is to be so designed that it can be easily carried by the tractor. The method adopted to decide the choice of prime mover is based on the capacity of prime mover to meet the power required for digging the soil, the speed, efficiency of power transmission system, type and fuel on which it is operating, lubricant system, repair, maintenance and specific fuel consumption to match with the functional requirements.

Commercially available 35 hp four wheel tractor has been selected as the power source for the tractor operated tree hole digger. The tractor will be having enough stages of PTO speed and hydraulic lift arrangement for effectively operating the digger. The specifications of the tractor is shown in Appendix I.

3.2. Power transmission to the tractor operated tree holder digger



Flow diagram of Power Transmission System

From the tractor PTO the power is transmitted to the bevel gear box through the propeller shaft. Through the bevel gear box the power is further transmitted to the tree-hole dgger. From the engine the power is also transmitted to the hydraulic system. A gib crane is attached to the tractor three point hitch system. The power from the hydraulic system is utilized for lowering and raising of the equipment.

3.2.1. Power to PTO shaft and hydraulic system

Power transmission is a speed reducing mechanism equipped with gears. It may be called a sequence of gears and shafts through the engine power is transmitted to the tractor wheels. The system consists of various devices that cause forward and backward movement of tractors to different field condition. The complete path of power from the engine to the wheels is called power train.

The power transmission system consists of clutch, transmission gears, differential, final drive, rear axle and rear wheels. Combination of all these components are responsible for transmission of power.

3.2.2. PTO drive

The power take-off shaft equipped with two universal joints is called a power take-off drive. American Society of Agricultural Engineers and Society of Automotive Engineers approved standards established the dimentional relationships inorder to suit the power take-off with any make of tractors. Tractors may be equipped with standard power take-off drive of either 540$\pm$10 or 1000 rpm.

Drive to the power take-off shaft is given either by a separate transmission system or by an independent drive.

In the transmission drive power take-off system, drive to the power take-off is controlled by the main clutch, that controls the ground speed of the tractor. With this arrangement power take-off shaft operates whenever the clutch is engaged to start the tractor. The disadvantage of the system is that when we stop the tractor or press the clutch, power take-off shaft also stops working. For the machine to operate with out tractor movement we have to shift the gear in neutral position and again re-engage the clutch.

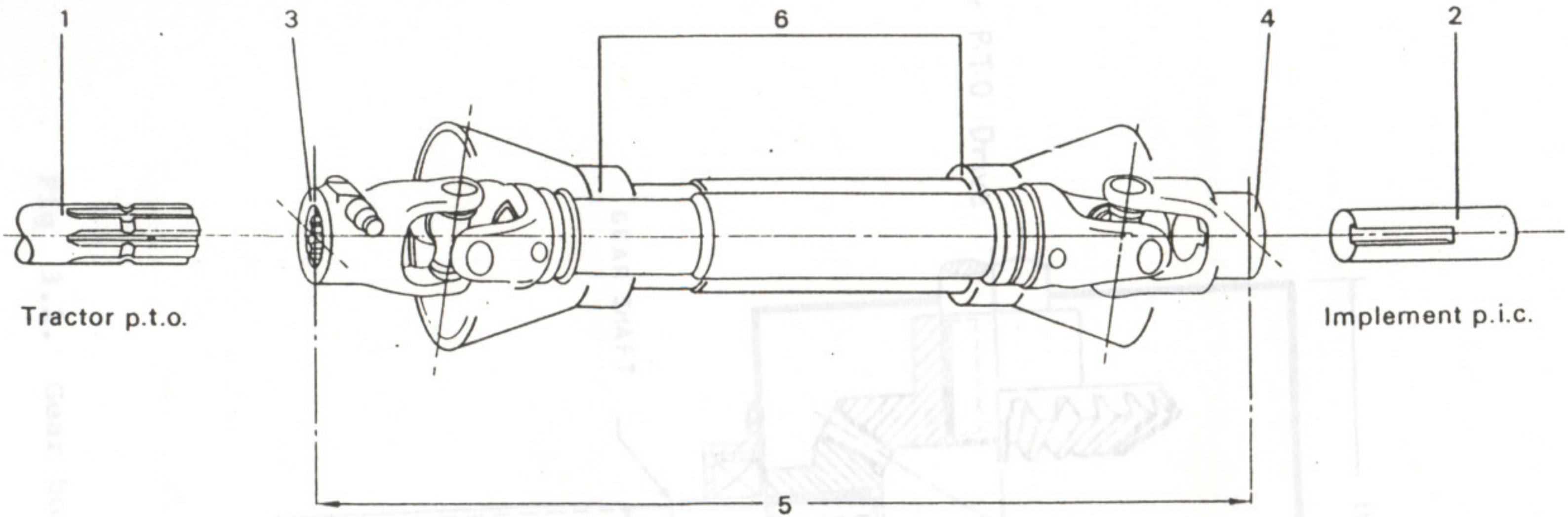
Independent drive were introduced to overcome the difficulty experienced in transmission drive power take-off. In this drive, the operation of machine can be continued when the tractor is in motion or stand still or in the process of being started or stopped. Power to the power take-off can be engaged or disengaged through a lever by shifting the dog-clutch.

3.2.3. Propeller shaft

Propeller shaft is also known as telescopic shaft used to connect power take-off shaft to the machine to be driven. Since the drive is not in straight line two universal joints are used one at each end. These shafts as the name suggests are telescopic so that length can be varied for correct fitting of the shaft as shown in Fig 3.1.

3.2.4. Bevel gear box

Bevel gears may be used when it is necessary to connect two shafts whose axes are at an angle to one another



1. Power take-off
2. Power input connection
3. P.T.O. Yoke
4. P.I.C. Yoke
5. P.T.O. shaft
6. P.T.O. shaft guard

Fig 3.1. Propeller shaft

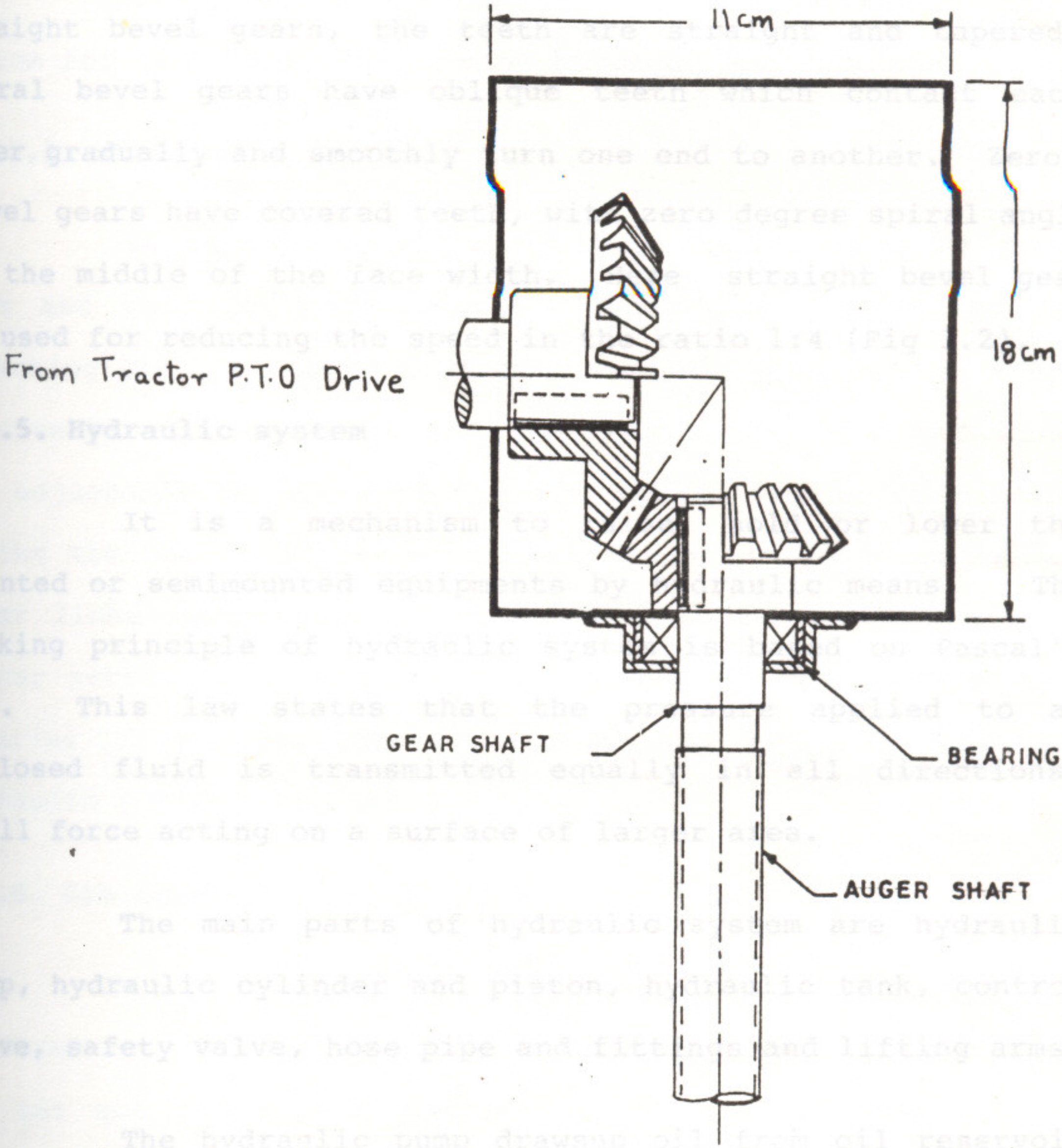


Fig 3.2. Gear box assembly

and intersect. The three basic types of bevel gears are straight bevel gear, spiral bevel gear and zerol bevel gear. Straight bevel gears, the teeth are straight and tapered. Spiral bevel gears have oblique teeth which contact each other gradually and smoothly turn one end to another. Zerol bevel gears have covered teeth, with zero degree spiral angle at the middle of the face width. Here straight bevel gear is used for reducing the speed in the ratio 1:4 (Fig 3.2).

3.2.5. Hydraulic system

It is a mechanism to raise, hold or lower the mounted or semimounted equipments by hydraulic means. The working principle of hydraulic system is based on Pascal's law. This law states that the pressure applied to an enclosed fluid is transmitted equally in all directions. Small force acting on a surface of larger area.

The main parts of hydraulic system are hydraulic pump, hydraulic cylinder and piston, hydraulic tank, control valve, safety valve, hose pipe and fittings and lifting arms.

The hydraulic pump drawsup oil from oil reservoir and sends it to the control valve under high pressure. From the control valve the oil goes to the hydraulic cyclinder to operate the piston which in turn raises the lifting arms. The lifting arms are attached with the implement. The hydraulic pump is operated suitable gears connected with engine. There are two types of arrangement for storing hydraulic oil in the system.

All tractors are equipped with hydraulic control system for operating three point hitch of the tractor.

3.2.5.1. Three point linkage

It is a combination of three links. One is upper link and two are lower links. These links are used for attaching the implements with the tractor. All the links are adjustable to some extent. The height of the lower links are adjustable by means of tie rod strut. The lateral swing of the tie rod is adjusted by lock chains. Due to upper and lower links being adjustable it becomes very easy to make proper setting of implements in the field. The raising and lowering of the implement is controlled by hand lever of hydraulic control system.

3.2.6. Gib crane

A gib was used to mount the tree hole digger with the tractor. This also aided in lowering the equipment into the pit and lifting it out of the pit. The lowering and raising of the equipment was achieved by mounting the gib crane on the tractor three point hitch system. This also facilitated in controlling the depth of cut. The details of gibcrane are shown in Fig.3.3.

3.2.7. Post hole digger with soil countersinking attachment

It is generally known in the art to manually dig pits in soil with the aid of pick axe and / or spade for planting saplings of trees including palms. It is however laborious, time consuming and involved human drudgery besides being expensive. Manually operated post hole diggers are used in not so hard soil. But it imposes limitations on the diameters of the hole as it is manually operated.

The post hole digger consists of an auger which is driven through bevel gears by the tractor power take off. Auger points and the leading blades are made replaceable and different shapes of point are available for dealing with different type of soil. With a typical machine the auger speed is about 80 rpm and it takes half minute to an average size hole. Working depth is 3.5 feet (0.9-1.5m) and auger diameter 6.24 inches (0.15 to 0.6m). Adjustment is provided to allow vertical holes to be drilled on sloping land.

Soil countersinking attachment is a replaceable unit on a co-operating auger of a post hole digger. The countersinking attachment comprises three inclined soil cutting blades placed 120° apart around and concentric to a sleeve but connected to it through equally spaced ties. It enables to simultaneously widen and bevel the hole being made in the soil by the auger of post hole digger.

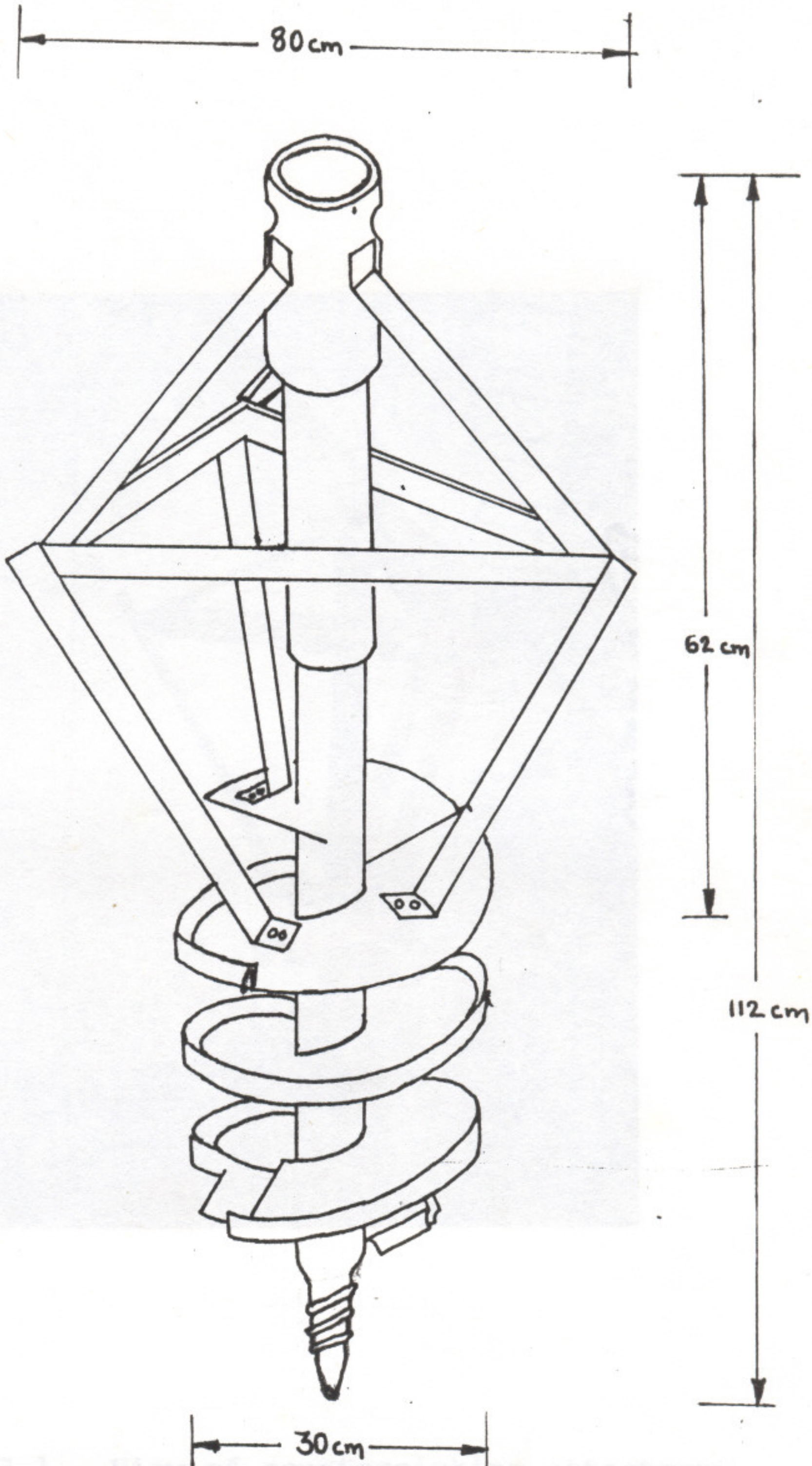


Fig 3.4. Countersinking attachment to the post-hole digger (Unit I)

Plate 3.1. View of countersinking attachment to the tractor operated post-hole digger (Unit I)

Fig 3.5. Exploded view of countersinking attachment to the post-hole digger (Unit I)

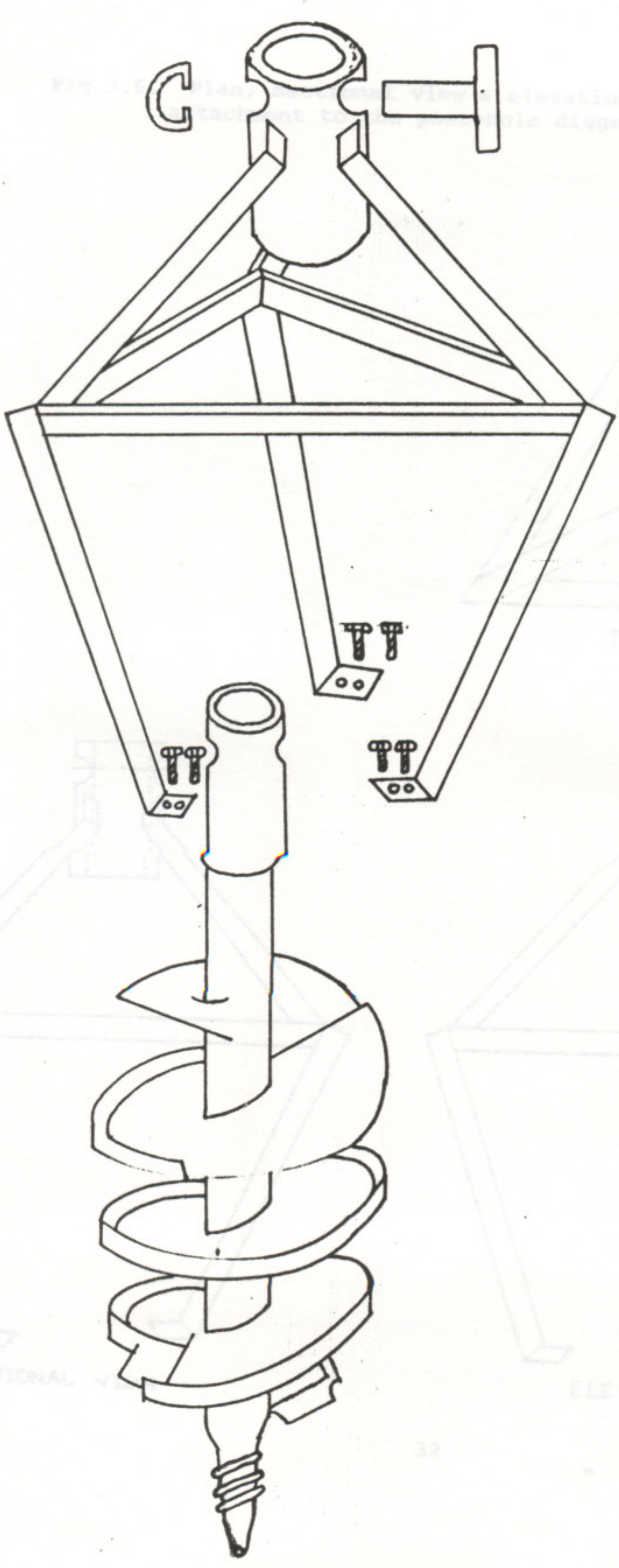


Fig 3.6. Plan, sectional view & elevation of countersinking attachment to the post-hole digger (Unit I)

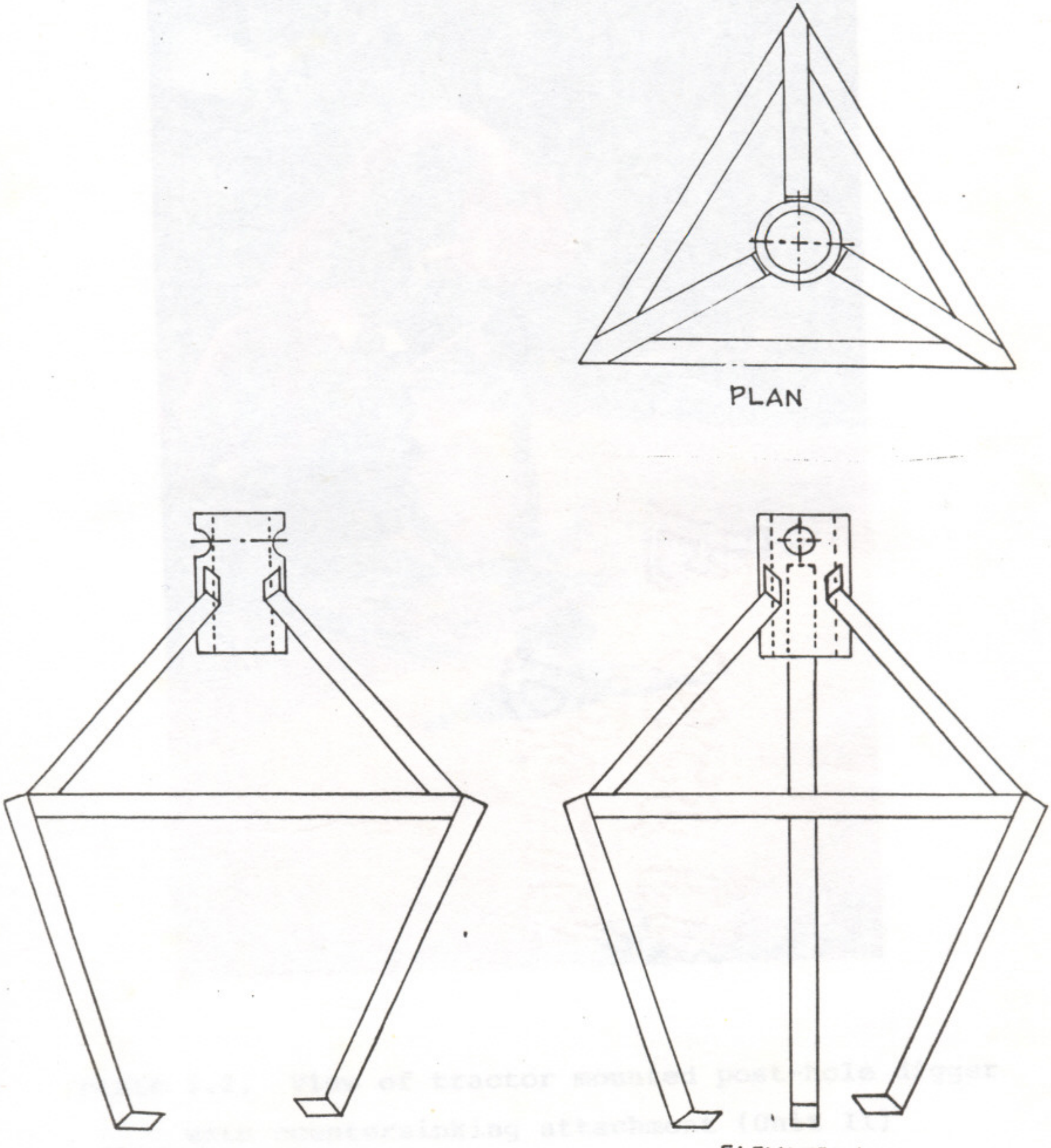


Plate 3.2. View of tractor mounted post-hole digger with countersinking attachment (Unit II)

From the bevel gear box the power is taken to the auger. The output shaft was made of 20 mm diameter MS round rod which extends vertically downward to a length of 230 mm. To this shaft the auger bits were fixed with the help of shear pins. 38mm x 6mm size bolts and nuts were used as shear pins.

The auger blades of 3mm MS sheets were welded spirally around a hollow MS pipe of 21mm diameter with a pitch of 125mm. The auger bits of 100mm and 115mm diameters were used.

3.3. Description of countersinking attachment

The soil countersinking attachment includes a sleeve to which are attached radially 120° apart but inclined downward three ties of equal length. Their outer end carry the soil cutting blades extending downward but inclined towards the longitudinal axis. The three blades at their lower end carrying the base plate having holes to match those on the corresponding flight of the co-operating auger.

The innerwall portion of the sleeve is so designed that it just engages the outerwall portion of the co-operating auger of the post hole digger. A hole of diameter, the same as that of the hole on socket of shank of the co-operating auger of the post hole digger is provided diametrically through the sleeve. The inner end wall portion of three ties placed 120^{0} apart are firmly connected to the outer end wall portion of the sleeve. The outer end wall portion of the three ties are also placed 120^0 apart. The three soil cutting blades are individually suspended from each of the ties by attaching the top end wall portion of the soil cutting blades to the outer end wall portion of the ties. The cutting edges of the soil cutting blades face outward, but tilted towards the longitudinal axis to fascilitate cutting and bevelling of the top wall portion of the cyclinderical hole made by the co-operating auger of the post hole digger. The bottom end wall portion of the soil cutting blades are attached to the end wall portion of the base plates. Holes are provided on the base plate matching the corresponding holes provided on the top wall portion of the flights of the co-operating auger of post hole digger.

The junction between the ties and soil cutting blades are interconnected by the struts.

3.4. Working of the tractor operated tree hole digger

The soil countersinking attachment is tilted on the co-operating auger of the post hole digger as illustrated in Fig 3.4. The innerwall portion of the sleeve just engages the outerwall portion of the co-operating auger of a post hole digger in such a manner that the hole on the sleeve is in allignment with hole on the socket of the co-operating auger. By inserting cotter pin through this hole and that on the propelling shaft of the post hole digger. The soil

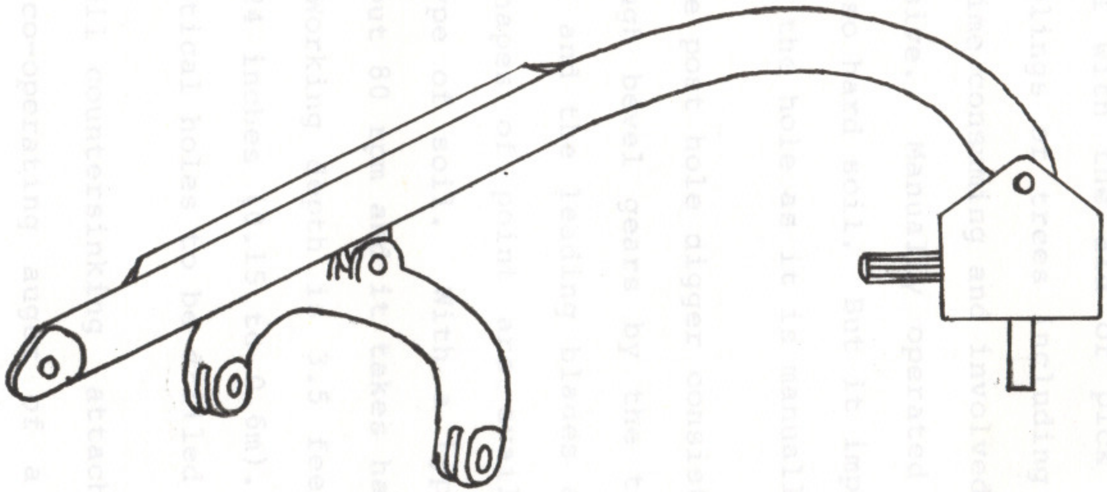


Fig 3.3. Gib crane

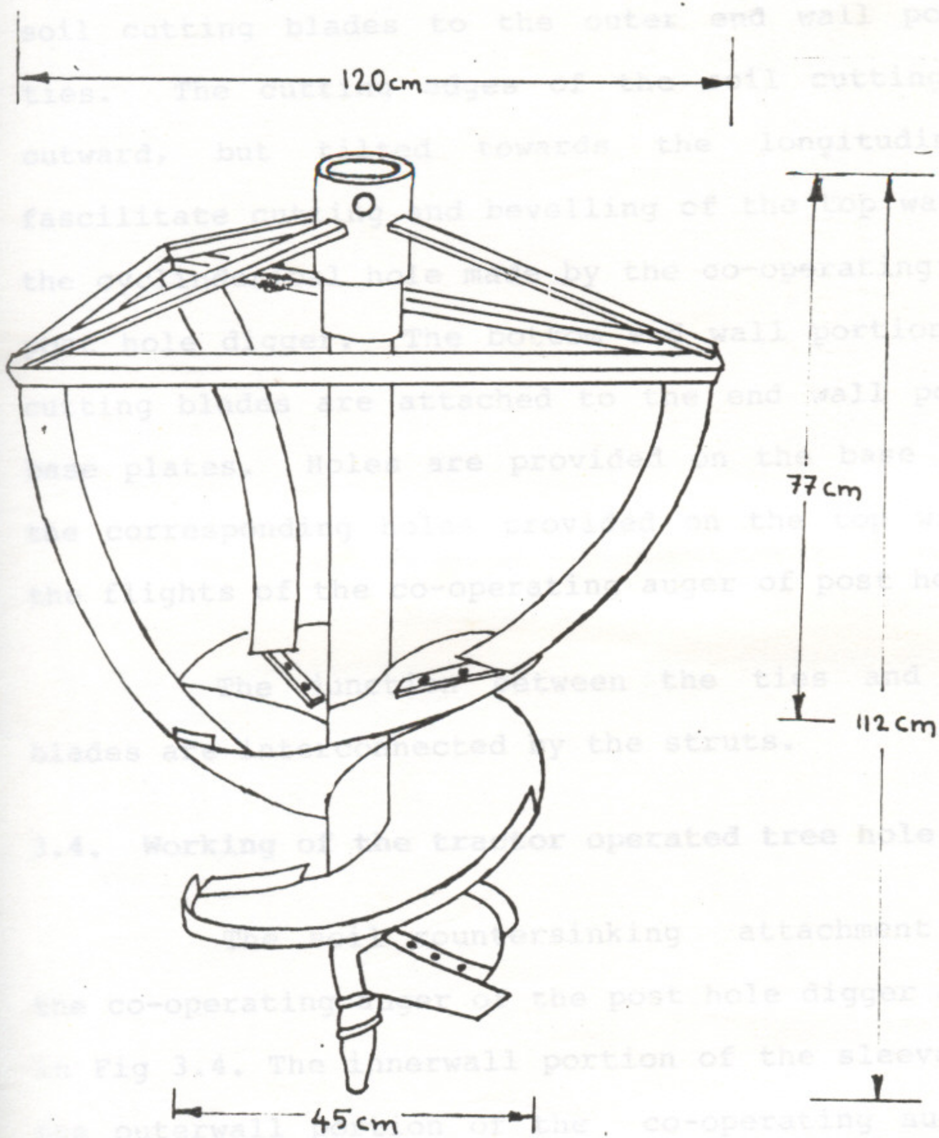
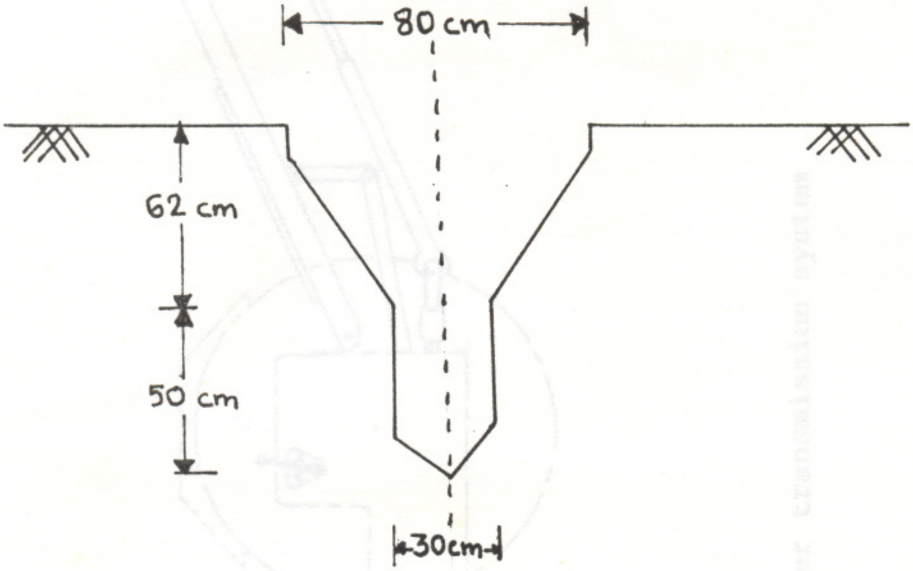


Fig 3.7. Countersinking attachment to the post-hole digger (Unit II)

Fig 3.10. Shape of pit formed by experimental model (Unit I)



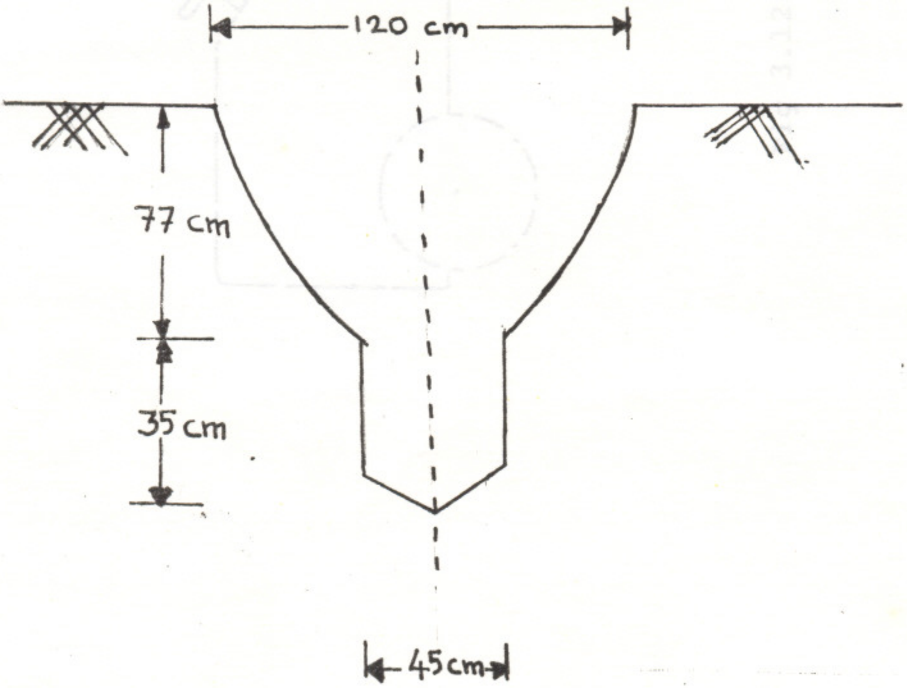


Fig 3.11. Shape of pit formed by modified model (Unit II)

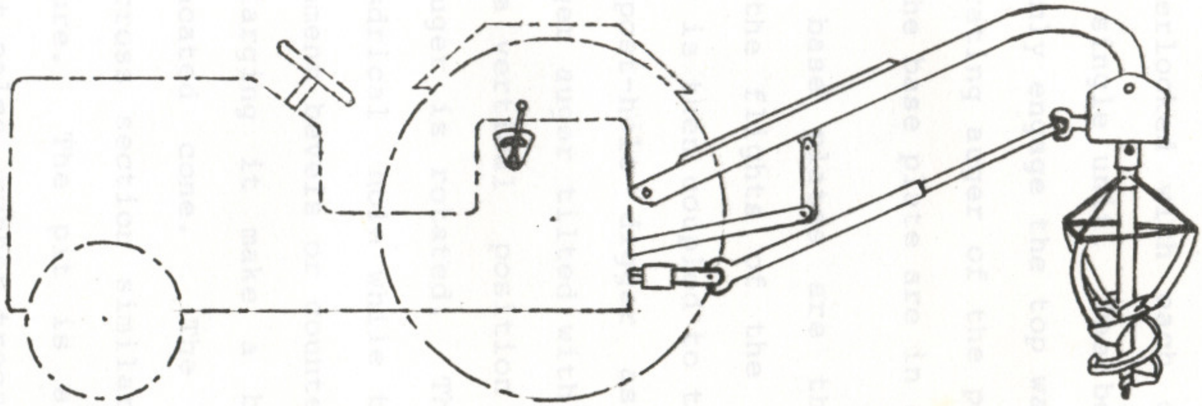


Fig 3.12. Power transmission system

Plate 3.3. Tractor operated post-hole digger with countersinking attachment during field operation (Unit I)

Plate 3.4. Tractor operated post-hole digger with countersinking attachment during field operation (Unit II)

Plate 3.5. Tractor mounted post-hole digger with countersinking attachment during field operation in laterite soil (Unit I)

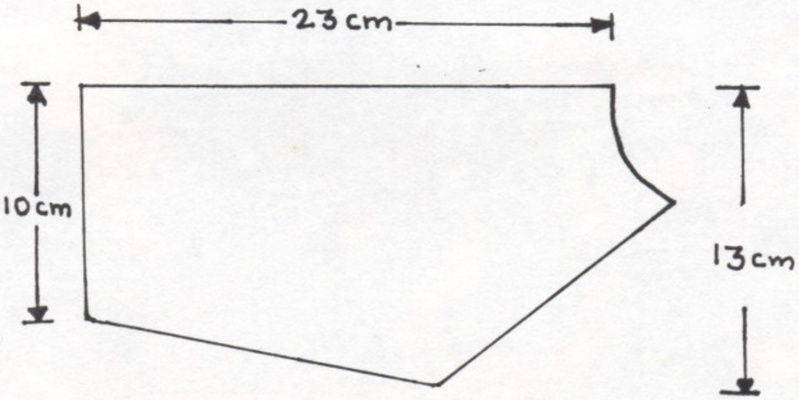


Fig 3.8. Modified base cutting blade

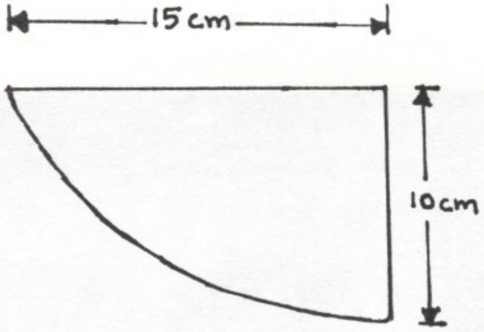


Fig 3.9. Existing base cutting blade

Plate 3.6. View of the pit taken by the Unit II in sandy loam soil

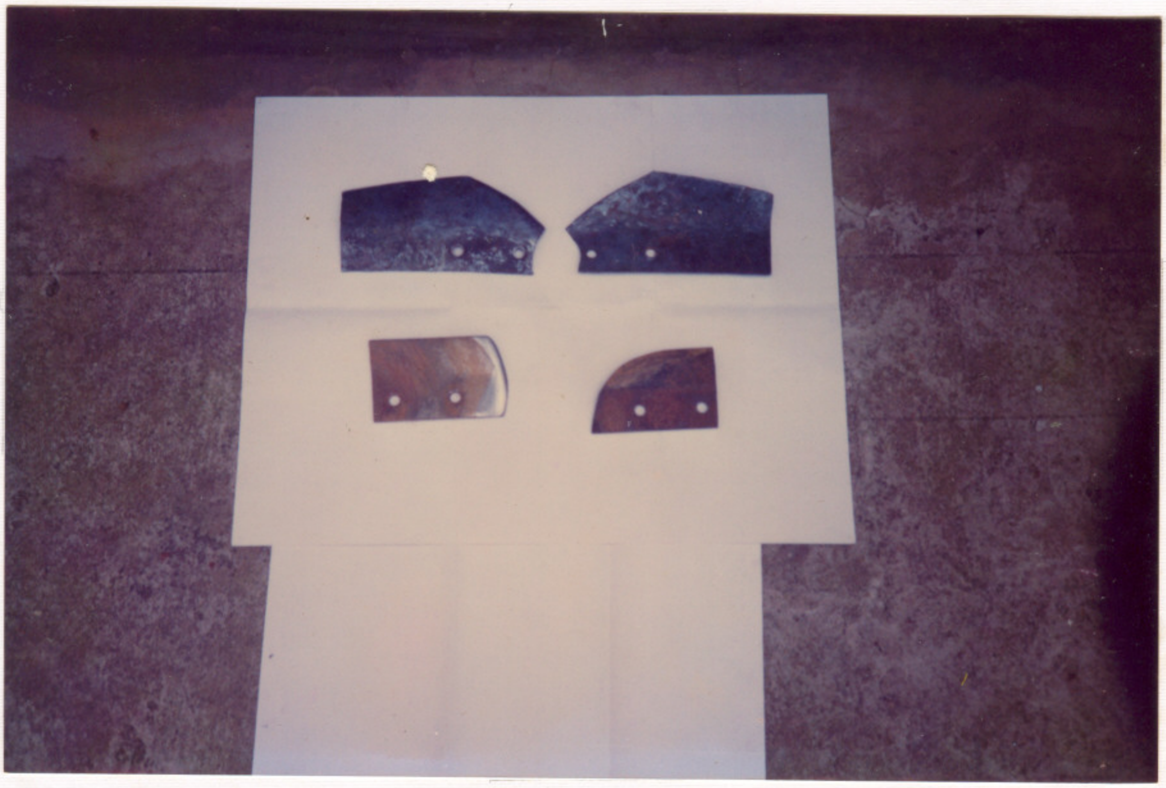


Plate 3.7. View of the base cutting blades attached to the post-hole digger (Unit II)

Plate 3.8. View of the modified post-hole digger

countersinking attachment, the auger and the propelling shaft are interlocked with each other fascilitating their location as a single unit. The bottom wall portion of the base plate firmly engage the top wall portion of the flights of the co-operating auger of the post hole digger such that the holes on the base plate are in alignment.

The base plates are then fastened firmly with fasteners to the flights of the co-operating auger. The whole assembly is then coupled to the propelling shaft of the co-operating post-hole digger as explained above. The post hole digger auger tilted with countersinking attachment is placed in a vertical position in the soil and the post hole digger auger is rotated. The auger portion leads in making a cylindrical hole while the trailing soil countersinking attachment bevels or countersinks the top portion of the wall, enlarging it make a basis in the form of an inverted truncated cone. The pit so completed has a longitudinal cross section similar to that of a funnel as given in figure. The pit is situable for planting and growing coconut palms, rubber trees and other trees.

The soil countersinking attachment is easy to be used in conjunction with a co-operating auger of a post hole digger particularly with a tractor mounted post hole digger. Besides the attachment is simple.

3.5. Performance evaluation of the tractor operated post hole digger

Tests were conducted for different soil conditions viz sandy soil, sandy loam, clayey soil and hard laterite. Tests were conducted for time taken to dig a pit, the depth of pit and diameter of pit, using various cutting blades and base cutting blades. The details of the cutting blades and base cutting blades are shown in Fig 3.7 & 3.8.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter deals with the technical details of the tree hole digger and results of the experiments conducted in the field to evaluate the performance and economics of the newly developed countersinking attachment to the tractor operated post-hole digger. The performance of counter-sinking attachment was evaluated at different soil conditions and is compared with conventional manual digging.

4.1. Technical details

The present study was conducted with different auger sizes of 30 and 45 cm diameter. The specification of these augers are given in appendix II . The additional attachment consists of a sleeve, 3 ties to connect the sleeve to the struts, three cutting blades of two types. Two additional base cutting blades are also fabricated to fix with top and bottom sides of the auger flight.

4.1.1. Countersinking attachment

The sleeve of thickness 0.6 cm and inner diameter of 7.5 cm was selected to connect the unit with the co-operating auger shaft. A hole of size 17 mm was drilled to insert the cotter pin. Usually a bolt of size 16 mm is used as the cotter pin. With this pin the three blades, sleeve, the bevel gear shaft and the co-operating shaft was fixed rigidly. To this sleeve 3 MS ties of size 44 cm x 4 cm x 1 cm was cut and welded to the struts. The struts are used to inter connect the ties and the MS cutting blades. Three angle bars of size 4 x 4 x 0.5 cm were cut and welded in the form of an equilateral triangle of sides 48 cm. Three cutting blades of sizes 75 mm x 5 mm were selected and welded to connect the flights of auger and struts. Spring steel of diamensions 22.5 cm x 15 cm x 0.45 cm is taken for base cutting blades.

4.2. Performance evaluation

The post hole digger is evaluated for the performance in digging holes under different soil conditions and the observations recorded are furnished in table 4.1.

From the result it is observed that eventhough the capacity of the unit in digging hole is high in sandy soil, the dug holes are not stable. In hard laterite the scouring and conveyance of soil from the pit is difficult.

4.2.1. Pit dimension

4.2.1.1. Depth of pit

The unit was tested under different soil conditions viz. sandy soils, sandy loam, clayey and hard laterite. In the sandy soil the maximum depth obtained was 120cm in 20 seconds and least of 80cm in 12.5 seconds. In case of sandy loam, the maximum depth obtained was 85cm in 47 seconds and for 80cm depth the implement took 40 seconds. For smaller depths (51cm) the unit performed well and the time taken was very less (16.54 seconds). The reason is that the top soil is loose and can be scoured and removed easily.

4.2.1.2. Diameter of pit

The top diameter of pit varies with the depth. the maximum diameter obtained was 126 cm for a depth of 120 cm in sandy soil. The maximum top diameter obtained was 75 cm depth in sandy loam.

Table 4.1. Performance of tree-hole digger in different soil conditions (Unit II)

Soil type	Moisture content %	Time (Sec)	Depth (cm)	Upper dia (cm)	Bottom dia (cm)
Sandy Soil	5.52	2.0	120	120	52
	8.31	12.5	80	90	50
	6.62	15.0	90	100	51
Sandy loam	12.00	37.0	75	75	52
	15.73	47.0	85	82	51
	15.96	40.0	80	78	51.5

4.3. Performance evaluation of the experimental model

The experimental model is evaluated for the performance in digging under different soil conditions and the observations recorded are furnished in table 4.2.

From the result it is observed that the experimental unit works satisfactorily in clayey soil than the original one. But the upper diameter is not so sufficient and the conveyance of soil from the pit is difficult.

Table 4.2. Performance evaluation of the experimental model (Unit I)

Soil type	Moisture content %	Time (Sec)	Depth (cm)	Upper dia (cm)	Bottom dia (cm)
	19.45	46	70	80	34
Clayey Soil	15.73	59	78	85	35
	18.43	34	65	75	35
	18.72	43	82	80	35
Loamy soil	19.43	37	75	84	35
	18.86	33	68	82	35
	20.48	35	70	70	34
Hard laterite	19.53	60	65	58	35
	21.17	31.49	60	65	35

4.3.1. Pit dimension

4.3.1.1. Depth of pit

The unit was tested under different soil conditions viz. sandy loam, clayey and hard laterite. In the clayey soil the maximum depth obtained was 78 cm in 57 seconds. In case of sandy loam soil the maximum depth obtained was 82 cm in 43 seconds and for hard laterite it is 70 cm in 35 seconds.

4.3.1.2. Diameter of pit

The maximum diameter obtained was 85 cm in clayey soil and 84 cm in sandy loam soil and in laterite the maximum diameter obtained was 70 cm.

4.4. Performance evaluation of modified post hole digger

Modified tree hole digger is evaluated for different soil conditions. The results were as shown in table 4.3.

The unit gave best results. The maximum depth obtained was 90 cm in 80 seconds. The least depth obtained was 60 cm in 76 seconds. In hard laterite also the implement gave good results. The depth obtained was 82 cm in 90 seconds with a top diameter 100 cm.

Table 4.3. Performance evaluation of modified tree-hole digger

Soil type	Moisture content %	Time (Sec)	Depth (cm)	Upper dia (cm)	Bottom dia (cm)
Sandy Soil	8.5	195	90	100	50
	7.8	60	75	100	50
	9.3	80	90	100	50
	9.3	70	82	100	50
Laterite soil	10.5	90	82	100	50

CHAPTER V

SUMMARY AND CONCLUSION

The normal technique of planting tree saplings is to plant in pits of size ranging from 45cm x 45cm x 45cm to 90cm x 90cm x 90cm. The size depends on type of plantation and root pattern. In India, digging of pits is done manually using implements like spade, pick axe etc. This method is not suitable for large quantity and require much labour and time. As per the new technique, conical shaped holes or pits having a upper diameter of 90cm and depth of 80cm are sufficient. It had better advantages over the present traditional method. A soil countersinking attachment to the tractor operated post-hole digger is more effective in easy trasportation and aids in lowering the labour consumption. Separate prime mover is not needed since power can be taken from the PTO of the tractor. The soil counter-sinking attachment to the tractor operated post hole digger consists of three cutting blades attached to an auger. It was mounted on a tractor through gib crane which was connected to three point linkage. The lifting and lowering of the implement was done by hydraulic system of tractor. Post-hole digger was driven through bevel gears by the tractor power take-off. The tractor operated post hole diggers are specially used to make holes for plantation trees, fence posting, erection of poles and erection of marking stones etc.

Field trials were conducted at Kelappaji College of Agricultural Engineering and Technology farm, Tavanur, to evaluate the performance of the countersinking attachment to the post hole digger. The experiments were carried out for two types of cutting blades. The time taken to dig out a pit and the pit diamensions were noted. It was found that the modified post-hole digger gave best results for different soil conditions. The soil countersinking attachment with flat base cutting blade did not give much good results in clayey and hard laterite soil. Due to the weight of the implement the soil gets compacted and hence the flat blade was not able to penetrate into the soil. Hence the cutting blade was modified.

From the studies, it was revealed that the soil countersinking attachment to the tractor-operated post-hole digger is technically and economically suitable for planting tree plantations in India. The soil counterlinking attachment to the tractor operated post-hole digger can be effectively used in plantation of coconut and rubber trees.

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APPENDIX - I

Specification of the Mahindra B 275 DI Tractor

Make-Model	:	Mahindra- MDI 1805
Horse power	:	36 H.P. category
Bore and Stroke	:	88.9 x 101.6 mm
Number of Cyclinders	:	3
Cubic capacity	:	1892 cc
Rated Governed engine speed	:	2300 rpm
Clutch	:	Heavy Duty Single Dry Plate Clutch
Transmission	:	8 forward and 2 reverse, with high and low selection levers.
Hydraulic system	:	Independent, fully live hydraulic pump and special reservior. Fully independent 2 lever vary touch hydraulic control provides a choice of (1) position control; to hold the lower links at any desired height. (2) Automatic draft control.
Hydraulic Linkage	:	Reversible cat. I & II three point linkage with adjustable outside check chains.
Power take-off	:	Maximum rpm at governed engine speed 627 rpm.
Operating weight	:	Basic tractor with hydraulic, 3 point linkages, regular PTO and standard wheels - 1645 kg (approx.)
Tyres and wheels	:	Front 6.00 x 16 ; Rear 12.1/11 x 28.

APPENDIX II

Specification of the countersinking attachment to a tractor operated post-hole digger.

Specification of Unit I

(a) 1 foot Auger

(i) Auger:

Material	:	Mild steel
Over all height of the unit	:	112 cm
Auger height	:	50 cm
Auger shaft diameter	:	7.35 cm
Weight of the unit	:	28 kg

Manufacturers : F 11 Earth Mover series, HOWARD, ITALY.
LEO BUSCH & Co., 52 Good Hope Street, Paddyngton, Sydney FA 3062.

(ii) Countersinking attachment:

Height of countersinking attachment	:	62 cm
Top diameter	:	80 cm
Bottom diameter	:	30 cm
Sleeve length	:	7.5 cm
Diameter of sleeve	:	7.5 cm
Thickness of sleeve	:	0.6 cm
Shear pin hole diameter	:	1.7 cm
Shear pin diameter	:	1.6 cm

Specification of Unit II

(b) 1.5 feet auger

(i) Auger:

Material	: Mild steel
Overall height	: 112cm
Auger height	: 35 cm
Auger shaft diameter	: 7.35 cm
Weight of the unit	: 40 kg

Manufacturers: Fll Earth Mover Series, HOWARD, Italy.
LEO BUSCH & Co., 52 Good Hope Street, Paddyngton, Sydney FA 3062.

(ii) Countersinking attachment:

Height of countersinking attachment	: 77 cm
Top diameter	: 120 cm
Bottom diameter	: 45 cm
Strut length	: 85 cm
Tie length	: 46 cm
Sleeve length	: 7.5 cm
Sleeve diameter	: 7.5 cm
Sleeve thickness	: 0.6 cm
Shear pin hole diameter	: 1.7 cm
Shear pin diameter	: 1.6 cm

APPENDIX III

Cost of operation

(A) Tractor : Mahindra - B275-DI Tractor

Assuming

1. Initial cost : Rs 2,00,000.00
2. Useful life period : 12 years
3. Annual working hours (h) : 1000 Hours
4. Salvage value (s) : 10 % of initial cost
5. Interest on initial cost (i) : 15 % annually
6. Repairs and maintenance : 10 % of initial cost
7. Housing, Insurance and Tax : 1 % of initial cost
8. Fuel consumption : 6 lit/hr
9. Fuel cost : Rs 8 per litre
10. Labour wages : Rs 100 per day of 8 working hours
11. Fixed cost

Depreciation $= \frac{C-S}{L} = \frac{2,00,000 - 20,000}{12}$

$= \text{Rs } 15,000.00$

Interest $= \frac{C+S}{2} \times i = \frac{(2,00,000+20,000)}{2} \times \frac{15}{100}$

$= \text{Rs } 16,500.00$

Repairs and maintenance $= \frac{2,00,000 \times 10}{100}$

$= \text{Rs } 20,000.00$

Housing $= \frac{2,00,000 \times 1}{100}$ $= \text{Rs } 2,000.00$

$$\text{Taxes} = \frac{2,00,000 \times 1}{100} = \text{Rs } 2,000.00$$

$$\text{Insurance} = \frac{2,00,000 \times 1}{100} = \text{Rs } 2,000.00$$

Total fixed cost = Rs 15,000.00 + 16,500.00 + 20,000.00 + 2,000.00 + 2,000.00 + 2,000.00

= Rs 57,500.00

12. Variable cost

Fuel charges = 1000 x 6 x 8

= Rs 48,000.00

$$\text{Lubrication charges} = \frac{48,000 \times 30}{100}$$

= Rs 14,400.00

$$\text{Labour charges} = \frac{1000 \times 100}{8}$$

= Rs 12,500.00

Total variable cost = 48,000 + 14,400 + 12,500 +

= Rs 74,900.00

Total cost = Fixed cost + variable cost

= (57500+74900) x 1/1000

= Rs 132.40 / hr.

(B) Tree-hole digger & its accessories

Cost of Auger (Unit II), Gib crane, bevel gear box & propeller shaft = Rs 31,182.00

Cost of countersinking attachment to the tractor operated post-hole digger = Rs 586.00

Total cost = Rs 31,182 + 586

= Rs 31,768.00

Salvage value @ 10% of initial cost = Rs 3,176.80

Life of implement = 10 years

Operating hours per annum = 100 hours

Fixed cost :

$$\text{Annual depreciation} = \frac{C-S}{L} = \frac{31768 - 3176.80}{10}$$

= Rs 2,859.12

$$\text{Annual interest on investment @ 10\% of initial cost per annum} = \frac{C+S}{2} \times \frac{10}{100}$$

$$= \frac{31768 + 3176.80}{2} \times \frac{10}{100}$$

= Rs 1,747.24

$$\text{Housing cost @ 1\% of initial cost per annum} = \frac{31768 \times 1}{100}$$

= Rs 317.68

Fixed cost per annum = Rs 2,859.12 + 1,747.24 + 317.24

= Rs 4,923.60

Variable cost :

$$\text{Repair \& maintenance cost @ 5\% of initial cost / annum} = \frac{31,768 \times 5}{100}$$

= Rs 1,588.40

Total cost = Fixed cost + Variable cost

= Rs 4,923.60 + 1,588.40

Total cost = Rs 6,512.00

Cost of operation per hour = $\frac{6,512}{100}$

= Rs 65.12

Total cost of operation of countersinking attachment to a tractor operated post hole digger in one hour = Rs 132.40 + 65.12

= Rs 197.52

DEVELOPMENT AND TESTING OF A COUNTERSINKING ATTACHMENT TO THE TRACTOR OPERATED POST - HOLE DIGGER

By

RAJESH. G. K.

SAJU VARNAN. A.

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ABSTRACT OF THE PROJECT REPORT

submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology in Agricultural Engineering

Faculty of Agricultural Engineering & Technology

Kerala Agricultural University

Department of Farm Power Machinery and Energy

Kelappaji College of Agricultural Engineering & Technology

Tavanur - 679 573 Malappuram

1996

ABSTRACT

In India, digging of pits are done manually using implements like spade, pick-axe etc. This method is not suitable for large quantity and require much labour and time. As per the new technique, conical shaped holes for pits having upper diameter of 90 cm and depth of 80 cm are sufficient. A soil counter sinking attachment to the tractor operated post hole digger can be used for making these conical pits. It consists of 3 cutting blades attached radially 120^{o} apart by means of 3 equal length ties. The lower end of these cutting blades are bolted to the flight of the auger. These blades and the ties are interconnected by the struts. This unit can be easily removed from the post hole digger as and when required. The unit is mounted on a tractor through gib crane which was connected to the three point linkage. The lifting and lowering of the implement was done by hydraulic system of the tractor. the unit is driven through bevel gears by the tractor power take-off. The auger leads in making a cylinderical hole while the trailing soil counter sinking attachment bevels the top portion of the hole. This unit can be effectively used in plantations of coconut and rubber trees. The total cost of operation / hr is Rs 197.52.