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Development of the "*Backscratcher*" for Site Preparation 1973–1987

G.T. Atkinson and V.F. Haavisto

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ABSTRACT

The concept and development of an easily manouverable, multi-row, site preparation machine with depth control capabilities began in 1973 and continued until 1987, culminating in the "Backscratcher," as it came to be known. This was a site preparation tool designed to be towed by a variety of prime movers with a universal hitch. The machine had three simple "middle-buster" ploughs mounted on the end of independently acting tool legs. The only other requisite for the prime mover was a rear-mounted winch to activate the lifter-bar. It raised the tool legs for turning and backing, or for dumping accumulated debris. Field observations indicated that the equipment was capable of preparing the ground surface in a variety of site conditions suitable for spot seeding, direct seeding, or planting. A number of accessories, such as seeders, pesticide applicators, or even automated seedling planters, could be added.

RÉSUMÉ

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INTRODUCTION

Canada's most valuable natural resource is the forest. About 44 percent of the country's land area is forested (Bonner 1982). Productive forest land (capable of producing a merchantable crop of trees in a reasonable length of time) occupies 61 percent of this area, and about 19 percent is economically inaccessible. Historically, harvesting was carried out with little consideration for regeneration. More recently, however, considerable effort has been made to ensure the restocking and sustainability of the resource (Kuhnke 1989, National Resources Canada 1993). As such, the backlog of unsatisfactorily stocked, burned, and cutover forest land is decreasing somewhat rather than increasing.

To maintain a strong forest industry it is imperative that a much greater proportion of the depleted forest be regenerated. Regeneration by planting is the most common method; however, the operation is expensive if costs of site preparation, seedling production, and planting are taken into account. The logistics of coordinating seedling production and planting on a scale required to restock most cutovers, which normally will not satisfactorily regenerate by natural means, seem insurmountable. The objectives of site preparation for any species are dependant on the site type, site conditions, and the regeneration technique to be subsequently used.

For planting purposes, site preparation is designed to remove the duff layers and expose a microsite that is suitable to seedling growth. Furthermore, it also removes competing vegetation from the proximity of the seedling, and provides less restricted access for the planting crews through the alignment of harvesting slash. For seeding purposes, whether natural or artificial, seedbed preparation ensures that seedbeds are not slash covered, exposes desirable seedbed by the removal of duff layers, removes undesirable vegetation and organic matter, and creates a microsite that is conducive to seed germination and seedling development.

Since the early-to-mid 1960s, when the first significant site preparation activities began in northern Ontario, a variety of tools have been used (Smith 1984). Site preparation was normally relegated to upland mineral soil sites. Straight and angled bulldozer blades, multi-function blades, and a variety of attachments, such as Young's Teeth on blades, were used for clearing debris and accumulated duff from both large areas and patches (Riley 1980). These proved to be not only expensive and overly harsh on the sites, but also inadequate in rocky or bouldery terrain. Flexible home built, drag type site preparation tools, often comprised of anchor chains and/or tractor pads with a variety of spikes welded on them, evolved and were the mainstay of site preparation throughout the 1970s and into the 1980s (Silversides and Haig 1977). These implements literally tore the surface of the ground, the intention being to expose mineral soil. Of course, if the duff layer was very deep, penetration was variable and often insufficient, and the seedbed or planting chance was inadequately prepared. Not only did the drag equipment exhibit poor manouverability and have high maintenance costs, but it also necessitated high powered and high cost prime movers. Spot scarifiers (e.g., Bräcke and Leno Patch Scarifiers), and disc trenchers (e.g., TTS) imported from Scandinavia in the early 1970s, introduced a more agricultural approach to forest land site preparation (Smith 1984). These latter implements treated only a fraction of the total area over which they rode, and produced a systematic pattern that could emulate a plantation when fully stocked. Furthermore, they created a variety of microsites suitable for seed germination, early seedling development, and planting chances for artificial regeneration. "Shear blading" (literally, simulated winter road building), became a popular form of site preparation in northeastern Ontario subsequent to developments started in 1975. Even though the technique was designed to produce suitable seedbeds on moss-rich peatland sites (G. Olford, pers. comm.), the technique has been applied on a wide range of site types and conditions. Shear blading during the frozen season assured minimal disturbance of the subsurface layers and competing vegetation was effectively removed. However, shear blading also removed advance growth, which may be present in considerable numbers.

Achieving the most appropriate site preparation for a specific site is therefore fraught with problems. Some, such as excessive logging slash, destruction of well established advance growth, and severe damage to site and seedbeds are caused by human interventions. Depth of organic mantle, depth to water level, rockiness, stand composition, etc., are naturally occurring stand and site parameters that need to be taken into consideration when planning and implementing site preparation. With bulldozer blading, the depth of treatment is totally dependant on the experience of the operator. There is some control over the depth of penetration with drag or spot scarifiers and disc trenchers. To achieve the most appropriate results with these, control is dependant not only on operator experience in adjusting the tools for optimum performance and the size/shape/weight of the implements, but also on the terrain type, the depth and type of organic mantle, amount of logging slash, etc.

Much of northeastern Ontario has a clay soil overlaid by a thin duff layer. Virgin stands of black spruce (*Picea mariana* [Mill.]B.S.P.), often intermixed with other boreal tree species, reportedly of fire origin, grow very well on these rich sites. Drag-type site preparation equipment not matched to local site conditions tends to remove the duff layer in sheets, leaving excessive amounts of exposed clay soil. Often, competing vegetation invades these sites. The roller-type disc trenchers do produce a small amount of desirable mix, but do not create a sufficient area free of competition. Scalps resulting from patch scarification can effectively collect water to the detriment of seeds and seedlings, or soil movement can cover seeds or seedlings. In contrast, well-drained jack pine (*Pinus banksiana* Lamb.) dominated sites generally have a thin duff layer over permeable sand. A breaking of this duff layer and exposing mineral soil is necessary to obtain successful regeneration.

Black spruce requires rather delicate site preparation, especially for direct seeding (G. Marek, pers. comm.). The most suitable seedbed material was ascertained to be the A or Ah horizon (Winston 1974). More recently, thin layers of partially and well-decomposed organic material over mineral soil, as well as upper mineral soil horizons, have been shown to be good seedbeds for black spruce on coarse textured soils (Fleming and Mossa 1994). It follows that delicacy can only be obtained if the depth of disturbance is controlled. With ground surface and subsurface inconsistencies and very thin organic soil horizons this can prove problematic. A mix of F, H, and mineral soil may be acceptable (Fleming et. al. 1987). The need for a tool with some depth control, and capabilities for removing surface duff and mixing upper layers confirmed the need for the development of the Backscratcher.

CONCEPT

The concept of a site preparation tool with multi row capabilities, depth controlled soil disturbance, ease of manoeverability, and simplicity in design emerged in 1973. With this in mind, and with ideas gleaned from discussions with numerous Ontario Ministry of Natural Resources (OMNR) and forest industry field personnel, the original design for the Backscratcher began to take shape. By 1976, the design had evolved and a small-scale wooden mock-up was produced. The model was shown to forestry field staff throughout the Clay Belt area of northern Ontario. The reaction was generally positive, and the many constructive ideas offered were utilized in developing the final working drawings.

The most critical element of the proposed scarifier was the ability to control the depth of penetration of the tools. It was obvious that several obstacles had to be overcome if this objective was to be attained. Because of the irregularities of the ground surface, a simple but variable depth control had to be developed. During initial design the thought was to attach the tools directly to the prime mover. However, it was determined that the unit should be independent of a specific prime mover. For example, the attachment mechanism and the mechanism needed to allow for the regulation of proper depth adjustment would need to be custom tailored for each prime mover. Thus, very expensive modifications for each prime mover would be needed unless the prime mover was dedicated, or the owner was assured of it being used regularly.

A separate tool carrier has a number of advantages over one onto which the site preparation tools are attached directly to a prime mover. The only prerequisite would be a winch and a universal hitch to permit movement in both the vertical and horizontal planes, thus allowing a single site preparation unit to be towed readily by a variety of prime movers. With a towable tool carrier, the tools are less susceptible to the pitching of the prime mover as it traverses irregular ground and any discontinuities on it (e.g., rocks, logging slash, etc.). An important feature of a separate tool carrier is the ease of transportation between sites. Attractive from the point of view of total cost is the fact that locally available prime movers can be used. Furthermore, considering the cost saving associated with smaller prime movers, the forest manager can realize an increase in the site preparation productivity by employing more than one unit for the same cost as one conventional larger unit.

One of the most serious drawbacks to acceptable site preparation in the cutovers of northern Ontario is the amount of logging debris left after conventional harvesting. Many of the site preparation tools merely rearranged the debris, and depending on the amount and distribution of the logging slash, did not necessarily reach the soil medium to be exposed or mixed. Front mounted slash clearing devices had been tried with varying degrees of success, and except for the Canadian Forestry Service (CFS) V Blade (Fleming et al. 1987) were generally not suitable for small prime movers. Currently, many logging operations are full tree to roadside, meaning that most of the cutover is relatively slash free, but deep windrows of slash occur at the roadsides. Even though more slash and tops will be left at the stump with the cut-to-length systems that are becoming more popular, the logging debris on the cutover would be relatively fine and regularly spaced, affording a good opportunity for natural regeneration, if some site disturbance could be accomplished.

The economics of site preparation demand that equipment treat as much area as possible with each pass and also be able to traverse most of the area to be treated without causing serious site damage. Therefore, both the prime mover and the tools that perform the required disturbance must be rugged, and capable of withstanding severe ground conditions such as stumps and rocks. Furthermore, the tools must be designed in such a way as to produce the ground disturbance most suitable for the task at hand, whether it be for planting or seeding.

The consensus of opinion among cooperators in this work was that a trailing (towed behind), wheeled unit from which the ground preparation tools could be suspended would be the most suitable to address a variety of site types and cutover conditions. The configuration of the tools were not specified, but it was agreed to test several for the width and depth of disturbance. Other design criteria included: design equipment that could readily be towed by a variety of prime movers, and that could be obtained locally; the need for easy dumping of accumulated debris from the tools for cutovers with heavy logging slash; multiple tool holders independent of each other to maximize effective site preparation; and, the need to control the depth of penetration, preferably to very specific horizons in the soil profile.

DEVELOPMENT

With the foregoing requirements as a guideline, the authors proceeded to develop the drawings and construct the first prototype (Fig. 1). For the wheeled tool carrier, an old skidding arch was purchased. The Algoma Central Railway, Sault Ste. Marie, Ont., supplied used rail for the tow beam and the tool arms. The OMNR Cochrane District and the CFS supplied the other steel products. Labour for construction was supplied by the OMNR Cochrane District and the authors.

The tow-beam was constructed from two 3 m lengths of steel rail, welded back-to-back and attached under the yoke and in front of the skidding arch's wheel frames (Fig.1). The tow bar was reinforced with appropriate bracing. Three 3-sided hanger boxes, approximately 30 cm per side, were fabricated from 3.8 cm steel plate, each with an appropriately located 6.3 cm diameter hole on each side to accept a pin that would act as a pivot for the tool leg. These hanger boxes were welded to the tow bar; one at the centre point and one near each end. These were the attachment points for the tool legs, allowing independent vertical movement for each.

The three tool legs were also constructed of two lengths of steel rail, welded back-to-back. These were 3 m long with custom formed upper ends to allow vertical pivoting in the hanger box. To each of these tool legs, one of three different ground disturbance tools was attached (Fig. 2): a vertical ripper tooth; a steel plate with a serrated edge (comb) welded cross wise to the bottom end of the tool leg; and a rudimentary plough constructed of 3.8 cm thick steel, formed into a V-shape, measuring 35 cm across at the transom. All tools were welded to the bottom ends of their respective tool legs. Some horizontal play at the pivot was designed between the upper end of the tool leg and hanger box, allowing the tools to skirt some of the obstacles in a cutover (e.g., stumps or rocks).

A cross bar, hinged to brackets on the frame of the skidding arch and located under the tool legs, had a clevice at its centre point for attaching the winch cable from the prime mover. By reeling in the winch cable, the lifter bar would rise and, with it, the tool legs, to effect a dumping of debris that accumulated on or in front of the tools. The dumping of debris can therefore be accomplished without stopping forward movement of the site preparation equipment (Fig. 3).

Field tests of the first prototype were carried out in 1977 on a small area of black spruce cutover licenced by Abitibi-Price Inc., Iroquois Falls Division, about 45 km east of Cochrane, Ontario. The cutover was heavily slash covered and the site ranged from Black Spruce-Labrador Tea (ST 11) (after McCarthy et al. 1994) with relatively deep peat (50–70 cm) to islands of typical boreal mixedwoods on fine soil (ST 6a). Attempts to use a front mounted slash clearing device (cherry-buster, G. Marek, pers. comm.) on the skidder (provided by Abitibi Price Inc.), proved to be ineffective, as the skidder was too small for the slash clearing device and there were problems with the attachment of the device onto the skidder blade. The Backscratcher was observed to perform reasonably well considering the heavy slash. The tools effectively dumped accumulated debris. With the ease in lifting the tools, the Backscratcher could be backed up readily. Therefore, it could be backed into corners of cutovers and thereby maximize the area available for treatment. The three ground disturbance tools worked reasonably well, and it was observed that the V-shaped tool (plough) created the most useful disturbance. However, the consensus among the cooperators was that the concept needed to be tested in an area that had minimal slash when effective slash alignment devices were not available for the prime mover (Fig. 4).

The next series of operational trials was done in 1978 on the licence area of Cochrane Enterprises

Ltd., north of Fraserdale, Ontario. The site approximated a Black Spruce-Medium Soil (ST 5b) (McCarthy et. al. 1994) with a considerable amount of silt in the growing medium. This area was reasonably slash free, with very little coarse logging debris. The prime mover was a Caterpillar D-8 bulldozer with an operator who had considerable experience in site preparation (Fig. 5). Even though the prime mover was over powered for pulling the Backscratcher, the gearing range allowed for testing the effectiveness of site preparation at various machine speeds. Here, the observed results demonstrated that logging slash has a detrimental impact on the effectiveness of site preparation. Where there were accumulations of slash, the process of dumping by lifting the cross bar while in forward motion proved effective at slash clearing, and did not leave significant areas unprepared. Furthermore, it became clear that of the three ground disturbance tools used, the most suitable was the plough. For seeding purposes, the plough configuration effectively removed the duff layer down to the receptive Ah and Ac horizons and provided ample microsites on which seed could either be placed, sown, or dispersed naturally. Having a narrow plough, the debris that was removed from the disturbed seedbed actually provided useful side shade and associated microsite protection for seeds during the susceptible germination and early survival phases. From a planting view point, the plough not only created a slash free corridor for easy planter access, but also exposed good planting locations.

The operational field tests verified that the concept had potential, that it could be used effectively in a variety of sites, that a range of prime movers could be used, and that some retooling was in order.

IMPROVED BACKSCRATCHER

In 1979, the OMNR provided funding assistance to modify and retool the Backscratcher. The services of a professional machine shop were used, not only for the fabrication of various components and assembly of the machine, but also for the design of certain parts, such as the ploughs.

Because the tires on the skidding arch were in poor condition, and since the likelihood of finding replacements was remote, a fire damaged Timberjack skidder was purchased from which the wheels and tires were taken and refitted onto the carrier. During the reconstruction, the original tow beam was replaced with a reinforced length of 25 cm steel "H-beam", 3.0 m long, the length kept within the maximum limits allowed for transport on public roads without escort. Onto this tow beam, three open ended hanger boxes constructed of 3.8 cm thick steel were fitted (Fig. 6). The hanger boxes were situated as before, one at the centre point of the tow beam, and one near each end. Up to five hanger boxes could be installed onto the tow beam to allow for different spacings for tool activity within the 3.0 m width. The boxes have 6.3 cm diameter holes in their sides to accept the pivot pin on which the tool legs hinge.

The tool legs were constructed of 25.4 cm H-Beam, and fitted with a pair of 3.8 cm thick steel gussets in the web of the H-beam (Fig. 6). Each leg is equipped with a pin hole to accommodate a 6.3 cm diameter steel pin at both the upper end, connecting to the hanger box and at the lower end, connecting to the plough flanges. To provide for a V-shape to facilitate clearing of debris, the centre tool leg is only 180.3 cm long, whereas the two outer ends are 245 cm long.

The lifter bar, the arms of which are hinged to the framework of the skidding arch, needed some modification because the tool legs were of different lengths. Retaining lugs were welded to the outer ends of the lifter bar to ensure that the tool legs would not fall during lifting. Furthermore, pads were welded to the lifter bar directly under the position of the outer tool legs, so that all three tool legs could be lifted simultaneously to the same height. By means of a retaining chain, the lifter bar can be used to control the depth of penetration of the tools. Because the winch cable of the prime mover is connected to the lifter bar, the operator can make adjustments during travel across cutovers, or lift the tool legs to clear accumulated debris. Another use for the lifter bar is to raise the ploughs from the ground to when turning at the end of a pass or, when needed, to back up the Backscratcher. The retaining chain also holds the three site preparation tools and tool legs in the transportation position while moving the Backscratcher from one location to another.

Each of the three redesigned ploughs were identical in size and design. The bottom was a triangular-shaped flat plate (2.0 cm thick steel), 110 cm long from the front point to the transom, and 114 cm wide at the transom (Fig. 7). The outside cutting edges of the bottom plate were built up using hard welding rod. These edges were kept sharp to provide for a clean shearing cut within the ground profile. Each plough was constructed with a 2.0 cm steel plate centreboard that runs from the prow to the transom. Three sets of bulkheads were welded to this centreboard, as was the transom plate. The bulkheads and transom were precut to accommodate the double rolled moldboards. Between the second and third bulkheads, a pair of flanges (3.8 cm thick), complete with reinforcing, were welded to form the plough flanges extending to a convenient height above the level of the plough (Fig. 6). The pin, situated at the pivot point, balanced the plough to keep it horizontal when at rest. A stinger (a ripper tooth), extending somewhat below the bottom plate, was attached to the prow to guide the plough and cut root materials, and to assist the plough to be aggressive and dig in. The leading edge of the stinger was hardened and kept sharpened. On the bottom of each tool leg, a stopper block was positioned to limit the plough from pitching more than 3° from the horizontal.

Between 1978 and 1981, a series of field trials took place in the Abitibi-Price Inc. Camp 11 area north of Thunder Bay. The purpose of these trials was to undertake tests to determine how effective several site preparation implements and techniques (CFS scarifier, mini-barrels and chains, Broyeur A.M., TTS disc trencher, modified C&H Plow, and the Backscratcher) could be in creating seedbeds for the direct seeding of black spruce (Fleming et al. 1987). The trial locations were chosen to represent typical upland sandy tills, which before harvesting had been black spruce dominated (V-33),(Sims et al. 1989), or had mixed stands of mature to overmature black spruce and jack pine (V-31), (Sims et al. 1989). The soils were primarily noncalcareous, silty to loamy, very fine sands. Various combinations of physiographic site types, soil textures, soil depths, stone and boulder contents, and soil moisture regimes created a mosaic of conditions.

The prime mover used for towing the Backscratcher during 1979 (Fleming et al. 1987) was a Caterpillar D6. Each pass created three shallow furrows and four spoil mounds. The treated area was about 3.6 m wide. Each of the furrows was clear of debris, and the spoil in the bordering mounds was well mixed, providing an opportunity for planting, or seedbed and microsite complexes for direct seeding (Fig. 8).

Since the preparation trial in 1979, some additional modification and strengthening has been done to the Backscratcher. No additional field testing, however, has occurred, but further extensive tests still are needed.

DISCUSSION

The development of the Backscratcher from a concept through the growing pains of a prototype, to operational field testing has not only taken a considerable length of time, but also has taken much effort on the part of all cooperators. The authors cannot claim total credit for this development because the concept resulted from the assimilation of many ideas, and the consensus of many opinions.

Much of the site preparation equipment used prior to 1973 had been jury rigged from whatever was available, or would break the surface layers to expose mineral soil. Some equipment tested had not specifically been designed for the rugged conditions of forest land cutovers, but had merely been modified from agricultural equipment. Disc trenchers, specifically designed for preparing cutover forest lands in Scandinavia were imported into Ontario in the early 1970s. However, since forest harvesting practices in Scandinavia do not leave logging slash on the site, the Scandinavian site preparation equipment was not capable of penetrating the slash to produce effective seedbeds.

Especially for parts of northern Ontario, where much logging slash had been left on the cutting site, the effectiveness of site preparation was often inadequate (Atkinson 1978, Haavisto 1979, Saltarelli 1980). Even though the value of site-specific ground treatment for particular purposes has been well understood, it has been recognized that no one could afford all types of equipment to treat each site condition for its specialized merits. This lead to the development of a piece of equipment that could be used in a variety of boreal forest cutovers with a variety of readily available prime movers.

To circumvent the necessity for custom designed hook ups onto specific prime movers, the Backscratcher was constructed on its own towable carrier, a two wheeled skidding arch. This carrier could be towed readily by almost any available prime mover (minimum 50 kw requirement), whether it be wheeled or tracked. The multi-row capabilities were designed to create microsites suitable for planting stock development without exposing mineral soil excessively, and thereby promoting competing vegetation or creating a surface that is inhospitable and not conducive to seed germination, early survival, or normal seedling development. The narrow ploughs on the Backscratcher created furrows akin to the desirable ground preparation that was attained by the CFS row scarifier (Mattice and McPhee 1979). A shallow furrow such as this is quite suitable for planting or seeding on a variety of mineral soil sites, and even some shallow organic sites.

The Backscratcher was designed to permit some control of the depth of disturbance. The ploughs were designed to float at a specific depth, at the interface between the organic duff and the mineral soil. For soil types where there would be a tendency for the ploughs to dig deeper, the lifter bar could be set to hold the ploughs at the most desirable depth.

Following the operational field trials in 1979 (Fleming et al. 1987), only minor modifications were done. For future consideration, a number of improvements are suggested below. Some of these are desirable to make the Backscratcher more convenient to use, some are for strength, and others are to allow for innovative accessories.

- use heavy gauge steel tubing for both the tow bar and the tool legs;
- make hanger boxes universal to permit the installation of other attachments;
- equip the pivot, where the tool leg attaches to the ploughs, with a hydraulic cylinder, thus allowing the operator to set the ploughs for a desired depth;
- equip the ploughs and tool arm with a compensator cylinder to buffer the pitching caused by terrain irregularities; and,
- equip the tool arm with attachment mechanisms so it can accept added weight, thus ensuring deeper plough penetration for certain site conditions and seedbeds.

With further development of the Backscratcher, the tool legs could be equipped with innovative accessories to create mounds for planting, produce scalps similar to patch scarifiers, allow for precision sowing onto specific locations of a disturbed site, dispense herbicides or other pesticides, or spread fertilizers. In place of the ploughs, attachments such as profilers, packers, or even automated planters could be added to enhance regeneration success.

Forest harvesting has evolved to full tree methods, therefore cutovers are relatively free of logging debris. As such, much of the site preparation equipment that was originally designed for

Scandinavian conditions will now produce adequate site preparation in boreal cutovers. With the advent of cut-to-length harvesting, larger quantities of logging debris will again be left on the cutover; however, this material will be relatively fine and should not pose a serious site preparation problem. The Backscratcher, with its various characteristics, should prove to be an effective site preparation machine for a variety of site types and cutover conditions across the boreal forest region. No one tool can do all tasks; however, with foresight and ingenuity, many of today's tools could be inexpensively modified to do tomorrow's jobs effectively.

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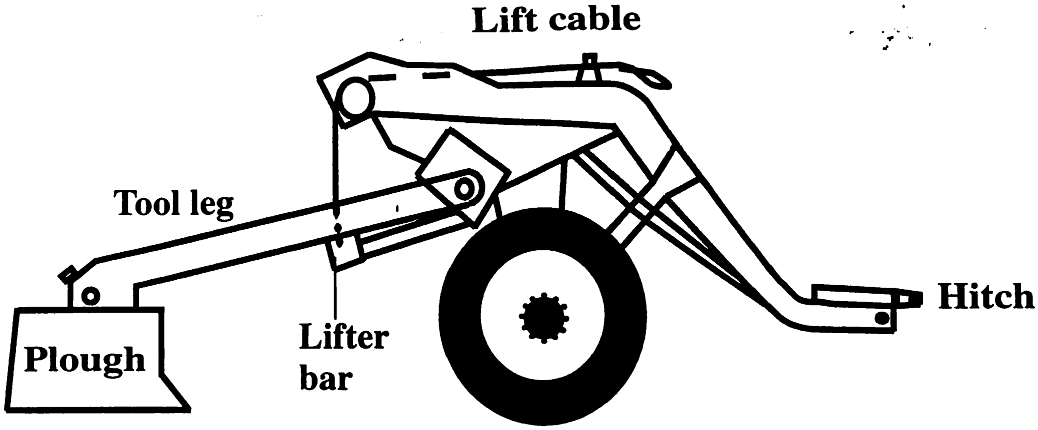
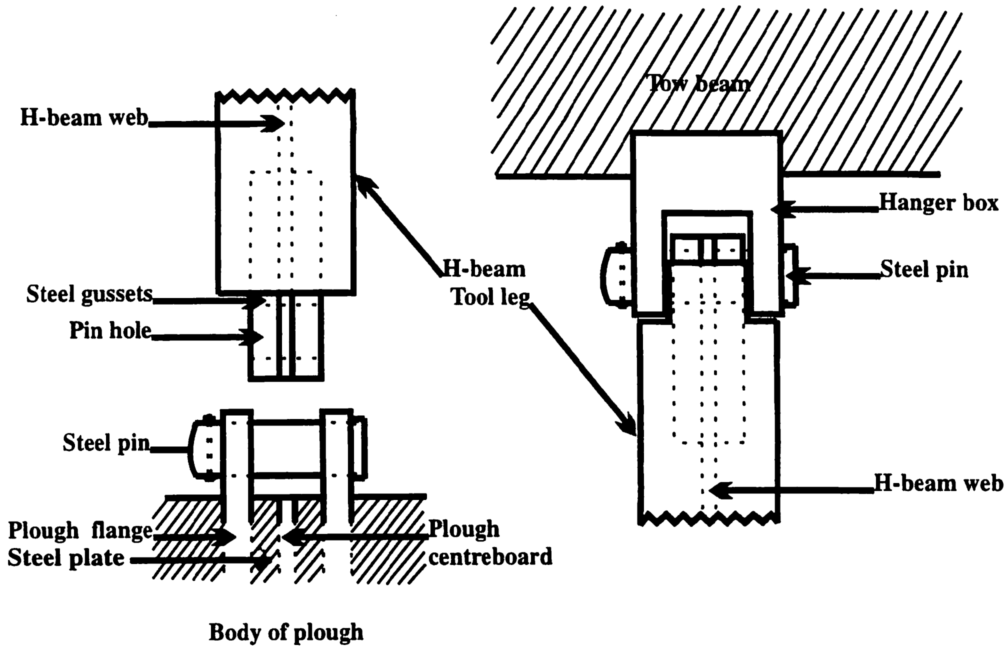


Fig. 1


H-beam web
Steel gussets
Pin hole
H-beam
Tool leg
Steel pin
Plough flange
Steel plate
Plough
centreboard
Body of plough
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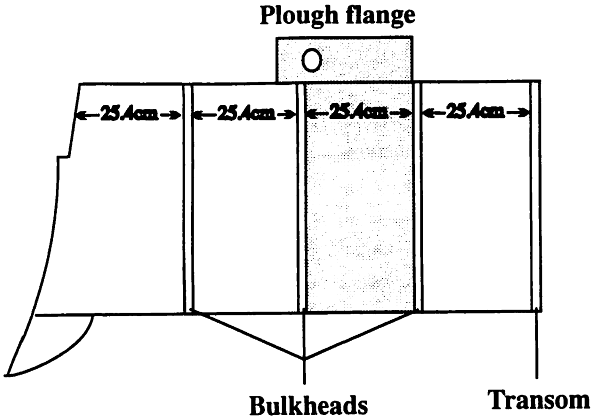
Hanger box
Steel pin
H-beam web

Fig 6

SIDE VIEW



TOP VIEW

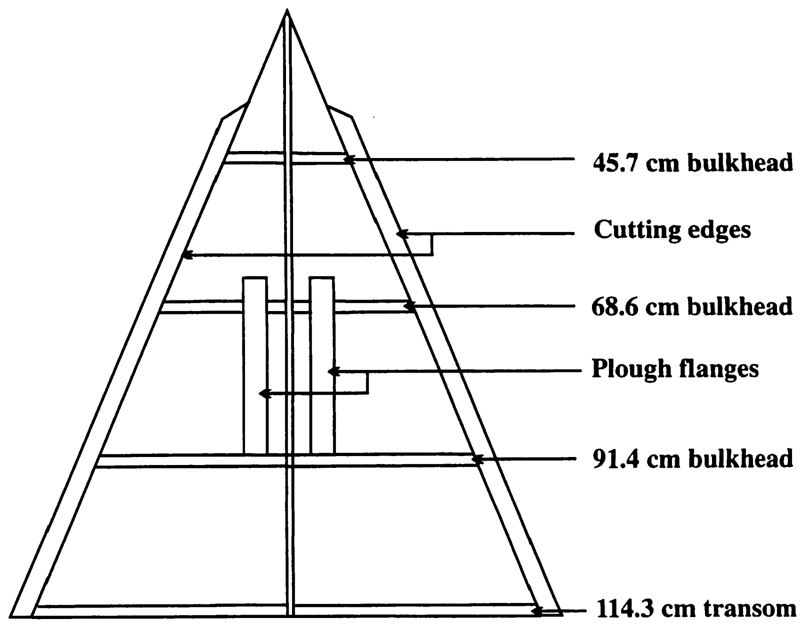


Fig 7

Figure 8