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strengthened by numerous connecting elements and inclined in a forward position - may be welded as a protective device against falling trees. This frame is also useful to hold back low up-rooted vegetative growth. The inclined position of the blade causes the felled trees to fall alongside the tractor and always on the same side to provide for easy collection.

This tool is also suitable for excavation and ground levelling work; for drain ditch digging (in a "tilt" position) and to collect and pile up the surplus material.

With more than one pass, it uproots the embedded logs. It is fixed to the C-frame in place of the angle blade.

- "V"-blade for felling trees

It is made up of two curved blades, converging at V. At the vertex it has a heavy-duty "splitter" or "stinger". The cutting parts are two angled serrated blades with sharpened saw-teeth. Converging protective brush racks are welded to the upper extremity of the blades to cut the vegetation on both sides of the tractor. It has trunnions hinged to the vehicle and these substitute the C-frame of the dozer.

This blade is very efficient and productive in the felling of trees, in stump digging and in the destruction of the undergrowth. However, it carries out a rough and disorderly demolition work which renders subsequent operations of gathering and land clearing more difficult. Considering the destructive action inflicted upon the vegetation, the "V" blade is used when a good output of trunk-gathering is not too important and the prevailing interest is to complete the work rapidly. No rubble piling or excavating works can be carried out with this blade.

- Tree Pusher

This is a rigid frame, made up of two converging brackets, hinged to the top of the C-frame of the dozer and fixed by means of forks and pins to the blade. At the vertex of the two arms is a tooth or a spur with multiple teeth, both well sharpened. The implement is placed on the blade in a straight position and has its end pointing upward.

It is used in the felling process of tree-uprooting since it exerts a much greater force on the tree-trunk than on the ground. Therefore, the stump digging operation is eliminated. But since the tree-felling process is very crude and the logs and roots are ripped out together, many deep holes are formed in the ground and these will eventually have to be filled up again.

There are also solutions of the tree-pusher which completely substitute the angle-dozer implement, preserving at the same time the hinges and the control by means of hydraulic jacks.

- Tree boom

This is a frame with a square rack, for both angle and straight dozers and can be either detachable or welded. The transversal bar of the frame, supported by angular cross members, constitutes the element of thrust of the implement and, considering its length, can act upon different trunks simultaneously. The tree boom is used in medium stock brushwood and can be applied both to the angle blade as well as to the brush-removing blade (as shown in figure).

1.2.2. Land clearing with chain

This method is adopted with a good result especially in uprooting the brushwood of an arid or semi-arid type.

- 2 -

A common naval anchor chain is used for this purpose and both its ends are attached to the tow bar of two angle dozers, of suitable power and rigged for forest-site work.

By moving in parallel line and at a certain distance from one another, the track-type tractors drag the chain which forms a curved line and, when scraping the ground, rips up the vegetation along the strip of land contained between the two towing dozers. The dozers are placed at a distance which is equivalent to $1/3$ of the chain's length. The latter is divided into segments to better overcome the resistances and each segment is linked to the other by joints. The diameter of the chain's rings is $50 + 80$ mm ($1.9 + 3.1$ ins.), according to the type of vegetative growth and to the class of the machines selected to tow it. Often, a third angle-dozer is called in as an auxiliary and is equipped with a plate or tree pusher which follows the course of the chain and intervenes at points of major resistance, to loosen it from any stubborn obstruction and to render the operation more regular and continuous. The auxiliary dozer will handle the felling of larger sized trees which cannot be uprooted by the chain. At times the chain is weighed down by one or more spheres - full or filled with cement - and at a set distance between them. This is done to prevent the chain from riding high on the vegetation instead of staying at ground level. This system cannot be adopted if the terrain is wet, muddy or very irregular. The weighted spheres or balls have a diameter of $1.20 + 1.80$ m (3 ft. 9 ins. + 5 ft. 9 ins.) and a weight of $2 + 6$ tons. In chain clearing, it is preferable to pass twice over the same area and in perpendicular directions.

1.2.3. Stump Digging

The stumps which remain buried, because the trunks have been sawn or sheared by means of tree-shears or split at the foot of the tree, are removed by means of suitable implements.

- Stumper for stump-digging

As for all land-clearing equipments, different versions are available. Essentially, the implement consists of a very thick and compact steel plate fitted with teeth underneath and is pivoted to the centre of the angle-dozer's C-frame in place of the blade. By exploiting the concentrated thrust force over a limited area and the penetration of the teeth, the stumper wedges itself under the tree stump and dislodges it.

The stumper may have a structure similar to a very short and robust blade, with one-piece teeth or a box-sectioned structure, with the plate placed at an angle in order to boost the machine's deviated thrust: in this case, the teeth are welded perpendicularly to the plate.

In order to root out the stump of large trees which are sawn at the base of the trunk, it is necessary to cut off the roots and split up the trunk into many parts which are then removed separately. For this purpose, a long sharp raking shore is welded to the side of the stumper, perpendicularly to the plate, and is designed to penetrate the stump and to split it.

- Traction Stumper

This is similar to a single-toothed ripper and is both long and robust. It could be hydraulically controlled or by a winch. The tooth is curved and sharp; sinking into the ground, it roots up the stumps and rocks, rips and cuts off the roots.

1.2.4. Sprouting and Removing of Undergrowth and Rubble.

This is the most common land-clearing operation. The implements used have a similar structure but differ considerably in the solutions given to the details in relation to the type of use: multi-application equipment (somewhat light) or prevaillingly specialized (somewhat heavy): they are used to fell trees of small diameter, remove stumps or rock and stony outcroppings, clear the ground of low vegetation, push and pile the residual debris.

- Blade Rake

This implement is available in a wide variety of types; of similar conception and consists of a strong frame, which approximately resembles the shape of an angle-dozer, and upon which curved teeth are fixed frontally. These jut out and are curved downwards. The teeth could be: fixed or removable, with two points (and therefore reversible) with or without an interchangeable point, long or short; according to the type of use. The blade rakes are, practically, multi-toothed pitchforks with suitable shape and strength to overcome the specific difficulties encountered in the land-clearing operation.

The teeth-bearing frame extends itself upwards to form a strong shelter and is inclined forward and supported by many beams to act as a thrust cross member to fell trees and as a trellis to stack and pile masses of vegetation.

The raking blade is fixed in place of the angle-blade; and its angular position is best suited for the piling of rubble into piles which are then removed by loaders or burned on the spot.

Rake blades are also available for more specialized and heavier tasks (especially for tasks such as the removal of boulders or stumps) or for use of a more general and lighter nature (such as the removal and rooting up of bushes, the clearing of the land).

A typical solution is that consisting of a toothed plate which is fixed to the angle-dozer blade by means of welded supports and hinges. This implement is easily dismantled and converts the angle-dozer suitable for lighter operations such as the removal of slightly resisting vegetation or the transporting and collecting of debris.

1.2.5. Dragging of felled trunks

This operation can be carried out by applying a winch to the dozer, as described in 1.1.4. For the dragging or skidding of trunks, the dozer is a suitable machine for every type of terrain whilst the skidder - as a wheeled machine - has certain limits of employ in relation to the consistency of the terrain and to the vulnerability of the tyres (jagging rocks or wood).

The winch is a fundamental equipment for the use of the dozer in land-clearing operations.

1.3. Superficial clearing of the land

If the exploitation of the soil is foreseen for agricultural growth or replanting, after having provided for the uprooting of the superficial vegetation, it is necessary to destroy the buried roots, to crumble the superficial ruggedness and to chop up the debris.

In this operational phase, the dozer is used for the towing of various equipments.

- Root-shearing blade

It substitutes the angle-dozer implement, is mounted at the rear and is pivoted by means of push arms to the hinged ends of the dozer's C-frame.

It lies horizontally and, by means of hydraulic jacks, is sunk into the ground and towed so as to tear up the buried roots.

- Rolling Choppers

This is a hollow roll which is filled with water to weigh it down to the ground. The drum of the chopper has welded on longitudinally cutting blades. It is towed by the dozer and carries out very accurate work of superficial clearance of the soil as the result of its weight and knife-action, which chop up the remaining vegetation and shatter the crust of the soil, without causing any damage to it in depth. The crushing drum is used singularly or in groups of two or three units.

- Disc Harrows for Land Clearing

These are implements which are towed to execute superficial works on the soil before it is ready for cultivation. Their common characteristics are their heavy supporting frame, for the provided discs and their cutting radial sectors. The harrows can be placed either in a perpendicular or inclined position in relation to the direction of the dozer's progress. If the frame is constructed in a V-shaped form, the harrow simultaneously presents counterposed movements with respect to the direction of the machine's progress. The frame of the V-shaped harrow may be rigid or flexible and, in this case, its setting may be manual, mechanical cable, or hydraulic.

2. Path Opening

The clearing of land for development requires the opening of paths for access to machines and labourers and for the dragging of felled trunks right up from the shearing site to the piling of trunks for hauling away on transport vehicles.

The path opening is rudimentary if the paths are destined for temporary use (e.g. for some months) and, namely, until the land clearing of a particular area is completed. Later on, if these areas are not abandoned, after a more or less lengthy period of inactivity, they may be repaired by using the same layout or are completely reset. The procedure is justifiable from an economical viewpoint since these paths are for an immediate purpose and do not require maintenance.

Instead, if the paths are later transformed into communication roads for access to hydroelectric stations, mines, grazing grounds or places of tourist interest, the initial undertaking will be more accurate as they will be arranged, at a later period, according to road-constructing techniques.

In any case, the specific machine for the opening of paths is the tract-type tractor with a semi-U blade having a hydraulic "tilt".

The "class" selection of the tractor is very different since it depends on the type of ground to move (sandy, clayish, mixed with rock or really rocky) and by the section of the trees to be felled. In these multi-application operations, the dozer has the advantage of having the hydraulic tilt available. For more engaging tree-felling work, machines and equipment indicated in the chapter on land-clearing are made use of. (If the undertaking is particularly simple, even the land-clearing angle-dozer may be adopted, as mentioned earlier in point 1).

2.1. Equipping clearing machines.

2.1.1. Blade with semi-U profile

In relation to the straight blade, the semi-U blade develops a more effective cutting action at its extreme ends which are angled in a forward position and offers a greater brush rack for greater load carry capacity.

2.1.2. Hydraulic Tilt.

When set in the "tilt" position, the "bull" blade is inclined in such a way as to point one of its ends to the ground. The hydraulic control of the tilt permits the blade to move continually and promptly according to the operator's intention.

The blade in a tilt position is particularly effective to oust slabs of rock or logs from the ground and to pile the loads of debris as its inclination can be continuously adapted to the irregularity of the terrain during the tractor's forward motion.

The tilt position of the blade is also used to shatter the surface of the soil, analogously to the ripping up when it is necessary to facilitate the digging process or to provoke a reaction in the ground when help is needed by the tractor to maintain its direction if it swerves as a result of ground obstacles or those of the load (excavation or vegetation debris) piled up not uniformly.

2.1.3. Power Shift Transmission

The need of having a power shift transmission depends from the same reasons discussed in 1.1.1. regarding land clearing. Analogously, there is a great advantage in the combination of an oil-bath clutch transmission with the power shift transmission.

2.1.4. Protective Guards and Equipping of the Clearing Machines
(See point 1.1.2.)

2.1.5. Winch

The winch which is applied to the bulldozer is one of the multi-application implements used in logging road construction.

It is used in reserve operations involving both itself as well as others when they are in difficulty or swamped down in muddy ground; it pulls out stumps, breaks up rocks and skids trunks out of the way. A raised fairlead winch is recommended as needy equipment to ease the manoeuvrability of the load-skidding tractor (See point 1.1.3.)

2.1.6. Ripper

This ripper is an alternative auxiliary tool for the bulldozer and is useful for path-clearing operations. The ripper is useful on clay loam soil or rock-studded ground since it is necessary to rip the soil, devoid of vegetation, to render excavation work more productive. The choice of the type of ripper (multi- or single-toothed) largely depends on the structure of the terrain.

As far as possible and if the material does not offer excessive resistance, one tends to choose the 3-toothed ripper (eventually only using two) for the sake of economy. The single-toothed ripper is needed when the breaking of the soil takes place in large dimension blocks or slabs. The operational technique consists of edging forward at minimum speed and maximum depth possible rather than at a high speed and lower depth. At low speeds, in fact, wear and tear of the dozer's mechanical properties and the dynamic stress intensity are reduced.

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

Ripping operations of a certain intensity call for the use of a bulldozer classified in the upper echelons for the necessary power and weight to boost the traction power and the penetration of the teeth into the ground.

2.1.7. Rolling Choppers

These implements are pulled by tract-type tractors and may be either simple choppers or vibrating ones which furrow the soil crust even in depth. The chopping evens the soil surface and tamps it to allow the downflow of water and therefore giving the path a longer life.

Heavily ballasted grided rolls are used in soil tillage when it is necessary to disintegrate rock outcroppings to render the surface hard and sufficiently smooth and to diminish the excessive wear of the tyres of load vehicles which ply back and forth.

Conclusion

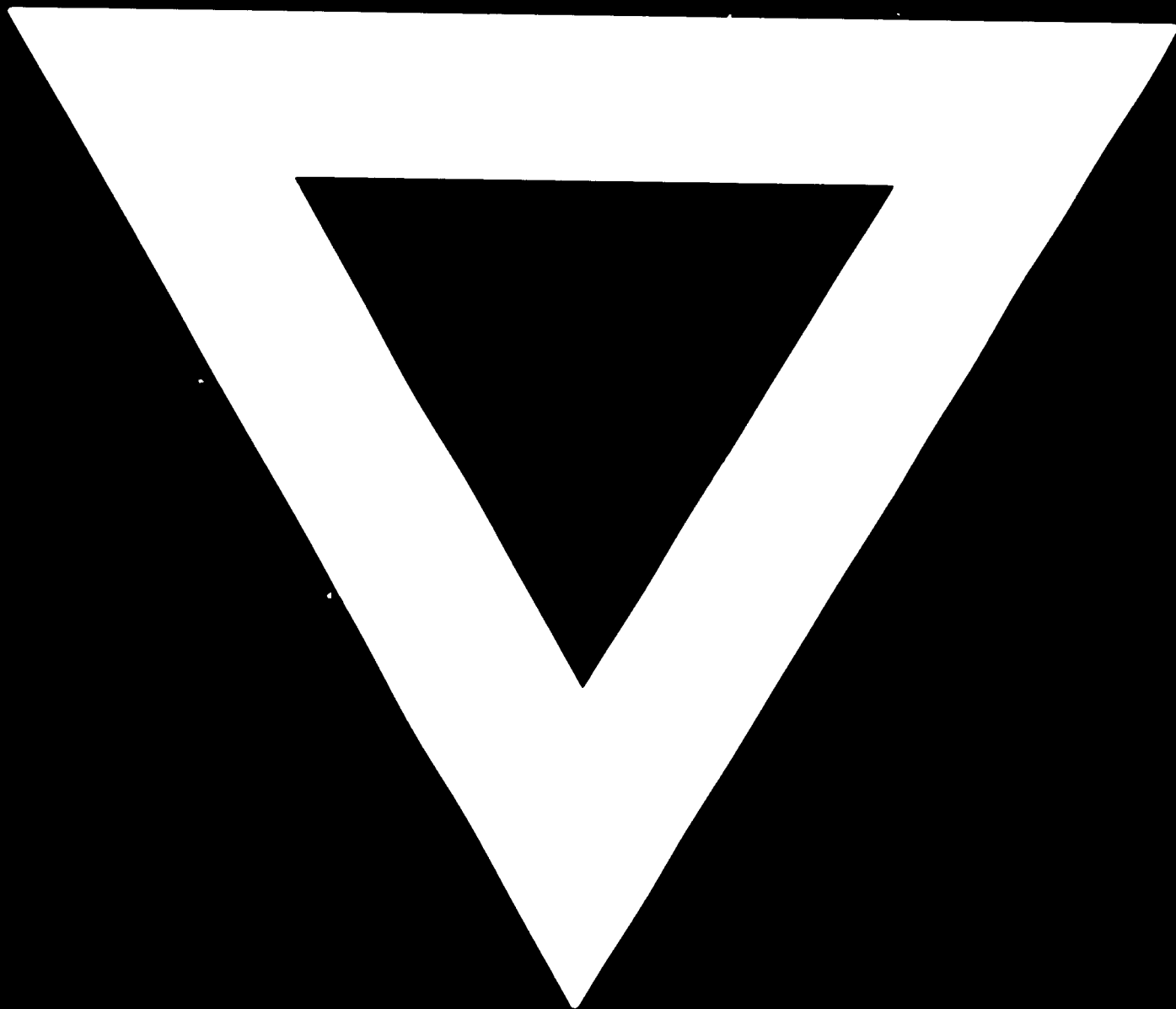
The tract-type dozer, specially equipped, is a universal machine for use in forest sites.

1. In land-clearing operations, the tract-type angle-dozer is the most suitable version having, as it does, the following distinct characteristics :
 - a) power-shift transmission, preferably with a clutch (in place of a converter); protective guards for man and machine;
 - b) availability of interchangeable special equipment with angle blade or substitutes of the entire tractor group: to fell trees, remove stumps, uproot vegetative growth and dispose of litter accumulated from the cleared land;
 - c) availability of rear or towed equipment to rip the embedded roots, to carry out tillage work on the soil to achieve as close to the desired condition for plant growth as possible;
 - d) availability of the winch for the skidding of trunks.

2. In path-opening works, the suitable version is the track-type bulldozer, with the following distinct characteristics:
 - a) equipping the clearing machines as in land-clearing operations;
 - b) bulldozer equipment consisting of a semi-U blade with hydraulic tilt;
 - c) availability of the winch or ripper according to the need for a special tool.



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MECHANIZATION OF FOREST OPERATIONS *

by

M. Caselli**

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** Expert in Forestry equipment.

<u>Introduction</u>	1
1. Land Clearing	2
1.1. Rigging out of angle-dozer	3
1.1.1. Power shift transmission	3
1.1.2. Protections	3
1.1.3. Winch	4
1.2. Clearance of vegetation from land	5
1.2.1. Tree-felling	6
1.2.2. Land clearing with chain	7
1.2.3. Stump Digging	9
1.2.4. Uprooting and Removing of Undergrowth and Rubble	10
1.2.5. Dragging of felled trunks	11
1.3. Superficial clearing of soil	11
2. Path Opening	13
2.1. Equipping clearing machines	14
2.1.1. Blade with semi-U profile	14
2.1.2. Hydraulic Tilt	14
2.1.3. Power Shift Transmission	14
2.1.4. Protective Guards and Equipping of Clearing Machines	15
2.1.5. Winch	15
2.1.6. Ripper	16
2.1.7. Rolling Choppers	16
- <u>Conclusion</u>	17

Introduction

The industry of products derived from the exploitation of forest wealth - which includes the industries for the cutting of wood, for the production of cellulose, of paper, plywood and chipped wood - is today of an outstanding importance to many countries and, for some, constitutes the major source of revenue.

At the very basis of the complex and diversified industrial cycles of the conversion of forest products, are the land-clearing works which are largely carried out by means of tracked earth-moving vehicles, fitted out and equipped with special mechanical tools.

It is known that, in the industry of forest products, there is a particular case of exploitation of the forest and woodland "cultures", practised with highly organized criteria and with the use of specialized wheeled machines and wheeled log loaders, equipped with a wide variety of interchangeable implements. At a more developed technical level and, subject to future growth, this type of industry is linked with the environmental characteristics, such as, the climatic conditions, the lay of the land and its nature.

Moreover, it implies the selection of suitable wood varieties and a sufficiently orderly arrangement of plants in tillage programmes.

Outside of this specialized sector, suitably equipped tracked earth-moving vehicles may be used everywhere in forest works and the dozer, in particular, plays an irreplaceable role.

The track-type tractor, suitably fitted out and equipped with appropriate implements, is the basic machine for all forest-site works since they require :

- thrusting power
- grappling power
- stability (on sloping or impervious terrain)
- manoeuvrability (in restricted spaces)
- floatability (on yielding ground).

The operational sectors of the dozer are schematically the following :

1. Land clearing
2. Track opening

1. Land Clearing

The uprooting of vegetation and the clearing of debris has as major scopes : the gathering of raw materials for wood industry, the preparation of land for reforestation programmes and crop production or the opening of areas of settlement.

In order to carry out these tasks, the angle-dozer with mechanical adjustment is used for the felling of trees, to undermine tree-stumps, to uproot bushes and undergrowth, to pile up the rubble, to skid the tree-trunks to the collection area and to prepare the land for further projects.

The angle-dozer is chosen for land clearing because of the special implements which are fitted to it straight or in an angular position according to the characteristics of the operation. The angle-dozer's thrust C-frame, because of its carrying structure, provides the maximum freedom of choice

of implements while the bulldozer - having its thrust-arms hinged to the blade - would render the substitution of implements more difficult, more expensive and more toilsome: there would neither be the possibility of turning the blade at an angle.

As far as the working conditions permit, the angle-dozer is capable of opening new transit lanes and for the skidding of tree-trunks (See Point 2).

1.1. The rigging out of the angle-dozer

1.1.1. Power shift transmission

The quick reversible gear is a necessary condition for the safety of the operator and a safeguard for the machine in case of danger (e.g., the falling down of trees, ditches hidden by vegetation, thick roots emerging from the ground after trees are felled).

The inching pedal control permits the dosing of a sufficiently gradual progress of the machine when working close to obstructions.

Another condition is that of combining the clutch to the power shift gear. This facilitates the use of the machine's total thrust power and sensitizes the operator. In fact, the rigid friction gearing immediately gives the operator the sensation or feeling of the variations of resistance to the dozer's advancement.

1.1.2. Protections

The bulldozer must be protected in order to provide safety to the operator and to avoid any damage to the machine as it penetrates into the vegetation during work: The causes

of damage are : ground obstacles (protruding rocks and roots); impacts against branches and bushes, the falling of trees.

A thick frame, fixed in relation to the operator's seat and linked by means of two sweeps to the radiator shield, protects the operator, the engine and the exhaust pipe. The sweeps must be shaped in such a way as to facilitate the machine's penetration into the forest. A heavy-duty cab guard and rear and lateral grill guards are applied to the tractor to prevent branches or foliage from entering. These guards are applied to the R.O.P.S. (Roll-over Protective Structure). The protection must have sufficient resistance to support the rolling-over of the tractor.

Various shelters are foreseen in certain parts of the machine to protect the most delicate mechanical parts.

1.1.3. Winch

A heavy-duty towing winch is used and applied to the rear of the machine at a convenient height to skid felled tree-trunks, even of a considerable diameter, or a bunch of them by keeping the end off the ground to avoid any possible stumbling over obstacles.

For such a purpose, a raised fairlead is often used as an accessory to the winch which hoists the cable's pulling line in relation to the ground. Generally, the winch has also a tow-hook for towing sledges, rolling choppers and other implements for ground preparation.

The dozer provided with a winch is suitable for towing operations on difficult, steep, muddy ground filled with jutting rocks or sharp wooden spikes where special wheeled machines for skidding would not be sufficiently effective or would be exposed to excessive tyre damage and wear.

1.2. Clearance of vegetation from land

It is stated that, in the more advanced industry of forestry, trees are accurately felled at ground level to obtain a greater quantity of raw material for industrial transformation. In this case, a truck-type tractor is more often used, fitted as it is with a tree-shearer in front to shear trees whose diameter is not over 60 cm (23.5 ins.) by cutting them at ground level.

However, the common mechanical saw is still widely used.

Otherwise, when the exploitation of the trunk is more rudimental or when it constitutes a sub-product of land-clearing, or there is an abundance of underwood and bushes, the angle-dozer finds a vast area of application, fitted with suitable implements for :

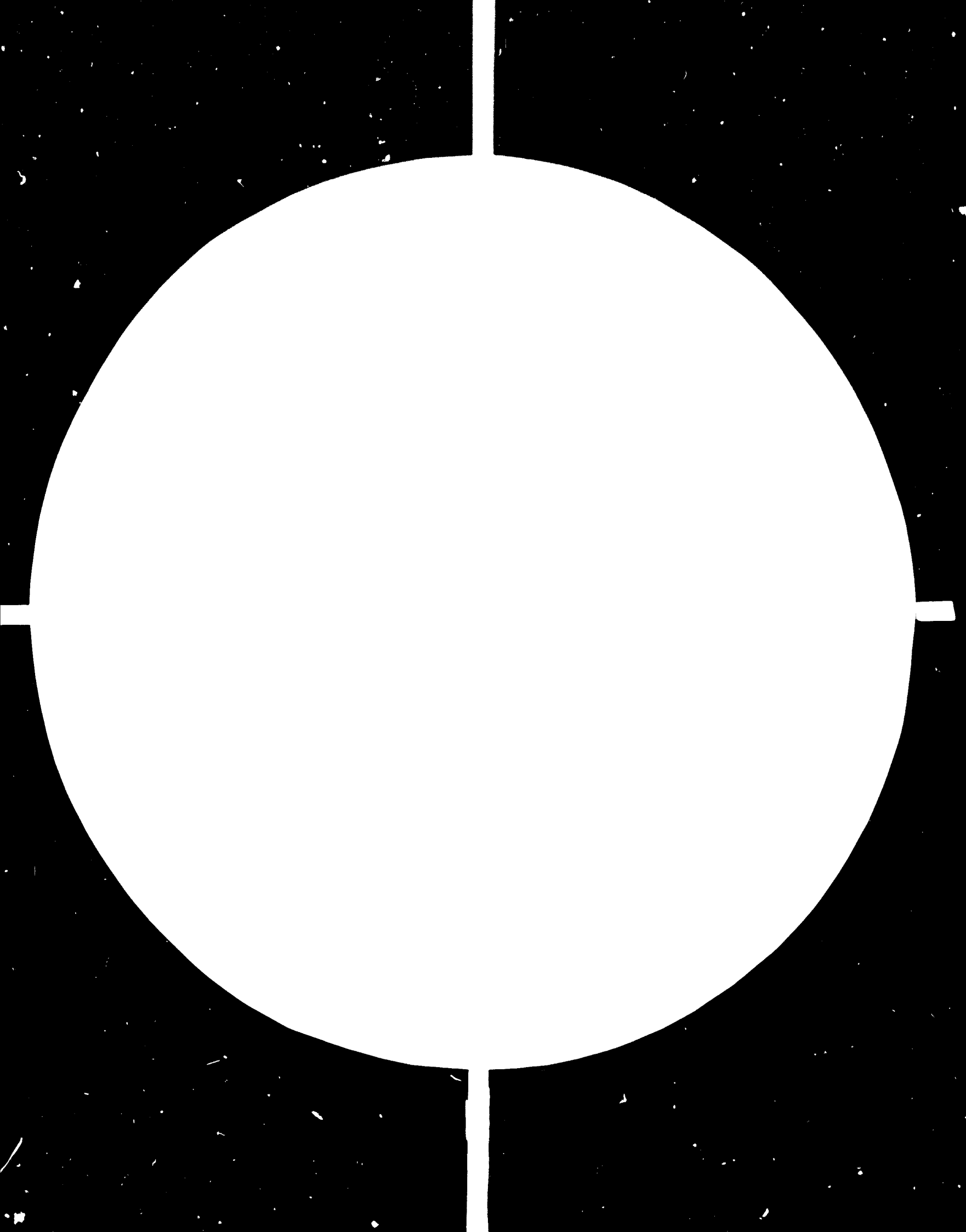
- 1.2.1. tree-felling,
- 1.2.2. land-clearing with chain,
- 1.2.3. stump digging
- 1.2.4. uprooting and removing undergrowth and rubble,
- 1.2.5. dragging of felled trunks.

1.2.1. Free-felling

The following special implements are used:

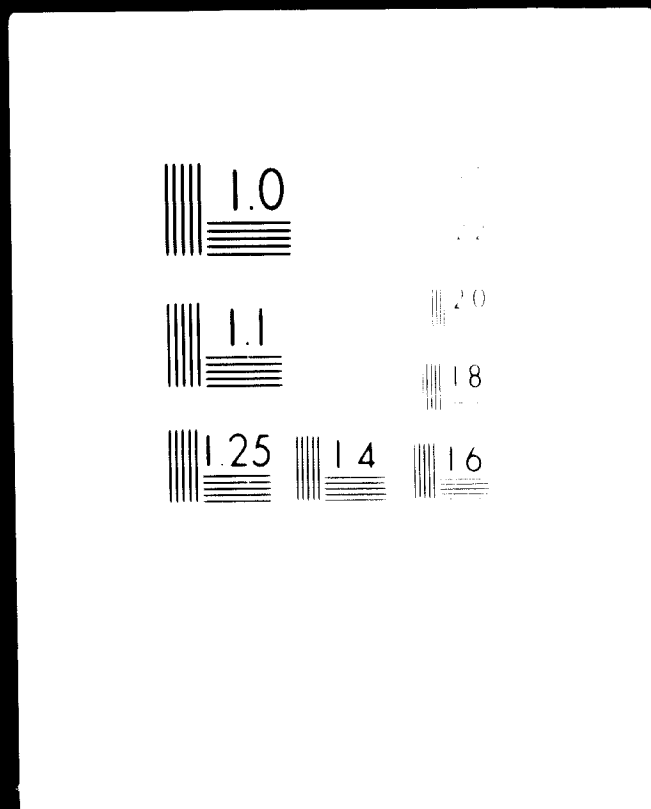
- Angle shear blade for tree-felling

This is a fixed position blade, set at an angle of 30° with a curved shape of the mouldboard and having a thick cutting edge and a stinger device at the extreme end, both capable of being re-sharpened and replaced (welded elements). The stinger cuts into the trunk and splits it as a result of the off-centred thrust of the dozer: the blade completes the demolition. On the upper part of the blade, a guide bar -



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- Tree Pusher (Fig. 4 and 4A)

This is a rigid frame, made up of two converging brackets, hinged to the top of the C-frame of the dozer and fixed by means of forks and pins to the blade. At the vertex of the two arms is a tooth or a spur with multiple teeth, both well sharpened. The attachment is placed on the blade in a straight position and has its end pointing upward.

It is used in the felling process of tree-uprooting since it exerts a much greater force on the tree-trunk than on the ground. Therefore, the stump digging operation is eliminated. But since the tree-felling process is very crude and the logs and roots are ripped out together, many deep holes are formed in the ground and these will eventually have to be filled up again.

There are also alternatives of the tree-pusher which completely substitute the angle-dozer attachment, preserving at the same time the hinges and the control by means of hydraulic jacks.

- Tree boom (Fig. 5)

This is a frame with a square rack, for both angle and straight dozers and can be either detachable or welded. The transversal bar of the frame, supported by angular cross members, constitutes the element of thrust of the implement and, considering its length, can act upon different trunks simultaneously. The tree boom is used in medium stock brushwood and can be applied both to the angle blade as well as to the brush-removing blade.

1.2.2. Land clearing with chain

This method is adopted with a good result especially in uprooting the brushwood of an arid or semi-arid type.

A common naval anchor chain is used for the purpose and both its ends are attached to the tow bar of two angle dozers, of suitable power and rigged for forest-site work.

By moving in parallel line and at a certain distance from one another, the track-type tractors drag the chain which forms a curved line and, when scraping the ground, rips up the vegetation along the strip of land contained between the two towing dozers. The dozers are placed at a distance which is equivalent to $1/3$ of the chain's length. The latter is divided into segments to better overcome the resistances and each segment is linked to the other by joints. The diameter of the chain's rings is 50 + 80 mm (1.9 + 3 ins.), according to the type of vegetative growth and to the class of the machines selected to tow it. Often, a third angle-dozer is called in as an auxiliary and is equipped with a plate or tree pusher which follows the course of the chain and intervenes at points of major resistance, to loosen it from any stubborn obstruction and to render the operation more regular and continuous. The auxiliary dozer will handle the felling of larger sized trees which cannot be uprooted by the chain. At times the chain is weighed down by one or more spheres - full or filled with cement - and at a set distance between them. This is done to prevent the chain from riding high on the vegetation instead of staying at ground level. This system cannot be adopted if the terrain is wet, muddy or very irregular. The dragged spheres or balls have a diameter of 1.20 + 1.80 m (3 ft. 9 ins. + 5 ft. 9 ins.) and a weight of 2 + 6 tons. In chain clearing, it is preferable to pass twice over the same area and in perpendicular directions.

1.2.3. Stump Digging

The stumps which remain buried, because the trunks have been sawn or sheared by means of tree-shears or split at the foot of the tree, are removed by means of suitable attachments.

- Stumper for stump-digging (Fig. 6 and 6A)

As for all land-clearing equipments, different versions are available. Essentially, the attachment consists of a very thick and compact steel plate fitted with teeth underneath and is pivoted to the centre of the angle-dozer's C-frame in place of the blade. By exploiting the concentrated thrust force over a limited area and the penetration of the teeth, the stumper wedges itself under the tree stump and dislodges it.

The stumper may have a structure similar to a very short and robust blade, with one-piece teeth or a box-sectioned structure, with the plate placed at an angle in order to boost the machine's deviated thrust: in this case, the teeth are welded perpendicularly to the plate.

In order to root out the stump of large trees which are sawn at the base of the trunk, it is necessary to cut off the roots and split up the trunk into many parts which are then removed separately. For this purpose, a long sharp raking shore is welded to the side of the stumper, perpendicularly to the plate, and is designed to penetrate the stump and to split it.

- Traction Stumper (Fig. 7)

This is similar to a single-toothed ripper and is both long and robust. It could be hydraulically controlled or by a winch. The tooth is curved and sharp; sinking into the ground, it roots up the stumps and rocks, rips and cuts off the roots.

1.2.4. Uprooting and Removing of Undergrowth and Debris.

This is the most common land-clearing operation. The attachments used have a similar structure but differ considerably in the solutions given to the details in relation to the type of use: multi-application equipment (somewhat light) or prevaillingly specialized (somewhat heavy): they are used to fell trees of small diameter, remove stumps or rock and stony outcroppings, clear the ground of low vegetation, push and pile the residual debris.

- Blade Rake (Fig. 8 and 8A)

This attachment is available in a wide variety of types; of similar conception and consists of a strong frame, which approximately resembles the shape of an angle-dozer, and upon which curved teeth are fixed frontally. These jut out and are carved downwards. The teeth could be: fixed or removable, with two points (and therefore reversible) with or without an interchangeable point, long or short; according to the type of use. The blade rakes are, practically, multi-toothed pitchforks with suitable shape and strength to overcome the specific difficulties encountered in the land-clearing operation.

The teeth-bearing frame extends itself upwards to form a strong shelter and is inclined forward and supported by many beams to act as a thrust cross member to fell trees and as a trellis to stack and pile masses of vegetation.

The raking blade is fixed in place of the angle-blade; and its angular position is best suited for the piling of debris into piles which are then removed by loaders or burned on the spot.

Rake blades are also available for more specialized and heavier tasks (especially for tasks such as the removal of boulders or stumps) or for use of a more general and lighter nature (such as the removal and rooting up of bushes, the clearing of the land).

A typical solution is that consisting of a toothed plate which is fixed to the angle-dozer blade by means of welded supports and hinges. This attachment is easily dismantled and converts the angle-dozer suitable for lighter operations such as the removal of slightly resisting vegetation or the transporting and collecting of debris.

1.2.5. Dragging of felled trunks

This operation can be carried out by applying a winch to the dozer, as described in 1.1.4. For the dragging or skidding of trunks, the dozer is a suitable machine for every type of terrain whilst the skidder - as a wheeled machine - has certain limits of employ in relation to the consistency of the terrain and to the vulnerability of the tyres (jagged rocks or wood).

The winch is an essential piece of equipment for the use of the dozer in land-clearing operations.

1.3. Superficial clearing of the land

If the exploitation of the soil is foreseen for agricultural growth or replanting, after having provided for the uprooting of the superficial vegetation, it is necessary to destroy the buried roots, to crumble the superficial ruggedness and to chop up the debris.

In this operation, the dozer is used for the towing of various pieces of equipment.

- Root-shearing blade (Fig. 9)

It substitutes the angle-dozer attachment, is mounted at the rear and is pivotted by means of push arms to the hinged arts of the dozer's C-frame.

It lies horizontally and, by means of hydraulic jacks, is sunk into the ground and towed so as to tear up the buried roots.

- Rolling Choppers (Fig. 10)

This is a hollow roll which is filled with water to weigh it down to the ground. The drum of the chopper has welded on longitudinally cutting blades. It is towed by the dozer and carries out very accurate work of superficial clearance of the soil as the result of its weight and knife-action, which chop up the remaining vegetation and shatter the crust of the soil, without causing any damage to it in depth. The crushing drum is used singularly or in groups of two or three units.

- Disc Harrows for Land Clearing (Fig. 11)

These are attachments which are towed to execute superficial works on the soil before it is ready for cultivation. Their common characteristics are their heavy supporting frame for the provided discs and their cutting radial sectors. The harrows can be placed either in a perpendicular or inclined position in relation to the direction of the dozer's progress. If the frame is constructed in a V-shaped form, the harrow simultaneously presents counterposed movements with respect to the direction of the machine's progress. The frame of the V-shaped harrow may be rigid or flexible and, in this case, its setting may be manual, mechanical cable, or hydraulic.

2. Path Opening

The clearing of land for development requires the opening of paths for access to machines and labourers and for the dragging of felled trunks right up from the shearing site to the piling of trunks for hauling away on transport vehicles.

The path opening is rudimental if the paths are destined for temporary use (e.g. for some months) and, namely, until the land clearing of a particular area is completed. Later on, if these areas are not abandoned, after a more or less lengthy period of inactivity, they may be repaired by using the same layout or are completely reset. The procedure is justifiable from an economical viewpoint since these paths are for an immediate purpose and do not require maintenance.

Instead, if the paths are later transformed into communication roads for access to hydroelectric stations, mines, grazing grounds or places of tourist interest, the initial undertaking will be more accurate as they will be arranged, at a later period, according to road-constructing techniques.

In any case, the specific machine for the opening of paths is the tract-type tractor with a semi-U blade having a hydraulic "tilt".

The "class" selection of the tractor is very different since it depends on the type of ground to move (sandy, clayish, mixed with rock or really rocky) and by the section of the trees to be felled. In these multi-application operations, the dozer has the advantage of having the hydraulic tilt available. For more engaging tree-felling work, machines and equipment indicated in the chapter on land-clearing are made use of. (If the undertaking is particularly simple, even the land-clearing angle-dozer may be adopted, as mentioned earlier in point 1).

2.1. Supplying clearing machines.

2.1.1. Blade with semi-U profile

In relation to the straight blade, the semi-U blade develops a more effective cutting action at its extreme ends which are angled in a forward position and offers a greater brush rack for greater load carry capacity.

2.1.2. Hydraulic Tilt.

When set in the "tilt" position, the "bull" blade is inclined in such a way as to point one of its ends to the ground. The hydraulic control of the tilt permits the blade to move continually and promptly according to the operator's intention.

The blade in a tilt position is particularly effective to oust slabs of rock or logs from the ground and to pile the loads of debris as its inclination can be continuously adapted to the irregularity of the terrain during the tractor's forward motion.

The tilt position of the blade is also used to shatter the surface of the soil, analogously to the ripping up when it is necessary to facilitate the digging process or to provoke a reaction in the ground when help is needed by the tractor to maintain its direction if it swerves as a result of ground obstacles or those of the load (excavation or vegetation debris) piled up not uniformly.

2.1.3. Power Shift Transmission

The need of having a power shift transmission is similar to that as outlined in paragraph 1.1.1. regarding land clearing. Analogously, there is a great advantage in the combination of an oil-bath clutch transmission with the power shift transmission.

2.1.4. Protective Guards and Equipping of the Clearing Machines
(See point 1.1.2.)

2.1.5. Winch

The winch which is applied to the bulldozer is one of the multi-application attachments used in logging road construction.

It is used in reserve operations involving both itself as well as others when they are in difficulty or swamped down in muddy ground; it pulls out stumps, breaks up rocks and skids trunks out of the way. A raised fairlead winch is recommended as auxiliary equipment to ease the manoeuvrability of the load-skidding tractor (See point 1.1.3.)

2.1.6. Ripper

This ripper is an alternative auxiliary tool for the bulldozer and is useful for path-clearing operations. The ripper is useful on clay loam soil or rock-studded ground since it is necessary to rip the soil, devoid of vegetation, to render excavation work more productive. The choice of the type of ripper (multi- or single-toothed) largely depends on the structure of the terrain.

As far as possible and if the material does not offer excessive resistance, one tends to choose the 3-toothed ripper (eventually only using two) for the sake of economy. The single-toothed ripper is needed when the breaking of the soil takes place in large dimension blocks or slabs. The operational technique consists of edging forward at minimum speed and maximum depth possible rather than at a high speed and lower depth. At low speeds, in fact, wear and tear of the dozer's mechanical properties and the dynamic stress intensity are reduced.

Ripping operations of a certain intensity call for the use of a bulldozer to provide the necessary power and weight to boost the traction power and the penetration of the teeth into the ground.

2.1.7. Rolling Choppers

These attachments are pulled by tract-type tractors and may be either simple choppers or vibrating ones which furrow the soil crust even in depth. The chopping evens the soil surface and tamps it to allow the downflow of water and therefore giving the path a longer life.

Heavily ballasted grided rolls are used in soil tillage when it is necessary to disintegrate rock outcroppings to render the surface hard and sufficiently smooth and to diminish the excessive wear of the tyres of load vehicles which ply back and forth.



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MECHANIZATION OF FOREST OPERATIONS *

by

M. Caselli**

* The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Expert in forestry equipment.

Conclusions

The tract-type dozer, specially equipped, is a universally recognized piece of equipment as being adaptable for work in the forests of the world.

1. In land-clearing operations, the tract-type angle-dozer is the most adaptable version, particularly because of possessing the following characteristics:
 - a) power-shift transmission, preferably with a clutch (in place of a converter); protective guards for both the operator and machine;
 - b) availability of interchangeable special equipment with angle blade or substitutes of the entire tractor group: to fell trees, remove stumps, uproot vegetative growth and dispose of litter accumulated from the cleared land;
 - c) availability of rear or other equipment to rip the embedded roots, to carry out tillage work on the soil to achieve as close to the desired condition for plant growth as possible;
 - d) availability of the winch for the skidding of tree trunks.

2. In path-opening works, the machine most suited is the track-type bulldozer, with the following characteristics:
 - a) supplying the clearing machines as in land-clearing operations;
 - b) bulldozer equipment consisting of a semi-U blade with hydraulic tilt;
 - c) availability of the winch or ripper in emergency situations.



FIG. No.1 - RAISED AIRLEAD

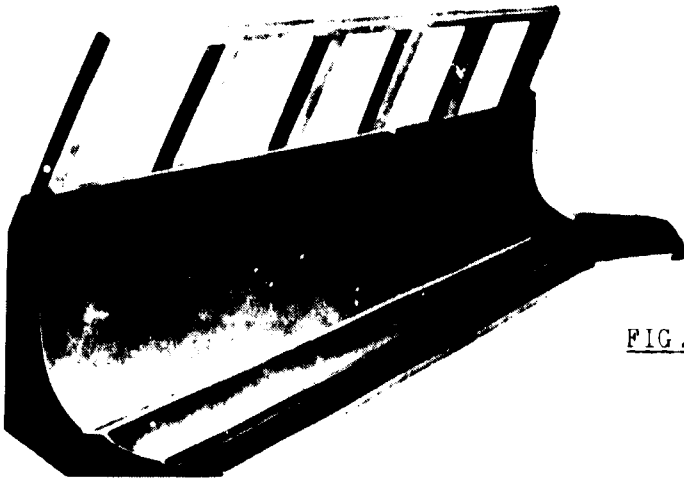


FIG. No.2 - ANGLE SHEAR BLADE

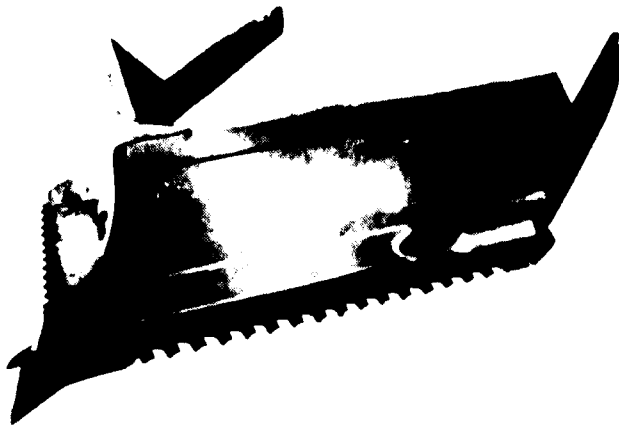


FIG. 3 - FELLING "V" BLADE

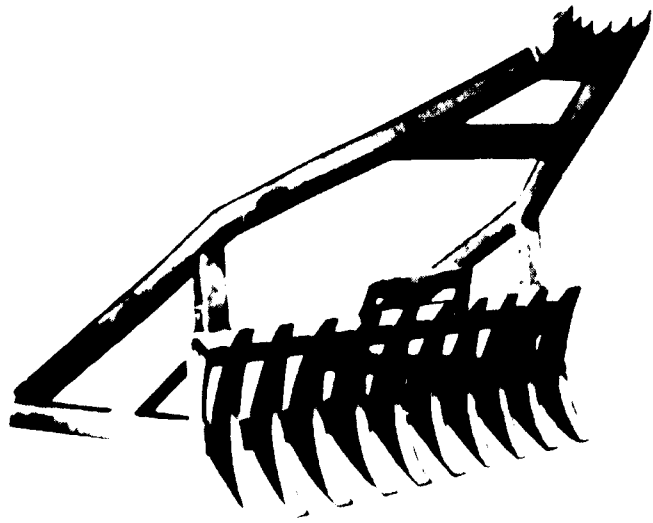


FIG. 4 - TREE PUSHER

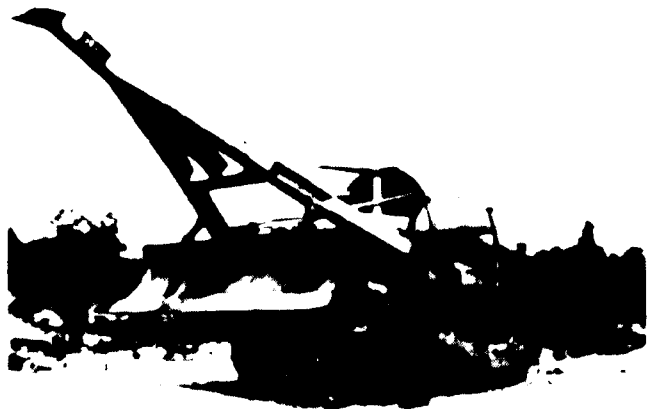


FIG. 4A - TREE PUSHER

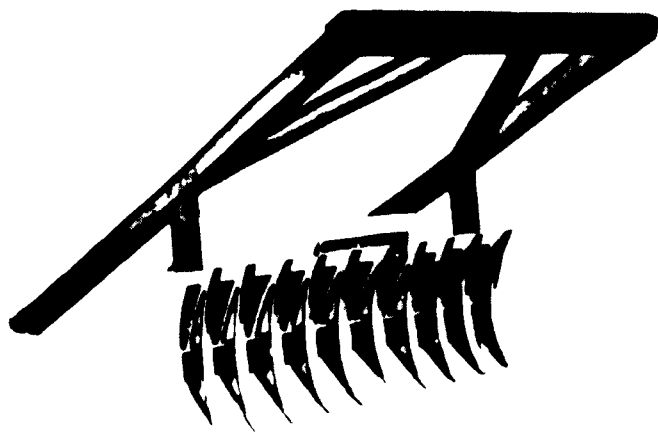


FIG. No. 5 - TREE BOOM

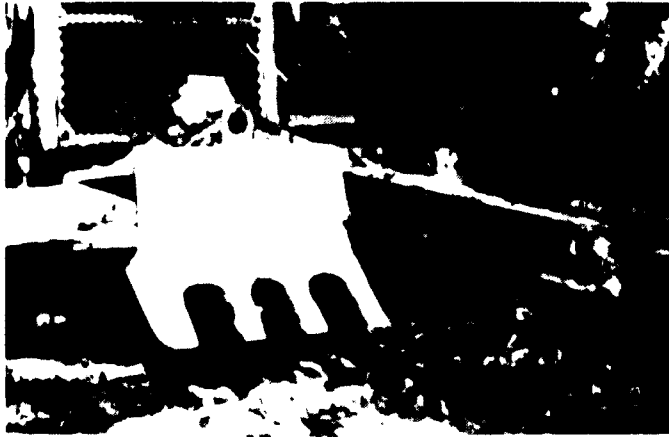


FIG. No. 6 - STUMP DIGGING
STUMPER

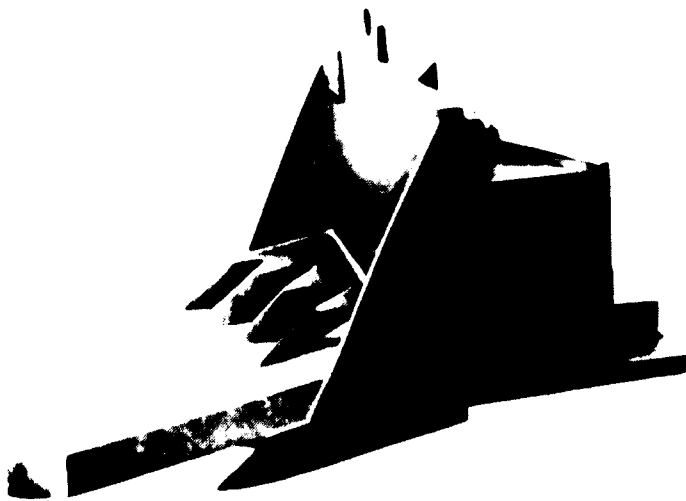


FIG. No. 6A- STUMP DIGGING STUMPER



FIG. No. 7 - TRACTOR STUMPER

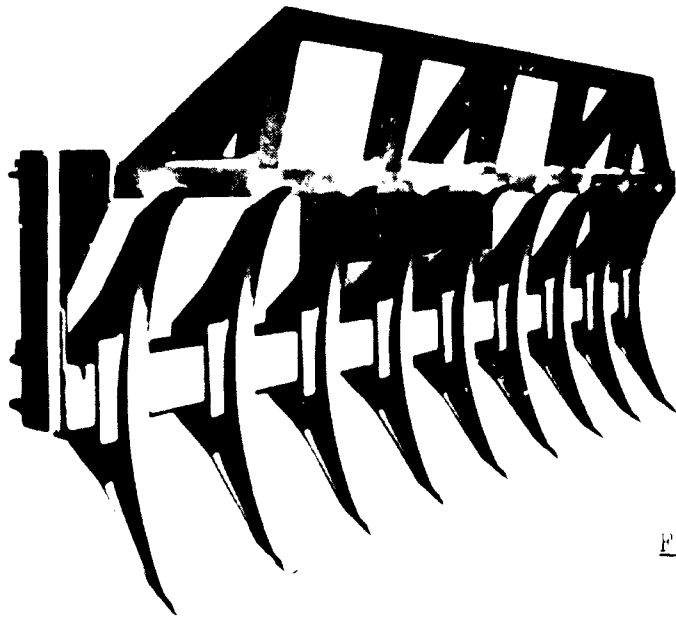


FIG. No. 8 - BLADE RAKE



FIG. No. 8A - BLADE RAKE FOR
ANGLE DOZER

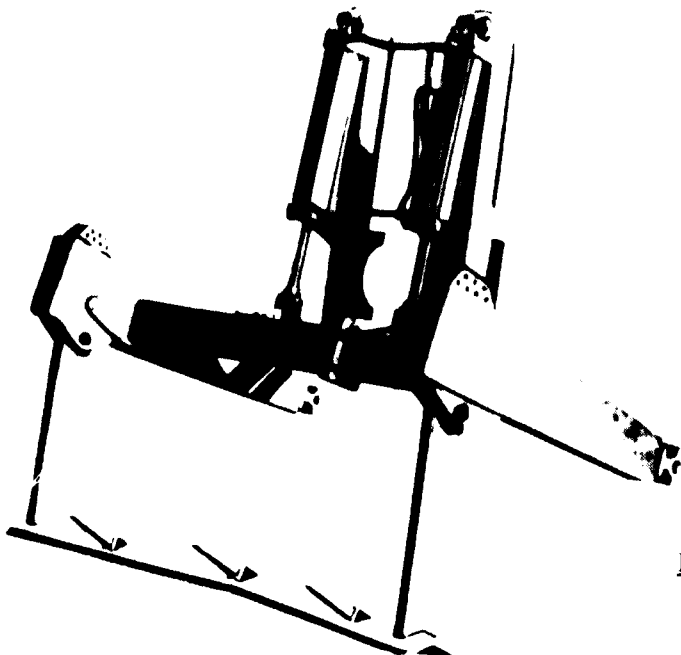


FIG. No. 9 - ROOT SHEARING
BLADE



FIG.No.10 - ROLLING CHOPPER



FIG.No.11 - DISC HARROW FOR
LAND CLEARING



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79.11.15

CONTENTS

<u>Item</u>		<u>Page</u>
	Introduction	1
1	Land clearing	2
2	Reeling out of the angle-dozer	3
3	Clearance of vegetation from land	5
4	Path opening	13
5	Conclusions	17

Figures

Fig. No.1	-	Raised fairlead	18
No.2	-	Angle shear blade	18
No.3	-	Felling 'V' blade	18
No.4-4A-	-	Tree pusher	19
No.5	-	Tree boom	19
No.6-6A-	-	Stump digging stumper	20
No.7	-	Traction stumper	20
No.8-8A-	-	Blade rake	21
No.9	-	Root shearing blade	21
No.10	-	Rolling chopper	22
No.11	-	Disc harrow for land clearing	22

CONCLUSION

When we refer to the Forest Products Industry, we must realize that this concerns with the selection of the desired tree by the Forestman, one then felled, barked and extracted for delivery to certain manufacturers who then process the raw material into a variety of products, such as saw timber, furniture, plywood and pulp. Most of these products are sold to distant foreign and export markets and in many instances represent a major source of revenue, particularly for those countries which happen to be blessed with large forested areas.

When we discuss the removal of trees from the forests in this document it is most important to adhere to both national and local government regulations which over recent years have been upgraded considerably for the purpose of conserving timbered lands, as well as to abide by environmental requirements. What is really happening here is that Government Forestry Departments, as well as those other Bodies which are involved in expanding and upgrading agricultural lands, are working in unison for the purpose of making full use of the land, be it for growing trees, agricultural crops, or just for grazing purposes.

Because of this approach by Government bodies it is no longer possible to exploit forested land at will, but instead one should first become knowledgeable with the requirements and laws as they pertain to soil erosion, road layout, fire protection and logging practices. Having become acquainted with the thinking and planning of the various Government bodies it is then possible to proceed in a businesslike manner to extract the needed raw product from the forests by selecting the type of equipment best suited for the work. In this connection it is apparent that over the past fifty years machinery and equipment for use in extraction of forest products, land development and road building, etc., has continuously been the object of upgrading in order to make it more useful and productive, while at the same time the inclusion of certain safety features for the protection of the operator has not been overlooked by the manufacturers.

fairly because of continued co-operation between the various segments of industry and the manufacturers of heavy duty equipment for the development of various pieces of equipment and machines one particular type of machine which has become universally popular is the Track-type Tractor. This machine which can be suitably outfitted with appropriate attachments is in reality considered to be the basic machine for use in port, forest-site work, development of agricultural lands and heavy-duty construction, particularly since it possesses-

- thrusting power
- grappling power
- stability (especially where sloping terrain is involved)
- manoeuvrability (in restricted areas)
- floatability (on yielding ground)

1. Land clearing

The **uprooting** of vegetation and the clearing of debris has as major scopes the gathering of raw materials for the wood industry, preparation of land for reforestation programmes and crop production, or the opening up of areas of settlement.

In order to perform these tasks, the angle-dozer with mechanical adjustment is used for the felling of trees, undermine stumps of trees, uproot bushes and undergrowth, pile up debris and to skid the felled trees, in whole or in part, to a collection area and to prepare the land for further use.

The angle-dozer is chosen for land clearing because of the special attachments which may be fitted to it in either an upright or angular position so as to fit in with the characteristics of the job. The angle-dozer's thrust C-frame, because of its carrying structure, provides the maximum freedom of choice of

attachments, while the bulldozer - having its thrust-arms hinged to the blade - would render the substitution of attachments more difficult, more expensive and more cumbersome: there would neither be the possibility of turning the blade at an angle.

As far as the working conditions permit, the angle-dozer is capable of opening new transit lanes and for the skidding of tree-trunks (See Point 2).

1.1. The rigging out of the angle-dozer

1.1.1. Power shift transmission

The quick reversible gear is a positive situation for the safety of the operator and a safeguard for the machine in case of danger (e.g., the falling down of trees, ditches hidden by vegetation, thick roots emerging from the ground after trees are felled).

The inching pedal control permits the dozing at a reasonably gradual progress of the machine when working close to obstructions.

Another advantage is that of combining the clutch to the power shift gear. This facilitates the use of the machine's total thrust power and sensitizes the operator. In fact, the rigid friction gearing immediately gives the operator the sensation or feeling of the variations of resistance to the dozer's advancement.

1.1.2. Protection

The bulldozer must be protected in order to provide safety to the operator and to avoid any damage to the machine as it penetrates into the vegetation during work: The causes

of damage are : ground obstacles (protruding rocks and roots); impacts against branches and bushes, the falling of trees.

A heavy duty frame , fixed in relation to the operator's seat and linked by means of two arms to the radiator shield, protects the operator, the engine and the exhaust pipe. The arms must be shaped in such a way as to facilitate the machine's penetration into the forest. A heavy-duty cab guard and rear and lateral grill guards are applied to the tractor to prevent branches or foliage from entering. These guards are applied to the R.O.P.S. (Roll-over Protective Structure). The protection must have sufficient resistance to support the rolling-over of the tractor.

Various shelters are noticeable in certain parts of the machine to protect the most delicate mechanical parts.

1.1.3. Winch

A heavy-duty towing winch is used and applied to the rear of the machine at a convenient height to skid felled tree-trunks, even of a considerable diameter, or a bunch of them by keeping the end off the ground to avoid any possible stumbling over obstacles.

For such a purpose, a raised fairlead (Fig. 1) is often used as an accessory to the winch which hoists the cable's pulling line in relation to the ground. Generally, the winch has a tow hook for use when towing sleds, rolling choppers and other implements for ground preparation.

The dozer provided with a winch is suitable for towing operations on difficult, steep, muddy ground filled with jutting rocks or sharp wooden spikes where special wheeled machines for skidding would not be sufficiently effective or would be exposed to excessive tyre damage and wear.

1.2. Clearance of vegetation from land

It is stated that, in the more advanced industry of forestry, trees are accurately felled at ground level to obtain a greater quantity of raw material for industrial transformation. In this case, a track-type tractor is more often used, fitted as it is with a tree-shearer in front to shear trees whose diameter is not over 60 cm (23.5 ins.) by cutting them at ground level.

However, the common mechanical saw is still widely used.

Otherwise, when the exploitation of the trunk is more rudimental or when it constitutes a sub-product of land-clearing, or there is an abundance of underwood and bushes, the angle-dozer finds a vast area of application, fitted with suitable implements for :

- 1.2.1. tree-felling,
- 1.2.2. land-clearing with chain,
- 1.2.3. stump digging ,
- 1.2.4. uprooting and removing undergrowth and debris,
- 1.2.5. dragging of felled tree trunks.

1.2.1. Tree-felling

The following special attachments are used:

- Angle shear blade for tree-felling (Fig.2).

This is a fixed position blade, set at an angle of 30° with a curved shape of the mouldboard and having a thick cutting edge and a stinger device at the extreme end, both capable of being re-sharpened and replaced (welded elements). The stinger cuts into the trunk and splits it as a result of the off-centred thrust of the dozer: the blade completes the demolition. On the upper part of the blade, a guide bar -

strengthened by numerous connecting elements and inclined in a forward position - may be welded as a protective device against falling trees. This frame is also useful to hold back low up-rooted vegetative growth. The inclined position of the blade causes the felled trees to fall alongside the tractor and always on the same side to provide for easy collection.

This tool is also suitable for excavation and ground levelling work; for drain ditch digging (in a "tilt" position) and to collect and pile up the surplus material.

With more than one pass, it uproots the embedded logs. It is fixed to the C-frame in place of the angle blade.

- "V"-blade for felling trees (Fig. 3)

It is made up of two curved blades, converging at V. At the vertex it has a heavy-duty "splitter" or "stinger". The cutting parts are two angled serrated blades with sharpened saw-teeth. Converging protective brush racks are welded to the upper extremity of the blade to cast the vegetation on both sides of the tractor. It has trunnions hinged to the vehicle and these substitute the C-frame of the dozer.

This blade is very efficient and productive in the felling of trees, in stump digging and in the destruction of the undergrowth. However, it carries out a rough and disorderly demolition work which renders subsequent operations of gathering and land clearing more difficult. Considering the destructive action inflicted upon the vegetation, the "V" blade is used when a good output of trunk-gathering is not too important and the prevailing interest is to complete the work rapidly. No rubble piling or excavating works can be carried out with this blade.