27. MACHINE TECHNOLOGY: A SURVEY

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What I have tried to do is to find existing machines throughout the industry--machines that have been upgraded and that could be used for large-scale decontamination operations outdoors. For this I have looked at the building industry, the mining industry, and the road construction industry. It is mainly the road construction industry that has yielded the machines in this presentation.

The kinds of operations we can do with the machines available now are shown (Table 27.1).

Wire brushing can be effective for removing thin layers of soil and is used even on asphalt and concrete. I don't know how far one can go and to what depth one can remove asphalt and concrete--at least one can clean it. There are wire-brush sweepers that are commonly used to clean city streets.

The next thing of interest is a force-feed loader, a kind of shovel th.. can be used to take out debris, windrows, and cut material. It has been used in North Carolina to remove PCB from shoulders of roads and to remove soil containing PCB.

Then there is the vacuum-cleaning equipment. To pick up the material a recycle air system is

Table 27.1. Existing Machines for Decontamination

Method	Device	Manufacturer	Application
Wire Brushing	Mobile Sweeper	Athey FMC	Thin-layer removal of soil, asphalt, concrete
Shoveling	Force-Feed Loader	Athey	Removal of cut material
Vacuum Cleaning	Recycle Air System (Air Blast and Suction)	TYMCO	Sub-micron to half-brick soil removal if scarified
	Filtered Air Sweeper	FMC	Removal of earth, debris
	Vac/All	Central Engineering	Removes concrete debris behind road planer
Road Planing	Hot Planing	Unknown	Asphalt removal
	200-Tooth Auger Scarifier	Galion	Cold removal of concrete, asphalt
	Rotomill Pavement Profiler	CMI	Cold planing and direct truck loading
Forest Clearing	Tree Extractor	Rome	Pulls tap root out, no stump left
	Tree Crusher/Chipper	Marathon-Letourneau	Clears wide swath, drums chop branches and undergrowth into mat

used, working with air blast and suction. Even an object as heavy as half a brick can be picked up. The equipment uses air filters for purifying the recycled air.

The "Vac-All" is another kind of equipment based on the same principle. It can remove debris and can be used behind other machines which break the soil or cut the concrete or remove a layer of asphalt. These latter machines are used for road planing. In the past, one used hot planing, meaning that the asphalt was melted with flames. This method has been abandoned because of the hazard represented by the fumes and by the combustible materials that were used to produce the flames. The method used now is cold planing: surface layers of roads are removed with automated machines. Galion and CMI manufacture these machines; they are called scarifiers or pavement profilers.

In the last category are machines used for forest clearing. One of these machines is a tree extractor which removes the stump of the tree at the same time. Because the stump can be a hindrance for subsequent operations, it is best to pull it out with the rest of the tree. Finally, if one has to employ brute force--as is necessary in the virgin forests--tree crushers and chippers are available. These are very powerful machines; they simply destroy everything, and after that one has to remove the litter that is left.

Figure 27.1 shows an Athey road sweeper. There are two small rotating wire brushes called gutter brooms, and another large horizontal brush and hopper behind that brings everything up into the box. Loose objects and dirt can be removed with the wire brush, if it is strong enough, and as much as four cubic yards of material can be picked up.

The FMC machinery shown in Fig. 27.2 can be seen in every city in this country. It is equipped with wire brushes and a cylindrical brush that brings the dirt to a mechanical elevator, which in turn dumps it into a box. Figure 27.3 shows the geometry: all the material is brought in by the rotating brushes and then swept into the hopper by the cylindrical horizontal brush. Figure 27.4 shows a front view of one of the small FMC machines.

Fig. 27.1. Athey Mobil sweeper, equipped with steel-wire gutter and pick-up brooms.

Figure 27.5 shows the Athey force-feed loader: it has shovels that can bring up any material. It can also pick up large windrows on the ground surface. The loader works in conjunction with a truck; it can dump on a truck. It has been used in North Carolina to remove a layer of soil contaminated with PCB.

Another way to pick up debris is the air-blast-and-suction mechanism (Fig. 27.6). A fan blasts air on the ground; there is a turbulent motion, and the air is sucked up again, entraining the debris. The debris remains in the box, and the air goes through a filter and back again to the ground. This is rather safe environmentally, because it is the same air that is recycled; the air is practically not released or exhausted into the environment. Figure 27.7 shows the same kind of system developed by another manufacturer (FMC). There is ample room in the box to hold the dirt picked up. Filters are also used. One of the FMC filtered air sweepers is shown in Fig. 27.8. The pneumatic equipment is visible. There is no mechanical

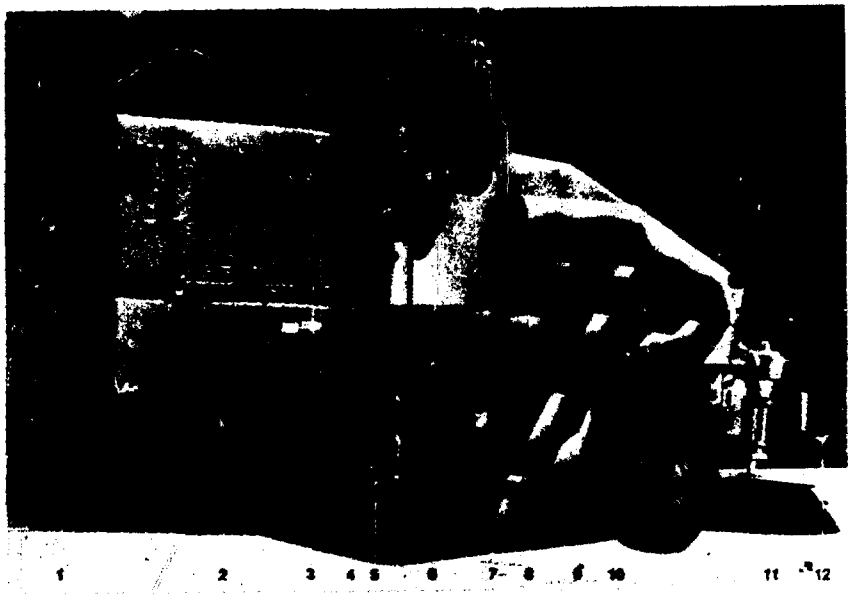

Fig. 27.2. Cutaway view of FMC three-wheel sweeper with 4-cubic-yard box.

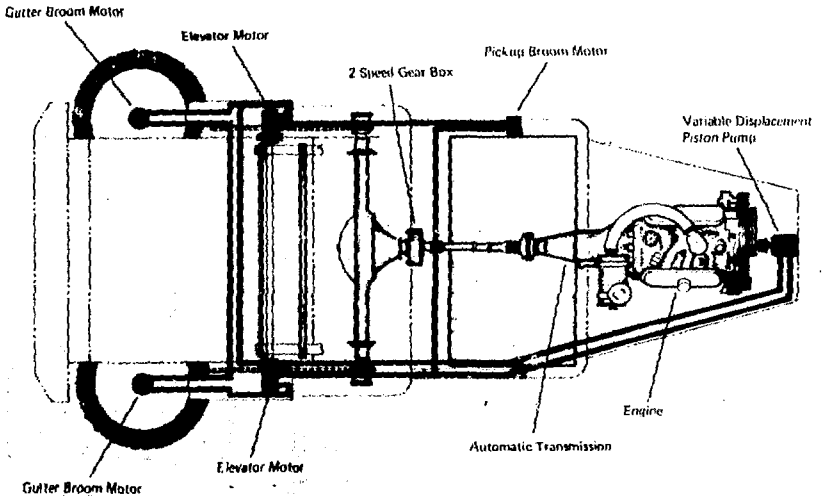

Fig. 27.3. Broom geometry on FMC sweeper.

Fig. 27.4. Front view of FMC sweeper.

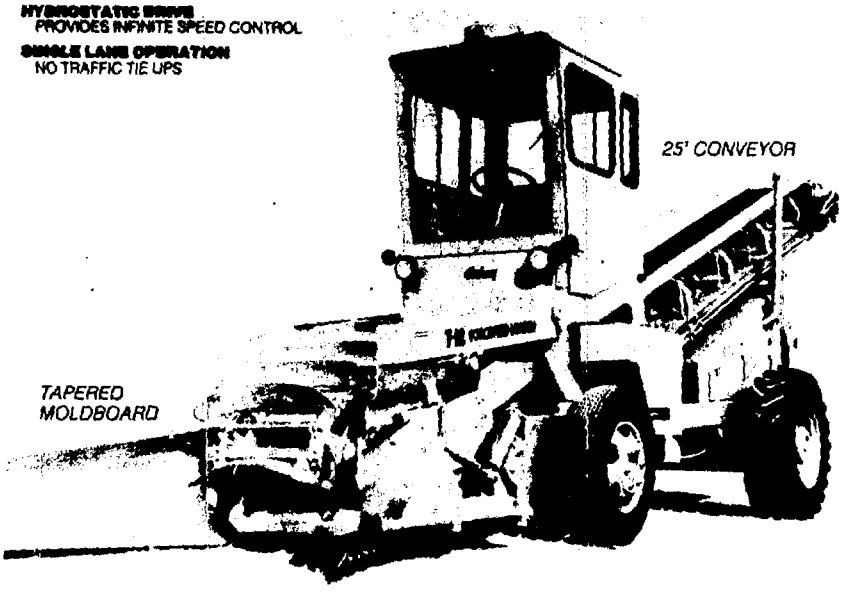

Fig. 27.5. Athey force-feed loader with conveyor.

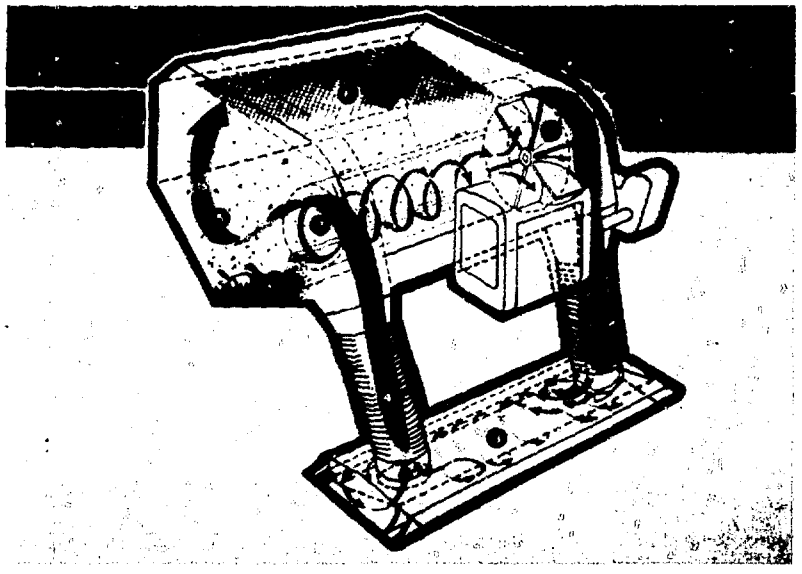

Fig. 27.6. Schematics of Tymco airblast and suction regenerative air system.

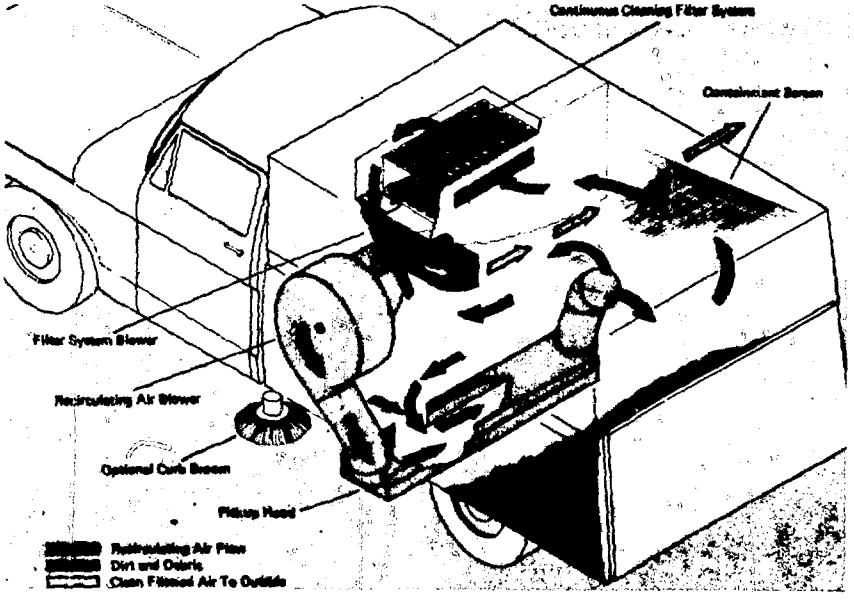

Fig. 27.7. Schematics of FMC filtered air-sweeping system.

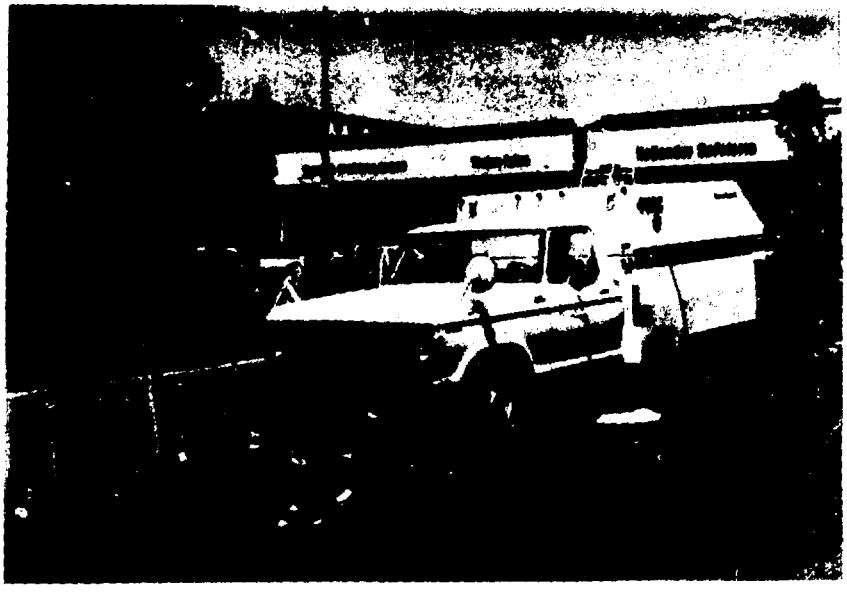

Fig. 27.8. FMC-filtered air sweeper with 4.5-cubic yard hopper.

elevator for the debris; one is only vacuum-cleaning what can be sucked in. This equipment is used extensively in cities. Another brand of the same kind of equipment (Fig. 27.9) is sold under the trade name "Vac-All" for municipal and industrial uses. This is a stronger model; very large models of these are made for industrial users (Fig. 27.10).

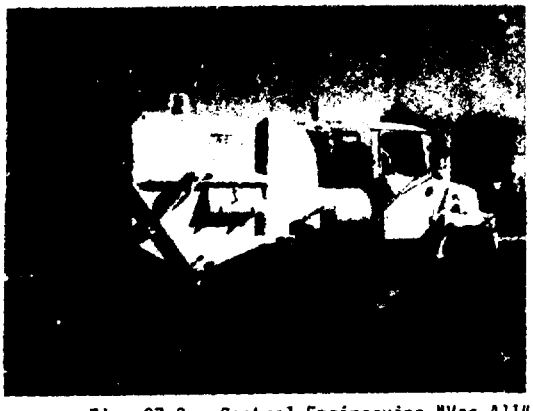

Fig. 27.9. Central Engineering "Vac-All" municipal street sweeper.

An additional feature of this model is a hose that can be used manually to pick up things that have not been reached by the machines. This type of heavy industrial system has been used in conjunction with road planers to pick up the cut debris or material from the road. As an example, Fig. 27.11 shows a Galion road planer; behind it the vacuum-cleaning truck is picking up all the debris that has been cut by the teeth of the planer.

Now we will examine road-planing machinery. The old way of doing the road planing (Fig. 27.12) used flames for removing a layer of asphalt. (Note the flames and release of fumes.) There were many explosions in the fuel tanks of these machines; currently there is a shift towards cold road planing. The Galion machine (Fig. 27.13) I showed you earlier in the photograph with the Vac-All (Fig. 27.11) is equipped with a cylinder that has 200 teeth that attack the pavement.

Another cold planer (Fig. 27.14), manufactured by the CMI Company, is very heavy; it is designed to avoid irregularities in the cutting

Fig. 27.10. Central Engineering "Vac-All" industrial sweeper.

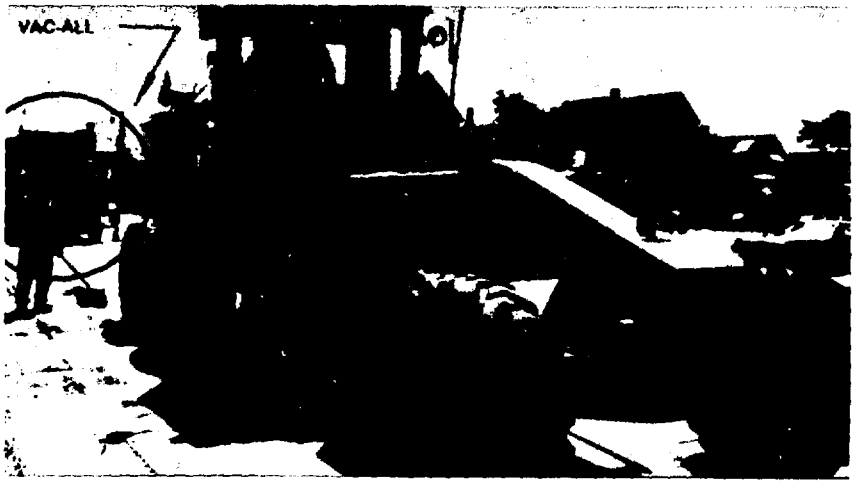

Fig. 27.11. "Vac-All" street sweeper following Galion road scarifier to pick up cut material.

Fig. 27.12. "Hot" method for removal of asphalt layer by road planer.

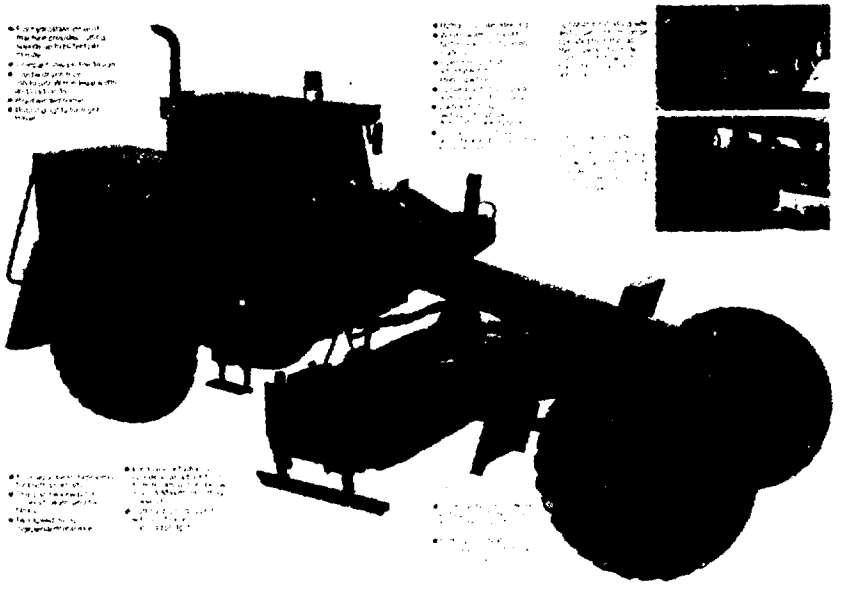

Fig. 27.13. Galion "cold" road planer. The 42-inch-wide cutting drum has a maximum cutting depth of 4 inches.

Fig. 27.14. CMI Rotomill pavement profiler with 80-inch-wide cutter.

level. This company also manufactures an even larger model that can cut up to 12 feet (half a highway) in one pass (Fig. 27.15). It is equipped with a mechanical system to carry the debris up and to dump it into a truck. This is the largest road planer that can be found. It can remove down to 6 inches of concrete but can also remove a layer as thin as 1/4 inch.

Fig. 27.15. CMI Rotomill pavement profiler with 12 ft-6 in. wide cutter.

Now we come to the forestry operation. If the trees are cut with the usual felling equipment, there are stumps that stay in the way of all subsequent operations. Fortunately, a machine has been developed that will pull up the entire tree, with the stump. Vertical blades (Fig. 27.16) go around the stump and cut all the horizontal roots, then the tree is clamped, and the vertical roots are pulled out with the tree. This machine is widely used for cutting pine trees throughout the southeastern United States. It has the advantage of leaving the surface in rather good condition for subsequent cleaning operations. Figure 27.17 shows a tree harvested with the bark and the stump. You can see that this machine is very powerful.

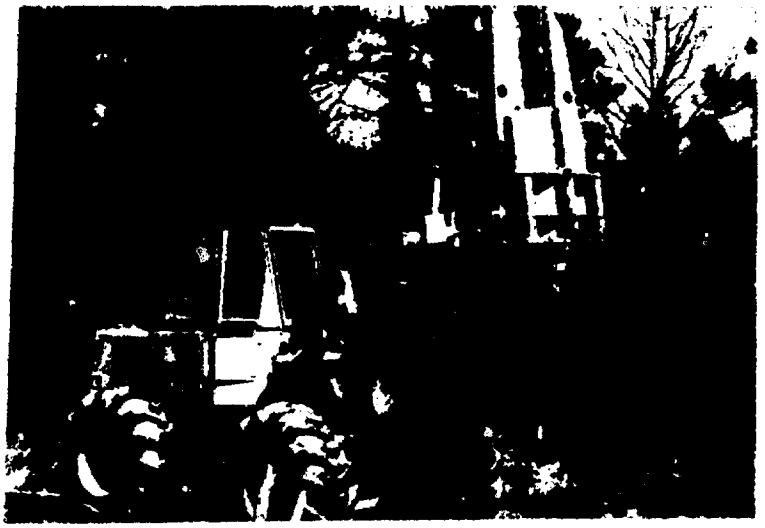

Fig. 27.16. Rome tree extractor harvesting whole tree with stump and taproot.

Fig. 27.17. Tree harvested by Rome tree extractor.

Figure 27.18 shows a machine that is used in the Amazon region in Brazil. This bar simply pushes down the trees that it encounters. On the wheels there are cutting blades that chop and destroy the undergrowth, brush, and the side branches of the trees. This is about the most powerful equipment that can be found: it will crush anything that is in the way. This machine cuts wide swaths in the forest, and after it has passed there is rather little to do; the whole forest is reduced to a litter.

In conclusion, we can say that these machines represent a starting point for the development of the technology required for decontamination. A few additional things are needed as well. First, we need to monitor the radiation field coming from the place decontaminated, so directional radiation counters are needed that will signal when the layer removed is sufficient. There is also a need to investigate shielded cabs, because in some cases radiation levels can be much higher than 2.5 millirem/hour, and a shielded cab can permit working with normal manual control in areas where radiation levels are 10 or 100 times higher than tolerance. Then, because much higher levels can still occur, we need to investigate remote controlled operation of all these machines. Cost and time estimates for the decontamination operations are needed, and the following information will be developed for each machine: the capital cost, the manpower requirements, the maintenance cost (including spare parts and fuel), and the productivity in square meters cleaned per hour. From there we will try to derive estimated costs per unit of area cleaned. It is hoped that this can be done for three models of each machine: the normal manned operation of the current model, the model equipped with the shielded cab, and the model equipped for remote control and completely unmanned operation. In this way, too, we hope to arrive at a better definition of the equipment that is needed and at the real cost of decontaminating.

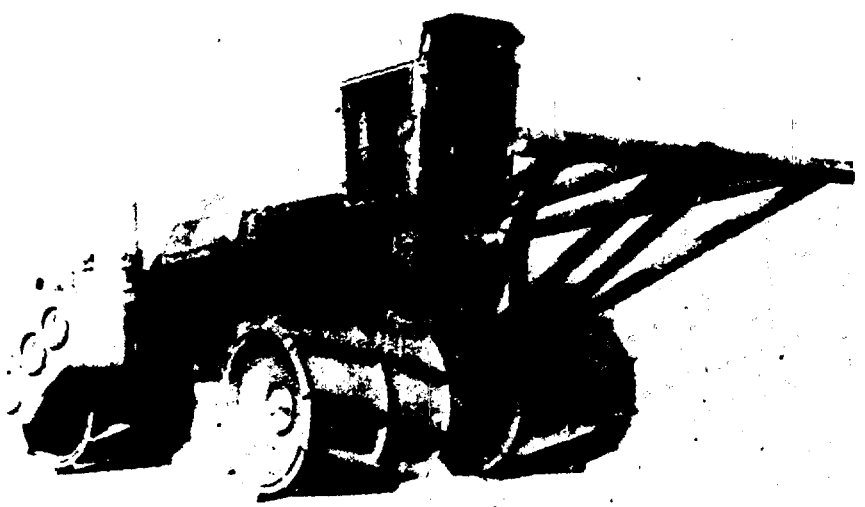

Fig. 27.18. Marathon-Letourneau tree crusher with cutting blades for chopping branches and undergrowth.