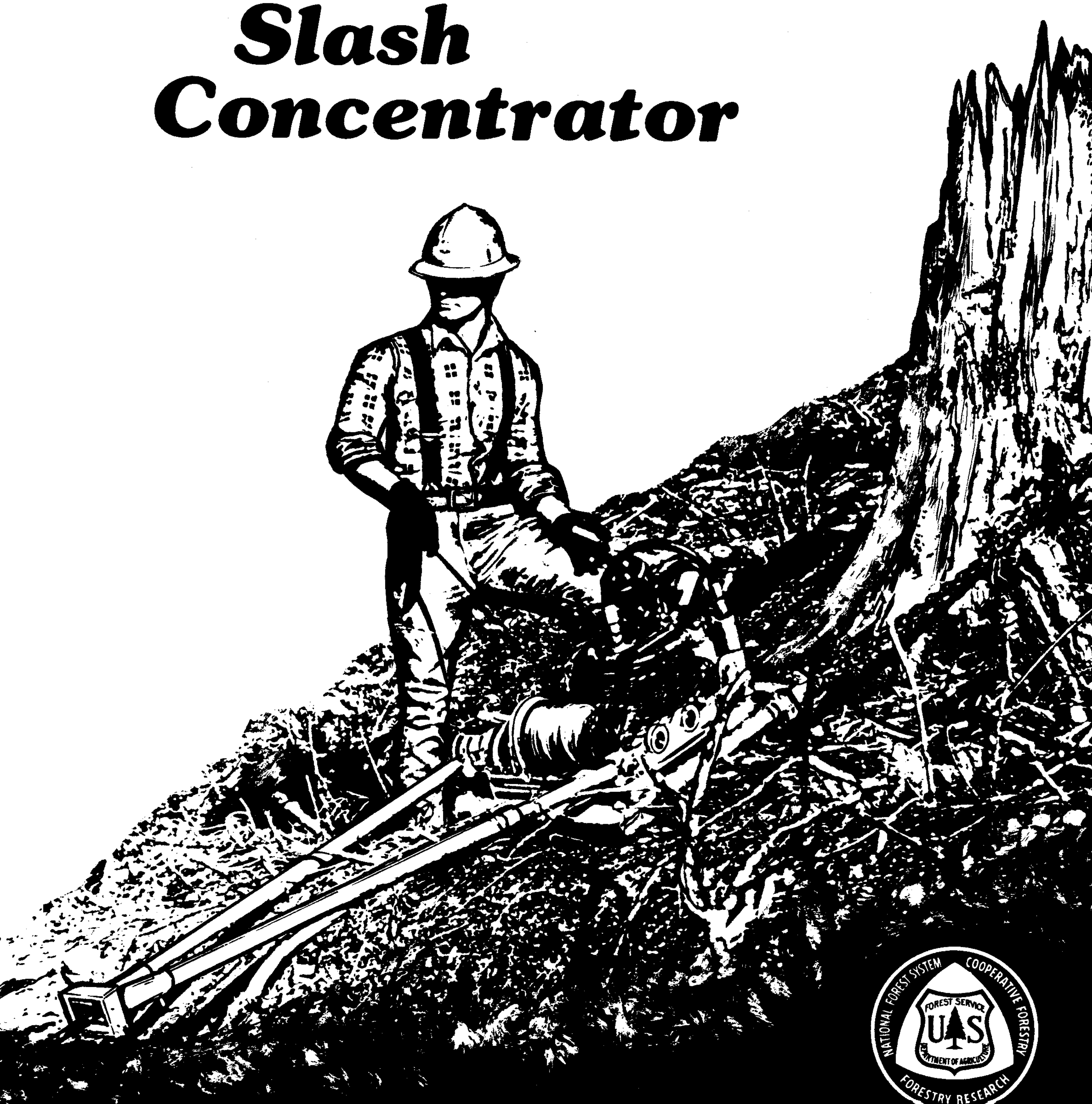
project record
OCTOBER 1979
SAN DIMAS EQUIPMENT DEVELOPMENT CENTER

Slash Concentrator



7924 1207

FOREST SERVICE U.S. DEPARTMENT of AGRICULTURE

Slash Concentrator

by

C. Fred Cammack, *P.E.*,
Mechanical Engineer

and

James W. Tour,
Mechanical Engineer

ED&T PROJECT NO. 2694
STEEP-SLOPE SLASH EQUIPMENT

FOREST SERVICE, U.S. Department of Agriculture
Equipment Development Center, San Dimas, California 91773

OCTOBER 1979

7924 1207

CONTENTS

ILLUSTRATIONS

INTRODUCTION

Treatment of forest residues ("slash") left on steep slopes as a result of logging operations (yarder, balloon, or helicopter) or fuel break construction present a costly problem to land managers. Indeed, mature stands on many steep slopes are not being logged because heavy equipment cannot be used safely, and handcrews are very costly, in slash treatment or disposal. This is especially true when residues are over 3-in (7.6-cm) in diameter and the slope exceeds 50 percent.

The San Dimas Equipment Development Center (SDEDC) was assigned a project in FY 1977 to develop equipment to support handcrews that would improve the efficiency, increase the safety, and lower the cost of handling slash on steep (35 percent and up) slopes. In early 1976, SDEDC had tested a portable winch (manufactured by the Fred A. Lewis Co., Medford, Oreg.) designed for use with a chain saw engine (fig. 1). The tests indicated that, while filling a need in special applications, it does not have the flexibility, reach, or overall safety features desired for handcrews that handle slash.

A market search disclosed that winches capable of moving slash the required distances at reasonable production rates were not designed to be hand-carried and were very expensive (approximately $10,000 and up). Since there was a definite need for a small, portable cable winch that could aid handcrews move slash on steep slopes, a decision was made to develop a winch system (slash concentrator) having the following features:

- Ability to spool 500 ft (152.4 m) of cable

- Capability of developing line pull great enough to move 10-in (25.4-cm) diameter by 10-ft (3.0-m) long slash material–i.e., 2,000 lb (907.2 kg), maximum

- Weigh no more than 200 lb (90.7 kg) so it can be hand-carried by 3 or 4 crewmembers

- Low price (a production model for less than $1,000).

Figure 1. Winch powered by chain saw engine.

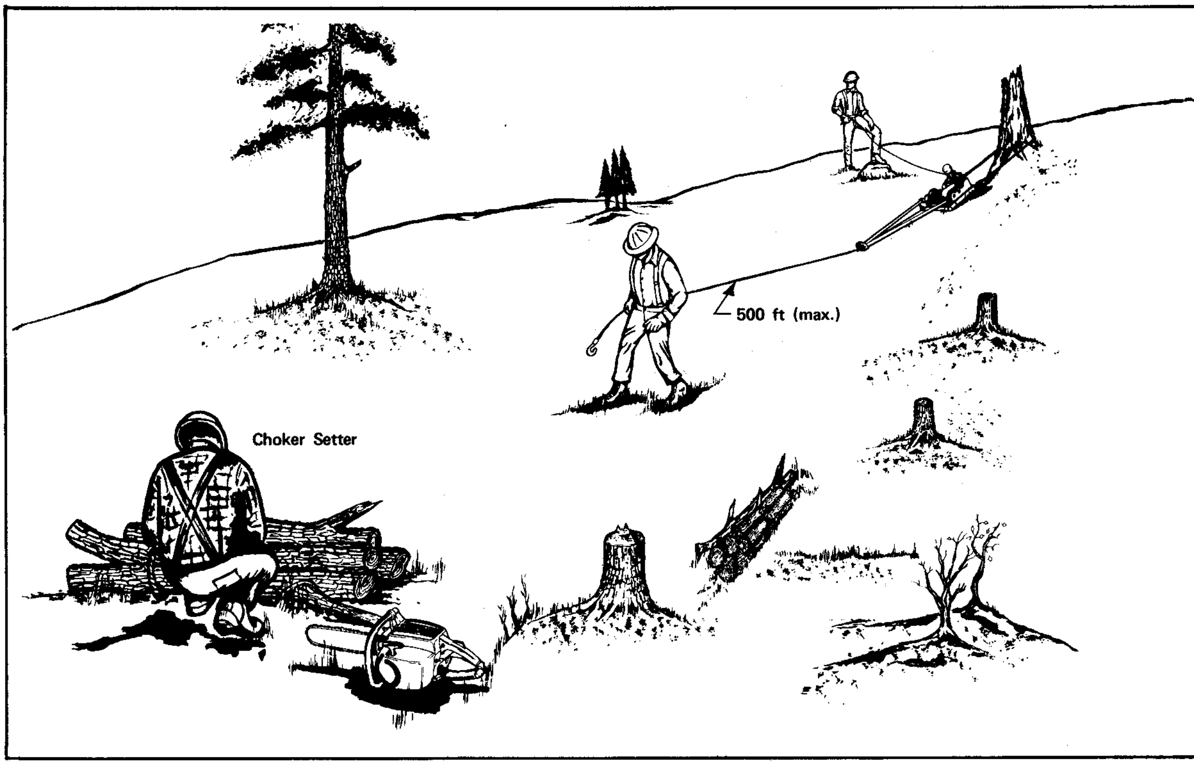


Figure 2. Single-drum approach to slash concentration.

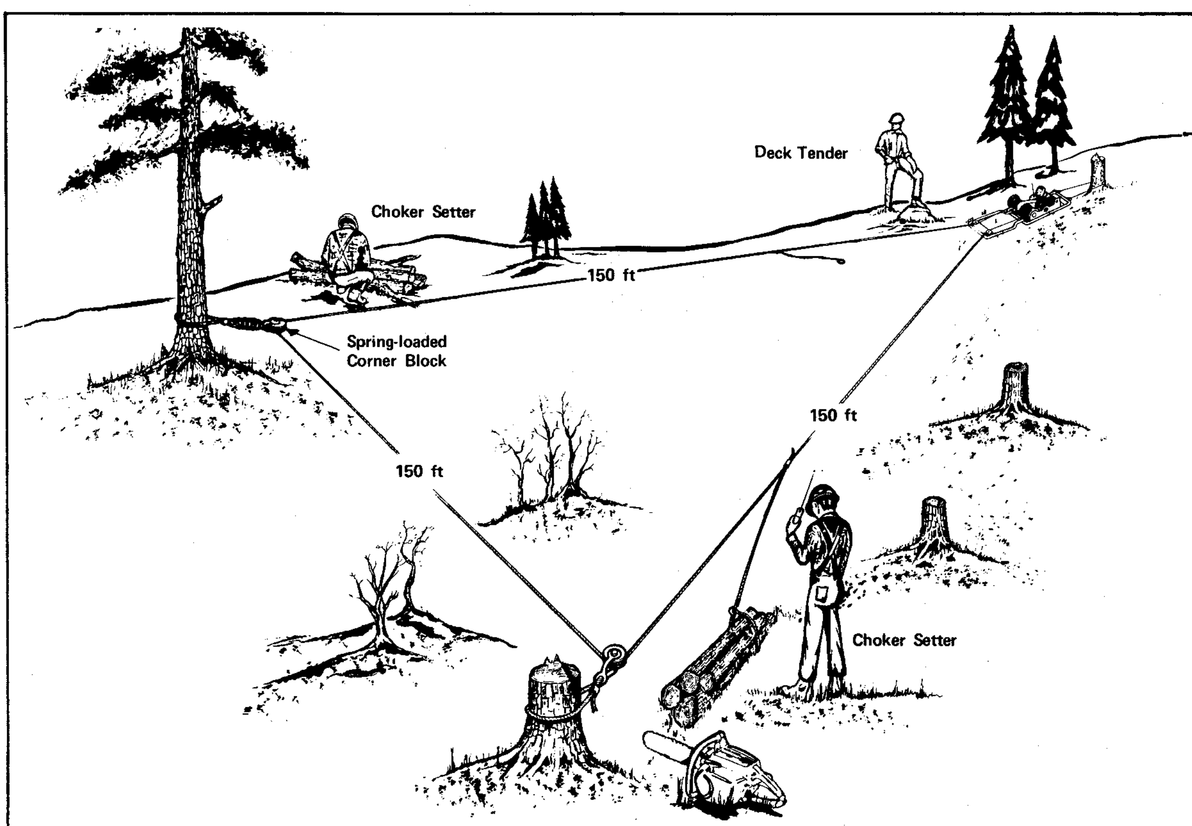


Figure 3. Double-drum approach to slash concentration.

Using these criteria, the development of a diversity of designs was undertaken to optimize a working concept in a minimum amount of time. These were:

1. Single-drum concentrator with direct worm-gear drive

2. Single-drum concentrator with hydrostatic drive

3. Double-drum, remote-controlled concentrator with interlocking drums.

The two single-drum prototypes were designed and fabricated in-house; the double-drum development was contracted to Developmental Sciences, Inc. (DSI), City of Industry, Calif. The basic difference in the operational approach of the two designs is illustrated in figures 2 and 3.

CONCENTRATOR PROTOTYPE DESIGNS

Cable Selection

Galvanized, 3/16-in (0.48-cm) diameter aircraft cable was chosen for all of the prototype machines. This cable has an ultimate breaking strength of 4,000-lb (1814.4-kg) pull, allowing a 2:1 working safety factor for a concentrator design pull of 2,000 lb (907.2 kg).

Single-drum Concentrators

A market search established the availability of several engines that could provide enough torque and power for the concentrators. The weight limitation resulted in the selection of a series of two-cycle engines, available from McCulloch Corp., Los Angeles, Calif., which are rated from 10 to 12 hp (7.5 to 8.9 kW) and weigh less than 13 lb (5.9 kg). The low weight-to-horsepower ratio of these engines meant that the concentrators could be compact and lightweight, and possess the desired performance characteristics.

Both of the prototype single-drum concentrators (figs. 4 through 9) have the following common features:

- A throttle cable assembly 10-ft (3.0-m) long that enables the operator to stand safely off to the side while operating the machine.
- A fairlead/boom assembly that aids in alignment of the concentrator with the incoming load, while minimizing the fleet angle of the cable to ensure orderly spooling of the cable. The boom can freely move up and down, conforming to the direction of pull on the cable.
- A boom assembly that disassembles for use as carrying handles for a two- or three-person portage of the concentrators (figs. 6 and 7).
- A single-cable winch drum.

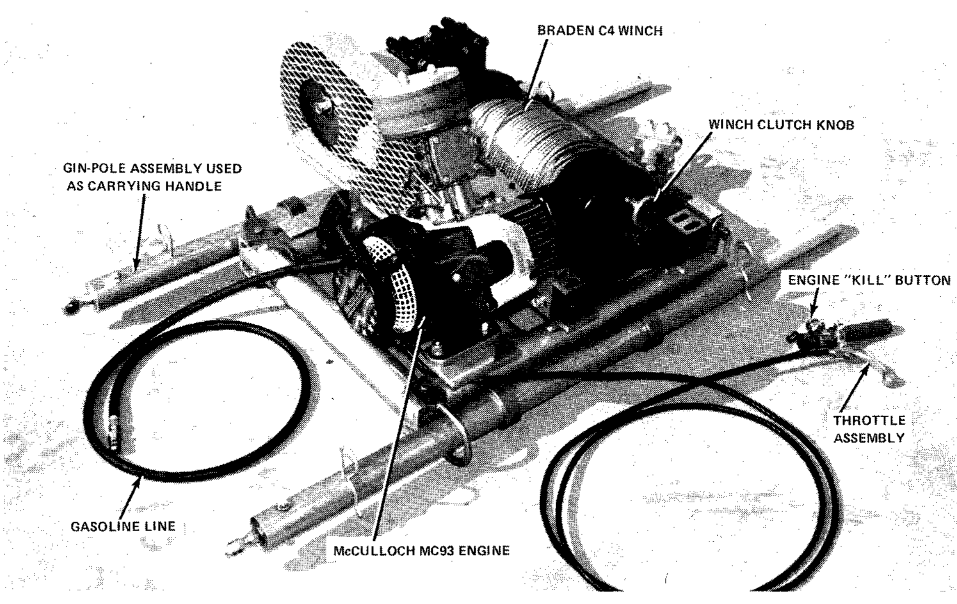


Figure 4. Single-drum concentrator transport configuration.

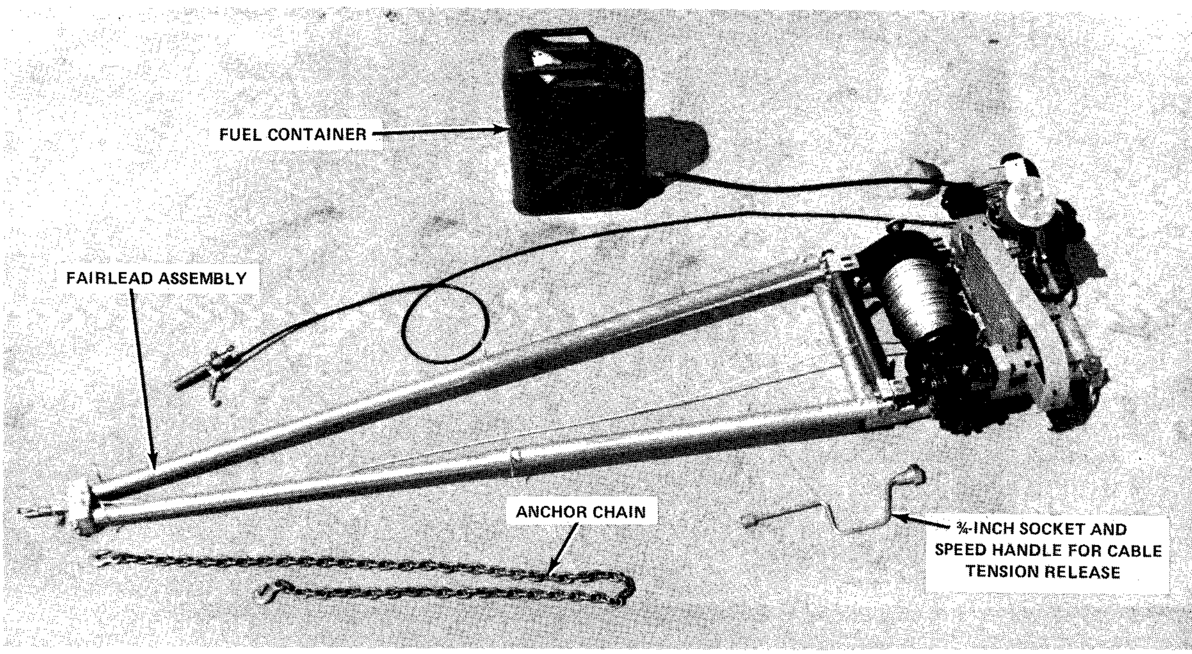


Figure 5. Single-drum concentrator working configuration.

Figure 6. Transport of single-drum concentrator.

The single-drum, gear-drive concentrator (figs. 4 through 7) uses a commercially available winch with a worm-gear drive mounted on an aluminum frame. If engine power is lost, the worm gear serves as a brake. To spool out cable, the winch drum is disengaged from the drive gear by a dog clutch—which is an integral part of the winch—allowing the winch drum to turn freely. To release tension on a loaded cable, the engine must be shut off, and a speed handle and socket used to turn the winch drive sprocket in the reverse direction. Total weight of the winch assembly is 175 lb (79.4 kg)—including 500 ft (152.4 m) of the 3/16-in (0.48-cm) cable, but not including fuel container and rigging hardware.

The single-drum, hydrostatic-drive (fig. 8) uses a commercially available hydrostatic transmission and gear train. The hydrostatic transmission has a five-position selector (two forwards, neutral, and two reverses). The forward and reverse positions are identical in function, with a high speed-low pull (450 fpm or 137.2 m/min-800 lb or 362.9 kg) and low speed-high pull (200 fpm or 61.0 m/min-1,600 lb or 725.8 kg) position. Total weight of the hydrostatic-drive concentrator is 200 lb (90.7 kg)—including 500 ft (152.4 m) of the 3/16-in (0.48-cm) cable, but not including the fuel container and rigging hardware.

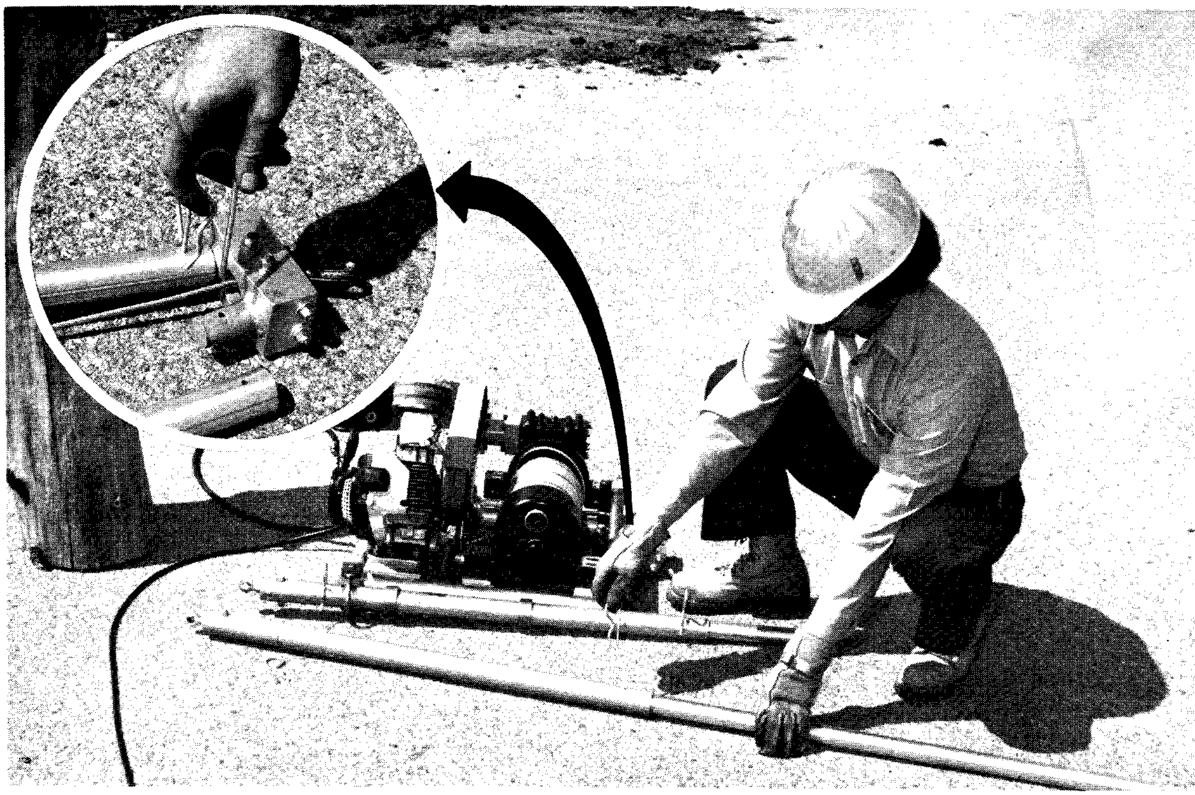


Figure 7. Removing and extending carrying handles to construct the fairlead assembly.

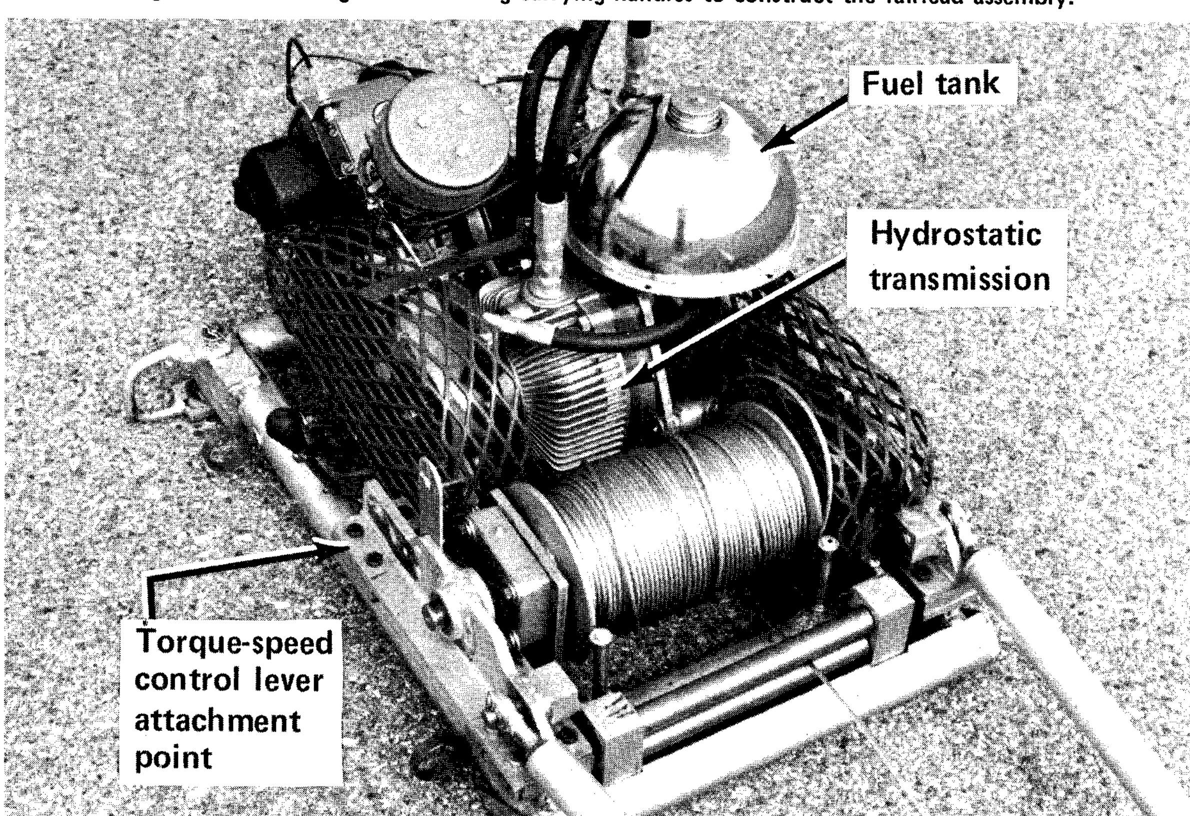


Figure 8. Single-drum, hydrostatic-drive concentrator.

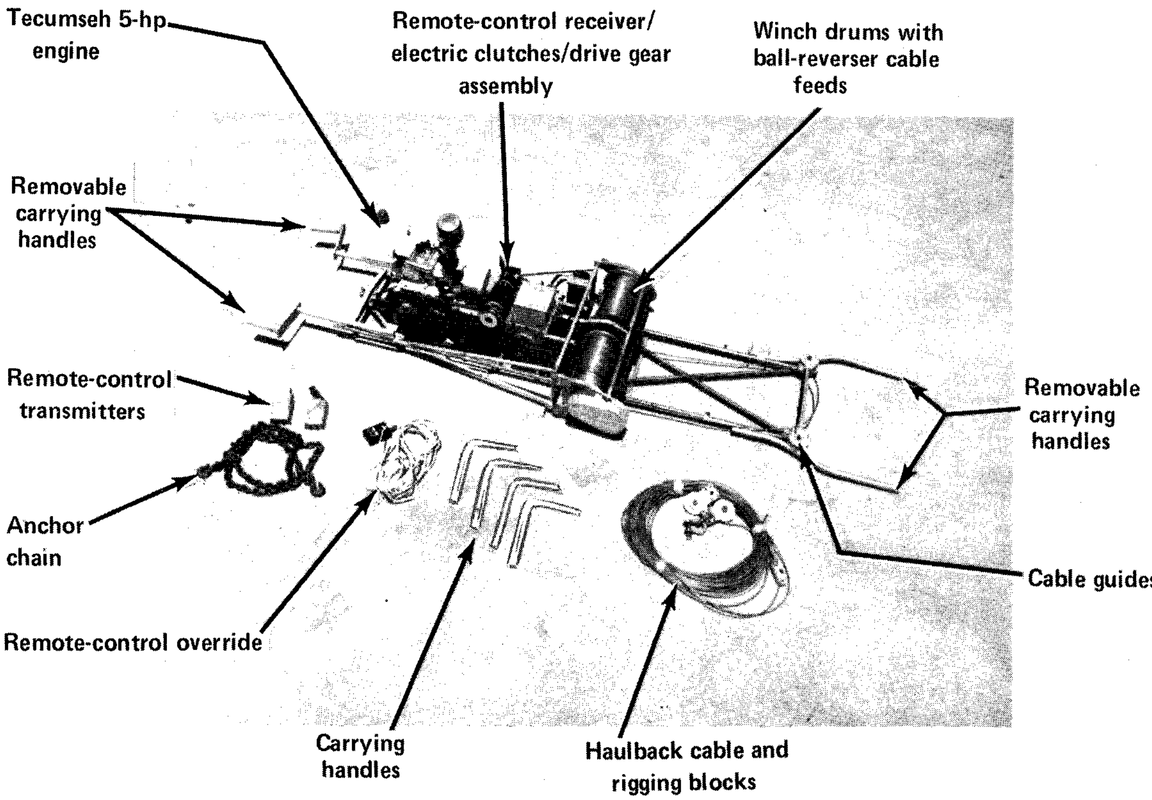


Figure 9. Double-drum, remote-controlled concentrator.

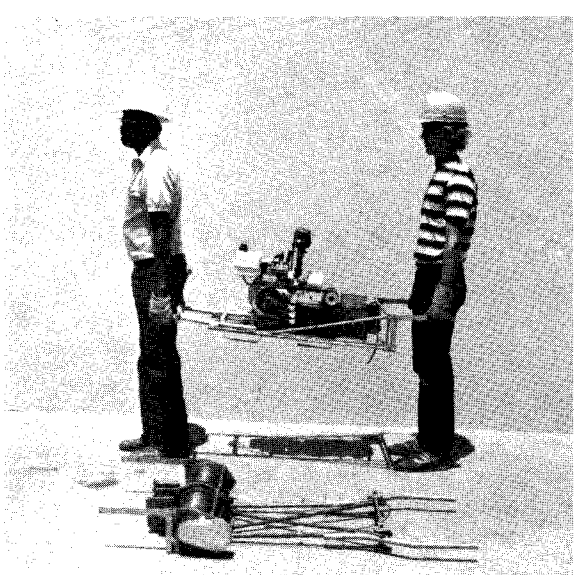


Figure 10. Transport of one of two major assemblies of double-drum concentrator.

Double-drum Concentrator

The double-drum concentrator (fig. 9) uses a 5-hp (3.7 kW), four-cycle engine (Tecumseh Products Co., Tecumseh, Mich.) and a custom-built gear box assembly having electric clutches. Remote-control transmitters, located with the choker setters and deck tender (fig. 3), are used to operate the machine. A ball-reverser feed mechanism facilitates orderly cable spooling. Total weight of this concentrator is 206 lb (93.4 kg); however, it breaks down into two assemblies of 82 and 124 lb (37.2 and 56.2 kg) for a four-person portage (fig. 10). The engine, fuel container, and rigging hardware can be carried separately.

PERFORMANCE TESTS

Preliminary

Preliminary tests were conducted upon delivery of

Table 1. Summary of field tests

MACHINE TESTED	DATE	R5 NATIONAL FOREST	TEST DESCRIPTION	ESTIMATED PULLING DISTANCE (ft)	(m)	SETUP TIME–AVERAGE (min)	CABLE TENSION PER LOAD–AVG. (lb)	(kg)	SLOPE OF TEST SITE (%)	NO.OF LOADS PER HOUR
Single-drum, gear-drive	Aug.'77	Klamath	Removal of slash consisting of 3 to 12 in (7.6 to 30.5 cm) dia. stems, from 6 to 30 ft (1.8 to 9.1 m) long.	100-200	30.5–61.0	30	2,000	907.2	100	5
Double-drum, remote-controlled	April '78	Klamath	Removal of fir stems 3 to 4 in (7.6 to 10.2 cm) dia., from 7 to 8 ft (2.1 to 2.4 m) long. Oak stems up to 14 in (35.6 cm), from 10 to 12 ft (3.0 to 3.7 m) long.	10-30	3.0–9.1	165	1,000	453.6	20-50	5
Single-drum, gear-drive	April '78	Klamath	Removal of fir stems 3 to 4 in (7.6 to 10.2 cm) dia., from 7 to 8 ft (2.1 to 2.4 m) long. Oak stems up to 14 in (35.6 cm) dia., from 10 to 12 ft (3.0 to 3.7 m) long.	30-40	9.1–12.2	15	1,500	680.4	20-50	5
Single-drum, gear-drive	May '78	Sierra	Removal of slash 3 to 12 in (7.6 to 30.5 cm) dia. stems, from 3 to 15 ft (0.9 to 4.6 m) long.	120	36.6	15	1,000	453.6	40	5
Single-drum, hydrostatic-drive	May '78	Sierra	Removal of slash 3 to 12 in (7.6 to 30.5 cm) dia. stems, from 3 to 15 ft (0.9 to 4.6 m) long	120	36.6	15	1,000	453.6	40	5
Double-drum, remote-controlled	May '78	Sierra	Removal of slash 3 to 12 in (7.6 to 30.5 cm) dia. stems, from 3 to 15 ft (0.9 to 4.6 m) long.	120	36.6	165	500	226.8	40	5

the double-drum prototype concentrator and assembly of the two types of single-drum concentrators. The tests consisted of dragging known loads and recording data on load limits, noise levels, operational parameters, safety aspects, support equipment, and needed improvements.

Field Test Program

All three of the concentrators were field tested in the Pacific Southwest Region (R-5) during FY's 1977 and 1978 (table 1). Field personnel recorded data on the number and type of loads pulled and site fuel loadings. They also kept notes on portability, ease of handling, and other likes/dislikes for each machine. Test results were periodically reviewed and used to prepare design modifications for the next generation of hardware.

Single-drum, Gear-drive Concentrator

Setup time for this machine varied between 15 and 30 min, depending on the terrain and the distance from the road to the operation site. In most instances, a three-person carry downhill and a four-person carry uphill was the best transport approach. In areas where there are very moderate (less than 20 percent) slopes, a two-person carry was used for short (200 to 300 ft; 61.0 to 91.4 m) distances. On slopes of 50 percent and greater, the concentrator was used to pull itself uphill. Field personnel comments on the application and efficiency of this machine were as follows:

- Good potential as a tool for aiding handcrews in the piling or moving of slash on steep slopes
- Can be used to remove up to 10-in (25.4-cm) diameter material to locations where they can be burned or decked
- Has potential uses in other

activities—stream and culvert cleaning and support of construction efforts (bridges, trails, structures, etc.).

A minimum crew of five is needed to use this machine efficiently for steep-slope slash concentration—two to gather materials and set chokers, one to operate a chain saw to cut large pieces into manageable lengths, one to operate the concentrator itself, and one to release chokers and return the cable to the choker setters.

With a crew of five, the average operation rate was five loads/hr, with pulling distances ranging from 100 to 200 ft (30.5 to 61.0 m). Cable tensions measured during the testing varied from 500 to 2,000 lb (226.8 to 907.2 kg). Support equipment requirements are three chokers, chain saw, anchor chain, tool set, and firefighting tools. Due to concentrator engine noise, a two-way radio is recommended (but not absolutely necessary).

Single-drum, Hydrostatic-drive Concentrator

The setup time, operational characteristics and procedure, crew size, support equipment, and field comments made were essentially the same for this machine as those for the gear-drive machine, except for the following:

- The winch power-feeds the cable out on this machine (no free-spooling). Because of the gearing, a considerable amount of time was required to power the cable out to the load point.

- The machine operator can constantly adjust the torque-speed control lever on the hydrostatic transmission (fig. 11) to match conditions.

Double-drum, Remote-controlled Concentrator

To set-up this system required between 2 and 3 hr. This included transporting components to the worksite, assembling them, and laying out the cable and corner blocks. The working configuration (fig. 3) covered approximately ½ acre (0.20 ha). Finding corner anchors (standing trees or stumps) appropriately spaced for the three legs of the setup was extremely difficult. The spring-loaded corner block (used to keep tension on the cable and take up the slack produced when a full drum spools off cable at a rate greater than the empty drum can spool it on) is complex and adds a considerable amount of time to the setup procedure. Approximately half the setup time was devoted to balancing the spring-tension adjuster in the corner, and adjustments continued throughout the operation.

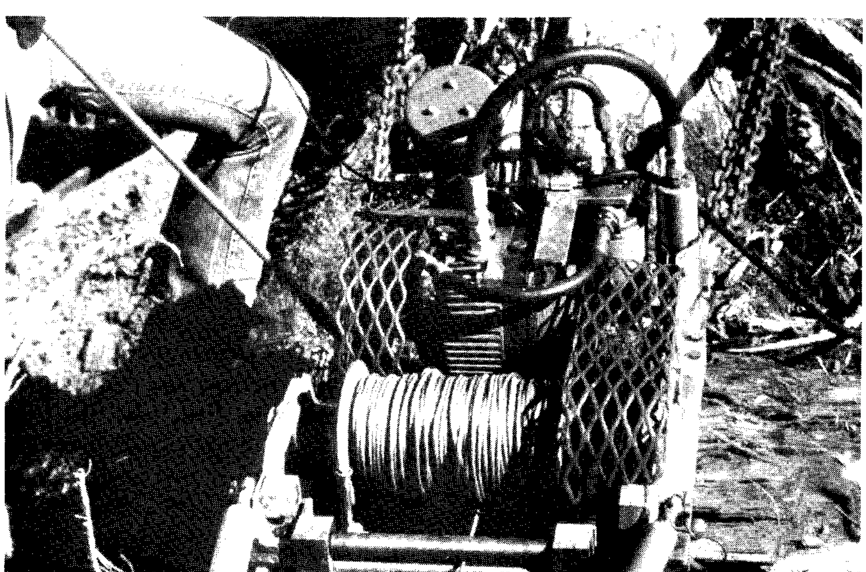


Figure 11. Torque-speed control lever on single-drum, hydrostatic-drive concentrator.

Minimum personnel required is four—two choker setters at the loading area, two (can get by with one) chain saw operators, and a person at the landing to release chokers and, if necessary, manually operate the machine. Support equipment included four chokers, two chain saws, anchor chain, tool set, and firefighting tools. A two-way radio is optional.

Generally, evaluators felt that the double-drum concentrator, in its present configuration, is not a benefit to handcrews. Crews could probably work at approximately the same production rate with or without this machine. Excessive setup time was considered to be a major part of the problem, coupled with a low line-pull capability—i.e., the concentrator appeared to be underpowered. To confirm this, the single-drum, gear-drive machine was used on the same test areas in a comparative test on the Klamath National Forest. In the same amount of time, the single-drum concentrator constructed slash piles approximately three times larger than those constructed by the double-drum concentrator.

The double-drum concentrator proved to be unsuitable and uneconomical. The interlocking drum set does not allow a differential speed control for each drum that would compensate for the variable drum diameters encountered when spooling/unspooling the cable. The automatic spooling mechanism did not improve spooling over that provided by the boom assembly on the single-drum concentrators. Cost of the mechanism is high, and the mechanism increases setup time—since it must be adjusted each time the double-drum machine is moved.

The only advantage of the remote-controlled package and sophisticated gear box assembly is the elimination of a full-time machine operator. The high cost of providing this option make it of doubtful benefit. To develop a suitable double-drum machine with independent drums would result in a concentrator that would be significantly more expensive than the existing single-drum prototypes.

CONCLUSIONS

Of the three design approaches that were evaluated, the single-drum, gear-drive concentrator proved to be the most effective machine for concentrating steep-slope slash. Its capabilities and design features came closest to meeting the criteria established at the outset of the ED&T project. However, indications at this time are that a production version of this machine will cost $2,000+.

The single-drum, hydrostatic-drive machine may offer some operational advantages, if redesigned to add a free-spooling drum. The shifting guide that had been added greatly helped to speed up shifting and, consequently, production rates. Nevertheless, the relatively high cost of the hydraulic drive, compared to that of the more conventional gear drive is hard to justify without evidence of a substantial increase in overall machine performance. A double-drum machine that could compete in all respects with a single-drum concentrator, and still be affordable, probably cannot be attained.

SECOND-GENERATION CONCENTRATORS

Recommendations resulting from the tests of the initial single-drum, gear-drive prototype were incorporated into updated designs and drawings. Eight second-generation prototype concentrators were fabricated by Winman Corp., Covina, Calif. Seven of these prototypes were sent for testing in May 1979 to seven different National Forests located across the country. The eighth second-generation prototype was kept at SDEDC for evaluation. Application test results are to be reported to SDEDC by the users during FY 1980.

RECOMMENDATIONS

Results from the tests on the second-generation, single-drum prototypes should be used to improve still further the design of this particular concentrator. Development of the hydrostatic-drive and double-drum machines should be terminated for now. Only if the lower cost gear-drive concentrator ultimately ***fails*** to fulfill the need, should more sophisticated and expensive machines be looked at again.

EQUIPMENT DEVELOPMENT AND TEST

The Forest Service's Equipment Development and Test (ED&T) program, conducted by two Equipment Development Centers (San Dimas, Calif., and Missoula, Mont.), provides systematic application of scientific knowledge to create new or substantially improved equipment, systems, materials, processes, techniques, and procedures that meet the objectives of advanced forest management and utilization in the United States. The ED&T effort, featuring Mechanical Engineering activities, encompasses projects in forest engineering, aviation and fire management, recreation, timber, range, wildlife, occupational safety and health, forest insect and disease, and forest residues to enable forest work to be performed more efficiently, at less cost, with minimum hazard.

As needs for field development services are identified and defined, the Centers determine if already available commercial products are suitable as is or if they require modifications necessitated by the forest environment. On the other hand, sometimes needs can only be met by the Centers taking advantage of the latest technology to create new concepts through a step-by-step product development program. These developments are typically achieved by active ED&T involvement with disciplines found throughout the Forest Service. The new equipment is field tested and demonstrated and user feedback is obtained to evaluate results. The role of the Centers is not considered complete until project output is implemented in the field.

FOREST SERVICE USDA • SAN DIMAS • EQUIPMENT DEVELOPMENT CENTER