HANDBOOK

RANGE SEEDING EQUIPMENT

DESCRIPTION OF EQUIPMENT ADAPTED OR DESIGNED FOR USE IN RANGE SEEDING AND NOXIOUS RANGE PLANT CONTROL

U. S. DEPARTMENT OF AGRICULTURE, U. S. DEPARTMENT OF THE INTERIOR,
RANGE SEEDING EQUIPMENT COMMITTEE

REVISED JANUARY 1957

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FOREWORD

In this publication the Range Reseeding Equipment Committee has attempted to assemble from all sources the best information on equipment used in range reseeding and noxious plant control work. This information should be of value where new equipment is to be purchased or the replacement of old equipment is contemplated. In general, the Committee has attempted to specify the conditions most suited for each type of equipment. The contents are not final or entirely conclusive and will be improved ultimately by future suggestions from the field. This is the third revision, and several significant changes have been incorporated as a result of trials and suggestions from the field.

The Range Reseeding Equipment Committee appointed a subcommittee from members of the participating agencies and charged them with the responsibility of bringing the handbook up to date. In this revision, many people prepared material intended for the Handbook or wrote reports that served as the basis for descriptions of certain equipment. Because of the number of people and the lack of author identity in previous editions, no attempt has been made to give authorship credit. The subcommittee served merely as a review board, functioning mainly to assemble and present the material in the format requirements of the Handbook. The names of this subcommittee are listed to show agency representation.

A. C. Hull, Agricultural Research Service
A. L. Hafenrichter, Soil Conservation Service
Royale K. Pierson, Bureau of Land Management
Joseph A. Wagner, Bureau of Indian Affairs
Eugene Silva, Forest Service
K. W. Parker (Chairman), Forest Service.

PREFACE

This handbook is issued in loose leaf style to facilitate future revision and to permit ready insertion of other pertinent information.

Breakage of equipment and unsatisfactory performance have been largely caused by one or all of the following:

1. Lack of training, improper maintenance, usage, and adjustment of equipment. Operating hints and instructions prepared by the Committee and the grease charts secured from implement houses should be provided and followed carefully by each operator.

2. Too much power for the equipment used. Equipment built for use with a 35 hp. tractor is literally torn apart when pulled by a 70 or 80 hp. tractor. The power unit should always be balanced with the equipment it is pulling, or a "weak link" should be used in the hitch.

3. Excessive speed of operation. A speed of 2 to 2-1/4 miles per hour for plowing, harrowing, railing, or drilling results in less breakage and greater effectiveness and should not be exceeded.

4. Use of equipment improperly designed for the site being treated. This can be minimized by making every effort to purchase or construct makes and models that so far have proved most efficient and durable.

In each chapter the discussions on equipment point out the necessary specifications for the most desirable makes and models, giving consideration to what is now available. When evaluating specifications, keep in mind that many companies have optional extra heavy or extra strong parts, which can be secured. For example, for the wheatland-type plow some companies have special hitches for crawler tractors and special alloy disks and spools. In putting out bids every effort should be made to specify these extra strong optional parts, which are also available for wheel-type tractors.

Detailed specifications for equipment not commercially available and information on adapting various makes and models for use on rangelands may be obtained by writing to the following:

Arcadia Equipment Development Center
Forest Service, U. S. Department of Agriculture
701 North Santa Anita Dr., P. O. Box 586,
Arcadia, Calif.

SAFETY IN THE USE OF REVEGETATION EQUIPMENT

Each piece of equipment presents hazards peculiar to it alone. To list all the precautionary measures essential to safe operation of the implements described in this handbook would be difficult. Suffice to say that, if costly accidents are to be avoided, the person in charge of the revegetation work should analyze the equipment to be used, determine the hazards connected with its operation, and instruct and orient the operators in its safe and proper use. Safety Codes and Safety Handbooks, where available, should be placed on every job.

A few suggestions to be considered in safety planning which should precede all revegetation projects follow:

1. Insofar as possible, use only experienced operators.
2. Keep the machinery clean, well lubricated, and in first-class operating condition.
3. Observe operating instructions.
4. Never grease or repair equipment while it is in motion.
5. In the use of aircraft, observe CAA regulations.
6. Use protective clothing and equipment on all jobs requiring it.
7. Never smoke in the vicinity of flammable material.
8. Never work directly under hoisted equipment.
9. Never mount moving equipment or dismount from it.
10. Furnish solid footing, readily available hand grasps, and protection from moving parts to men who must work on moving equipment.
11. Use the proper method of lifting; avoid lifting excessive weight.
12. Frequently check hitches, hoist cables, and other equipment items that are subject to frequent and heavy strain.
13. Respect the rear end of a horse.
14. When using equipment on slopes, plan ahead for safety.
15. Think safety and work safely.

CONTENTS

A. GROUND PREPARATION OR MECHANICAL ERADICATION EQUIPMENT

Offset Disk Harrows Including Horse Portable

Offset disk harrows consist of two gangs of disks mounted on separate frames, one directly ahead of the other so that the soil is thrown in one direction by the lead gang and in another by the rear. Essentially, this is a two-way disk plow with the entire weight resting on the disks. It differs from the disk tiller or wheatland-type plow that has one-way action and is supported by wheels. When used under similar conditions, breakage is usually less on offset disk harrows than on disk-tiller plows.

These implements may be purchased commercially in various sizes from 4 feet or less to 14 feet in width, with disk sizes ranging from 16 to 32 inches, and construction light to extra heavy. For convenience, offset disk harrows are separated into four classes: extra heavy duty, heavy duty, light duty, and horse portable extra light duty.

Extra Heavy Duty

Description. The extra heavy duty harrow conforms to the general design of an offset disk harrow but is built heavier throughout (fig. A-1).

Figure A-1. --Extra heavy duty offset disk harrow.

Adaptability. This implement is broadly adaptable in preparing seedbed for rangeland revegetation.

Advantages:

1. The harrow is the best implement available for heavily crusted or compacted rock-free soils.

2. Breakage is light in rock-free areas or where rocks are small and loose.

3. The disk is one of the most effective implements available for removal of deep-rooted plants where penetration up to 8 inches is necessary for high mortality.

4. The disk normally removes a higher percentage of sagebrush on rock-free areas with once-over treatment than do most other types of equipment.

5. The cutaway disks, available on this equipment, do a better job of cutting the vegetation into mulch than do other disks or plows.

6. High mortality of undesirable annuals and other forbs normally are obtained by use of this disk.

Limitations:

1. Much more power is required than for other types of disk harrows and approximately double that for the brushland plows.

2. Breakage is excessive where many large rocks or solid outcrops are encountered.

3. Depth of plowing is difficult to regulate without depth regulator attachments. The looser the soil, the deeper the cut.

4. When disks become worn or broken and partial replacement by a new, larger diameter disk is necessary, all disks in the section must be replaced to prevent excessive strain on any one or any group of replaced disks. (Not a serious limitation.)

5. In some makes of the extra heavy offset disk, the tongue assembly is not heavy enough, and reinforcement or redesign is necessary. On some makes the tongue does not permit towing in a noncutting position.

6. High mortality in the desirable grass, forbs, and browse species normally is caused by treatment with this equipment.

7. Clogging between disks often occurs in heavy, willowy brush, particularly when the ground is moist.

8. Because of limited coverage, treatment with this plow is somewhat costly.

Power Requirements. An 80 db. hp. tractor is needed to pull a 10-foot model. More power is necessary on steeper slopes.

Specifications:

Disks--28 to 32 inches in diameter (complete or cutaway), heavy duty, alloy heat-treated.

Spacing--9 to 12 inches.

Spools--Extra heavy duty.

Bearings--Metal, dust sealed, fitted for high-pressure lubrication.

Arbor bolts--Not less than 1-3/4 inches in shortest dimension.

Weight--500 pounds or more per foot of cutting width.

Frame--Extra heavy forged or welded into solid construction.

Adjustments--Adjustable for right or left turns.

Angling devices--Proper controls for changing the angle of disk gangs shall be provided.

Leveling devices--Disk harrows shall be equipped with some means for holding the gangs approximately level with enough flexibility to permit them to follow uneven ground.

Accessories--All special tools, such as the gang-lock-nut wrench, shall be included.

Hitch--Crawler-tractor type.

Heavy Duty

Description. This implement conforms in design to an offset disk harrow but is heavier than most standard makes, and is usually referred to as "heavy duty" by manufacturers (fig. A-2).

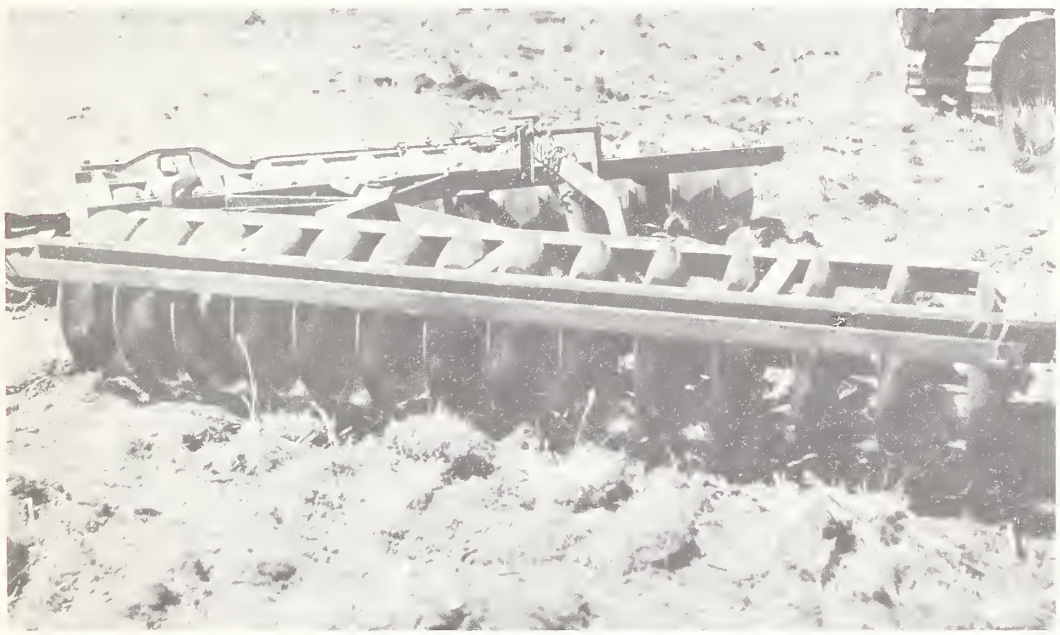

Figure A-2.--Heavy duty offset disk harrow.

Adaptability. This equipment has proved effective in removing sagebrush provided the soils are not too rocky. It has been effective in firm soils similar to those on which the use of the extra heavy duty type is recommended but additional weight must be added, and even then it is often necessary to go over an area twice. Because of the additional strain caused by adding weight, excessive breakage may result if these plows are used constantly on firm soils.

Advantages:

1. Maintenance costs are much lower than for wheatland-type plows. Little breakage is encountered under normal operation.

2. The implement is reasonably effective for fairly rock-free areas and will stand a limited amount of weighting down to plow firm soils.

3. Dependent upon the uses to be made of the units, any size may be purchased up to a 14 or even a 20-foot cutting width if a squadron hitch is used. If a hitch is secured that is designed for a specific size and make of tractor, the implement may be turned either right or left and can be backed for short distances.

4. Using tractors of similar power ratings, more ground can be covered with this weight disk than with the extra heavy duty disk in areas where vegetative cover and soil are light enough to be effectively farmed.

Limitations:

1. Use must be confined to relatively rock-free soils to obtain the best results and to reduce excessive breakage.

2. Offset disk cultivation usually loosens the soil deeply and as a result will kill out the native grasses.

3. Depth of plowing is not easily controlled unless depth regulators are used.

4. Disks often chip on rocks, and if the gang assembly is allowed to loosen, disks, spools, and arbor bolts will break.

5. The size of brush that can be effectively removed with this equipment is more limited than that effectively treated with the extra heavy duty disk.

6. In heavier brush stands, disks do not cut deeply enough to effectively kill deep-rooted resprouting plants.

Power Requirements. A 45 db. hp. tractor is needed for a 10-foot model on fairly level ground and a 70 db. hp. tractor for a 14-foot model.

Specifications:

Disks--26 to 28 inches, heavy duty, alloy heat-treated.

Spacing--9 inches.

Spools--Extra heavy duty.

Bearings--Antifriction preferable, oil bath second choice.

Arbor bolts--Not less than 1-1/8 inches in shortest dimension.

Weight--250 pounds or more per foot of cutting width.

Frame--Extra heavy forged or welded into solid construction.

Adjustments--Adjustable for right or left turn.

Angling devices--Proper controls for changing the angle of disk gangs shall be provided.

Leveling devices--Disk harrows shall be equipped with some means for holding the gangs approximately level, yet which allows flexibility and permits them to follow uneven ground.

Accessories--All special tools, such as the gang-lock-nut wrench, shall be included.

Hitch--Crawler-tractor type.

Light Duty

Description. This implement contains the fundamental features of all offset disk harrows; because of the comparatively lighter construction and weight, it is designated here as "light duty." Some manufacturers may classify their harrows of this class as "heavy duty."

Adaptability. Harrows in this category have proved to be well suited for small pilot plantings and for the removal of undesirable annuals, for open stands of small sagebrush, and for use on mountain parks having loose textured soils.

Advantages:

1. This lighter implement is more easily transported than the heavier offset disks, brushland plow, or other heavy implements, such as the wheatland-type plows.

2. The power required is also less than for the heavy types indicated above and therefore is more economical to operate.

Limitations:

1. This light unit has a somewhat limited range of usefulness. It is not effective on dry, hard soils even though additional weight is used.

2. Like other offset disks, to obtain the best results the soil should be fairly free from rocks. Cultivation with this type of equipment usually kills the desirable native vegetation that may be on the area.

Power Requirements. Power requirements will vary with harrow widths. A 6-foot harrow requires a 20 db. hp. tractor on fairly level ground; a 30 db. hp. tractor is needed for a 9-foot width.

Specifications:

Disks--20 to 26 inches (complete or cutaway), alloy heat-treated.

Spacing--7 to 9 inches.

Spools--Extra heavy duty.

Bearings--Antifriction; sealed oil bearing, second choice.

Arbor bolts--Not less than 1 inch in shortest diameter.

Weight--185 pounds or more per foot of cutting width.

Adjustments--Adjustments for right or left turns.

Angling devices--Proper controls for changing the angle of disk gangs shall be provided.

Accessories--All special tools, such as the gang-lock-nut wrench, shall be included.

Hitch--Wheel or crawler-type tractor, depending on use.

Horse Portable, Extra Light Duty

Description. This implement conforms to the general design of an offset disk harrow except that it is adaptable to horse-drawn operation and breakdown for packhorse transportation (fig. A-3). It is smaller and lighter than the harrows of the light duty class. Each gang has eight 14-inch disks spaced 6-5/8 inches apart.

Adaptability. This harrow has been modified for use on alpine weed types to which the only means of transporting equipment is by packhorse. The disk may be readily dismantled for transportation by packhorse.

This implement is effective when used singly in light growth of annual weeds under proper moisture conditions. However, it is better adapted for use as a complement to the alpine cultivator, especially where taprooted herbaceous plants are a part of the ground cover.

It may be pulled either by light crawler or wheel tractors, or if a dolly and pole is attached it can be horse-drawn by two or three horses. In horse-drawn operation, rock baskets have been designed for adding weight as needed to the rear gangs. These baskets are collapsible to facilitate transportation by packhorse.

Advantages:

1. Easily pulled--may be either tractor or horse drawn.

2. Maneuverable and light.

3. Breakage is nominal in fairly rock-free areas. It can be used on moderately rocky ground with care by operator to avoid larger rocks.

4. Trip action can be made from either front or rear.

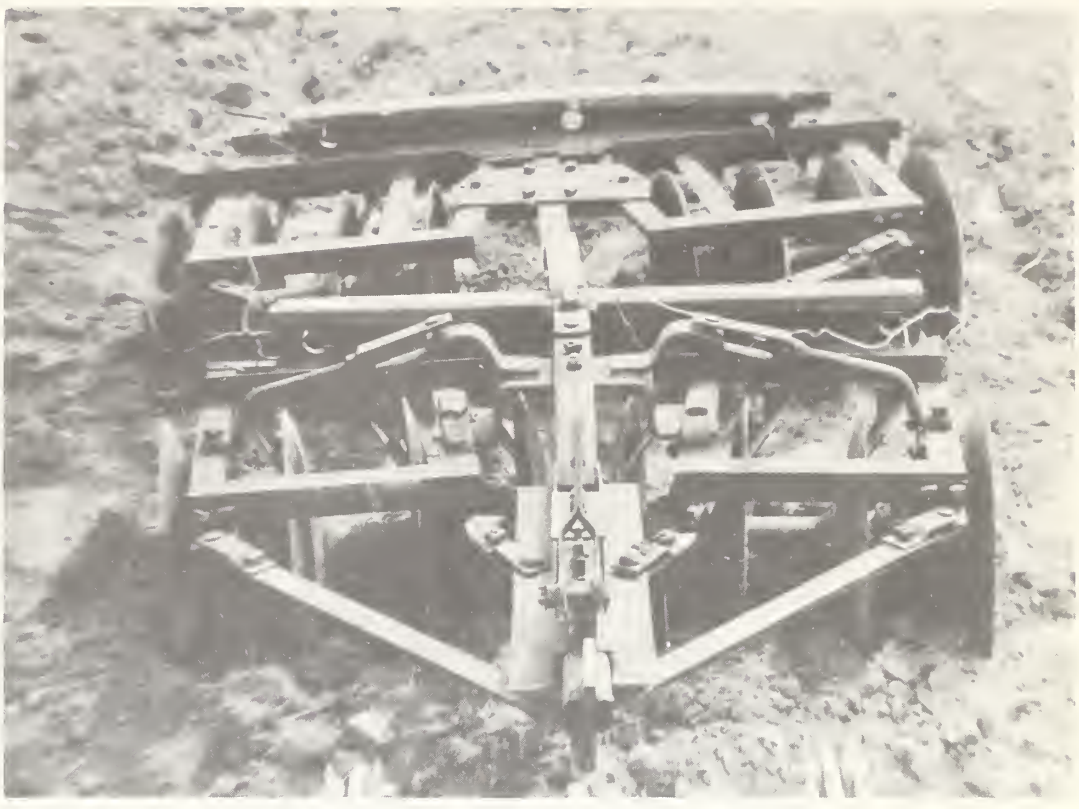

Figure A-3.--Horse portable, extra light duty, offset disk.

Limitations:

1. Because of narrow width (4 feet) ground coverage is extremely slow.

2. When used singly, effectiveness is limited to areas of light annual weed type.

Power Requirements. A 20 db. hp. tractor or 2 or 3 horses.

Specifications. Since this piece of equipment is not commercially manufactured with modifications, specifications can be obtained from the Arcadia Equipment Development Center.

Alpine Cultivator

Description. This cultivator is a wheeled implement with two rows of staggered shanks (a total of nine), which pivot horizontally from the forepart of a solid frame (fig. A-4). Each shank is equipped with spring arms, which provide for release and reset upon striking obstructions. Depending upon need, these shanks may be used with duck foot shovel points 2 inches or 6 inches wide. Total weight 472 pounds.

Adaptability. The alpine cultivator may be used for deep taprooted weeds and is readily dismantled for packhorse transportation into alpine areas that are not accessible by road.

It is adaptable to tractor operation or, by attaching a long tongue, to horse-drawn operation. Penetration from 5 to 14 inches can be obtained depending upon power source. It may be used singly, but in heavier soils a second coverage with a horse portable offset disk of extra light construction provides a better seedbed.

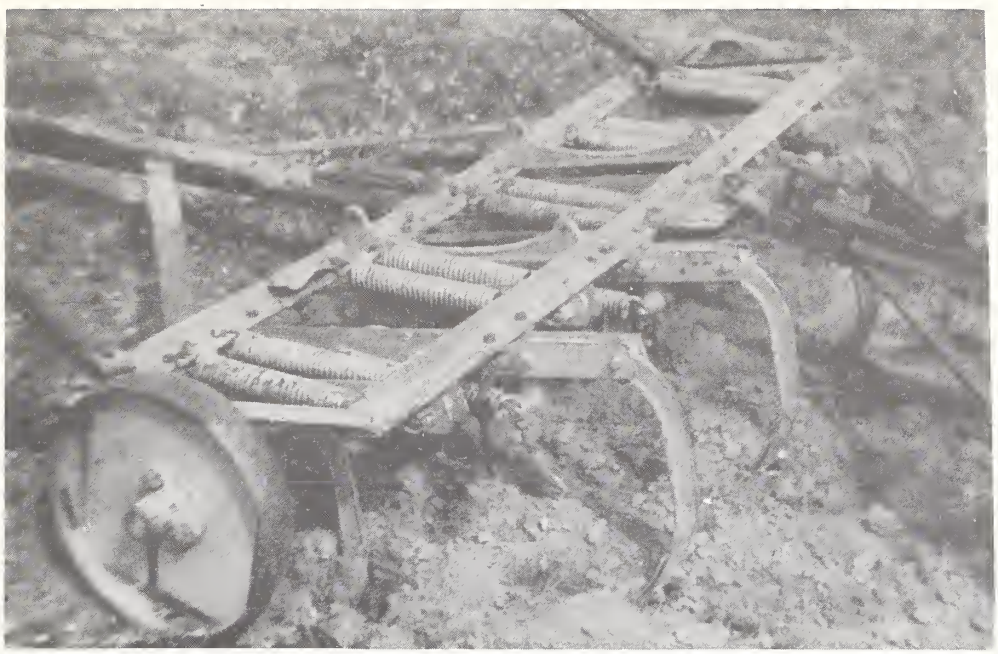

Figure A-4. --The alpine cultivator.

Advantages:

1. May be readily dismantled for transportation by packhorse.
2. Adaptable to either tractor or horse-drawn operation.
3. Maneuverable and light (total weight 472 pounds).
4. Breakage is nominal even on somewhat rocky ground.
5. Penetration up to 14 inches allows for removal of deep taprooted herbaceous plant cover.

Limitations:

1. Horse-drawn operation does not provide best depth penetration. Small crawler tractor is most satisfactory.
2. When operating in dense stands of rank weed growth (i.e., Veratrum), the cultivator tends to clog up under the frame, thus the shovels are lifted out of the ground. The cultivator must then be cleaned by hand.
3. There is a tendency for the machine to jump downhill when striking rocks on slopes of 20 to 30 percent.
4. Turning the cultivator on slopes overloads horses and small wheel tractor units.
5. Larger horses are required to pull this implement. Three or four are desirable.
6. The tongue is heavy on horses necks.
7. The effectiveness of the alpine cultivator is limited to weed type or very small light brush.

Disk Plows

Standard Disk Plow

Description. The standard disk plow usually has one to six disks with an average cutting width of 9 inches per disk (fig. A-5). Each blade has a separate bearing and is slanted at an angle to the vertical. This angle on some plows can be adjusted for different soil conditions. The implements are supported by wheels and have adjustable depth control.

Figure A-5.--Standard disk plow.

Adaptability. The disk plow is comparable to a moldboard plow in the type of work it can do. It is usually used for deep plowing. The disk will do satisfactory work in heavy brush, rockier ground, or sticky soil where a moldboard plow cannot be used effectively.

Advantages:

1. This implement is most effective for plowing thick stands of heavily taprooted competitive plants, such as Wyethia, in firm soils.

2. It can be forced to penetrate soil that is too hard and dry for the moldboard plow and will also handle sticky soils where a moldboard plow will not scour.

Limitations:

1. The narrow width of cut, combined with heavy draft requirements, usually makes this implement too costly for range reseeding work.

2. The plow cannot be used where large, imbedded rocks are present.

Power Requirements. A 60 to 70 db. hp. tractor is needed to pull a 6-gang plow with a cutting width of 54 inches.

Wheatland-Type Plow
(One-way disk, disk tiller, vertical disk)

Description. The wheatland-type plow consists of a series of disks that are spaced at fixed distances on a common axle or gang bolt (fig. A-6). The axle with the vertical disks rotates as a unit and at an angle of 35° to 50° with the line of

travel. The machine is supported by three wheels designated as front furrow, land, and rear furrow. Both leveling and depth of penetration adjustments are essential parts of the design. This plow first came into widespread use in the Great Plains about 1927.

Figure A-6.--Wheatland-type plow.

Adaptability. The wheatland-type plow, as a brush eradication implement, is best suited to the removal of sagebrush on fairly rock-free ground. When operating under such conditions and in proper adjustment, brush kills of 80 to 95 percent can be obtained.

Advantages:

1. Plowing depths can be adjusted to fit varying soil conditions. In general, satisfactory brush kills can be obtained without plowing more than 2 to 4 inches deep.

2. The wheatland-type plow will kill 5 to 10 percent more sagebrush than the heavy offset disk.

Limitations:

1. Careful and frequent maintenance is essential to prevent unnecessary breakage. Much greater care is required than when using the offset disk harrows.

2. Because of the number of adjustments, the fairly light frame, and the rigidity of design, breakage and inefficient operation are often common.

Power Requirement. A 40 hp. crawler-type tractor provides sufficient power for a 9-foot plow in fairly level ground.

Specifications:

Disks--26 or 28 inches in diameter, heavy duty, alloy steel disks spaced 10 inches apart. Super alloy disks are desirable.

Weight--300 pounds or more per foot of cutting width.

Bearings--The land wheel bearing and thrust bearing should be antifriction.

Spools--Extra heavy duty.

Hitch--Crawler tractor type. This hitch is longer and heavier than the hitch for wheel tractors. At least one manufacturer has a special spring release hitch that appears to be desirable in eliminating excessive strain. However, as far as is known, this device has not been field tested in our work. No hitch can withstand backing or right turns without undue strain.

Lift--A mechanical power lift is desirable.

Seeder box attachment--See Section D. Ground Seeding Equipment.

Eccentric Disk Plow

Description. One type, commercially produced at the present time, has eccentric disks that are 20 inches in diameter with mounting holes 2 inches off center. Between the two eccentric disks, there is an 18-inch disk with a hole in the center. The eccentric disks are arranged spirally so that only every fourth eccentric disk is cutting its full depth at any time. The eccentric disks cut about 3 inches deeper than the concentric ones and leave the surface of the soil pitted--6,000 to 7,000 pits to the acre (fig. A-7).

Figure A-7.--Eccentric disk plow.
(Photo by Soil Conservation Service.)

The conventional wheatland-type plow can be converted for pit plowing by placing every other disk 2 inches off center.

Adaptability. The eccentric disk plow is useful for pit plowing, which may prove desirable for some ranges, particularly in the Southwest. This plow is

primarily useful for rejuvenating rangelands by increasing moisture infiltration and retention. Eccentric disk plows are not effective in removing plant competition preparatory to reseeding.

Specifications. Not enough is known about eccentric disks of various types to set up specifications.

Brushland Plow

Description. In the winter of 1947-48 the Forest Service Equipment Laboratory (then in Portland, Oreg.), under the direction of the committee, developed a new disk-type plow called the brushland plow (fig. A-8). The principles of disk plowing and disk tilling were followed except that disks are mounted in pairs and are held in the ground by spring tension. If a solid obstruction, such as a rock or a heavy root is met, the obstructed pair of disks raises while the others continue to work.

Figure A-8.--Brushland plow, 1948 model.

The implement is rugged with a steel frame, all-steel castings, and sealed roller bearings, and weighs nearly 6,000 pounds. The plow has a 10-foot cutting width.

The original plows placed in service in 1949 had disk-bearing failures, structural weaknesses, and some undesirable features. These were corrected by the Arcadia Equipment Development Center in the 1951 units. A single tail wheel replaced the dual wheel assembly, and the point of attachment was moved ahead to improve maneuverability. The 1951 units are shown in figure A-9.

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Figure A-9. --Brushland plows in tandem.

The current design now incorporates a strut or provision for attaching a strut for tandem-hitch operation. The plows of 1955 design have dual rear wheels and can be readily used either singly or in tandem when supplied with the strut on the front plow.

The 1955 design uses a cartridge-type bearing, which has no inner sleeve. The disk shaft directly contacts the bearing inner race and provides a rigid assembly with less chance of losing the bearing adjustment. For units built previous to 1955 the bearing can be used if the shaft is replaced with the same newer design. Other bearings of the spherical roller type can be substituted for the conical roller type. Design details can be obtained from the Arcadia Equipment Development Center.

Failures that may occur:

1. Axle breakage. To avoid breakage, larger axles and a standard Timken hub should be adapted to the wheels. Drawings available for making this change may be obtained from the Arcadia Equipment Development Center.

2. Disk-bearing failure has been materially reduced. Two test arms were made by Arcadia Equipment Development Center and have operated trouble free for years. All new plows should be equipped with this improvement.

Adaptability. The machine is primarily adapted for plowing sagebrush lands. It will tolerate considerable rock without excessive breakage and in this respect is possibly superior to other implements used in ground preparation.

The brushland plow can be converted to an effective pitting implement by removing all the standard circular disks. These are replaced by mounting 28-inch cutout disks at the end and center positions, according to experience in the Bureau of Land Management. Specifications for the cutout disks may be obtained from the Arcadia Equipment Development Center.

Advantages:

1. Extremely low breakage and maintenance cost are the outstanding features of this plow even when used on moderately rocky sagebrush lands.

2. Sagebrush removal is nearly 100 percent where the soil is fairly free of rock and 90 percent or more even where fairly rocky conditions exist.

Limitations:

1. Heavy initial cost. The present cost per plow is approximately $4,000 (1955 prices).

The plow is not now commercially available but may be in the near future. In the meantime its unavailability should not be a serious limitation since it may be readily secured on special order.

To insure proper service from the plow, it must be mechanically inspected by competent people at frequent intervals and must receive proper lubrication and everyday minor maintenance. The plow will produce a suitable seedbed and eradicate brush efficiently if it is properly adjusted and maintained. Like other plows the disk angle must be set for each soil and ground cover condition. Large woody plants are more difficult to cut than small grasslike competition; therefore, the disks must be maintained sharp and set at the best cutting angle. If plowing is to be done in exceptionally rocky areas, no attempt should be made to maintain razor-sharp disks. Plowing in rocky areas necessitates a reduction in speed, and therefore a corresponding reduction in acres plowed is to be expected.

Transporting the brushland plow is best accomplished with a "lowboy" or truck and a semitrailer equipped with a special hoist. A trailer bed 26 feet long should accommodate two plows (1951 design). These plows have single rear wheels and no disassembly is necessary. Loading and unloading the plows should be done by people used to handling heavy machinery.

Power Requirements. A 40 db. hp. crawler tractor can handle this plow on fairly level ground. Ordinarily a 60 to 70 db. hp. tractor is more suitable where the ground is steep. An 80 db. hp. tractor can pull two brushland plows under normal conditions of terrain and soil.

Costs. Costs vary according to size of individual areas to be plowed and the amount of rocks encountered. On areas smaller than 50 acres, or on larger areas broken by numerous gullies or tree clumps, costs will increase appreciably. Some 1954 average costs per acre are:

Big sagebrush, few rocks, areas over 100 acres	$2..73
Snakeweed, few rocks, areas over 100 acres	2.37
Snakeweed, numerous lava stones, areas 30-100 acres ..	4.43

Baby Brushland Plow

Description. Equipment was needed which would give about the same ground preparation as the brushland plow, but which could be transported more easily. During 1953, when a baby brushland plow was needed to establish pilot plots of 5-10 acres, Region 3 of the Forest Service developed a pilot model (fig. A-10).

Construction. The baby brushland was made from two arms, springs, and disk assemblies removed from one large brushland plow. The disk arm springs were mounted vertically in order to hold the length of the plow to a minimum. A special frame to mount the disk arms and vertical springs was constructed with a drawbar attachment arranged to pull the plow and allow the 3-point hitch to control raising and lowering. A depth limiting chain was attached to each arm. This design permitted the plow to float from side to side on a 3-point hitch drawbar. In this way it sought its own draft position and thus reduced to a minimum side thrust shocks on the tractor. A spring-loaded thrust wheel was provided to stabilize the disk side thrust. Standard parts were used throughout wherever practical.

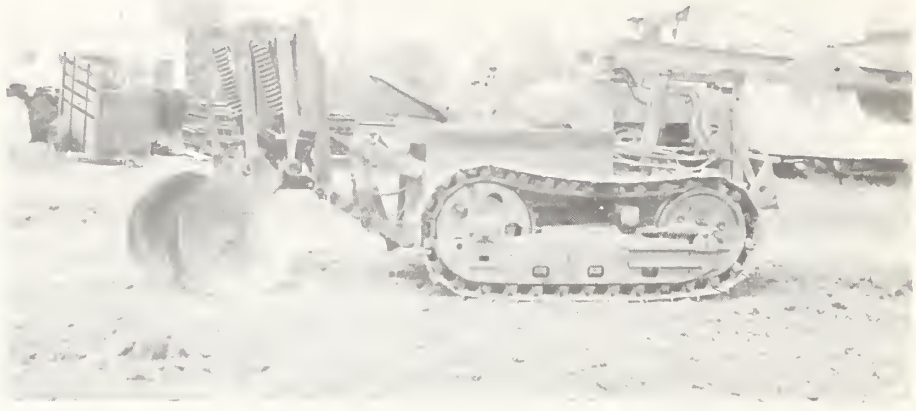

Figure A-10.--Pilot model, baby brushland plow.

The plow can be operated with a 22 hp. drawbar pull, crawler tractor. It weighs 1,200 pounds and cuts a 30-inch swath.

The pilot model has been used successfully on several plots under varying conditions. The possible deficiencies noted are:

1. Steering corrections needed, often in hard or rocky soil.

2. In heavy, compact soils, ground preparation may not be satisfactory unless area is double plowed.

Hula Dozer

Description. The hula dozer in the hands of a skilled operator is a versatile machine that will do a number of different types of improvement work efficiently, in both timbered and rangeland areas.

It is a hydraulic power-controlled tilt dozer equipped with four removable digging teeth mounted in a fixed position on the moldboard (fig. A-11). A tooth shank is mounted on each end of the dozer blade; two tooth shanks are spaced evenly between them; each tooth is mounted above the dozer cutting edge.

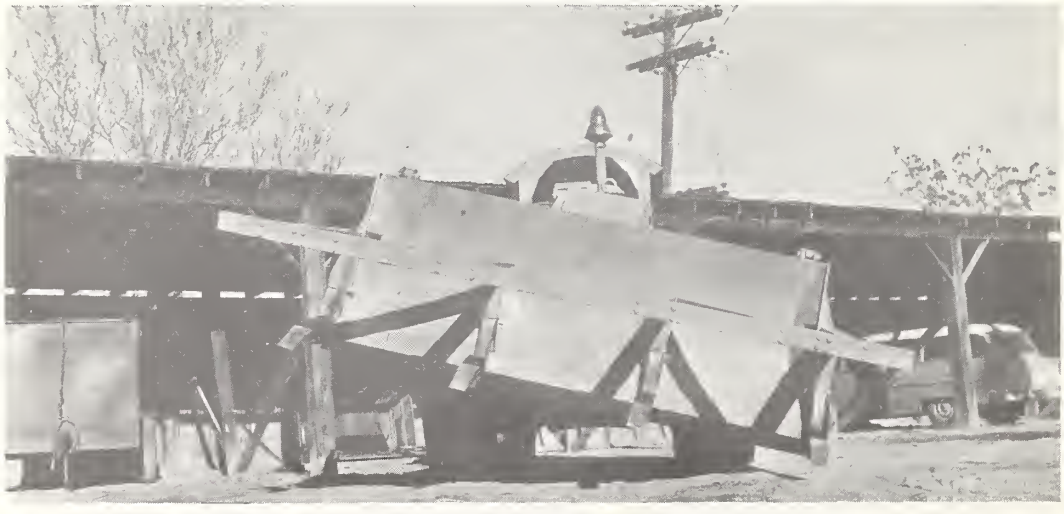

Figure A-11.--Crawler-type tractor equipped with hula dozer.

All moldboard adjustments are made from the operator's position by two control levers, which actuate a dual valve front end hydraulic pump driving from the engine. Two tilt cylinders are pivot-mounted, one on each side, anchored to the dozer push arm. The piston rod is attached to the top of the dozer.

The dozer push arms are pivot-mounted on the rear side of the dozer moldboard approximately 12 inches above the cutting edge. If both cylinders are fully expanded by the pistons pushing forward on the top of the moldboard, they produce the maximum "pitch" to the blade. In this position the teeth extending about 20 inches in front of the blade are pointed downward in order to penetrate the soil.

This feature permits the operator to adjust the digging angle of the four teeth from 15° if the moldboard is retracted at the top to a maximum tooth angle of approximately 45°. If one cylinder is held stationary and one expanded the full stroke of the piston, the digging tooth on the stationary side will raise; thus the opposite tooth will be lowered and placed in a digging position approximately 3-1/2 feet below the raised tooth.

The hinged push bar is an attachment. It can be removed or replaced from the moldboard by one man in approximately 10 minutes. The push bar is a little longer than the dozer moldboard and is supported approximately 4 feet ahead by 4 support arms, each fitted with a hinge-bearing pin and hinge shank. The height of the push bar in relation to the ground is determined by the pitch and tilt adjustment of the hula dozer. The push bar contacts the tree 6 to 12 inches above the ground. The tractor pushes the tree over, and as the root system turns up toward the tractor the hinged bar slides up the trunk and relieves the force at this point. Simultaneously, the tooth timing allows the tooth digging point to slide under the root ball, jacking it out of the ground.

Adaptability. The hula dozer is versatile in that it can adjust its moldboard and the tooth angle while the tractor is working. A steep tooth angle permits rapid penetration, and by reducing the tooth angle a mechanical advantage approaching 20 to 1 makes it possible to increase digging and moving efficiency from 30 to 100 percent as compared to a conventional dozer. Converting the hula dozer from an earth mover to a brush or rock rake is done in a matter of seconds.

Advantages:

1. The hula dozer meets a great many needs efficiently and effectively in timbered areas as follows:

   a. Slash piling.
   b. Flood control work, including seedbed preparation in excavated areas and old logging roads, contour construction on steep or low slopes, and gully plugging.
   c. Road building.
   d. Fireline construction.
   e. Digging out and moving boulders for bridge construction or changing stream channels.

2. In rangeland improvement work the hula dozer is used primarily for stock tank or water development and juniper control work. However, in addition to accomplishing this work, the tractor may also be used as a draft machine.

3. Dozers with teeth, when used for tree removal, have less contact area at ground surface and consequently disturb less grass sod and earth than conventional dozer blades.

4. In earth movement, the hula dozer is able to dig quickly into hard-packed earth (including soft or stratified rock formation); thus the moldboard is loaded in a shorter distance with less power than a conventional dozer. Tooth angle and side

tilt can be changed by the operator while working. Hence, it is possible to take advantage of the increased power available through the wedging action of the teeth.

Limitations:

1. As yet, hula dozer equipment has not been designed for larger tractors, such as those with a 150 db. hp., which might prove useful to remove low-value trees under most rugged conditions. Similarly, such equipment has not been designed for small tractors in the 20 to 35 db. hp. class, which could be employed on recent invasions of small trees 1 to 4 feet high.

2. The hula dozer requires an operator of above average skill.

Costs. Tree removal costs vary according to the number of trees per acre, as well as soil and rock conditions and species of trees. Some 1954 average costs were:

Alligator juniper, 22 trees per acre	$2.22
Alligator juniper, 38 trees per acre	2.74
Utah juniper, with some pinyon, 85 trees per acre	3.95

Power Requirements. Crawler-type tractor with minimum of 80 db. hp. and a minimum of 17,000 pounds drawbar pull.

Pipe Harrow (Dixie Harrow)

Description. The pipe harrow is a series of spiked pipes (usually 10 to a section) trailing lengthwise behind a spreader bar, swiveled so that they rotate freely, and thus they clean themselves of trash (fig. A-12). Sleeves to prevent pipes from jumping across one another are provided for work on sloping ground. The spreader bar is attached to either a multiple hitch bar (if used in multiples) or to four cables evenly spaced on the spreader bar, which converge at the point of attachment on the power unit.

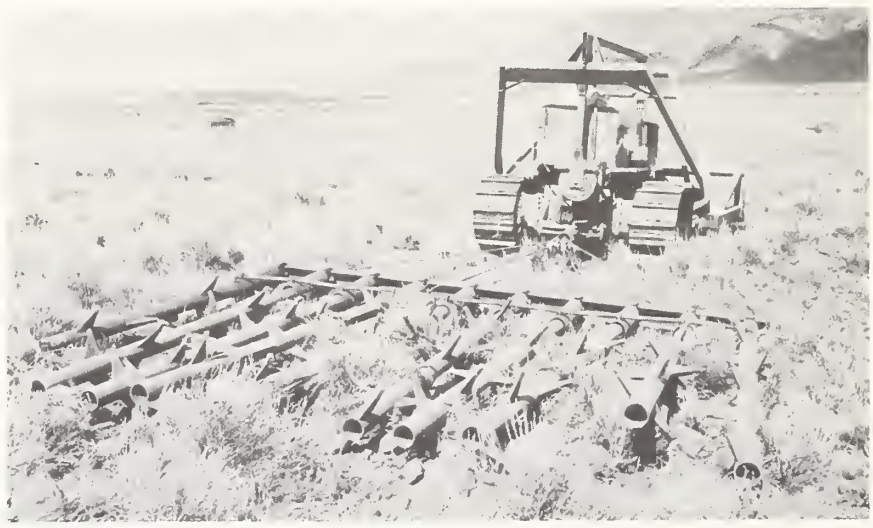

Figure A-12. --Pipe harrow.

Adaptability. This implement was devised for removal of mature sagebrush on moderately to extremely rocky ground where sufficient soil remains to insure seeding success. The ripping and gouging action caused by the pipes bouncing along the rocks removes from 30 to 70 percent of the sagebrush and disturbs enough soil for seed coverage. Twice-over application is recommended to obtain satisfactory sagebrush removal. The direction of travel should be reversed the second time for maximum effectiveness.

The primary place for the pipe harrow seems to be as a complement to a plow or disk on projects where there are both relatively rockfree and rocky areas to be seeded. The harrow should be used on those portions that are too rocky to plow. This permits treatment of all the area needing seeding as one project. The pipe harrow is also effective in covering broadcast seed on rocky scablands, burns, abandoned roads, or excavation scars where competition reduction is not a problem.

The harrow is a poor choice if other, more effective machinery will work satisfactorily without undue breakage.

Advantages:

1. This implement makes it possible to treat some very rocky ground that other machines, including the brushland plow, cannot work.

2. Breakage is nominal on pipe harrows. Swivels and teeth show the most wear.

3. Operating cost on rocky areas is less, because of low breakage, than that of other machinery.

4. Desirable browse species that readily resprout from the stem base are not greatly injured by the pipe harrow treatment.

5. Mortality of perennial grasses on pipe-harrow treated areas is low.

Limitations:

1. Even under operating conditions for which it was designed, the implement does not always do a good job of removing plant competition.

2. The harrow will not clean itself of brush in willowy stands or where rocks do not cause the pipes to spin and bounce.

3. Even in areas for which this machine was designed to treat, it will not satisfactorily remove willowy shrubs (i.e., young sagebrush, Chrysothamnus, etc.) or small sparsely spaced shrubs (i.e., Artemisia arbuscula).

4. Undesirable browse species (i.e., Artemisia cana) readily resprout after treatment with the pipe harrow, and thus have low mortality.

5. In areas for which its use is designed, the pipe harrow surfaces many large rocks; often these are so large as to prohibit second coverage treatment.

6. When transporting the pipe harrow, it is usually necessary to disassemble the harrow and then reassemble it again. For short hauls, this work can be overly expensive.

7. Undesirable annuals and forbs are not materially damaged by pipe harrow treatment and may even become more vigorous if brush competition is removed.

Power Requirements. A 50 db. hp. tractor can pull a unit 14 feet wide. If two harrows are used, an 80 db. hp. tractor can handle them although a 90 db. hp. unit is preferred. Where appreciable slopes are encountered, crawler-type tractors are necessary.

Specifications. Complete and large scale copies of plans may be obtained from the Arcadia Equipment Development Center, U. S. Forest Service, Arcadia, Calif.

Recommendations. These implements are not manufactured commercially, so all construction is confined to local shops. Those planning to build are advised to conform to plans and not attempt shortcuts. Experience has proved that the shock absorber and no-jump features are essential.

Rails and Cabling

Rails

Uprooting, breaking off, or mashing down dense stands of big sagebrush by pulling a heavy railroad rail across them is one of the oldest methods of removing sagebrush.

Description. There are a large number of designs for sagebrush rails. The only feature that the designs have in common is that they are made of railroad rail and are pulled along the ground to break off or uproot the sagebrush. A number of types of rails have been tested and the three recommended designs are the "A" rail, the Supp rail, and the "rail drag."

The "A" rail, as the name indicates, is a rigid frame made of railroad rails pulled with the apex forward (fig. A-13). The Supp rail is a 3-section straight rail built with flexible couplings between the sections (fig. A-14). It is pulled at right angles to the direction of travel. The "rail drag," designed and placed in use in Utah by the Bureau of Land Management, consists of a single 90-pound lead rail 33 feet long (or preferably 10-inch channel iron) to which is attached a section of 2 rails of lesser weight by 4 chains (3/4 inch) each 40 inches long. To follow this section are 3 rails also attached by chains (5/8 inch) each 40 inches long. Three pulling cables (3/4 inch) form the hitch to the lead rail.

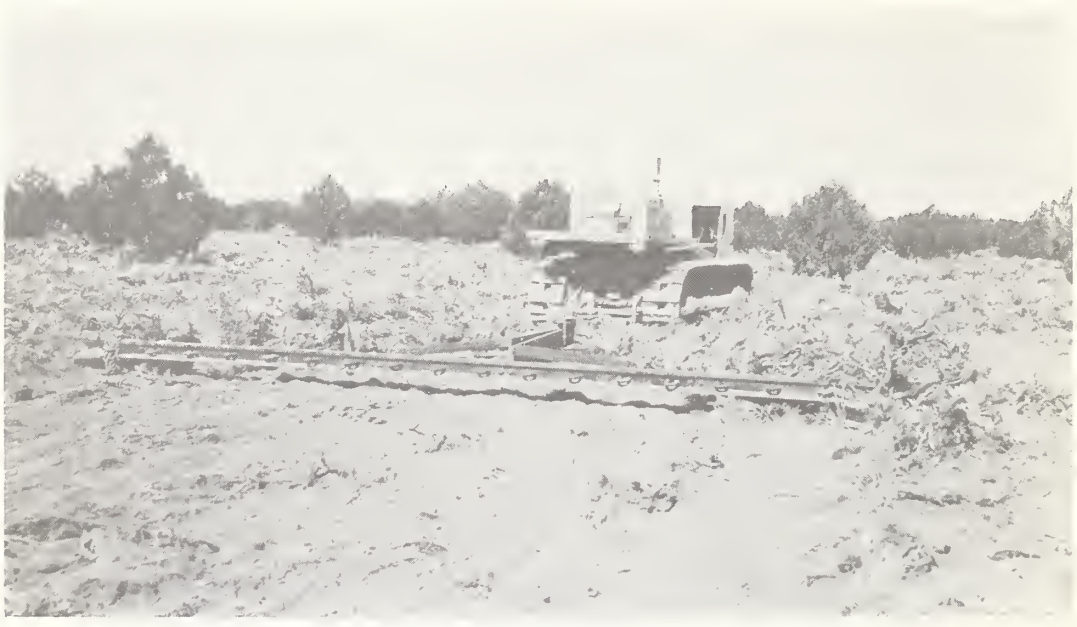

Figure A-13.--"A" rail.

Adaptability. Railing has proved satisfactory as a low cost method for removal of old, mature, brittle stands of big sagebrush on large acreages, especially when the areas support a fair stand of native grass and do not need to be seeded. Seeding should be confined to areas of tall, brittle, big sagebrush where a high percentage of sagebrush will be killed and considerable soil disturbed. Seeding is usually accomplished by broadcasting ahead of the rail, but seed coverage is not very satisfactory. Where brush sites are burned following railing, the area can usually be drilled.

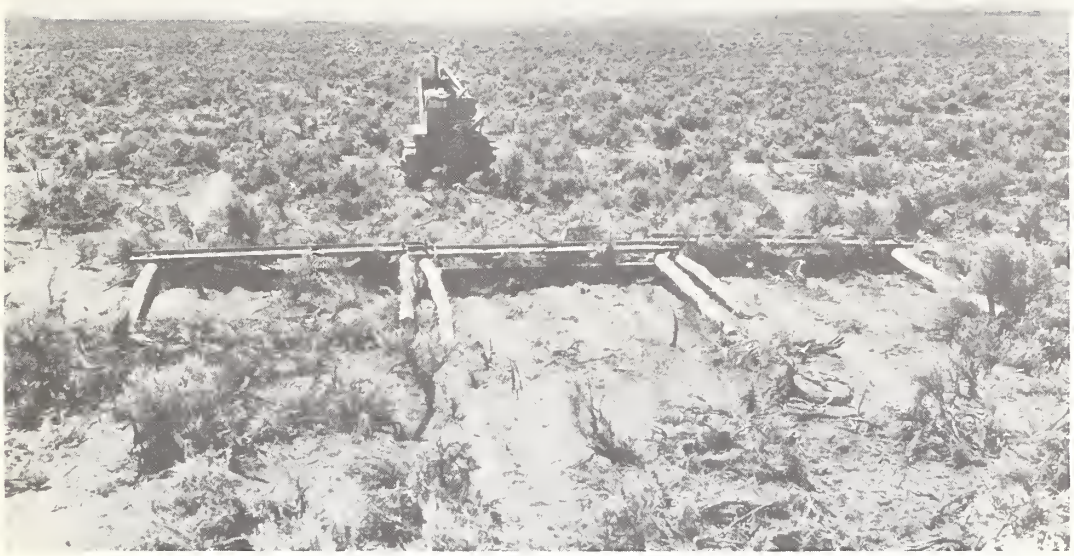

Figure A-14. --Supp rail.

Advantages:

1. Large acreages can be railed in a day and costs are low.

2. Most perennial grass and weed remnants are not greatly damaged except for strongly pedestaled bunchgrasses like Sandberg bluegrass.

3. Debris left on the ground protects the soil from wind and water erosion.

Limitations:

1. A satisfactory sagebrush kill is not secured where sagebrush less than 2 feet in height or younger than 15 to 20 years of age is plentiful in the stand, or where the work is attempted when plants are limber as shortly after a storm.

2. Large boulders and rock outcrops cause excessive breakage.

3. Most other undesirable shrubs that sprout readily, such as rabbitbrush and horsebrush are not damaged very much.

4. Except in somewhat loose soils, railing fails to give adequate coverage of the seed.

Power Requirements. Rails under normal conditions require about 1-1/2 to 2 hp. per foot of width. The "A" and Supp rails are designed to be pulled by a 40 db. hp. crawler tractor.

Specifications. Plans fully describing the three types of rails recommended by the committee may be obtained from the Arcadia Equipment Development Center, U. S. Forest Service, Arcadia, Calif.

Recommendations. Rails can be constructed in any ordinarily equipped machine shop. Since the most common point of breakage is at the welds, extra precautions should be taken during construction to reinforce these places. New rails are recommended where the equipment is for large scale projects because used rails have usually become crystallized and break easily.

Cabling

A cable rail has been developed and used successfully on sagebrush in the Chaco Grazing District of New Mexico. Exact specifications have not been perfected, but trials to date indicate that the most effective length is about 1,000 feet.

Used drill cable from the oil and gas fields is utilized for this purpose. Sturdy clevises are attached to both ends, and 200 feet of cable at each end is left clear. The center 600 feet are weighted by linking short lengths (10-12 feet) of rail steel to the cable at 15-foot intervals. A coldfast clevis is used to link the rails to the cable to avoid their slipping out of place. Two D-8 cats are required to pull the cable over average topography. The cats are spaced 660 feet apart, which results in a cabled strip about 600 feet wide. Two passes in opposite directions are necessary to effectively kill sagebrush. In 1955 the cost per acre of using cable rail was reported to be $0.30.

Rockland Tiller

Description. The rockland tiller is an extremely heavy type of scarifier (fig. A-15). The overall width is 9 feet with 1 tooth every 6 inches. Teeth are mounted on 3 main crossbeams and staggered so that there is 18 inches of clearance between any two. The teeth are mounted on the main frame and kept in the ground by a compression spring that allows the tooth to come out when an obstruction is encountered. Depth control is secured by raising or lowering the supporting wheels.

Figure A-15.--Rockland tiller in operation during spring on site typical of that for which it was designed.

Adaptability. This piece of equipment was designed specifically for preparing a good seedbed and eliminating competition from annual grasses and weeds and small perennial weeds on fairly rocky areas. Where there is an erosion pavement of rather large rocks, it is an excellent tool, but it will not do a satisfactory job in sod, in brush, or on taprooted weed species, such as Wyethia or Veratrum.

Specifications and Recommendations. The first model was completed and given its initial trial in 1949. Subsequently it was rebuilt and given additional field trials in several regions. The machine has excellent possibilities for use on the type of areas for which it was designed.

Blueprints and specifications can be obtained from the Arcadia Equipment Development Center.

Contour Furrower (Improved Model B)

Range managers and conservationists for years have expressed a need for an efficient, practical means of constructing contour furrows on rangelands throughout Western United States in order to: (1) Retard and control storm runoff waters; (2) improve moisture conditions on sites either for seeding operations or to increase the forage production of native vegetation.

In response to this need the committee began work on the furrower project in 1952. A survey of commercially produced agricultural equipment of the type needed showed that there were no plowing or furrowing machines available that were satisfactory or capable of doing the job. As a result it was decided to design and develop a machine that would meet the requirement. The improved Model B (fig. A-16) is the current result of that work.

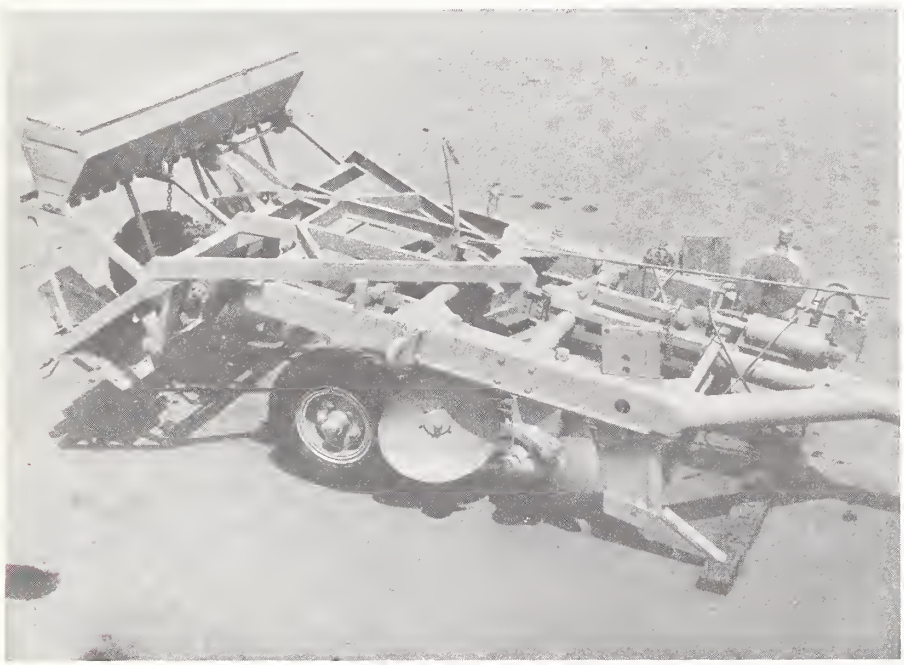

Figure A-16.--Contour furrower--improved Model B.

Description. The Model B contour furrower is a sturdy, ruggedly built machine designed to perform under severe field conditions.

The unit consists of four components: subsoiler, ditcher, dammer, and seeder. The complete unit weighs about 6,000 pounds and measures 8 feet wide by 18 feet long and is mounted on two rubber-tired wheels located inside the main frame of the machine. If the machine is raised, it can be easily towed, considering its size and weight.

The machine is equipped with a hydraulic lift system and powered with an air-cooled gasoline motor. This lift has proved more satisfactory than the earlier mechanical one that depended on engagement of dogs with the main support wheels for operation, and that proved to be too slow and undependable. It was inoperative except when the unit was in motion. The control valve of the present hydraulic lift is mounted on the tractor within easy reach of the operator.

Two ripper or subsoiler teeth, one mounted ahead of each pair of disks, are for the purpose of breaking the ground ahead of the disks. The teeth are adjustable to a depth of 12 inches below the furrow depth or can be raised above the ground surface. Each tooth is equipped with a replaceable cutting point.

Following the rippers, pairs of disks of 26-inch diameter throw the soil to either side of the furrow. The disks are mounted on adjustable bearing supports, can be set to give furrow widths ranging from 18 to 30 inches, and can be adjusted to a maximum furrow depth of 8 inches. Distance between furrows is 5 feet center to center.

Behind the furrowing disks are the "dammers" built in the form of four bladed paddle wheels. They drag in the furrow, and when tripped by the automatic release, the dirt pushed ahead of the "down position" paddle is left as a dam or check in the furrow. Operation of the dammers is adjustable and furrow checks can be placed at intervals from 9 to 96 feet apart. The dammers are operated by a rubber-tired trailing wheel having sprocket and chain drive with automatic tripping assembly.

The trailing wheel also runs the seeding mechanism of the seedbox by chain drive. The seedbox is mounted above the dammers and is adapted from a standard agricultural seeder. Four seed spouts deliver seed to the furrowed area, on each side and slightly behind the dammer paddle-wheel shafts.

Adaptability. Field trials were carried out in 1955 by the Bureau of Land Management in Nevada, New Mexico, and Montana with personnel from the Arcadia Equipment Development Center, Forest Service, cooperating.

The unit worked successfully from almost level terrain up to slopes of 30 percent and in several soil types. The severest test was probably that conducted in heavy silt hardpan-type soil in Willow Creek, Valley County, Mont. The unit performed well in a very heavy and hard soil type. The only problem that developed occasionally was when the D-6 tractor would have to operate in low gear with some "track spinning" if an extremely hard spot was encountered, and when at times the soil would be plowed up in chunks, which interfered with the smooth operation of the trailing wheel and trip mechanism of the dammers.

The unit is not recommended for use in extremely rocky soil because of excessive disk breakage. However, some rock was encountered in the Nevada trials, and rocks as large as 18 x 20 x 36 inches were uprooted with no serious breakage of equipment.

Power Requirements. In light soils with medium depth furrowing, a crawler-type tractor with a minimum of 40 db. hp. and a minimum of 8,000 pounds drawbar pull should handle one unit.

In heavy soils with the unit set for medium to deep (5 to 8 inches) furrowing, a crawler-type tractor with a minimum drawbar of 60 db. hp. and 16,000 pounds drawbar pull will furnish sufficient power.

A crawler-type tractor with a minimum of 80 db. hp. and 17,000 pounds drawbar pull should handle two units under most field conditions and soil types.

In the very heavy soil type on Willow Creek, Mont., trials, a rate of 2-1/4 acres per hour was made with the unit furrowing at a depth of 6 inches over level ground. The furrow length was approximately 1/4 mile and required 4 turns per mile of travel with an 80 db. hp. crawler-type tractor operating in second gear.

Specifications. The present unit is custom built and specifications can be obtained from the Engineer in Charge, Arcadia Equipment Development Center, Arcadia, Calif.

Recommendations. The field trials led to the following modifications and recommendations:

1. A change from mechanical lift to hydraulic.

2. Attach lubricating and servicing chart to the unit's toolbox.

3. Odometer installed on unit to measure distance furrowed. An odometer record allows a treatment contract to be let on a mileage or footage basis instead of an acreage basis. This simplifies the specification writeup for contract work and saves the cost of area surveys in computing amount of work done.

4. Greater clearance provided between the ground and dammer tripping mechanism to prevent interference from such obstacles as clods, brush, and rocks, with the tripping actions.

5. The attachment of a light weight drag disturbs the soil in the furrows behind the unit and covers the seed, but does not level or fill the furrows or ruin the furrow dams. A flexible linkage of metal strips, rings, or chain may be utilized to do this.

6. Extra disks and ripper teeth points should always be on hand to make replacements if breakage occurs or while the implement is being sharpened, so that time lost will be minimized.

7. Equip the hydraulic lift with a motor of common distribution so that the repair parts and service can be obtained locally and so that the parts are of a design proved to give the most trouble-free operation under severe conditions of weather and climate. Have on hand spare parts for field tuneups, such as ignition points and spark plugs.

8. Provide a complete parts list and the names of source of supply.

9. On models equipped with a hydraulic lift, provide a hydraulic hose clamp with spring and mast to hold slack-loop of hoses to control valve high enough to prevent the hoses from being caught and damaged between tractor and furrower when turning.

Miscellaneous Implements

A number of commercially available farm implements have been used with varying success in reducing undesirable plant competition and in preparing seedbeds. Usually, however, these implements are not of a satisfactory design or sufficiently strong to do the job at a cost commensurate with that of other equipment described in detail elsewhere in this handbook. Brief descriptions of a few are as follows:

Moldboard Plow

This implement is well adapted for eliminating undesirable annuals and perennial herbaceous species and in some places open stands of sagebrush, but costs are usually high and often prohibitive. It is readily available through dealers in farm machinery.

Harrows

This group includes the spring-tooth and spike-tooth harrows, the tandem disk and the rotary harrow (fig. A-17). All are useful in eliminating plant competition under certain soil and vegetative conditions but are primarily used for covering seed, and will be discussed in Section F of this handbook.

Sagebrush Grubber

This special type of machine has a single V-shaped sweep with a cutting width of 8-1/2 feet (fig. A-18). Some makes have two or more smaller sweeps. The sweeps are set to run under the surface of the ground and cut off the plants below the soil surface. The grubber offers special possibilities where rabbitbrush occupies the better, largely rock-free sites along stream and valley bottoms.

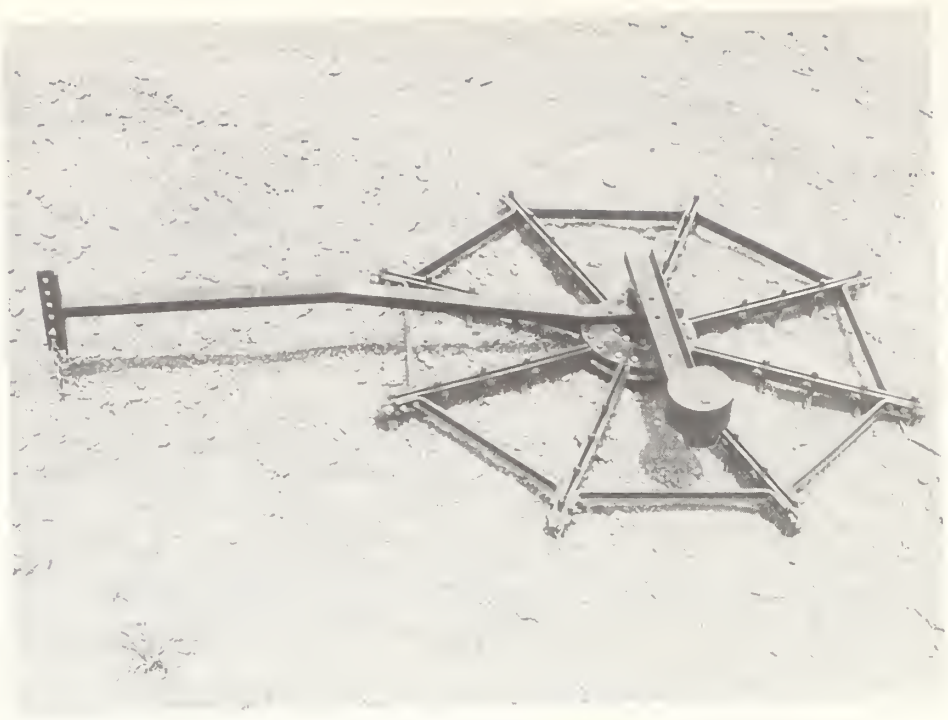

Figure A-17. --Rotary harrow.

Figure A-18. --Grubber.
(Photo by Soil Conservation Service.)

Be-ge Power Rotary Harrow

This implement is a four-row rotary cross harrow, with power-driven rotating disks equipped at their periphery with 22 spike teeth (each tooth 5/8 inch square, 14 inches long) mounted on a 28-inch circle. Weight is 1,870 pounds. It is self clearing but not suitable for rocky ground. Unit is mounted on two wheels fitted with 6.50 x 16, 6-ply tires, and requires a three-plow tractor or a larger one equipped with P. T. O. outlet. Additional information on this implement can be obtained from the Arcadia Equipment Development Center.

Brush Rake

This implement is a wheel rake having five or more large trash wheels 4 feet in diameter, mounted on an angular frame supported on pneumatic tires (fig. A-19). The brush rake has proved effective in removing plowed brush from areas to be seeded if the areas are not too rocky or rough.

Advantages:

1. Makes for better drilling operation.
2. Eliminates brush not completely plowed.
3. Eliminates extra plowing or disking.
4. Eliminates considerable breakage of grain drill.
5. Ideal for use after brush grubber.

Limitations:

1. Limited to rock-free soils.
2. Present available equipment not heavy enough.
3. Acreage covered per day is small.

Power Requirements. Wheel tractor or small crawler-type tractor. The machine should not be used on light, sandy soils that have a tendency to blow. In this type of soil it may be necessary to leave the brush for protection against wind erosion.

Figure A-19.--Rotary brush rake at work.
(Photo by Bureau of Land Management.)

B. BRUSH BURNING EQUIPMENT

Fireline Preparation Equipment

Foresters are familiar with the several types of equipment used for fireline construction. These same implements are adaptable for preparing control lines before brush burning. Common implements in use that make a good safe fireline are bulldozers, motor patrols, and fire plows. Reseeding equipment, such as offset disk harrows, wheatland-type plows, and the brushland plow, has also proved adaptable.

The reader is referred to U. S. Department of Agriculture Farmer's Bulletin 1948, Sagebrush Burning Good and Bad, revised 1954, for information on fireline construction.

Burning Equipment

Useful implements for controlled burning can conveniently be divided into two categories according to the fuel conditions present. If the range to be burned is characterized by readily flammable vegetation, ignition is more dependent upon mobility than upon heat or intensity of flame. A herbaceous understory that is fairly uniform and dense is the prerequisite for an easy-to-burn condition. Cheatgrass beneath sagebrush is an ideal combination for successful burning. A number of torches using kerosene under pressure or liquefied petroleum gas (propane and butane) as fuel will satisfactorily ignite such areas.

In contrast to the above, there is another condition where sagebrush grows openly and is devoid of a herbaceous understory. To successfully burn such a stand in other than extremely hazardous conditions requires the creation of a head of fire that will move forward as a solid wall of flame. To accomplish this, the igniting equipment must be readily transportable and able to produce a well-directed flame with intense heat. Several types of equipment possessing some of these qualifications are described below.

Pneumatic Back Pack Flame Thrower

This unit, equipped with an external air pump (fig. B-1), weighs about 15 pounds when empty and approximately 47 pounds when filled with 4 gallons of diesel oil. It is designed to fire cold diesel oil and is most effective with a tank pressure from 40 to 60 pounds. At this pressure it will project a flame from 6 to 18 feet. Fuel is consumed at the rate of approximately 0.5 gallon per minute when operated under a pressure of 50 pounds. The flame thrower is designed for either continuous or impulse firing. The hand pump permits a rapid buildup of pressure.

Butane-Diesel Flame Thrower

The butane-diesel flame thrower was developed by the Forest Service from an original unit constructed by the Los Angeles County Fire Department. It has proved very effective in back firing under adverse burning conditions, a quality that makes this unit desirable for use on range revegetation projects.

The butane-diesel flame thrower uses diesel oil, which is ignited by passing through a butane flame. The ignited diesel is projected 30 feet or more by means of compressed air. The primary purpose of the butane is to produce a sure-fire ignitor for the diesel oil.

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Figure B-1. --Pneumatic back pack flame thrower.

The unit is mounted on a sturdy trailer with a wide wheelbase and a low center of gravity (fig. B-2). The tongue of the trailer is equipped with two hitches, one for secure and safe trailing behind a truck on the highway and the other for pulling behind a tractor. Three "crash bars" are installed over the trailer for protection of equipment in the event of an upset.

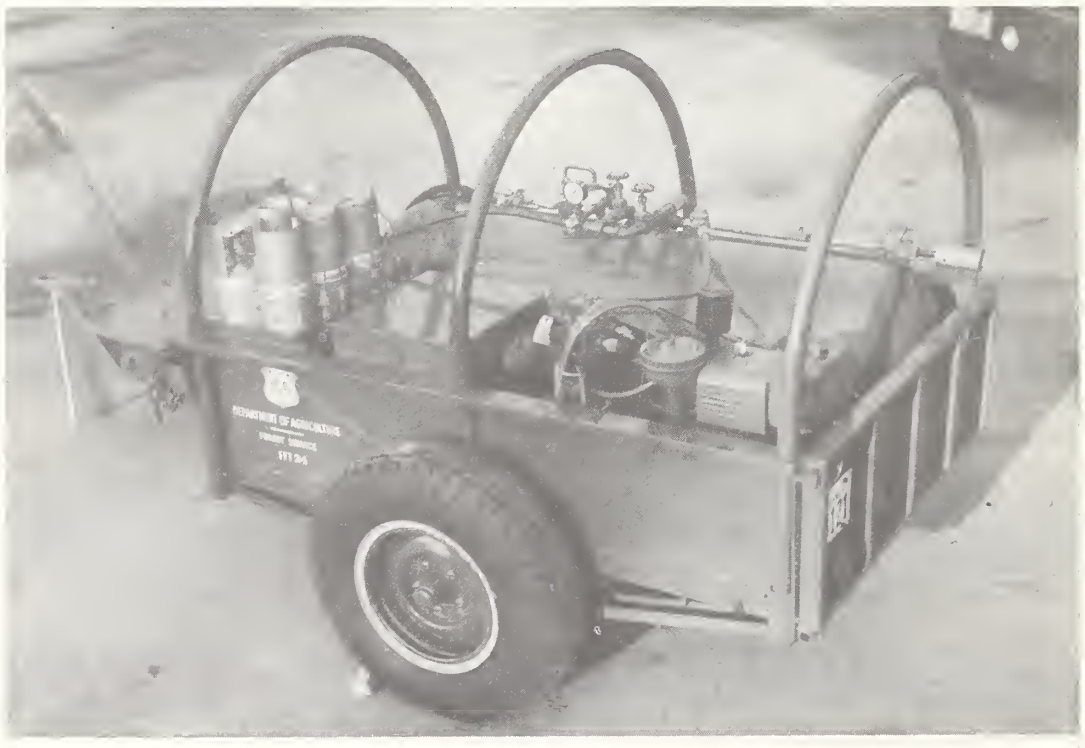

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Figure B-2. --Butane-diesel flame thrower unit.

The unit has a 120-gallon tank, which provides space for 100 gallons of diesel and compressed air. Six small butane tanks are mounted separately. A 5-hp. engine and compressor with proper relief valves and safety controls supply the compressed air. Operating pressures between 80 and 110 pounds give the best operational characteristics.

The gun is 5-1/2 feet long and has a specially designed nozzle. The connecting hose from tank to gun is 50 feet in length, allowing large areas to be worked without moving the trailer.

The unit will project a flame 30 feet and deposit extra fuel for maintenance of the fire. Continuous firing consumes 4.8 gallons of diesel per minute when a 5/36-inch tip base is used.

Cost per unit is about $1,500.

Propane-Diesel Oil Flame Thrower

This flame thrower is very similar to the butane-diesel flame thrower except that in the former a compressor is used to pressurize the diesel oil, but in this unit the fuel is pressurized with propane. This makes a compressor and engine unnecessary. The pressurizing principle is based on the fact that propane will vaporize at -44° F., but butane retains its liquid state below 32° F.

The propane-diesel flame thrower is trailer mounted and in performance is comparable to the butane-diesel unit (For details, see Fire Control Notes, January 1949.)

Fire Fog Apparatus

This is a truck-mounted unit, which employs the principles of backfiring and line control in one operation. A set of sprays applies water to a strip in the rear of the transporting unit while a battery of torches ignites the fuel on one side of the wet-down vegetation.

This apparatus has proved useful in a grass and cheatgrass type of vegetation but is not considered practical enough for use on sagebrush or other heavy fuel types.

For details, see Equipment Development Report 16, U. S. Forest Service, Department of Agriculture, December 1948.

Portable Power Flame Thrower

A small, power flame thrower, weighing 80 pounds, is available and includes all accessories except the fuel supply. The unit consists of an air-cooled motor attached to a vane pump, equipped with a pressure regulating bypass valve, suction hose, discharge hose, and burner. Flaming diesel oil is projected 15 feet and flaming kerosene 20 feet. The unit uses about 0.4 gallon per minute at 85 pounds pressure. Depending upon local requirements, any size fuel container is suitable.

Backfiring Projectiles

Backfiring projectiles are not considered practical for rangeland brush burning due to their limited effectiveness, their somewhat high cost, and the hazards associated with their use.

General

For most effective use, burning equipment should be mounted on a sturdy trailer and pulled by a 4-wheel-drive vehicle, or mounted on a 4-wheel-drive outfit.

Figure B-3. --Portable power flame thrower.

As a general rule, it is not wise to combine equipment for spraying and flame throwing into one unit. Most spraying equipment is not constructed to handle the pressures needed for successful flame thrower operation.

Pumps designed to handle water should not be used with oil. The converse is also true.

Fire Control Equipment

Precautionary measures must be taken to keep a fire under control after it is once ignited. Fire control techniques and equipment are known by most range men. Depending upon the circumstances under which burning is accomplished, a crew of men should be provided with adequate handtools for control; and suitable heavy equipment, such as a bulldozer or tanker, should be on hand for emergency use. Mobility is essential for sagebrush burning.

Specifications. Fire control equipment standards are satisfactory.

Recommendations. That no special equipment be purchased unless fire control equipment is not available.

C. CHEMICAL SPRAYING EQUIPMENT

Chemical control of undesirable plants may be undertaken either to allow natural revegetation or artificial seeding. Outstanding success has been achieved by spraying brush species, such as big sagebrush and herbaceous species, such as Wyethia, to release the suppressed native forage plants and to allow natural revegetation.

Where seeding is to follow, chemical control is not always adaptable. For example, on brushy lands needing seeding the dead standing brush killed by chemicals may be as big an obstacle to seeding as were the live plants. On the other hand, the complete kill of brush by chemicals may be such an advantage over partial kill by mechanical means that it is better to kill with chemicals and then to break down the dead brush before seeding than to have recurrent mechanical treatment for brush eradication.

Chemically killed herbaceous plants, such as Wyethia and sneezeweed, do not present a barrier to seeding, and many such weedy areas have been converted to grass by chemical spraying. Whether followup seeding is required will depend on the amount of desirable forage species remaining after removal of the competing noxious plants.

Federal, State, and county units; dealers in spray equipment, aircraft, and chemicals; private operators and weed control companies are carrying on research to determine the best chemicals, and the rate, time, and method of application. Much is still to be learned and new chemicals, methods, and equipment are being put to use every day. Consequently, rangeland managers need to keep up-to-date on what is being done. Changes in equipment and chemicals and the economic situation frequently make the use of sprays more practical than tillage or cutting for control of weeds, brush, and low-value trees on grazing lands.

Agencies testing chemical and spraying equipment include the Agricultural Research Service in the U. S. Department of Agriculture, and the Western State Agricultural Experiment Stations. Information on performance of individual makes and models of equipment can be obtained from these agencies.

Ground Spraying Equipment

Hand-Operated Sprayer

This type of equipment is adapted for spraying spots of noxious weeds, widely scattered individual shrubs and trees, or roadsides and trails. Direction of the spray stream is hand-controlled from a single nozzle or a short boom of 3 feet or less having 2 or 3 nozzles. The 1- to 5-gallon sprayer may be carried by hand. Pressure for this type may range from 10 to 40 pounds, supplied by hand pump or by CO_2 cartridge attachment. The larger sprayers have 10- to 100-gallon tanks mounted in a pickup or on a tractor. A long hose is carried and spray is directed by hand. Pressure is supplied by a pump operated by a small motor or by a power takeoff attachment.

Power Sprayers

These differ from the hand machines in that they have fixed booms or nozzles for spraying and are not moved around by hand. The spray unit is mounted on a mobile unit, such as a pickup, jeep, tractor, or truck trailer that can be driven over the area to be sprayed. Pressure can be adjusted and ranges from low (20 to

100 pounds pressure per square inch) through medium to high (usually 400 to 800 pounds per square inch). In general, the higher the pressure the more gallons of liquid delivered per minute. The size and number of jet openings affect the pressure and the rate of delivery. With a standard or fixed pump, if the size of the jet openings are increased, more gallons per minute will be delivered, but at a lower pressure. High pressure is maintained by a motor with a piston or plunger-type pump. Rotary or centrifugal pumps are sufficient for low pressure.

Low-pressure units usually cost considerably less, weigh much less, and are cheaper to operate and maintain than high-pressure equipment.

At one time it was thought that high-pressure spraying was best. However, the trend now is toward low-pressure because it seems as effective in weed and brush kill and is much cheaper. However, where the same machine is to be used to spray livestock, high pressures are necessary.

Power sprayers can go any place the transporting unit can take them. However, they are more adapted to level or moderately rough topography. Where the going is rough or the brush tall, there is considerable breakage, speed is cut down, and costs increase. By mounting these units on crawler-type tractors, their use can be greatly increased. For open range work a jeep or crawler-type tractor transporting unit is probably the most satisfactory.

Boom-Type Sprayers

Boom-type sprayers have been commonly used on mobile ground units, such as tractors and pickups. The boom is horizontal with fan-type nozzles spaced 12 to 24 inches apart along the length of the boom, ordinarily 10 to 20 feet. Some booms are longer. Usually they are adjustable for height. Booms may be equipped with swivels one-fourth to one-half the distance in from each end, stabilized by springs and guide cables. These modifications permit raising or swinging past obstructions, such as trees, posts, or embankments to avoid breakage. To give the desired amount and pattern distribution of the spray, adjustments are made in the spacing and size of nozzles, speed of tractor, and pressure applied to the liquid as it leaves the nozzles.

Advantages of the boom-type sprayer are (1) its high versatility for use on a wide variety of crop plants and range situations, (2) uniform distribution of spray over entire swath, and (3) comparatively low cost to purchase and operate. Chief disadvantages of boom type for spraying rangelands are (1) difficulty of operation on rough, rocky ground or through tall, heavy brush or trees, and (2) plugging of the extremely small nozzles by foreign particles.

Turbine-Type Sprayers

The turbine-type sprayer produces an air stream that carries and distributes the spray across a 60- to 80-foot swath. The turbine fan creates an air stream about 12 inches in diameter with a wind velocity approaching 125 miles per hour at the sprayer outlet. A fan-shaped outlet may be used in place of the circular shape, but the area of cross section should be about the same as that for a circle 12 inches in diameter. Four jets or nozzles inject the spray solution into the air stream. The width of the swath may vary, since it is dependent upon wind currents, height of outlet above ground level, and uniformity of coverage required. A 24-horsepower gasoline engine is necessary to operate the turbine fan and sprayer pump.

Several characteristics of the turbine sprayer are advantageous for use on rangeland. The wide swath requires less travel through the areas sprayed than do the narrow-swath boom-type sprayers. Some obstructions, such as small clumps of trees, may be avoided because the turbine sprayer does not protrude

beyond the sides of the vehicle pulling or carrying it. Spray particle size, pattern, and distribution across the swath are good.

Disadvantages of the turbine sprayer are concerned primarily with the greater size, weight, and initial cost. More power is required for operation than for the boom-type sprayers. Variable winds may interfere with uniform distribution of spray and swath width. Dense brush may be heavily covered with spray on portions of plants next to the sprayer and insufficiently covered on the side away from sprayer outlet. Higher and heavier brush can be covered and the sprayer used over rougher, rockier rangeland by mounting the turbine sprayer on a track-type tractor instead of pulling it as a trailer unit.

Broadjet Sprayers

The broadjet sprayers, also known as power-jet, wide-jet, wide-fan, or boomless sprayers, were designed to overcome some of the difficulties of the long, unwieldy boom. Two designs have been tested: a large single nozzle and a cluster of five nozzles.

The principal advantage obtained in the broadjet-type sprayer is compactness with freedom from interference by obstructions, such as trees or heavy brush. Also, the single large jet becomes plugged less often than do many small jets or nozzles along a horizontal boom.

The greatest disadvantages of the broadjet sprayer has been erratic distribution of spray across the swath width and generally poor spray pattern. Extremely large drops of spray fall at the margins of the swath. This poor coverage results in unsatisfactory kill of range weeds and brush. Attempts to use greater volume of solution were not successful in overcoming the poor distribution and coverage. Wherever comparisons were made, the boom and turbine types were superior to the broadjet sprayer.

Aircraft Spraying Equipment

Airplanes

Airplanes may be used effectively and economically to spray rangeland too wet, rough, or rocky for ground sprayers. Spray distribution has been very satisfactory when applied by approved equipment and competent people. Successful spraying requires careful mixing of solutions, calibration of equipment, flagging, and checking of drift. Early morning spraying helps avoid loss of herbicide by volatilization and evaporization. These losses may be high under conditions of low humidity, high temperatures, and wind. Spray should be applied in the early morning when atmospheric conditions favor safety and increase effectiveness of spray application. A wind of 12 to 15 miles per hour may be set as the upper limit for spraying by airplanes.

Airplanes may be more economical than ground sprayers for use on large projects covering 200 acres or more. Consideration must be given to lateral distance and vertical climb between airport and area to be sprayed. The extra time and expense required may add greatly to the cost of spraying by airplane and favor the use of ground equipment. Trees, snags, or poles scattered through range areas to be sprayed present certain hazards for airplane spraying. Also, steep-walled box canyons present a hazard when airplanes are used for seeding or spraying.

Helicopters

The principal advantage of helicopters lies in safety in operation on rough topography or on areas containing scattered trees. Also, the helicopter can usually land on the project area and thereby save time and expense required by airplanes

going from air strip to the rangeland to be treated. Both kinds of aircraft will give satisfactory distribution of spray or seed if care is taken in calibration and adjustment of equipment, flagging the field, and checking the swath width to avoid missed strips.

Rigid safety precautions should be taken in the use of all types of aircraft.

D. GROUND SEEDING EQUIPMENT

Grain Drills

Description. The disk drill used in regular farming practices has proved to be the most effective commercially available type of equipment for range reseeding work. Essentially this implement consists of a boxlike seed hopper and a bank of disks mounted on a metal frame with the weight of the entire machine supported by two wheels (fig. D-1). Gears deliver seed from the hopper to tubes leading to the disk boot. As the disk opens furrows in the soil, the seed falls into the furrow and is ordinarily covered as the soil falls back into place. Chains and press wheels are supplemental equipment for seed coverage.

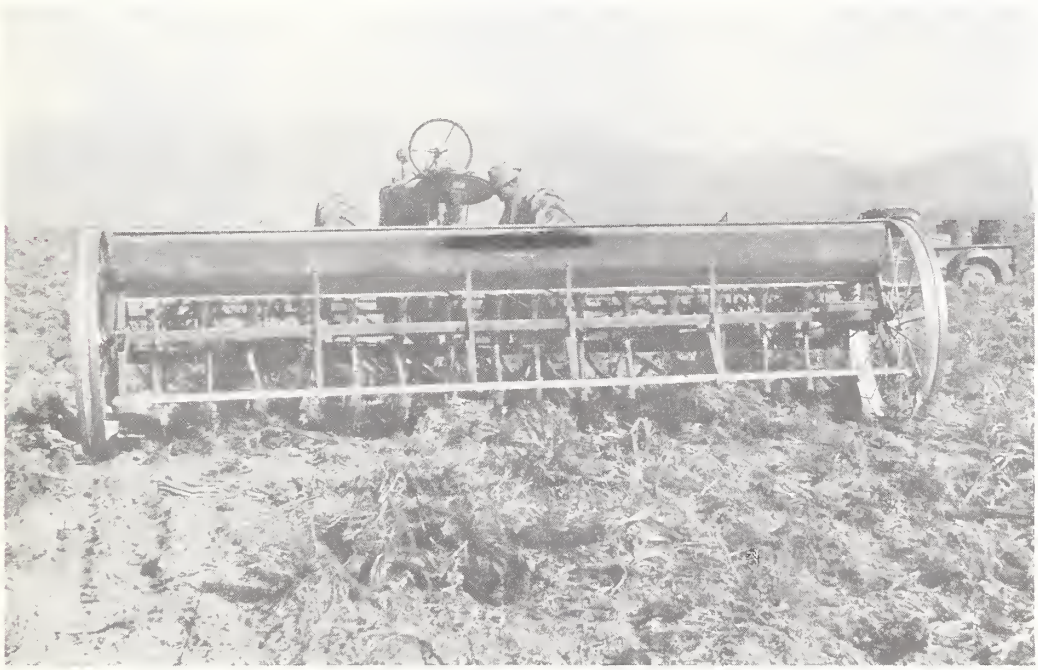

Figure D-1.--Grain drill.

Adaptability. Commercial grain drills are being used successfully on plowed, harrowed, or railed sagebrush range. Drills will perform satisfactorily only if pulled at 2 miles per hour or less and given a reasonable amount of care. Plowed brush impairs the efficiency of the drill since the disks roll over the brush, and the seed is prevented from being placed in the soil at the proper depth. Where the ground surface is relatively smooth and free of brush, as on burned sagebrush range, the drill is ideally adapted. Where seeding brushy, rough ground, the rangeland drill is better suited and more economical because there is less breakage.

Advantages:

1. Drills should be used wherever possible to provide uniform seed distribution, to get the seed into the soil, and to get it covered.

2. Drills can be used on slopes as steep as can be traversed by a crawler-type tractor.

Limitations:

1. Drills should not be used on rocky ground where breakage will be excessive.

2. They cannot be used to advantage on loose seedbeds where, despite complete release of tension on the disks, the seed is planted too deeply.

Note: Depth regulation bands can be used to prevent deep sowing in loose soils. (See figs. D-2, 3, and 4.)

3. Drills also should not be used where standing shrubby vegetation prevents the normal operation of the drill.

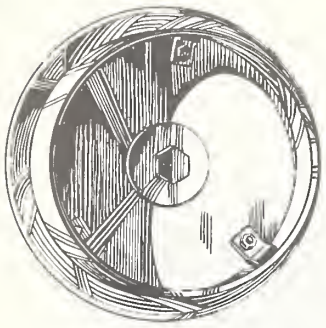

Figure D-2. --Soil Conservation Service fabricated depth regulator.

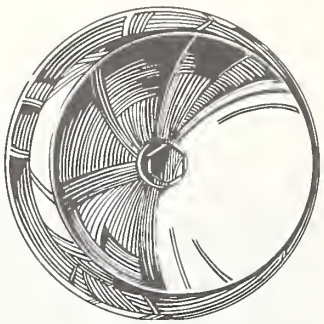

Figure D-3. --Commercial depth regulator available in three sizes.

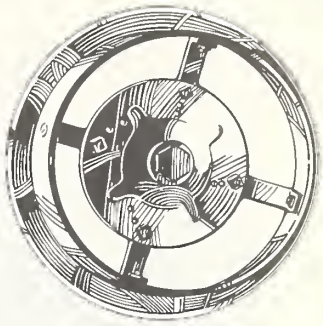

Figure D-4. --Commercial depth regulator (adjustable).

Power Requirements. A 10- to 14-foot drill can be pulled with a 20 to 25 hp. wheel-type tractor. When 2 or 3 such drills are used with a multiple hitch, a 35 to 40 hp. crawler-type tractor is necessary. (See Section G for hitch designs.)

Specifications:

Width--On rough, uneven areas, drills generally not wider than 10 or 12 feet have given good results. Where greater widths can be used, it is generally more desirable to pull two or more drills with a single tractor. However, on fairly level areas a wider drill may be more satisfactory. Drills of 14- and 16-foot widths have proved to be very effective on this type of land.

Feed--Adjustable gate, force-fluted feed.

Row spacing--6 to 12 inches.

Furrow openers--The choice of furrow opener depends upon the most common conditions under which the drill is to be used. Single disk openers are desirable on firm, litter-covered ground, where a definite cutting action is needed to open the furrow. Double disk openers are best adapted to prepared, plowed, or loose seedbeds and on sloping ground. Deep furrow openers are useful on prepared seedbeds free from trash or where eradicating a limited amount of herbaceous vegetation is desirable with the drilling operation.

Disks--Disks should be made of tough, abrasion-resistant high-grade steel, carefully heat treated. Diameter of the disk should be 14 or 16 inches.

Bearings--Main wheel bearings should be antifriction and the furrow opener bearings either of steel or chilled iron.

Hitch--Tractor.

Hoppers--Both grain and grass seed attachment should be of steel or equivalent (not wood).

Lifts--Power.

Wheels--Rubber or steel. Some manufacturers are using rubber wheels exclusively.

Grass seed attachment--Necessary wherever small-seeded species, such as timothy, Kentucky bluegrass, and alfalfa, are used unless a diluent, such as rice hulls, is used.

Seed agitators--If light or trashy seed is used, a seed agitator should be available for a large hopper.

Seed tubes--Flexible steel ribbon or rubber. When drills are used on plowed or harrowed sagebrush ranges, the metal tubes usually are damaged or stretched and often pulled from the disk boot. Under such conditions, rubber tubes are more desirable and, if they are not on the drill, the flexible metal tubes should be replaced with the conventional rubber tube or with 1-1/2- to 2-inch high compression or radiator hose.

Grain Drill Depth Regulators

Practically all reseeding instructions emphasize the need for a firm seedbed to accomplish shallow seeding and uniform establishment. In many places this is hard to achieve. Depth regulators have been developed and used to meet this need. Two different types are described below.

Depth Regulator Developed by the Soil Conservation Service. The Nursery Division of the Pacific Coast Region has developed a depth regulator that is easy to construct and attach (fig. D-2). The regulators can be used on any drill having straight disks for furrow openers. A piece of strap iron 1-1/2 to 1-5/8 inches wide is made into a circular band 2 inches less in diameter than the disk. To this band are attached three pieces of strap iron about 5 inches long. The pieces are bent to form a right angle. Where equipment for drilling holes in the disk is available, the depth regulator band can be fastened to the disk with a 3/8- or 1/2-inch carriage bolt. Welding may be necessary where holes cannot be drilled. The result is a band fastened to the disk so that seeds can be planted no more than 1 inch deep.

Long experience indicates that nearly all grasses and legumes can safely be planted at a 1-inch depth, hence no provision is made for adjustable bands. One band per furrow opener gives more satisfactory results than two bands. The bands, if bolted to the disk, can be removed if rain makes the surface of the ground muddy.

Commercial Type Depth Regulator. Commercial companies have developed depth regulators for their beet and bean drills, which can be adapted to use on grain drills. Figure D-3 shows one of the newest types used with double disk openers. Three sizes of depth bands are available: 11-1/2 inch for planting 1 inch deep, 10-1/2 inch for planting 1-1/2 inches deep, 9-1/2 inch for planting 2 inches deep.

Figure D-4 shows another type of depth regulator, which is available from some commercial sources.

Rangeland Drills

Field experience has shown that the commercially available grain drill seeders, designed for agricultural use, are not strong enough to withstand field conditions considered normal in range seeding operations. Failures of commercial units have not been the result of the basic design but of the light, structural

construction which, although adequate for agricultural needs, would not withstand the stresses encountered during range reseeding operations. Surveys of standard equipment substantiated the reports that no commercial unit could be considered adequate. Because of the limited market, manufacturers did not display interest in the development of the proposed rangeland drill.

The original model of the rangeland drill was constructed on the Fremont Forest in fiscal year 1951. Basically it was a standard commercially available grain drill with reinforced frame, oversize wheels, and modified seeder disk arms (fig. D-5). In fiscal year 1952 the Arcadia Equipment Development Center designed and built an entirely new model. This was given thorough field tests in 1952 and 1953 and certain changes were made in parts that proved weak. The design is now complete, and the implement has proved eminently satisfactory for rough, brushy, rocky conditions.

Figure D-5. --Original model of rangeland drill.

Description. The latest model weighs approximately 2,100 pounds, is 13-1/2 feet wide, and drills a swath approximately 10 feet wide at 12-inch intervals (fig. D-6). It is equipped with 51-inch rubber-tired wheels and can be towed behind a truck over the highways at speeds up to 15 miles an hour (fig. D-7). For truck transportation, the wheels and drawbar can be removed, and the unit loaded on a stakeside truck. In 1955 the cost of the completed rangeland drill was approximately $2,000.

The seeder arms are solidly plated on the lower sides so as to eliminate difficulties due to brush catching in the structure ahead of the disks. This has the effect of presenting a sled surface ahead of the disks, and results in raising the disk assembly when heavy brush conditions are encountered. Figure D-8 shows this construction.

Adaptability. The rangeland drill is adapted for seeding moderately rough, rocky rangeland that is covered with broken up brush. It is built to permit the disk openers to pass freely over rocks, broken up sagebrush, and brush piles without clogging or interference. The drill is also adapted for use on hard soils, which are often found on burned-over unplowed sage lands.

Figure D-6. --Close-up of rangeland drill mechanism showing disks, depth regulators, and seeding tubes. Each disk operates independently.

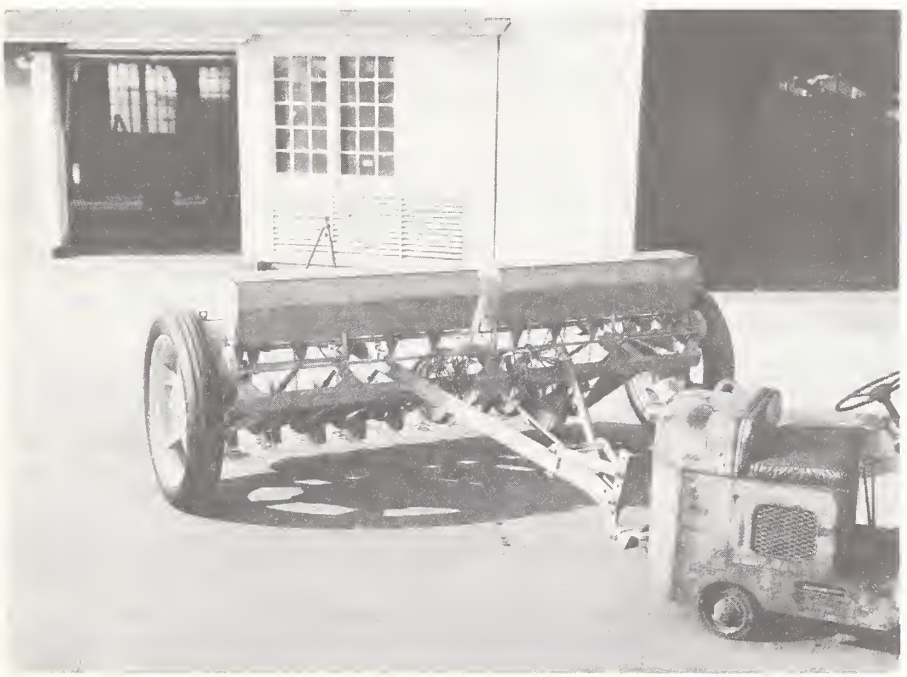

Figure D-7. --Front view of 1956 model rangeland drill.

The implement is of rugged construction having a welded and bolted frame. It has large rubber-tired wheels for easy travel over rough and rocky ground. Depth of seeding is controlled at 1 inch. The implement may be quickly dismantled into 3 sets of parts: (1) Drawbar, (2) frame with hopper, and (3) disk arm assemblies complete with disks.

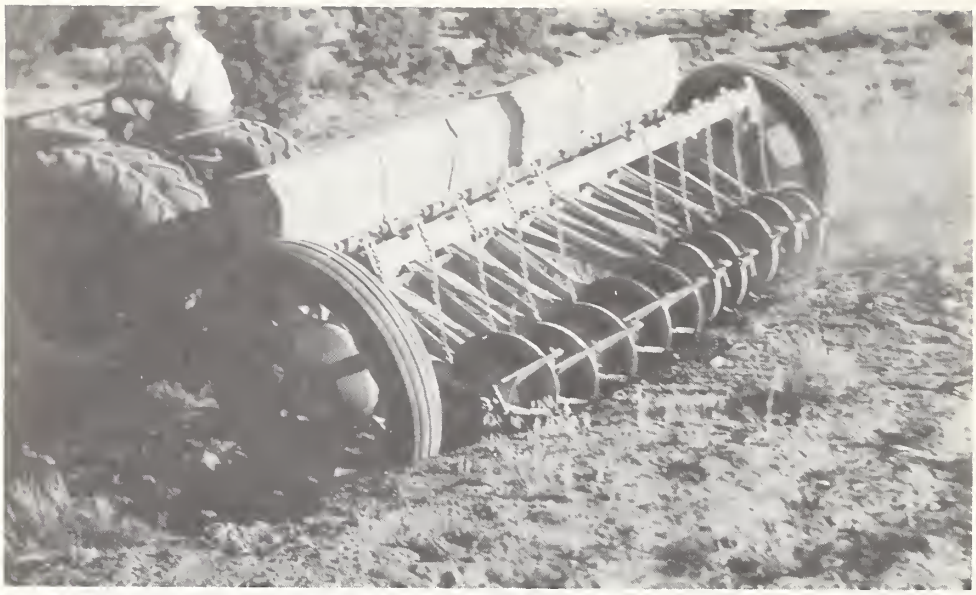

Figure D-8.--Rangeland drill in operation, 1956 model.

Power Requirements. A wheel-type tractor with 40 hp. engine and weighing about 5,000 pounds handles this unit easily as does a smaller crawler-type tractor of similar drawbar pull. Either of these machines should be able to pull 2 units on fairly level ground. The unit will withstand a speed of 4 miles per hour where large rocks or heavy brush is not encountered.

Specifications. Specifications are available at the Arcadia Equipment Development Center, P. O. Box 586, Arcadia, Calif.

Broadcasters

Broadcasters are primarily of two types: rotary spreaders and seeder boxes of the drill-like or fertilizer spreader type.

In the seeder box a fluted or force gear-type feed mechanism lets seed fall out of the bottom of the box onto the ground. In the rotary spreader, seed falls from a hopper onto a rotating ribbed disk, which distributes the seed by centrifugal force. The rotating disk is usually parallel to the ground but may also be vertical (fig. D-9). Width of throw from the disk depends on size and weight of seed, speed of rotating disk, and direction and velocity of wind.

Broadcasters may be powered by gasoline or electric motors, power takeoff, or traction. They may be carried by hand, mounted on a tractor or seedbed preparation unit, or trailed behind. Their adaptability varies with the machine.

Broadcasters, irrespective of type, are not recommended when drilling is possible. A description of some of the more common types follows:

Hand Seeders

Description. The common type and most widely used hand seeder (also called hand broadcaster) consists of a canvas bag (hopper) attached to a wooden or metal base (fig. D-9). A metal plate on the bottom of the base is easily adjusted to govern the size of the opening through which the seed falls. A hand crank rotates a distributing disk and agitates the metal plate which, to a limited extent, aids in the flow of seed.

Figure D-9. --Hand seeder.

Adaptability. The hand-operated broadcaster is well suited for sowing in deciduous brush, aspen stands, timber burns, and logging-disturbed areas where power equipment and the airplane and helicopter cannot operate efficiently because of physical obstructions or size of area.

Advantages:

1. Seed is distributed with greater uniformity than broadcasting by hand.

2. Widely adaptable--can be used on areas where power equipment cannot be used.

3. Costs of equipment are very low.

Limitations:

1. Width of spread and seed distribution will not be uniform unless the operator gives special consideration to the speed of travel and the rapidity with which the crank is turned.

2. Where seed mixtures are used, sorting or stratification of the seed by weight is common because of the absence of a positive agitator.

3. Light or chaffy seed often bridges the opening and makes the rate of seeding uneven or variable.

Note: Continual agitation with the free hand can prevent both sorting and bridging, but often this becomes tiring to the operator.

Specifications and Recommendations. Several makes are commercially produced but a few performance records are available. A heavy duty model, which is equipped with extra heavy duty gears and brass bushed bearings, is available and should be more durable for use under most conditions. Specifications may be obtained from the Bureau of Land Management, Salt Lake City, Utah.

Traction-Operated Seeders

Description. Several types of rotary distributing seeders fall under this class. They include the well-known endgate seeders with power taken from a wagon wheel, and trailer models constructed from automobile rear ends with power taken from the wheels and transferred to a distributor through the differential (fig. D-10).

Figure D-10.--Traction-operated rotary seeder. (Photo by Bureau of Land Management.)

Adaptability. This type of broadcaster has not been widely used for range reseeding. A probable use includes seeding ahead of seed-covering devices, such as brush drags and pipe harrows when seeding and coverage are a single operation.

Once calibrated, these machines sow at a uniform rate per acre but distribution varies with the speed of operation. Rate, width, and distribution of seeding should be determined for the average operating speeds; then, the speed selected should be maintained as constantly as possible.

Advantage:

1. Minimum breakage is anticipated as there are few moving parts; the chance for motor failures, common on power broadcasters, is eliminated.

Limitations:

1. There should be a minimum of rubbish or rocks on the area to obtain maximum efficiency because power is taken from ground contact.

2. Seed distribution is not uniform because it is difficult to maintain a constant speed of travel.

Specifications and Recommendations. Because broadcasters of this type have not been intensively used on reseeding jobs, specifications are not available nor can recommendations be made.

Gasoline-Powered Broadcasters

Description. A small gasoline engine is used to power a rotating disk that distributes the seed (fig. D-11). Early designs were used for spreading grasshopper bait, and this same machine is used for seeding with little modification. A new design fabricated under the supervision of the Range Reseeding Committee provides a clutch to disengage the motor and permit easy starting.

Figure D-11.--Gasoline-powered broadcaster mounted on a tractor to sow ahead of a wheatland-type plow.

Adaptability. The gasoline-powered broadcaster is a complete unit and is useful under several conditions. It can be installed on the back of a tractor, jeep, or weapons carrier. This type of broadcaster is satisfactory for areas too rough and rocky for grain drills and is a desirable implement for spreading seed ahead of a pipe harrow or rail. It is also useful for seeding raw roadside cuts and fills or skid roads and landings. The seeder may be used to seed plowed ground too trashy for drilling if some method of seed coverage is provided.

Advantages:

1. Power seeders will do a more efficient job of seeding at less expense than hand seeders and should be used to replace them wherever practical.

2. It is possible to get a 14-foot spread of seed with one machine. If a greater width is desired, two machines can be mounted on the rear end of a tractor.

Limitations:

1. Broadcasters of this type do not spread the seed as evenly as do seeder or drill boxes. The amount of seed is greater near the center of the swath.

2. This machine was designed to distribute bait made up of uniform-sized material. Seed mixtures of varying sizes and weights, when broadcast with this machine, further add to the problem of uneven distribution.

3. Since there is no control over the speed of the motor, the uniformity of seed distribution is directly dependent upon the speed of the machine conveying the broadcaster.

Specifications:

Hopper--Minimum capacity 17 gallons, heavy metal.

Agitator--Machine should be equipped with an agitator that operates directly from the fan or blower shaft.

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Feed mechanism--This should be adjustable to regulate the amount of seed and direction of swath.

Seeding width--Desirable to have broadcaster capable of spreading the seed uniformly over an area 14 feet wide in one swath.

Power--2-1/2 to 5 hp. air-cooled gasoline engine complete with attached fuel tank.

Assembly--The motorized broadcaster should be complete as a unit and ready for operation without additional fabrications.

Recommendations. It is desirable to purchase a commercial broadcaster with the above specifications and then install a clutch as shown in the attached drawing (fig. D-12). This clutch adds to ease of operating the broadcaster as well as to its safety.

Power Takeoff Broadcasters

Description. A power takeoff broadcaster operates from a power takeoff of the drawbar implement. Seed falls from the hopper into a whirling distributor cone. Present designs do not provide for an agitator in the hopper, although a worm type should be easy to install.

Adaptability. This implement spreads seed just as well as gasoline-powered broadcasters. The major disadvantage, however, is that it is adapted for use on the one make and model of machine for which it was constructed.

Specifications and Recommendations. Anyone interested in this broadcaster can obtain additional information from the Bureau of Land Management, Salt Lake City.

Electric Broadcasters

Description. The electric broadcast seeder is the outgrowth of field experience with commercial electric broadcasters for farm use. Power is derived from a tractor, pickup, or jeep battery, serving readily to broadcast seed with more dependable results than those from hand broadcasters and without the fatigue of constant hand operation.

The Arcadia Equipment Development Center undertook the design of a heavy duty type of electric broadcaster in 1953, which incorporated both agitator and broadcaster fan driven by a single motor. The present design consists of a 3-bushel hopper attached to a stand with braces to hold the hopper on either a platform or a heavy plank support. Within the hopper is a cone to prevent compaction of the seed, an agitator to insure constant seed passage through a gate, which is opened by the pull of a cord or closed by the spring released by a second cord.

The motor is supported by a mounting fastened directly to the underside of the hopper. It is controlled by an on-and-off switch. The mounting of the hopper to the frame allows the hopper to be rotated approximately 90° to permit broadcasting to the side, as well as the rear.

Adaptability. Use of a heavy duty motor results in low current consumption. Width of seed pattern is approximately 27 feet, or seed is thrown on a 13-1/2-foot radius, the last 2 feet of lesser concentration.

Specifications. Design details may be obtained from the Arcadia Equipment Development Center.

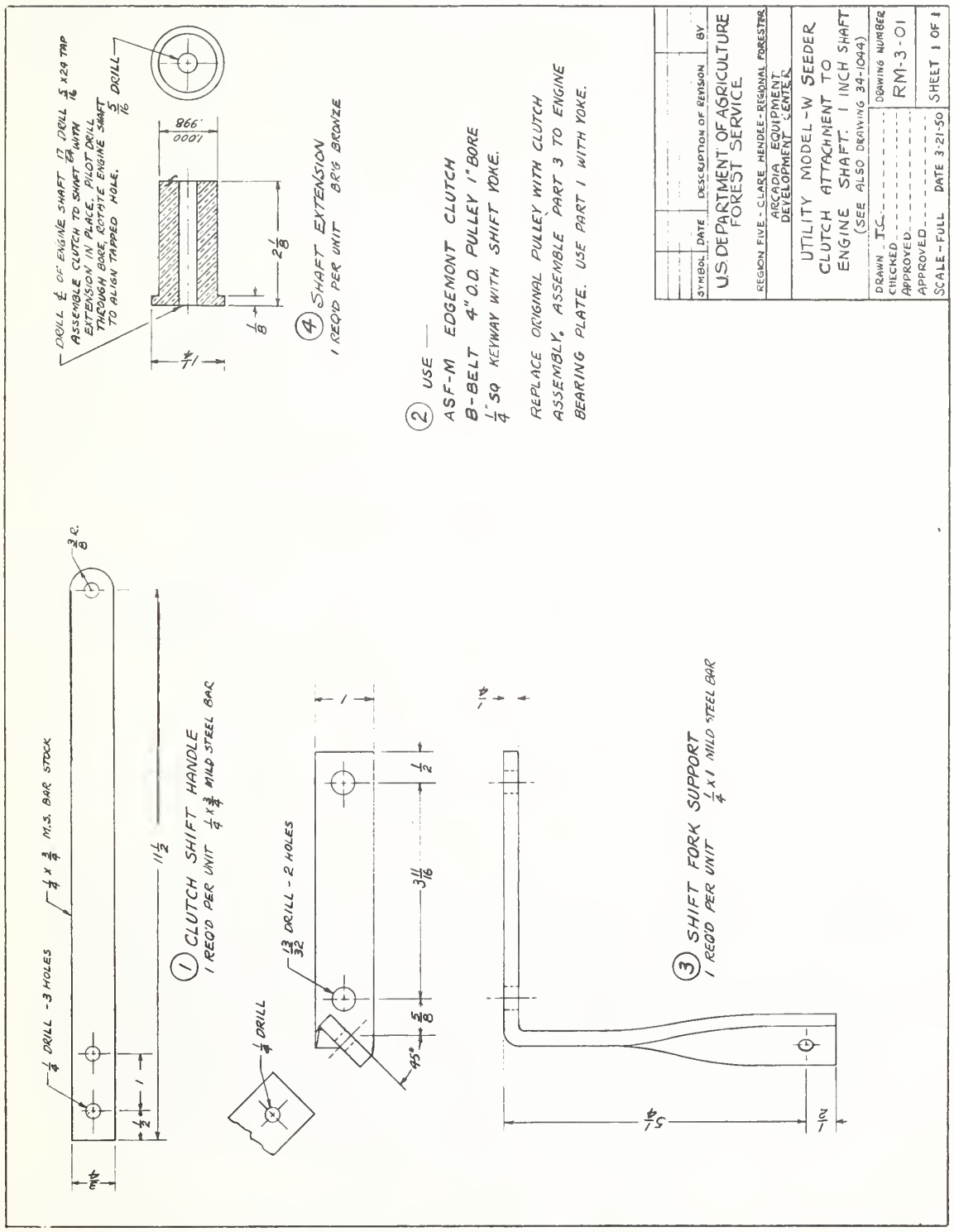

Figure D-12. --Utility model-W seeder clutch attachment to engine shaft.

Seeder Box Broadcasters

A number of implements, both improvised and manufactured, fall within this category. Because of the principles used, this category can be subdivided into three groups--wheeled or trailer, tractor-mounted, and implement-mounted seeders. Some of these broadcasters can often be used where excessive wear or breakage is likely to be incurred by the conventional grain drill. Rocky areas, exceedingly dense stands of plowed or harrowed brush, and poor brush burns are examples. Circumstances may permit the eradication and seeding operation to be combined, and this can be accomplished by seeder boxes or hoppers mounted on the implement used for eradication.

In general, the seeder box type of broadcaster distributes seed more uniformly than does the rotary type. The positive feed mechanism in the seeder box broadcaster is responsible for this greater uniformity. Whether or not the seeder box type is more efficient in operation or maintenance than the rotary type is not definitely known.

Wheeled- or Trailer-Type Broadcasters

Description. In general these implements are essentially a drill box or hopper suspended between two wheels. The feed mechanism is usually of the forced feed fluted type operated from the running gear of the broadcaster, or in some makes it may be operated from the power takeoff of the tractor. In the commercial broadcasters of this type, the hopper is closer to the ground than is customary for drills, except those using low rubber wheels; this prevents excessive drift of seed by the wind. The conventional grain drill can be converted to a broadcaster of this type by removal of the entire disk assembly and seed tubes.

Adaptability. These broadcasters can be used any place where obstructions, such as trees or large shrubs, do not prevent their use, but they should not be used where drilling is possible. Rocky areas, exceedingly dense stands of plowed or harrowed brush, and brushy burns are sites where the wheeled broadcaster might be used.

Advantages:

1. Gives more uniform seed distribution than the rotary-type broadcaster or the hand broadcaster. It is essentially comparable to the drill in this respect.

2. Is comparatively low in cost.

Limitations:

1. Similar to other broadcasters, coverage of seed must be provided by some other implement either as a separate operation or as part of the same operation.

Specifications and Recommendations. Because wheeled-trailer type broadcasters have not been extensively tried on range reseeding projects, no specifications can be set up. However, certain features, such as fluted feeds, widely spaced wheels, metal hopper boxes, and antifriction bearings would be desirable. Old or worn drills are often converted to broadcasters by removal of the disk assembly and seed tubes. Grain drills should not be purchased and used exclusively as broadcasters.

Tractor-Mounted Broadcasters

Description. These broadcasters differ from the wheeled and trailer type only in that the seeder box is mounted on the tractor instead of on a separate set of wheels. The seed feed mechanism and agitators are driven from a power takeoff on the tractor.

Adaptability. The general adaptability is the same as for the wheeled or trailer-type broadcaster.

Advantages:

1. More maneuverable than the wheel or trailer types of box broadcaster.

2. Will permit pulling of seed covering or cultivating equipment behind the tractor without a material change in hitches.

Limitations:

1. Is usable only on tractors equipped with power takeoff.

2. Present models do not have satisfactory agitator.

Specifications. No specifications can be prepared at the present time because the available equipment has not been adequately tested in the field.

Implement-Mounted Seeders

There are several types of mounted seeders, differing primarily in the types of implements they can be mounted on. One of these is the conventional-shaped seedbox mounted on the wheatland-type plow, another is mounted on a cultipacker, and there are those that can be mounted on any type of implement. The latter two have received little use on reseeding projects but are listed because they may have specific usefulness.

Wheatland or One-Way Disk Plow Seeder

Description. A metal seeder box or hopper is mounted directly on the plow (fig. 13). Fluted force feeds, the same as used in drills, assure uniform seed delivery. Flexible metal tubes deliver the seed between the disks and near the axle. A chain drive from the power wheel of the plow provides power to the seed shaft. An automatic gear throwout permits the seeding mechanism to operate only when the disks are in the ground.

Figure D-13. --Seeder box mounted on wheatland-type plow.

Adaptability. The plow-mounted broadcaster can be used wherever the plow can be satisfactorily operated.

Advantage:

1. The major advantage of using the broadcaster in conjunction with plowing lies in the reduction of operation cost.

Limitations:

1. There is no particular advantage in having a seedbox on the plow other than during the suitable planting season.

2. The seeder requires more attention than the plow, which reduces the effective time of the plow and large-size tractor. This loss may be such an important factor on some jobs that slowing down the operation may offset the major advantage listed above.

3. Some factory mounted seedboxes are mounted so that the seed is delivered so far forward that too deep coverage results.

Note: This can be remedied by shifting the seedbox farther to the rear, reversing the mounting, or attaching the seed tubes so that the seed falls in the immediate wake of the individual disk.

Specifications:

Feed--Adjustable gate, fluted force feed.

Hopper--Galvanized, rust-resisting steel.

Throwout device--Fully automatic so that seeding is done only when the disks are in the ground.

Guards--Steel shields around sprockets.

Seed tubes--Flexible metal tubes are standard equipment; rubber tubes, such as drills, would probably prove desirable in some areas.

Agitators--Desirable when light or trashy seed is used.

Recommendations. Performance of the plow should govern the selection of the seeder box.

Grass Seeder and Pulverizer

Description. This seeder and pulverizer combines the principles of a soil packer and seeder box (fig. D-14). The seed is dropped into down spouts, which are flanged at the bottom so as to distribute the seed in an even pattern over the seedbed. The front roller wheels have a very shallow tooth so that they open small, shallow furrows less than 1/2 inch deep, into which the seed is dropped by the seeding mechanism. The rear roller wheels then split the front roller wheels in such a way that the seed is covered lightly and the soil packed firmly around the seed.

This type of seeder is available in three different sizes. It may also be purchased in any one of these sizes with either a single seedbox or two seedboxes. Two boxes are preferred because the combination will handle both the legumes and the larger types of grass seed. The three widths are as follows: 5 feet 4 inches, 8 feet 3 inches, and 10 feet 8 inches.

Adaptability. This implement has rather limited application on most rangeland. It may be used, however, where the ground has been well prepared, where the soil surface is smooth, and where rocks, brush, and other debris are absent.

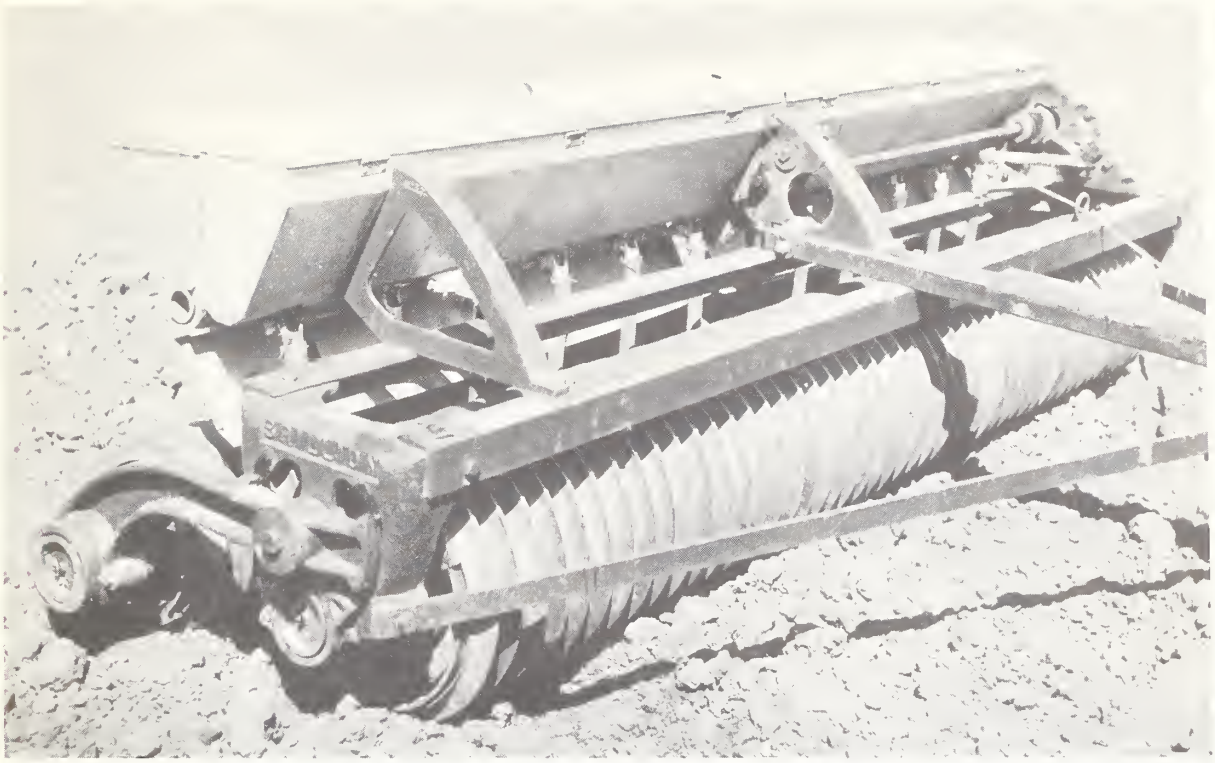

Figure D-14. --Grass seeder and soil packer.
(Photo by Soil Conservation Service.)

Advantages: Where conditions are present as described above, this machine appears to have the following advantages:

1. Seeding and seedbed firming job is completed in one operation.
2. Seed is distributed accurately and uniformly.
3. Seed is placed at a uniform shallow depth.
4. Soil is well firmed around the seed.

Limitations: This type of implement cannot be used if the area to be seeded possesses any one of the following characteristics:

1. Soil surface not smooth and likely to pulverize readily.
2. Topographically uneven soil surface.
3. Rocks and brush, or other debris on soil surface.

Specifications. Detailed specifications will be included after this implement has proved its adaptability for range reseeding work.

E. AIRCRAFT SEEDING EQUIPMENT

Airplanes

Considerable use of airplanes equipped for crop dusting or seed sowing has been made by land managing agencies during the past several years. Both Service-owned and contract planes have been used for this method of broadcasting seed, varying from small planes carrying 100 pounds of seed to heavier craft carrying 3,000 pounds or more.

The overall uses of the plane determine both permanent and demountable installations of the hopper and venturi flume. Because of the many uses of any Service-owned plane, the design must be made for quick installation and removal. Hoppers built in the plane may be of sufficient size for a capacity load or may be constructed so that a "dropper" refills while the plane is in the air. The seed drops from the hopper through gates to a venturi flume mounted underneath the fuselage and is carried away by the propeller slipstream.

Civil Aeronautics Authority approval is required for all extra equipment mounted outside an airplane's cabin.

Two gates are required for precise control of seed flow: (1) A metering gate to control the rate of seed flow through an orifice of variable size; and (2) the seed release gate to start and stop the flow of seed. Both gates are conveniently operated by the pilot on conventional crop dusting and seeding planes.

Airplanes used for seeding should be able to get down into steep canyons for proper seed distribution and should have sufficient power to maneuver without danger of crashing into the sides of the canyon. Speed of airplanes is the least essential qualification. In fact, the faster a plane is required to fly to keep itself aloft, the less effective and more dangerous it is for mountain flying.

No specifications are being included as each airplane rigged must be given tests on performance and seed distribution prior to field use.

The Forest Service has designed a hopper and flume for installation in several types of airplanes. Plans can be furnished upon request and modifications made for installation on other types of airplanes.

Recommendations. Airplanes are recommended for seeding extensive areas of aspen, mountain brush, and timber burns where broadcasting is a successful reseeding method. They may also be used ahead of pipe harrows on larger areas.

Helicopters

The use of helicopters for seeding and spraying is increasing annually (fig. E-1). Broadcasting from one of these machines under good conditions gives the most uniform rate and distribution of seed for any mechanical broadcaster excepting seeder boxes.

Depending upon the altitude at which seeding is desired, the operation of the individual machine, its range, the load to be carried, and other factors will of necessity be tailored to the particular operation and area to be covered.

Figure E-1.--Helicopter spraying 2, 4-D on sagebrush.

The ability of the helicopter to take off and land at unprepared spots in restricted areas, to fly close to the ground in rugged terrain, to operate at very low flying speeds, and to make autorotational landings in event of engine failure makes this aircraft a highly flexible, efficient, and safe tool for sowing range grass seed.

Helicopters attain their maximum efficiency in dense air, which is found at sea level, and in moderate temperatures. Forward speed increases the lifting power of a helicopter as it does the conventional airplane, so that a wind may increase hovering ceilings. Altitude directly affects the operation of helicopters because of the decrease in density of air with the increase in elevation. Temperature also affects operation as the density decreases with increased temperature.

Landing-area requirements for spot landings and takeoffs of the helicopter are the same for all elevations. A ridge-top location is preferred to take advantage of the wind and the resultant increased "lift," and also because flying speed is more quickly gained by losing elevation.

One commercial company manufactures agricultural dusting equipment for their helicopters, which consists of two detachable hoppers with agitating, metering, and dust-ejecting equipment. The same equipment is used for seeding.

Performance comparisons of the helicopters in common use are being made so that the land manager can determine if helicopter seeding is practical on any particular elevation (table E-1).

Table E-1.--Comparison of airplanes and helicopters[1]

Item	Airplane	Helicopter
Payload (dependent upon density, altitude)	100 to 3,000 pounds and over.	100 to 1,250 pounds.
Rentals.....	$0.50 to $1 per acre.	$0.75 to $1.50 per acre.
Control.....	Considerable control needed ranging in cost from $0.25 to $0.75 per acre.	Little control needed ranging from $0.10 to $0.25 per acre.
Landing strips.....	Long runways must be provided and the distance from the strip to the job will increase flying time and costs. Seldom can strips be provided on or adjacent to the area, except for quite small planes.	At lower elevations only a landing spot is required. At higher elevations a short runway may be satisfactory. In many places these can be provided on the area.
Seeding height.....	Sowing is at a 300-500 foot height under optimum conditions and at 1,000 feet over canyons and rougher areas, at an air speed of 80 to 100 miles per hour. This is a safety requirement.	Sowing is at a 50-foot height under optimum conditions at an air speed of 25 to 35 m.p.h. and somewhat higher over canyons and rough areas. Flying can be accomplished at lower heights and less speed than with a plane.
Seeding accuracy.....	Owing to variations in seeding heights, normal wind drift, inaccurate strip flying, etc., even seeding is difficult to accomplish.	An even rate of seeding is produced by flying low and using the positive method of seed dispersal.
Job execution.....	A large project can be completed in a short time provided inclement weather does not set in.	A large project can be completed in a fairly short period of time provided inclement weather does not set in, e.g. perhaps two or three times more quickly than by using an airplane.
Availability.....	Airplanes are available in all areas.	Helicopters and operators are not plentiful.

[1] Prices are for 1949.

F. SEED COVERING EQUIPMENT

Some implements, such as the grain drill and pipe harrow, provide for seed coverage at the same time seed is distributed. When broadcasting under deciduous cover, on timber burns, or on certain types of plowed land, leaf fall, soil movement, or deep ashes will provide adequate coverage for seed germination and growth. The increasing use of motorized broadcasters has however, demanded that other methods of seed coverage be provided.

Commercially manufactured equipment is suitable under some conditions, and local shop-constructed equipment is adequate under others. Some of the more common devices will be discussed in detail.

Harrows

Spike-tooth Harrows

Description. Both metal and wood frame harrows have been commercially produced for a long time. Spike-tooth harrows are manufactured in gangs, 5 or 6 feet in width. Gangs can be assembled by the use of eveners until working widths measure 24 to 30 feet. Teeth are set at a slightly backward angle so that they clear the trash, and the tooth action plus accumulated trash provides seed coverage.

Adaptability. Spike-tooth harrows are sometimes used to cover seed on plowed or disked ground too trashy for drilling. As a general rule, however, other means of seed coverage can be accomplished by implements or devices more effectively and less subject to damage.

Advantage:

1. Compared to drills and other similar implements, the spike-tooth harrow has wider use on very trashy ground for obtaining seed coverage.

Limitations:

1. Rough use under range reseeding conditions tears the harrows apart rapidly. (Wood-bar spike-tooth harrows are supposed to be slightly superior to metal frame harrows in this respect.)

2. Somewhat ineffective in doing a good job of covering seed to a uniform depth and in providing a firm seedbed.

Specifications. None.

Recommendation. If a situation develops where the use of metal spike-tooth harrows is desirable, angle iron reinforcements are needed wherever they can be welded on and the teeth should be spot-welded to the frame.

Spring-tooth Harrows

Description. Spring-tooth harrows are manufactured in gangs ranging from 4 to 10 feet in width. By using eveners, gangs can be assembled to a width 24 to 30 feet. Spring teeth are mounted in 2 or 3 rows on the frame. Harrows may be obtained with either hand or power lifts, and special types are made whereby the teeth can revolve to clean themselves of trash. Cultivating attachments bolted on the teeth are manufactured in several designs.

Adaptability. This implement can be used as a ground preparation and eradication tool or for seed coverage, or both. By attaching sweep or hoe-type openers on the teeth, annual vegetation can be removed on loose to semifirm soils fairly free from large rocks, stumps, and other obstructions. It can also be used on abandoned farmlands and mountain parks, and under other similar conditions.

On areas with comparatively loose soil devoid of shrubby vegetation but too gravelly or rocky for drilling, the spring-tooth harrow can be used to cover seed.

Advantage:

1. This implement is portable, flexible, and fairly well adapted to the same situations as outlined above.

Limitations:

1. In spite of its flexibility, there are other types of equipment which, if available, are more suited to the work and will do a better job.

2. This implement will collect too much brush and debris on areas not free from this material, in spite of the fact that the trash can be dumped.

Specifications:

Sturdy construction is desirable.

Frame--2-inch square tubing or equal welded construction.

Bars--3-bar construction.

Tooth spacing--12 inches.

Teeth--spring steel 3/8 x 1-3/4-inch minimum.

Cultivator attachments--as needed.

Stabilizer attachment.

Recommendations. The user should select the manufactured implement that most closely fits his needs. Generally, it is believed that other types of implements are more suited to the work and do a better job. The choice is dependent upon local situations.

Two-Inch Pipe Harrow

Description. A 2-inch pipe harrow, similar in principle to the larger 4-inch pipe harrow, has been used in the Intermountain Region for seed coverage.

Spikes are staggered on 2-inch pipe as on 4-inch, excepting that it is not essential to have a spike-holder casting or brace. One-half inch swivels or clevis arrangements are used to attach the individual pipes onto a rail, I-beam, or other type spreader bar. A 14-foot width is about the maximum for simple construction.

Adaptability. The 2-inch pipe harrow has proved efficient for seed coverage on ground too rocky for drilling. In addition, it removes a minor percentage of the competition remaining after plowing.

Specification. Specifications may be obtained from the U. S. Forest Service, Ogden, Utah.

Recommendation. The 2-inch pipe harrow is recommended for seed coverage on rocky, trashy, plowed areas that cannot be seeded by a conventional farm drill or the rangeland drill.

Rotary Harrow

This particular harrow with a rotary action was developed for cultivating vineyards (fig. F-1). In preparation for broadcast seeding, it shows promise as an instrument for loosening soil that has become compacted as a result of logging.

Figure F-1.--Rotary harrow in use on skidroad.

Drags

To cover broadcast seed on relatively loose seedbeds, a number of improvised drags have been used. Perhaps the most common is simply a drag consisting of brush, conifer branches, or several suitable-sized junipers. A mat of brush or several small trees are spaced on a spreader to provide soil movement and seed coverage.

A light log chain may be allowed to drag in a loop behind a drill if sufficient coverage is not obtained by either natural soil slough or by the drag chains.

A heavy log chain looped behind a rail or other type of spreader has been used with success on loose, trashy seedbeds when seeding is accomplished by broadcasting. Some additional sagebrush is removed by the rail (fig. F-2).

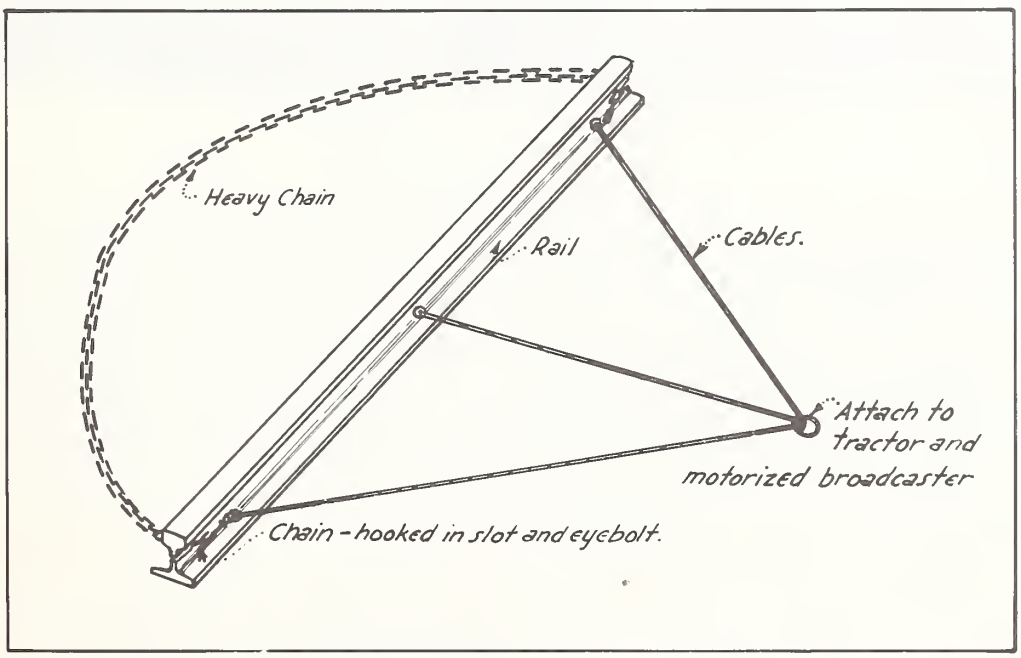

Figure F-2.--Rail and chain drag for seed coverage and additional sage removal after ground is plowed.

Soil Packers

Packers, firmers, or pulverizers may prove useful for covering seed if only light coverage is desired. Ordinarily such implements are used in conjunction with other seeding or covering equipment to firm the soil covering the seed. Cultipackers or similar machines may be used either before or after seeding to create a firm seedbed. On some agricultural lands they are used both before and after seeding. Press wheel gangs usually can be obtained for any drill as extra equipment and tend to serve much the same purpose as a packer although they may be more subject to breakage or slowdowns. Logs and concrete filled culverts have been used as soil packers with fair success in some places.

Flexible Cultipacker

This particular cultipacker has been designed with individual rollers so that it can roll over large rocks and uneven ground without changing the axle or drawbar alignment (fig. F-3). This implement offers some promise where a cultipacker is needed on loose, moderately rocky or uneven ground. It can be pulled ahead of a drill.

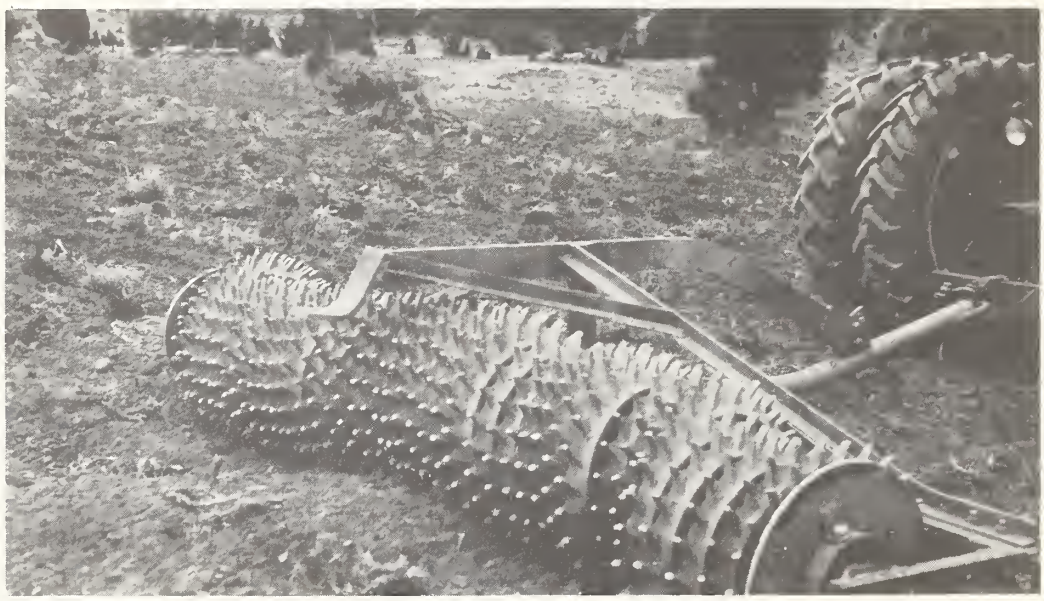

Figure F-3. --Flexible cultipacker.

Auto Tire Compaction Unit

Description. The auto tire compaction unit consists of two sections. The front portion consists of 7 wheels and tires with a spacing of 11 inches from center to center. The rear section has 6 wheels and tires with spacing identical to the first but offset 5-1/2 inches from the center line of those of the front section. Each wheel is separately suspended on its own spindle and is equipped with a heavy adjustable spring, permitting portions of the load to be distributed to each wheel. Also, each wheel can be lifted independently for repairs or removal. This design allows each wheel to act independently when traversing rough terrain (fig. F-4).

The unit provides an excellent base on which to mount a seeder. This has been done successfully.

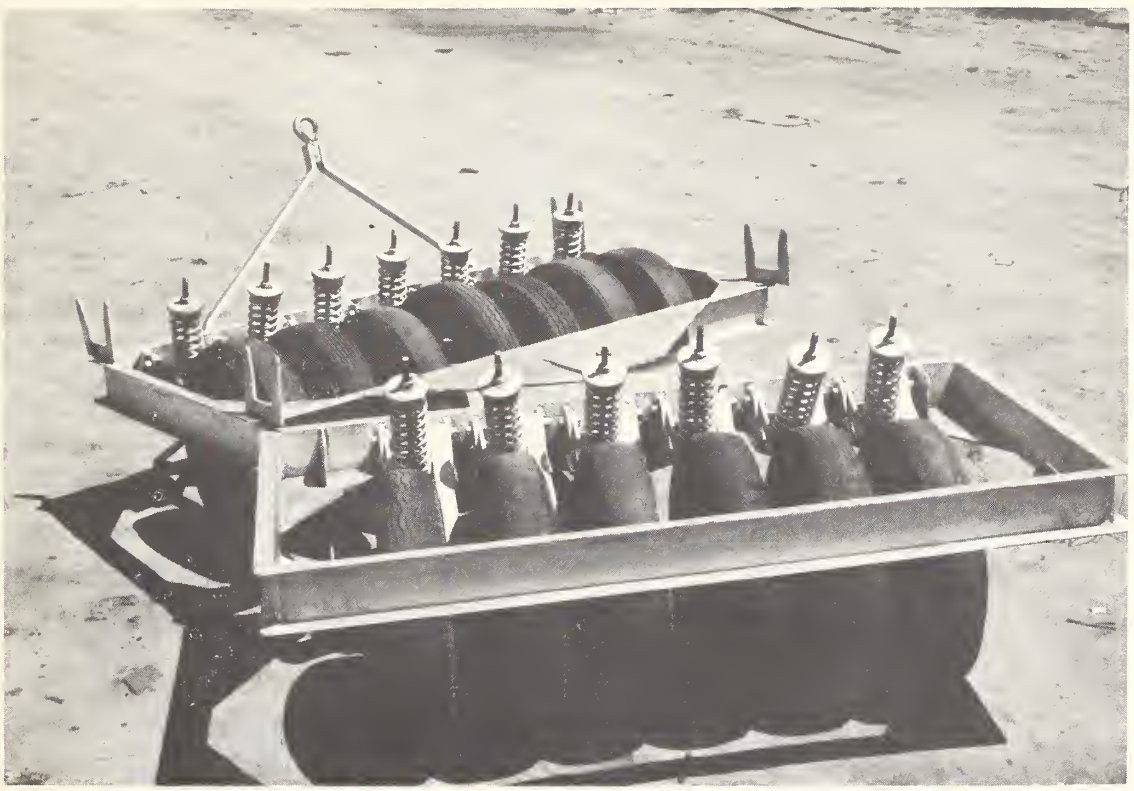

Figure F-4. --Auto tire compaction unit.
(Photo by Bureau of Indian Affairs.)

Adaptability. The unit does a good job in compacting the soil on moderately rough and rocky, plowed, sagebrush land. When equipped with a seedbox, the unit successfully serves as both a seeder and compactor.

Advantages:

1. Implement is portable, comparatively reasonable in cost, and does a good job in compacting loose seedbeds.

2. Cost of operation is reasonable.

3. Unit is sturdy and not subject to excessive breakage.

Limitation:

1. The seeder presently used on the unit is inadequate. If used both as a seeder and a soil compactor, a new seeding device should be installed.

Specifications:

Frame--6 x 2-inch standard weight channel iron.

Tires--6.50 x 16 smooth.

Hitch--2 x 3/4-inch flat iron with either a standard trailer hitch or coupling hitch--a "Quick Coupler;" 1/4-inch plate iron, triangular in shape, braced and tied together with a 1-1/2-inch belt.

Sectional Roller-Seeder

This seeder is similar to the auto tire compaction unit but has the advantage of a more effective seeding device (fig. F-5). This implement is especially well adapted for use on seedbeds of light and sandy soils. It is less effective in compaction coverage than the other unit.

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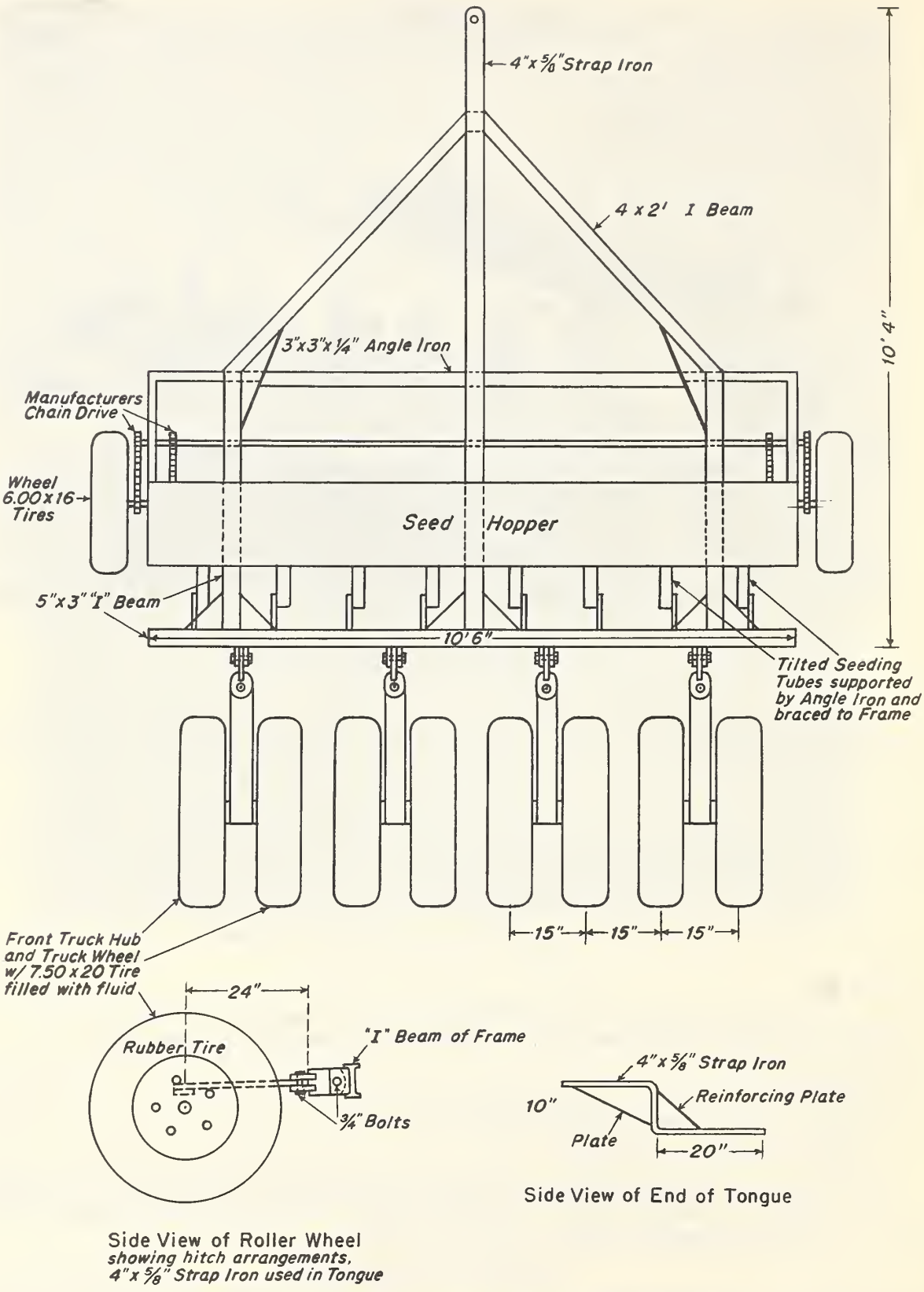

Figure F-5. --Top view of roller seeder (Bureau of Land Management).

G. MULTIPLE HITCHES

One man operating a large tractor can often handle more than one implement; in this way the tractor power is fully utilized and overall costs are reduced. Work on uneven ground is handled easier with smaller implements hitched together than with a single large one.

Most implement companies manufacture multiple or squadron hitches for specific use with their implements; if this restricted use is desired, purchase should be made. It is easy to build a "homemade" multiple hitch for a variety of implements. Certain rules applying to the construction and use of all multiple hitches are as follows:

1. The hitch must be strong enough to transmit the pull of the tractor.
2. It must allow the implement attached to turn without interference.
3. It should be so constructed that implements may be quickly attached or detached.
4. If the hitch is wide, it should have joints or other provisions for flexibility on uneven ground.
5. Some operators prefer to mount these hitches on wheels. When this type of construction is used, it is very important that wheels of ample size and tire width be used so as not to materially increase the draft of the multiple unit. It is important also to attach the hitch member to the axle so that the pull from the tractor drawbar to the center of resistance of the load does not cause a downward pressure on the wheel.
6. When hitching several drills for use on hilly land, it is necessary to provide either stiff cross-connecting bars or a rigid brace and connection. This prevents the drills from running ahead and holds them in place on the hillsides.
7. The hitch should be easily adapted to different sizes and kinds of implements.
8. It should be constructed so that it can be quickly dismantled for transporting.

Materials for constructing multiple hitches can be made of pipe, angle iron, wood, chain, cable, or a combination of these materials. Where wood is used, the various members should be reinforced by steel plate to strengthen the connections.

For Drills

The two-drill hitch (figs. G-1, G-2) and the three-drill hitch (figs. G-3, G-4) indicate some of the multiple hitch arrangements that have proved satisfactory and are now used extensively in the Intermountain Region. Figure G-1 shows details of construction for the two-drill hitch. The three-drill hitch shown in figure G-3 is being used to good advantage by the Bureau of Land Management.

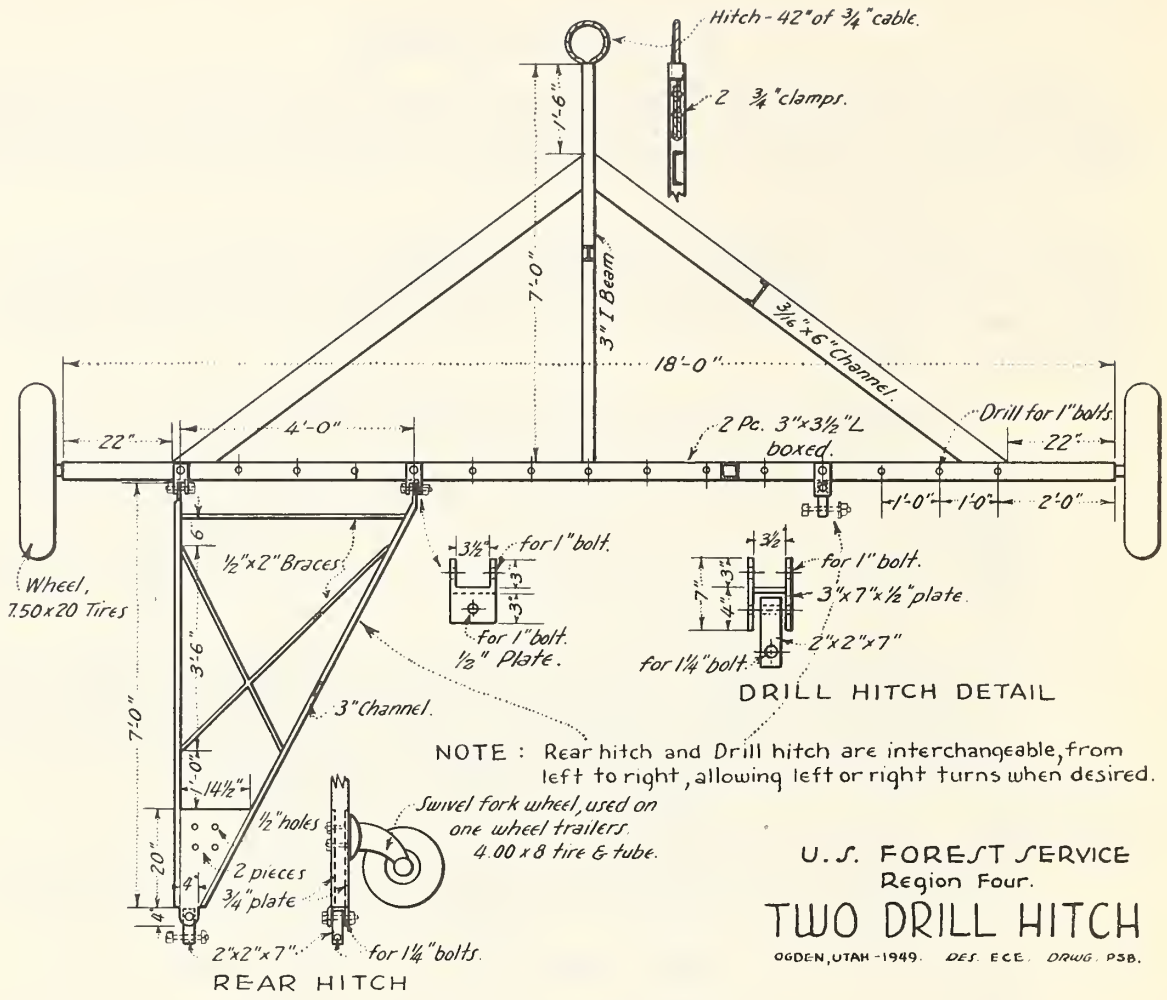

Figure G-1.

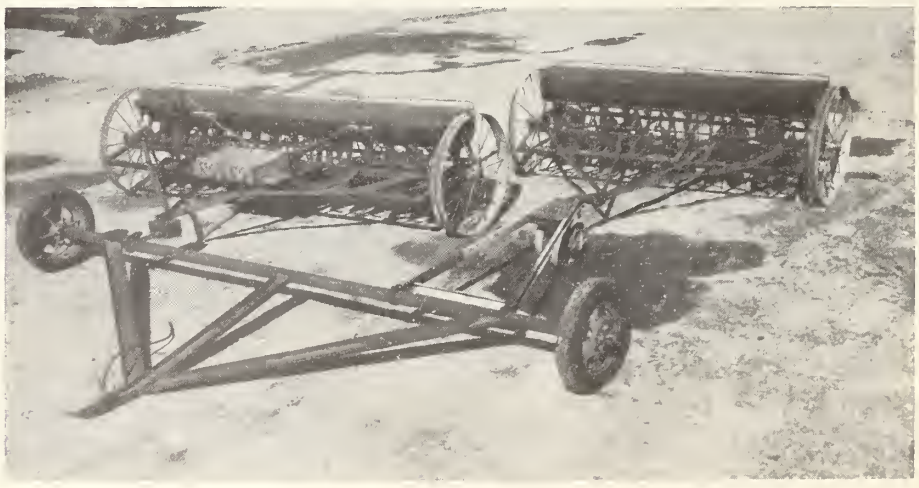

Figure G-2.

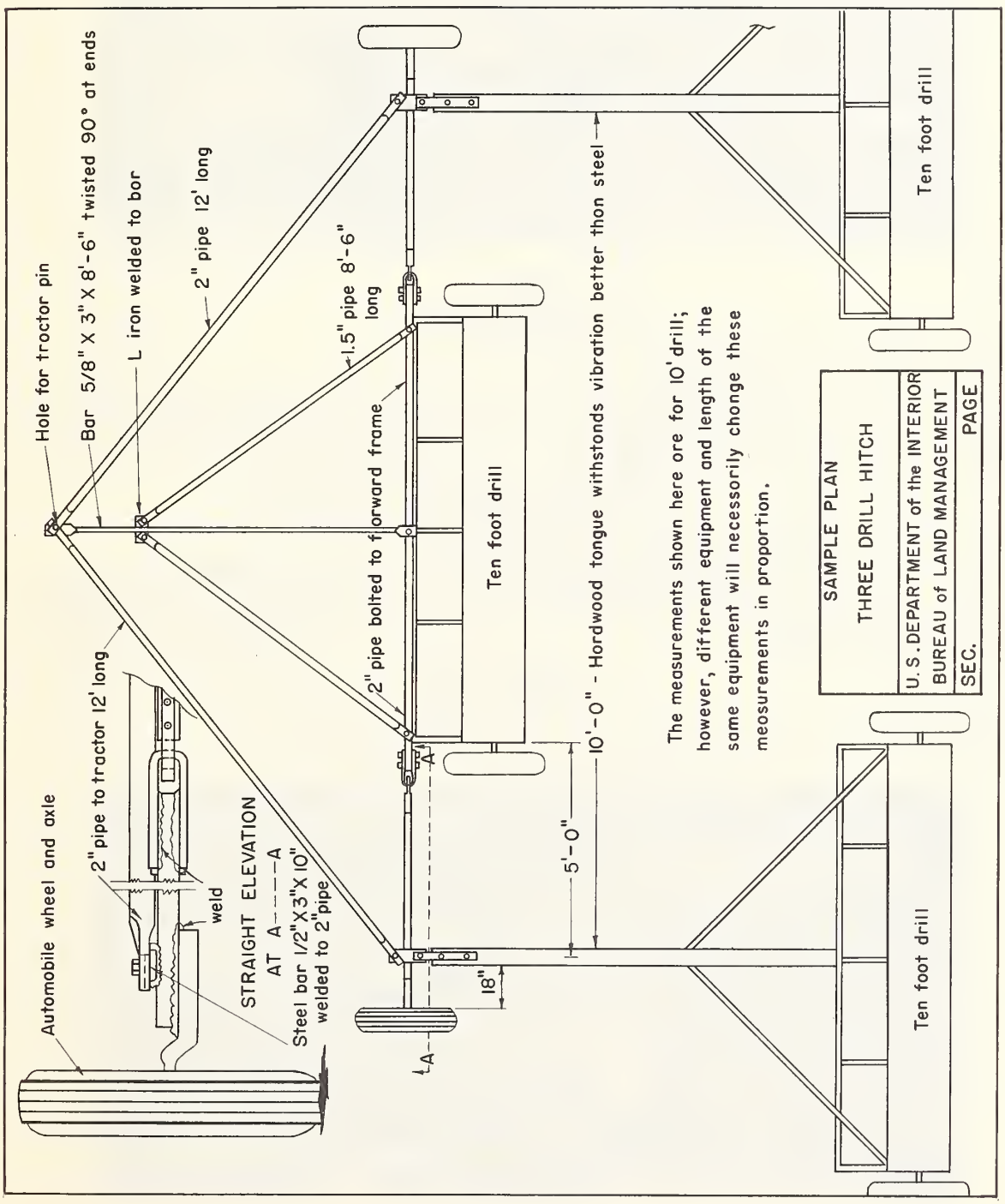
Hole for tractor pin
Bar 5/8" X 3" X 8'-6" twisted 90° at ends
L iron welded to bar
2" pipe 12' long
1.5" pipe 8'-6" long
2" pipe bolted to forward frame
Ten foot drill
10'-0" - Hardwood tongue withstonds vibration better than steel
Ten foot drill
Ten foot drill
Automobile wheel and axle
2" pipe to tractor 12' long
weld
STRAIGHT ELEVATION AT A----A
Steel bar 1/2"X3"X 10" welded to 2"pipe
18"
5'-0"
A
A
The measurements shown here ore for 10' drill; however, different equipment and length of the same equipment will necessorily chonge these meosurements in proportion.
SAMPLE PLAN
THREE DRILL HITCH
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Figure G-3.

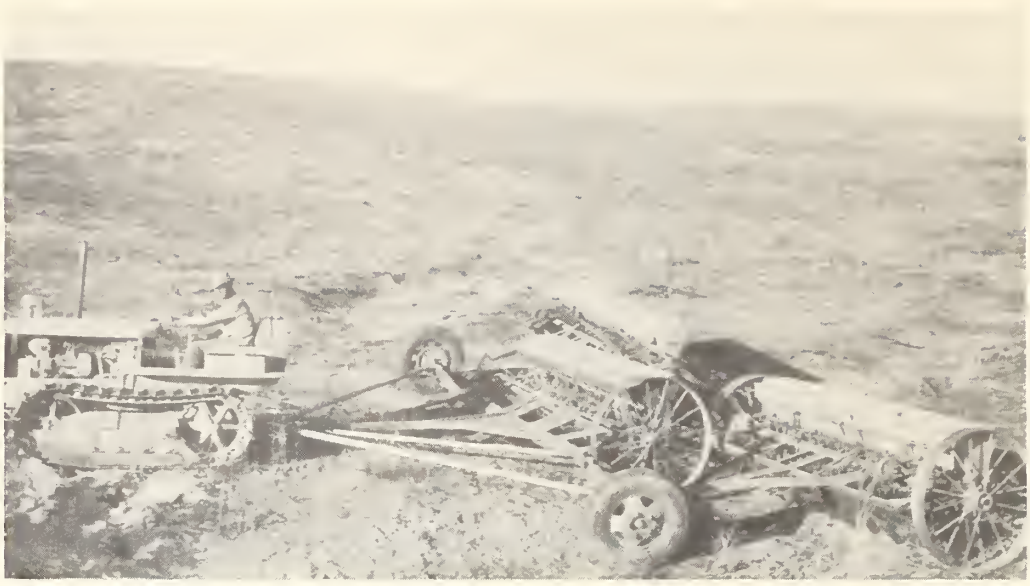

Figure G-4.

For Rangeland Drills

A hitch can pull two drills in three ways:

1. Side by side, each drill hooked to a drawbar beam on the tractor, which in turn is controlled by a hydraulic tool bar attachment. This arrangement functions all right except that about a 4-foot unseeded strip results, even with the inside drill wheels as close together as possible.

2. Offset tandem with the rear drill attached to the front one.

3. Offset tandem with the rear drill attached to a drawbar beam on the tractor through a flexible linkage and supported by a fifth wheel or dolly.

The above are suggestions only. No actual use designs have been made other than (1), which was actually tried in the field. A tractor of 40 db. hp. or its equivalent can pull two drills.

For Offset Disks

Figures G-5, G-6 (sample plan for the couplings for offset disks), and G-7 (tractor dual hitch for offset disks) provide specific information on one type of

Figure G-5.

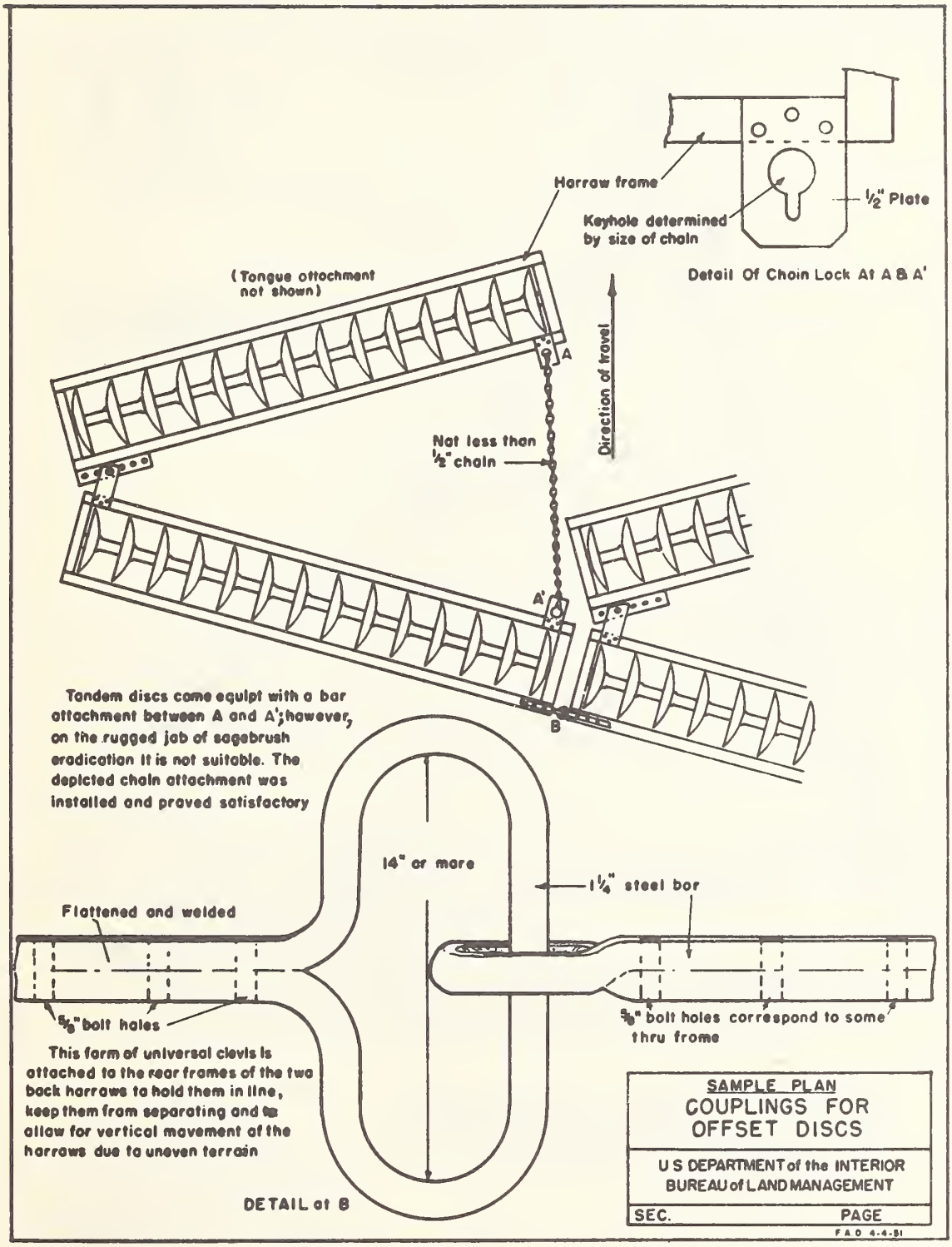
Harrow frame
Keyhole determined by size of chain
½" Plate
Detail Of Chain Lock At A & A'
(Tongue attachment not shown)
A
Direction of travel
Not less than ½" chain
A'
B
Tandem discs come equipt with a bar attachment between A and A'; however, on the rugged job of sagebrush eradication it is not suitable. The depicted chain attachment was installed and proved satisfactory
14" or more
1¼" steel bar
Flattened and welded
⅝" bolt holes
⅝" bolt holes correspond to some thru frame
This form of universal clevis is attached to the rear frames of the two back harrows to hold them in line, keep them from separating and to allow for vertical movement of the harrows due to uneven terrain
DETAIL at B
SAMPLE PLAN
COUPLINGS FOR OFFSET DISCS
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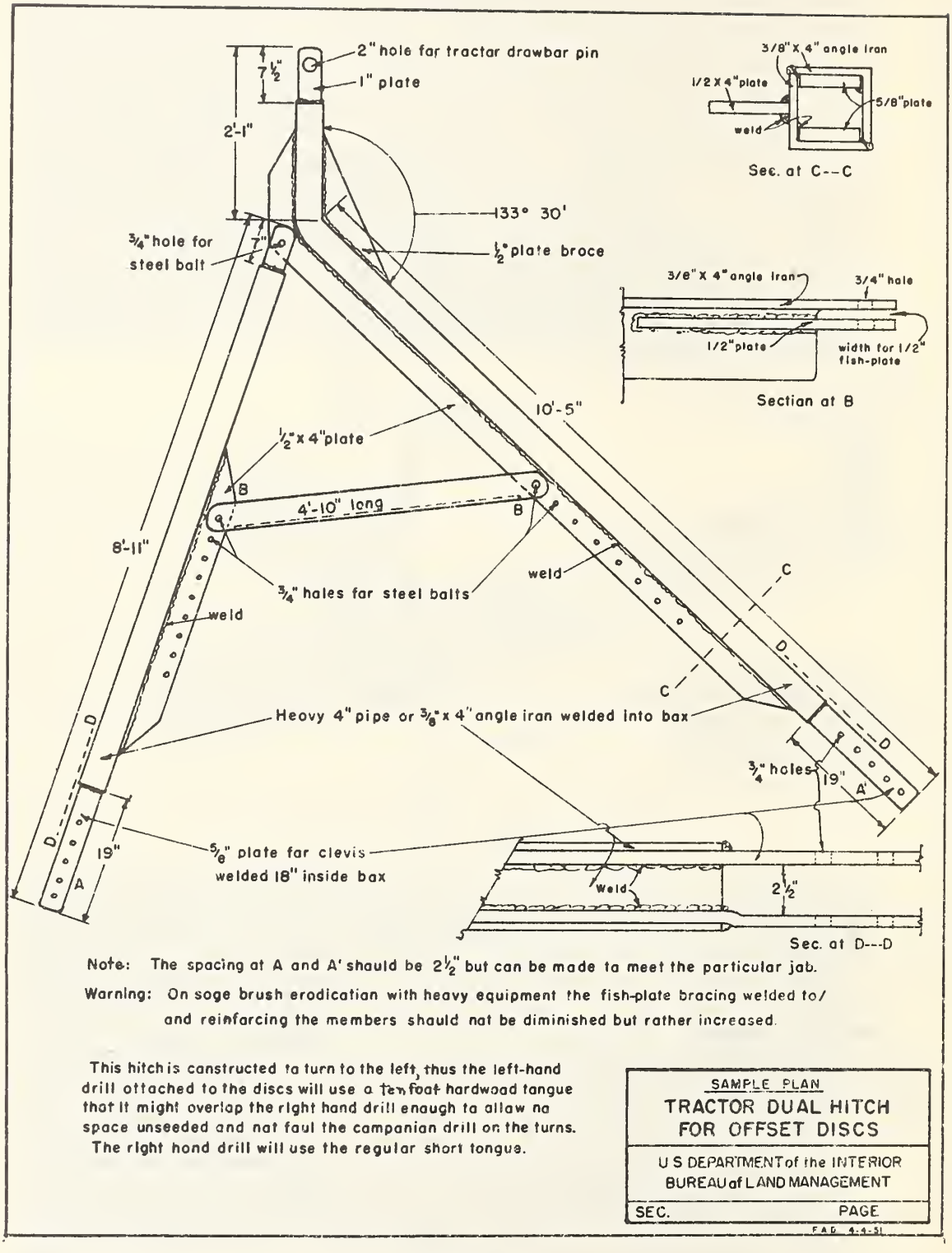
Figure G-6.



Note: The spacing at A and A' shauld be 2½" but can be made ta meet the particular jab.

Warning: On soge brush erodicatian with heavy equipment the fish-plate bracing welded to/ and reinfarcing the members shauld nat be diminished but rather increased.

This hitch is canstructed ta turn to the left, thus the left-hand drill attached to the discs will use a ~~ten~~ foot hardwoad tangue that it might overlap the right hand drill enaugh ta allaw na space unseeded and nat faul the campanian drill on the turns. The right hand drill will use the regular short tongue.

SAMPLE PLAN

TRACTOR DUAL HITCH FOR OFFSET DISCS

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Figure G-7.

multiple hitch used by the Bureau of Land Management. The chain works much better than the standard separator bar and allows for more rapid adjustment. Where a tandem hitch is desired, a clevis is used to connect the two disks.

As indicated in figure G-5, it is the practice in some areas to pull tandem disks and trail grain drills behind each disk. This practice has proved satisfactory in light stands of sagebrush provided it is possible to keep from planting the seed too deep.

For Brushland Plows

The hitch developed by the Bureau of Land Management was designed to connect two brushland plows to a single tractor (figs. G-8, G-9, G-10). A crawler-type tractor of 40 db. hp. or its equivalent will handle two plows very well.

Essentially the job consists of:

1. Removing the rear wheel and tail beam assemblies, the trunnion, and the drawbar assembly from one plow. This plow becomes the front unit.

2. A shaft and an axle machined for one of the rear wheels from the rear wheel assembly and attached by a weld and bolts outside the main side frame assembly at the point where the tail beam assembly joins the main side frame assembly. Also at this point, placed in a horizontal position under the main side frame and main beam assemblies, is a somewhat fan-shaped hardened steel plate. The narrow end of this plate protrudes to the rear and becomes the drawbar for the rear plow, by a clevis being fitted to a hole drilled in the plate.

3. A tubular steel drawbar beam, one end welded to the front end of the plate (2) above, and the other welded to the drawbar beam of the plow at a point midway between the tie angle and the draft angle link, terminating in a flattened steel plate keyhole slotted to receive a heavy chain. This chain is fastened to one end of a spreader bar; the other end of the spreader bar is connected to the drawbar and the steering drag link of the plow; from each end of the spreader bar heavy chains extend to the tractor drawbar.

4. Reinforcing the plow by a steel beam fastened to the main side frame assembly and the forward frame angle assembly.

After the above alterations, this unit is always used as the front plow; no alterations are made on the rear plow. This change is not recommended if it is anticipated that the unit will be used in the future as a single plow. This hitch has been satisfactorily used for two field seasons.

The multiple hitch developed for the 1948 model of the brushland plow by the Southwestern region of the Forest Service (Region 3) is also shown in figure G-11. The hitch must be varied slightly to fit the 1951 model, which has a single tail wheel.

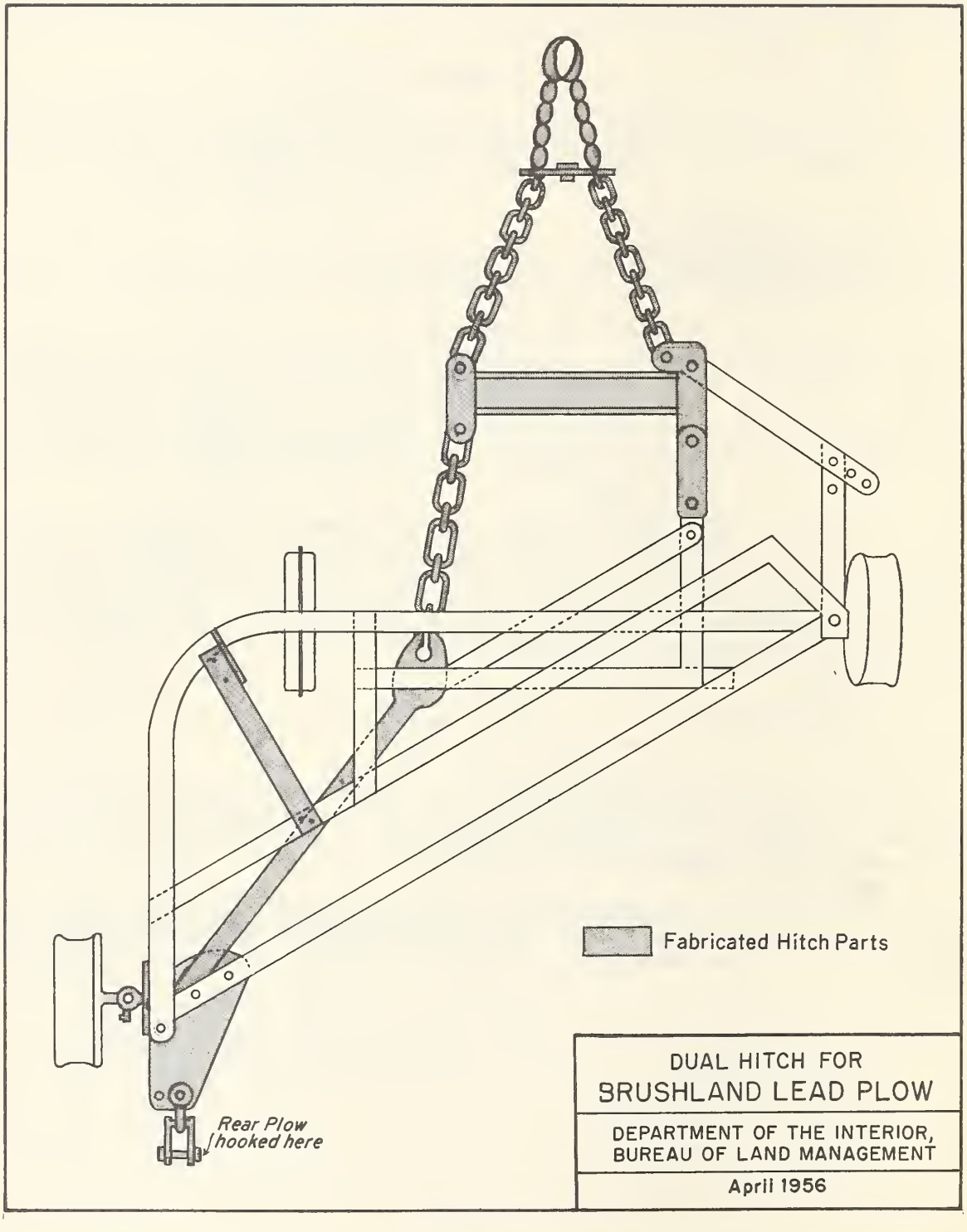
Fabricated Hitch Parts
Rear Plow hooked here
DUAL HITCH FOR
BRUSHLAND LEAD PLOW
DEPARTMENT OF THE INTERIOR,
BUREAU OF LAND MANAGEMENT
April 1956

Figure G-8.

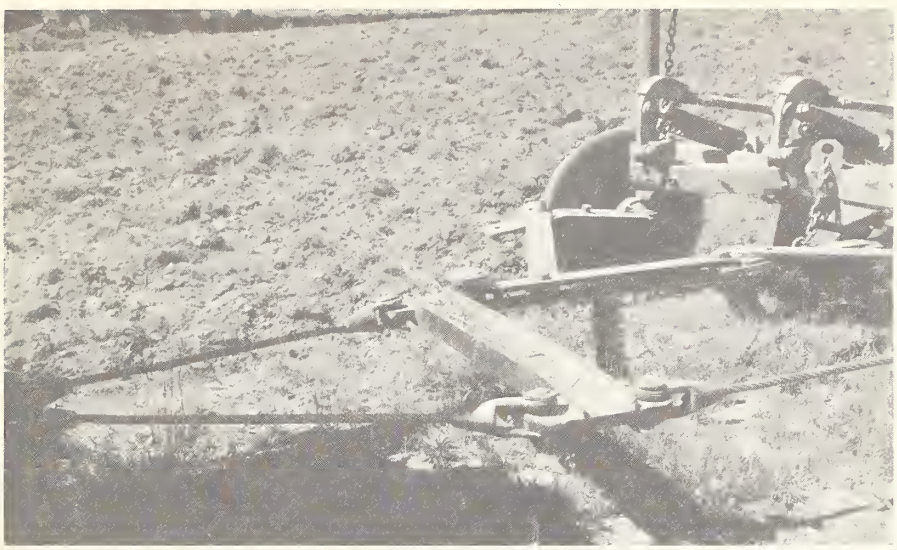

Figure G-9. --Front hitch, tandem hookup, brushland plow, 1951 model.

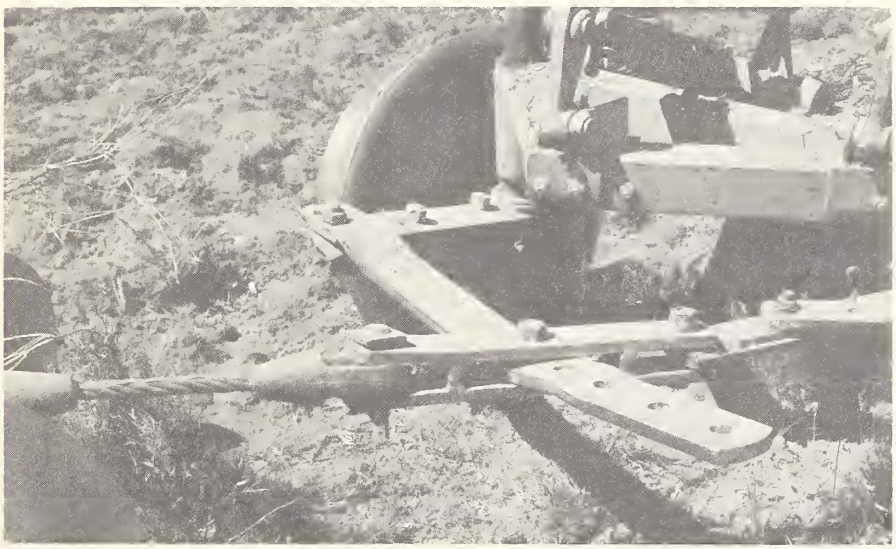

Figure G-10. --Rear hitch, tandem hookup, brushland plow, 1951 model.

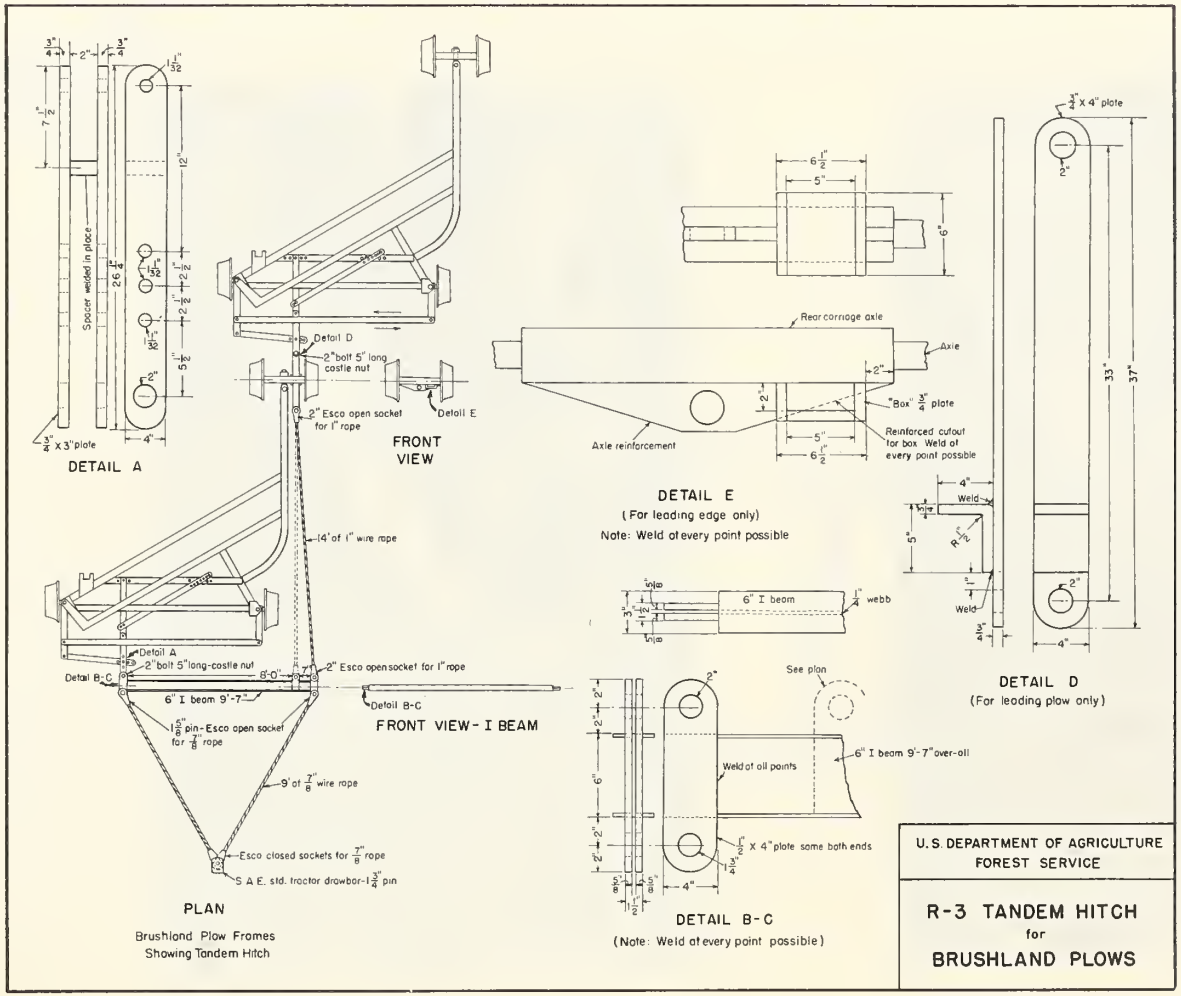
DETAIL A
Spacer welded in place
FRONT VIEW
Detail D
2" bolt 5" long castle nut
Detail E
2" Esco open socket for 1" rope
14' of 1" wire rope
Detail A
2" bolt 5" long-castle nut
Detail B-C
6" I beam 9'-7"
2" Esco open socket for 1" rope
FRONT VIEW - I BEAM
9' of 7/8" wire rope
Esco closed sockets for 7/8" rope
S.A.E. std. tractor drawbar-1 3/4" pin
PLAN
Brushland Plow Fromes
Showing Tandem Hitch
DETAIL E
(For leading edge only)
Note: Weld at every point possible
Rear carriage axle
Axle
"Box" plate
Axle reinforcement
Reinforced cutout for box Weld at every point possible
6" I beam
webb
DETAIL B-C
(Note: Weld at every point possible)
See plan
Weld at all points
6" I beam 9'-7" over-all
DETAIL D
(For leading plow only)
Weld
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
R-3 TANDEM HITCH
for
BRUSHLAND PLOWS

Figure G-11.

H. DRAWBAR EQUIPMENT

Adaptability. The size and type of power units most desirable for a reseeding project may differ depending upon the size of project, soil topography, and equipment being pulled. For example, a tractor smaller than, or equal to, a 50 db. hp. is adapted to small, inaccessible areas or tracts of small acreage. A track-laying tractor will be most useful on sandy or light soils, or in steep, rugged topography; whereas a wheel tractor may be most efficient on level areas. A wheel tractor seems best for drilling, but a track-laying tractor is desirable for plowing, harrowing, or railing. Even in these latter operations, the larger wheel tractor can sometimes be used with considerable savings in operating costs. In any event the Equipment Engineer should be consulted for advice and guidance.

Specifications:

Track-laying tractors should be wide gage and track cleats must not be worn.

On wheel tractors avoid the use of rubber wheels on sagebrush burns. To avoid slippage when rubber wheels are used, fill with calcium chloride for additional weight.

Weapons carriers, jeeps, and other 4-wheel-drive vehicles have been used for pulling lighter draft equipment, such as drills and light drags, but their use for the purpose is not recommended since they cannot stand a heavy continuous pull in low gear.

In deciding on the size of tractor needed, tables H-1, H-2, and H-3, showing power of tractors and drafts of different types of equipment, should be used.

Figure H-1 shows acres covered in an hour as related to working width in feet of the implement.

Table H-1.--Pounds pull for reseeding equipment[1]

Equipment	Working width	Average pull	Extreme pull
	Feet	*Pounds*	*Pounds*
Grain drill	10	500	1,000
Light offset disk harrow	6	1,200	2,000
Heavy offset disk harrow	10	4,000	6,500
Sagebrush pipe harrow # 2	14	4,000	6,500
Sagebrush pipe harrow # 2 (with I-beam evener)	28	9,000	15,000
Wheatland-type plow	6	3,000	4,500
Wheatland-type plow	10	3,500	6,000
2 Wheatland-type plows (with I-beam evener)	14	4,500	6,500
3 Wheatland type plows (with I-beam evener)	20	5,500	8,000
Brushland plow	10	2,500	4,000

[1] Measurements are from Chatillon drawbar pull recorder and are an average for a variety of conditions.

Table H-2.--Comparative specifications of industrial track-laying tractors

Model	Weight[1]	Hp. eng.	Hp. db.	First gear		Second gear		Third gear		Fourth gear		Fifth gear		Sixth gear	
				Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull
Allis Chalmers	*Pounds*			*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*
HD-21 AC	44,000	204	144	0-3.0	[2] 65,000	0-7.5	[2] 35,000	.....	.....	.....	.....	.....	.....	.....	.....
HD-16 A	31,500	.....	125	1.4	33,100	2.1	21,735	3.0	15,105	3.9	11,270	4.5	9,465	5.8	6,930
HD-16 AC	31,600	150	105	0-2.5	[2] 60,000	0-4.3	[2] 47,000	0-7.2	26,000	.....	.....	.....	.....	.....	.....
HD-11	20,500	.....	75	1.4	20,000	2.1	13,250	2.9	9,300	3.8	7,000	4.4	5,700	5.7	4,200
HD-6	12,400	.....	45	1.5	11,525	2.4	6,780	3.3	4,890	4.0	3,960	5.5	2,650	.....	.....
Caterpillar															
D-9 Conv	56,700	286	.....	0-4.1	[2] 80,000	0-5.8	[2] 61,000	0-7.8	45,000	.....	.....	.....	.....	.....	.....
D-9	56,800	.....	230	1.6	54,200	2.1	41,600	2.9	30,250	3.9	21,000	5.0	14,840	.....	9,720
D-8 Conv	39,900	191	.....	0-3.6	[2] 52,000	0-5.3	[2] 44,500	0-7.4	32,000	.....	.....	.....	.....	.....	.....
D-8	39,100	.....	155	1.5	39,150	1.9	30,900	2.8	21,000	3.8	14,100	5.2	9,490	.....	.....
D-7	26,000	.....	102	1.5	25,900	2.2	17,700	3.2	11,960	4.6	7,550	5.9	5,280	.....	.....
D-6	17,600	.....	75	1.7	17,000	2.6	10,900	3.6	7,550	5.0	5,150	6.6	3,600	.....	.....
D-4	10,700	.....	50	1.9	9,550	2.7	6,930	3.4	5,350	4.2	4,110	6.1	2,600	.....	.....
D-2	7,450	.....	38	1.8	7,250	2.7	5,200	3.2	4,220	3.9	3,430	5.5	2,230	.....	.....
International															
TD-24 Conv	40,000	200	.....	0-2.7	[2] 70,000	0-3.5	[2] 70,000	0-6.1	[2] 40,000	0-7.6	35,000	.....	.....	.....	.....
TD-24[3]	39,670	.....	161	1.6	37,160	2.1	28,490	2.5	23,415	3.2	18,180	4.2	13,125	5.4	9,690
TD-18	28,400	.....	103	1.6	24,300	2.1	18,290	2.6	14,520	3.4	10,860	4.5	7,920	5.5	6,100
TD-14	20,000	.....	78.5	1.7	16,500	2.3	12,400	2.9	9,320	3.7	7,100	4.8	5,120	6.3	3,650
TD-9	11,000	.....	54	1.7	11,160	2.5	7,850	3.4	5,530	4.3	4,160	5.9	2,850	.....	.....
TD-6	8,000	.....	41.5	1.6	8,260	2.3	6,190	3.3	4,250	4.1	3,380	5.7	2,220	.....	.....
Oliver[4]															
OC-18 (D)	32,000	.....	133	1.4	31,000	2.6	18,500	3.7	11,800	5.4	6,880	.....	.....	.....	.....
D (D)	13,250	.....	60	1.4	14,700	2.2	9,630	3.0	7,275	4.8	3,975	.....	.....	.....	.....
OC-12 (D)	11,000	.....	53	1.5	11,330	2.2	8,300	3.3	5,700	5.2	3,390	.....	.....	.....	.....
OC-6 (D)	5,600	.....	34	1.8	6,775	2.4	5,200	3.2	3,700	4.2	2,725	5.1	2,100	8.9	922
OC-6 (G)	5,450	.....	33	1.8	6,200	2.4	4,675	3.2	3,425	4.1	2,525	5.1	1,990	8.9	897
OC-3 (G)	3,250	.....	21.8	2.0	3,940	3.2	2,500	5.2	1,470	.....	.....	.....	.....	.....	.....
American Tractor Company Terra-Trac[4] [5]															
600 (G)	7,040	56	39	0-1.9	[2] 15,800	0-3.4	.....	0-4.0	.....	0-7.0	.....	.....	.....	.....	.....
600 (D)	7,290	56	39	0-1.9	[2] 15,800	0-3.4	.....	0-4.0	.....	0-7.0	.....	.....	.....	.....	.....
500 (G)	5,150	45	36	0-1.9	[2] 11,200	0-2.9	.....	0-4.8	.....	.....	.....	.....	.....	.....	.....
500 (D)	5,350	40	32	0-1.9	[2] 10,080	0-2.9	.....	0-4.8	.....	.....	.....	.....	.....	.....	.....
400 (G)	5,500	33	30	1.7	5,990	2.7	.....	4.5	.....	.....	.....	.....	.....	.....	.....
400 (D)	5,350	33	27	1.7	5,300	2.7	.....	4.5	.....	.....	.....	.....	.....	.....	.....
300 (G)	5,180	34	27	1.7	5,580	2.7	.....	4.5	.....	.....	.....	.....	.....	.....	.....
200 (G)	5,160	33	26	1.7	5,120	2.7	.....	4.5	.....	.....	.....	.....	.....	.....	.....
John Deere															
40	4,200	Not available		.87	.....	2.25	.....	3.0	.....	5.25	.....	.....	.....	.....	.....

[1] Figures indicate approximate bare shipping weight based on wide gage standard roller track frame; most model tractors can be furnished with extra roller frames.

[2] Drawbar pulls of torque converter models are calculated pulls based on zero track slippage; actual maximum drawbar pulls in low range speeds are estimated at 90 percent of tractor operating weight.

[3] 7th gear: 6.3 m.p.h., 7,320 pounds pull. 8th gear: 8.0 m.p.h., 5,490 pounds pull.

[4] (D)-Diesel; (G)-Gas.

[5] 500 and 600 Models--Converter type.

Teble H-3.--Comparetive specifications of industrial wheel trectors

Model	Weight[1]	Hp. db.	First gear		Second gear		Third gear		Fourth gear		Fifth gear		Sixth gear	
			Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull	Speed	Pull
Allie Chelmers	*Pounds*		*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*	*M.p.h.*	*Pounds*
WD-45 Gas	4,450	40.01	2.1	5,441	3.6	3,679	5.0	2,719	11.4	1,113	.....	.....	.....	.....
WD-45 Diesel	4,730	30.59	2.2	4,634	3.7	2,921	5.0	2,165	11.4	870	.....	.....	.....	.....
B Ges	2,060	20.60	2.4	2,667	4.2	1,650	8.4	762	.....	.....	.....	.....	.....	.....
G Ges	1,285	9.59	1.2	1,143	1.9	1,167	3.1	1,062	6.5	512	.....	.....	.....	.....
Cese														
500 Diesel	7,850	58.55	2.4	7,409	3.6	5,762	5.0	4,252	10.6	1,827	.....	.....	.....	.....
411[2] Gas	5,900	47.21	1.2	6,147	1.7	6,045	2.3	6,022	3.7	4,183	4.8	3,208	7.0	2,160
401[3] Diesel	6,150	44.84	1.2	6,018	1.7	6,033	2.3	5,982	3.7	4,418	4.7	3,439	6.9	2,287
300 Ges	3,100	35.00	2.3	.....	3.3	.....	4.4	.....	10.8	.....	.....	.....	.....	.....
John Deere														
80 Diesel	8,000	61.76	2.0	7,394	3.2	6,587	4.3	5,161	5.1	4,412	6.6	3,416	12.3	1,708
70 Gas	6,400	44.21	2.1	5,453	3.3	4,467	4.5	3,318	6.5	2,318	9.0	1,576	12.9	1,031
70 Diesel	7,140	45.66	2.2	6,189	3.3	4,941	4.5	3,687	6.5	2,589	9.0	1,840	12.9	1,243
60 Ges	6,175	36.94	1.2	4,319	2.2	4,373	3.3	3,636	4.3	2,881	6.3	1,894	11.3	950
60 All-fuel	5,347	30.09	1.2	4,499	2.3	4,263	3.4	2,967	4.4	2,386	6.4	1,537	11.3	761
40 Gas	2,750	22.88	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ferguson														
TO-35 Gas	3,000	31.68	1.0	3,409	1.5	3,414	2.9	3,400	4.5	2,380	7.0	1,519	13.3	593
Ford														
860 Gas	3,000	40.18	1.9	4,514	3.2	4,139	4.4	3,090	6.2	2,128	11.4	1,069	.....	.....
660 Gas	2,800	29.75	1.9	3,859	3.4	2,930	4.6	2,100	6.6	1,394	11.9	693	.....	.....
640 Gas	2,800	29.37	3.1	3,008	4.4	2,291	6.3	1,625	13.6	688	.....	.....	.....	.....
Fordson mejor														
Diesel	5,125	36.29	1.7	5,315	2.5	4,777	3.4	3,703	5.0	2,627	7.1	1,814	13.11	850
Harris														
F&W (FWD) Gas	5,000	52.07	2.0	6,160	3.3	5,512	4.9	3,816	15.0	974	.....	.....	.....	.....
FDW-C (FWD) Diesel	5,650	44.65	1.8	6,999	3.1	5,125	4.5	3,529	13.5	971	.....	.....	.....	.....
Massey Harris														
55 Ges	6,775	60.45	2.6	6,377	4.1	4,957	5.2	3,928	12.5	1,507	.....	.....	.....	.....
55 Diesel	6,980	54.49	2.6	5,865	4.1	4,754	5.2	3,772	12.3	1,492	.....	.....	.....	.....
I H-McCormick														
Super WD-9 Diesel	6,630	59.40	2.0	8,416	2.9	6,908	4.3	4,955	5.3	3,993	16.4	1,092	.....	.....
Farmall 400 Ges	6,580	47.34	2.1	6,508	3.7	4,335	4.8	3,386	6.7	2,399	17.3	794	.....	.....
with torque amplifier[4]	.....	.....	1.4	6,447	2.3	6,348	3.1	5,073	4.4	3,531	11.6	1,318	.....	.....
Farmall 400 Diesel	6,990	44.72	2.2	6,415	3.7	4,228	4.7	3,353	6.7	2,356	17.3	795	.....	.....
with torque amplifier[4]	.....	.....	1.4	6,479	2.3	6,125	3.1	4,919	4.4	3,512	11.5	1,305	.....	.....
IHC 300 Utility Gas.	4,250	39.48	2.2	4,379	3.6	3,573	5.0	2,620	6.6	2,006	16.7	709	.....	.....
with torque amplifier[4]	.....	.....	1.5	4,313	2.3	4,296	3.2	3,848	4.3	3,002	11.0	1,121	.....	.....
Farmall 200 Ges	3,350	22.27	2.2	3,166	3.7	2,033	5.0	1,515	10.6	651	.....	.....	.....	.....
Farmall 100 Gas	2,700	18.99	2.3	2,503	3.9	1,564	5.2	1,142	11.1	488	.....	.....	.....	.....
Minneapolis Moline														
GS Gas	6,600	61.45	2.3	6,718	3.5	5,923	4.2	5,086	6.2	3,437	15.0	1,270	.....	.....
GBD Diesel	7,400	58.15	2.3	7,330	3.5	5,899	4.1	4,978	6.1	3,370	14.6	1,203	.....	.....
UB Gas	5,700	45.43	2.4	5,505	3.7	4,101	4.4	3,428	6.6	2,316	15.7	773	.....	.....
U Trector Fuel	5,500	35.30	2.2	4,953	3.4	3,439	4.0	2,920	6.0	1,929	14.5	602	.....	.....
Oliver Super														
99 GM Diesel	7,800	77.44	2.0	10,075	2.9	8,941	4.1	6,661	5.5	4,887	7.0	3,773	12.7	1,901
99 D Diesel	7,400	60.90	2.0	9,212	3.0	7,030	4.1	5,290	5.3	3,872	6.9	2,942	12.6	1,483
88 HC Ges	5,200	49.81	2.2	6,354	3.0	5,467	4.2	4,090	5.5	3,136	6.9	2,509	12.1	1,343
88 D Diesel	5,400	49.58	2.2	6,287	3.0	5,700	4.2	4,220	5.5	3,338	6.9	2,677	12.0	1,427
77 HC Gas	4,600	40.16	2.1	5,366	3.0	4,253	4.2	3,174	5.6	2,378	6.6	1,987	11.8	1,039
77 D Diesel	4,700	40.04	2.1	5,659	3.0	4,570	4.1	3,381	5.5	2,562	6.6	2,158	11.7	1,130
55 HC Ges	3,150	30.75	1.4	3,539	2.1	3,455	3.0	3,221	5.1	2,071	6.1	1,715	13.1	693
55 D Diesel	3,250	28.97	1.4	3,641	2.1	3,510	3.0	3,191	5.0	2,067	6.0	1,688	12.8	735
66 HC Ges	3,300	29.60	1.9	4,309	2.8	3,556	3.4	2,920	5.1	2,019	6.1	1,658	10.7	899
66 D Diesel	3,300	28.97	1.4	3,641	2.1	3,510	3.0	3,191	5.0	2,067	6.0	1,688	12.8	735

[1] Figures indicate epproximete bare shipping weights on rubber.
[2] 7th gear: 9.6 m.p.h; 1,456 pounds pull. 8th gear: 14.1 m.p.h; 875 pounds pull.
[3] 7th gear: 9.6 m.p.h.; 1,483 pounds pull. 8th geer: 14.1 m.p.h.; 895 pounds pull.
[4] Tractors with torque amplifier drive have two speeds in eech gear, and, in effect, provide added power on rough terrein without changing transmission gears.

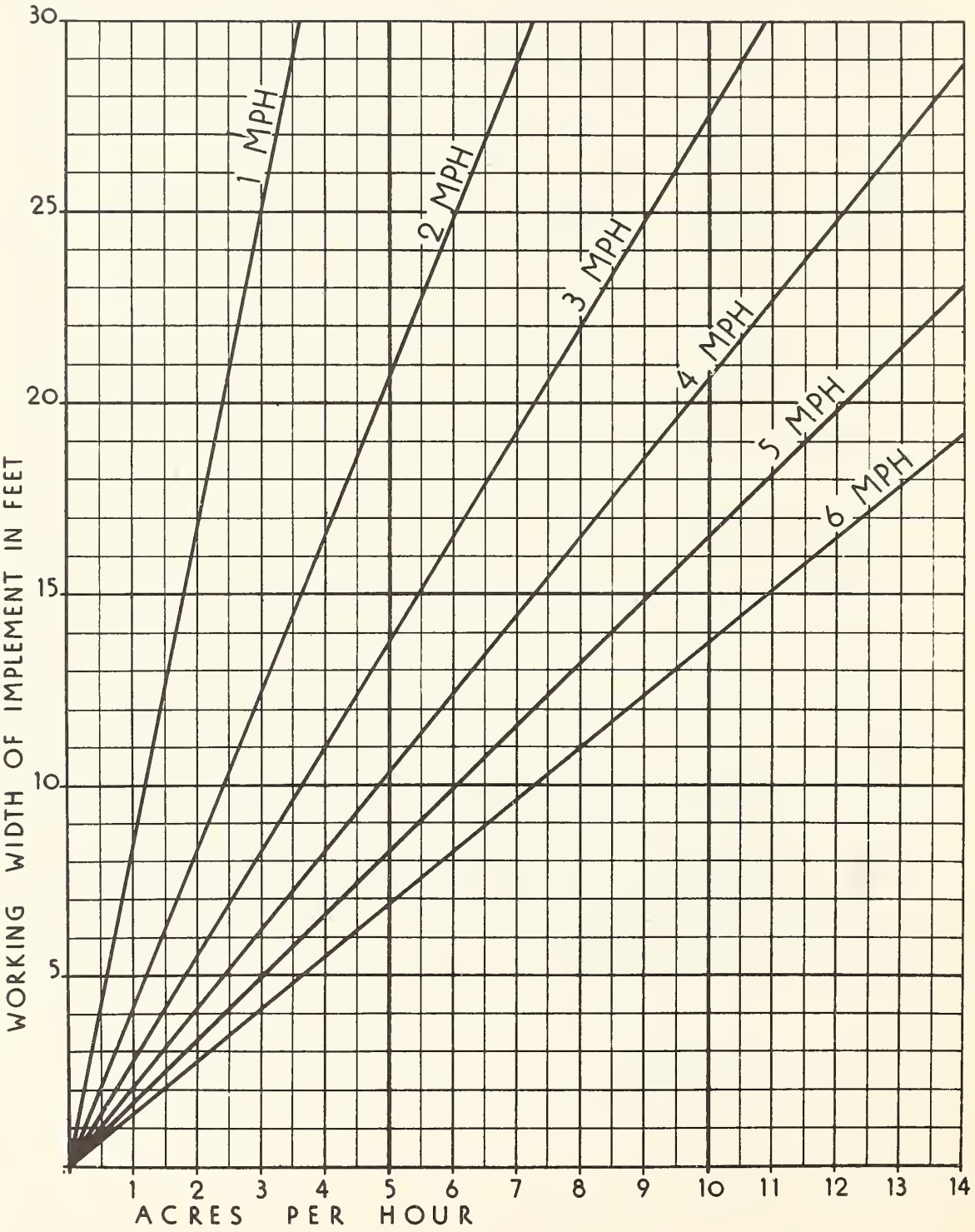

Figure H-1. --Acreage chart.

I. TRANSPORTATION EQUIPMENT

Reseeding equipment is usually transported on any type of trailer or truck currently available. In most places, satisfactory service at economical cost has been had by hauling larger equipment on tractor transports and other equipment on various sized flat-rack trucks.

The increasing use of heavier types of equipment, such as brushland plows, has presented problems. These implements are difficult to load and unload from standard truck and trailer beds. Hauling costs are high when a tractor-transport is used.

The Southwestern region of the Forest Service (Region 3) uses a semitrailer of the oil field float type. This unit has a means of separating the trailer from the tractor unit, and drops the front end to the ground. This leaves the tractor unit available for installation of the detachable crane, which is mounted on the rear of the truck and operated from the truck winch located behind the cab. This combination makes it possible to pick up the plows, set them on the truck, individually remove the crane, and pull the trailer up onto the tractor. One man can handle brushland plows with power from a single rear wheel. In handling brushland plows with dual tail wheels, the plow must be partly dismantled to fit it onto the truck bed satisfactorily for transporting. For this work it is desirable to have two men.

The Soil Conservation Service has designed straddle-type equipment carriers, and the departmental shops, formerly located in Portland, constructed several hundred. Present designs are too light for heavy equipment but can handle grain drills, light offset disk harrows, and similar equipment. The trailers are handy for moving equipment on a project and are useful as a hoist when repairing equipment. The models in use have several apparent weaknesses. These should be corrected before any additional models are made. Blueprints can be obtained from the Arcadia Equipment Development Center upon request.

The Soil Conservation Service has also designed a small inexpensive tilt-bed trailer adapted for hauling grain drills. Details of its construction are shown in figure I-1.

A fuel supply trailer is desirable on project operations for delivery and storage of fuel supplies on the job and for servicing equipment.

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K. SUGGESTED SEEDING OUTFITS FOR VARIOUS CONDITIONS

1. Good, relatively rock-free, fairly level sagebrush sites with few or no perennial forage species.

   Wheatland-type or brushland plow with 40 hp. crawler tractor
   Heavy offset disk harrow with 65 hp. crawler tractor

   Large areas:

   2 wheatland-type or 2 brushland plows
   70 hp. crawler tractor, 2-plow hitch
   2 heavy offset disk harrows, 80 hp. tractor, squadron hitch

   If area is large, it is usually impracticable to seed during plowing, therefore, grain drills, wheel tractors, or additional caterpillar-type tractors should be included.

2. Moderately rocky sagebrush sites with occasional areas of steep terrain.

   Brushland plow
   65 hp. crawler tractor
   Drill for relatively rock-free areas
   Motorized broadcast seeder for rocky areas

   Since seeding is combined with eradication for greater efficiency, the work must be done during the suitable seeding season.

3. Rough, rocky sagebrush sites badly cut up with gullies.

   Pipe harrow
   40 hp. crawler tractor
   Motorized broadcast seeder

   Since seeding is combined with eradication for greater efficiency, the work must be done during the suitable seeding season.

4. Clean sagebrush burns, free of rocks and competitive vegetation.

   Grain drill or rangeland drill
   Wheel tractor

   If topography and land conditions are favorable, several drills may be pulled by one crawler-type tractor.

5. Rough, rocky, incompletely burned-over sagebrush sites.

   Motorized broadcast unit mounted on a weapons carrier or tractor

   If area is large, mount two seeders on one vehicle. If practicable, the broadcast seeding may be accomplished by use of airplane or helicopter. A pipe harrow or some other similar piece of equipment should be used to cover seed, irrespective of the broadcasting method.

6. Fairly level areas comparatively free from rocks with a stand of mature sagebrush and an understory of perennial grasses.

   Supp rail or A-rail
   35 hp. crawler tractor