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United States

Department of the Interior

Bureau of Reclamation

OPERATION AND MAINTENANCE EQUIPMENT AND PROCEDURES

RELEASE NO. 37

July, August and September 1961

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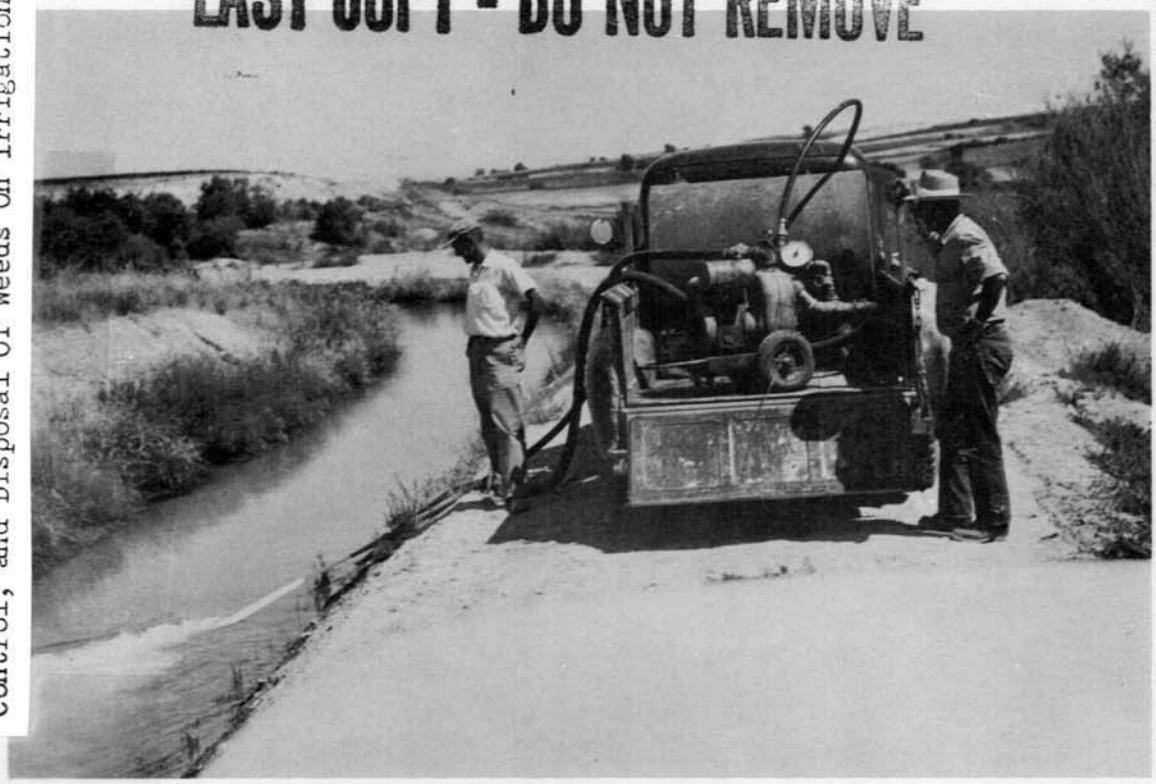

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CONTENTS

Equipment for the Prevention, Control and Disposal of Weeds on Irrigation Projects

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Releases No. 3, 8, 16, and 37 were on the subject of Weed Control Equipment and have been superceded by Release No. 97, "Equipment For The Prevention, Control, and Disposal Of Weeds On Irrigation Projects."

Front Cover

The application of aromatic solvent for the control of pondweed and algae on the Owyhee Project. Equipment used in the operation is easily transportable in a small pick-up truck. P43-100-72.

OPERATION AND MAINTENANCE
EQUIPMENT AND PROCEDURES
Release No. 37

July, August, and September 1961

PREFACE

This release of the Operation and Maintenance Equipment and Procedures release (No. 37) is being devoted exclusively to a presentation of equipment and devices suitable for the prevention, control, and disposal of weeds on irrigation systems. It has been prepared after a review of present field practices and a review of previous bulletins in which articles on the subject appeared in an attempt to present newer developments, practices, and procedures. Therefore, this release of the bulletin will supersede previous Releases No. 3, 8, and 16, which also were devoted exclusively to the subject of weed control and will include much of the material on the subject included in more recent issues.

The Operation and Maintenance Equipment and Procedures release is published quarterly by the Division of Irrigation Operations in the Office of Assistant Commissioner and Chief Engineer, Bureau of Reclamation, U. S. Department of the Interior, Denver Federal Center, Denver, Colorado. It is circulated for the benefit of irrigation project operation and maintenance people to serve as a medium of exchanging operation and maintenance information. It is hoped that the labor-saving devices and less costly equipment developed by the resourceful water users will be a step toward commercial development of equipment for use on irrigation projects in continued effort to reduce costs and increase operating efficiency.

This issue of the bulletin has been made possible by the assistance of many Bureau field organizations, water users operating irrigation projects and others interested in the field of weed control. Special recognition is due Mr. Delbert D. Suggs, Agronomist, from the Bureau's Columbia Basin Project, for his helpful assistance in the general assembly of material after a review of present practices being used in the control of weeds throughout the western portion of the United States.

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Division of Irrigation Operations
Office of Assistant Commissioner and Chief Engineer
Denver, Colorado

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INTRODUCTION

The prevention, control, and disposal of weeds on an irrigation system are necessary prerequisites to the delivery of the quantity and quality of water for which the system is designed. Equipment for handling the weed problems must be adequate to get the job done at the proper time and at the least expense.

Few of the commercial devices available to the operators of irrigation systems are well adapted to the handling of weeds. Manufacturers are unable to spread the cost of designing, tooling, and marketing a few pieces of special equipment and sell the equipment at a cost that project operators can afford. However, excellent components for such equipment, such as pumps, nozzles, burner-heads, seed-metering devices, and power units, are available. Most of the machines and devices described herein, are an adaptation by project operators of these commercially available components and other materials at hand to meet their specific needs.

The Problem

The control of weeds is a worldwide problem. Contamination of farm lands by noxious weeds in the irrigation water may be compared to permitting an animal infected with foot and mouth disease to run free on the range. Compared with the few weeks or months required for the spread of the disease, the infestation of crop lands by weeds may take several years.

The person most immediately concerned with the weed problems on an irrigation project is the one who has direct responsibility for the operation and maintenance of the irrigation system. However, planners, designers, and constructors of the system should be informed of the needs which will occur and plan the system so that motorized weed control equipment can be used.

Other agencies involved in flood control, in water conservation, in the construction of highway, municipal and industrial water supply systems, in weed and mosquito control and in power transmission have weed control problems. Many of their problems are similar to those on irrigation projects and require similar types of equipment.

The data in this bulletin, for the most part, applies to the 17 states in the western part of the United States of America. It could apply to certain other countries in which machine power is less expensive than manpower. However, of the pieces of equipment described, many may be useful in irrigation systems where the cost of manpower is relatively low.

Equipment Design

Rights-of-way on most irrigation systems are long narrow strips of land which may be wet or dry, sandy or rocky. Slopes are usually steep. Access to the right-of-way, especially on older irrigation systems, may be limited.

Farm-type equipment, designed for the culture of crops on arable land, is not readily adapted to steep canal banks, or to rough areas adjacent to the canals. Heavy construction equipment can be and often is used, but only at a high cost considering the amount and type of work to be done.

The physical needs of two projects may appear to be similar, but because of different labor costs, water demand, operating practices, and other factors, considerable variation occurs. Before the advent of herbicides and motorized equipment, prevention, control, and disposal of weeds was accomplished primarily by hand methods. One alternative was to let the weeds grow until the use of heavy construction-type equipment could be justified.

Today, preventive maintenance so far as weeds are concerned, is as practical on an irrigation system as it is on a fleet of automotive equipment. The missing factor is availability of suitable equipment from commercial sources.

There must be suitable means of access to the canals for the use of motorized equipment. Flat berms along the canals must be provided on which the motorized equipment can be operated. The design and construction of motorized equipment for the prevention, control and disposal of weeds must provide for efficient operation. These factors are necessary to an efficient and effective weed program.

Seeding, spraying, burning, and weed disposal equipment is most often mounted "offside." Offside mounting presents a side-draft problem with most motorized equipment. Equipment may be designed and built to fit a given set of circumstances. Certain principles, however, may be incorporated into a piece of equipment for performance of similar work elsewhere. It is these principles that are being stressed in this bulletin.

Program Timing

Preventive practices in weed control must be done before weeds are present in significant numbers. This is a part of the planning, design, construction, and operation of an irrigation system. One slogan worth repeating is: "A dollar's worth of seeding is worth ten dollars' worth of weeding."

The disposal of weeds, a term used in this release to describe all other practices required after prevention and control have failed or have not been done, is more expensive than prevention or control and "Ten dollar's worth of control is better than thirty dollar's worth of removal."

Sources of Additional Information and Assistance

This publication does not cover such items as adapted grasses, weed chemical mixture formulas, and detailed application procedures. The general principles of prevention, control, and disposal of weeds on irrigation systems are being treated in the Bureau of Reclamation publication "Weed Control on Irrigation Systems," which is now being revised and should be available for distribution in late 1961.

Much specific data on land weeds may usually be obtained locally for each project from the Agricultural Extension Service, the Soil Conservation Service, the Agricultural Research Service, and other state and federal agencies concerned with crops, soils, and agriculture.

Procedures which have been proven on a project or in a general area have been assembled into a pocket-sized booklet in many areas. One such booklet is that prepared for the Tracy Division of the Central Valley Project, by Mr. Gene Cakin, Irrigation Agriculturist of the Bureau's Region 2 Office in Sacramento, California. A few pages of Mr. Cakin's booklet are included in the appendix of this publication to illustrate its contents.

Specific data on aquatic weeds were not readily available from local sources in 1961. Much of the information is developed cooperatively by regional offices of the Bureau of Reclamation and the Weed Laboratory of the Bureau's Division of Engineering Laboratories in Denver, Colorado, where a team of scientists representing the Agricultural Research Service and the Bureau of Reclamation investigate specific problems as well as basic data. Copies of reports prepared by these specialists are available. Equipment for the control and disposal of aquatic weeds, based upon project experience as well as the recommendations of the weed specialists are included in a separate section of this bulletin.

Other agencies have weed control equipment problems. Equipment development and improvement is a function of the U. S. Forest Service at its Arcadia Development Center, Arcadia, California, where such equipment as the rangeland drill, the browse seeder, the Oregon press seeder, broadcast seeder, and spray equipment are under study.

Definition of Terms Used

To better understand the terms used in this bulletin a few definitions are given. By classification used herein they are:

Weeds--A weed is a plant out of place. Generally speaking when a plant in a particular situation lacks economic or aesthetic value or is injurious, it becomes a weed.

Land or Ditchbank Weeds--Land weeds infest channel banks, rights-of-way, and farms.

Aquatic or Channel Weeds--Aquatic weeds grow in water, below and above the water surface.

Waterline Weeds--Waterline weeds may be water tolerant land weeds or aquatic weeds which emerge from the water.

Phreatophytes--Phreatophytes, a relatively new term meaning "well-plants," obtain water from the water table. They may remove large quantities of water from land which is wet or dry at the surface.

Weeds, like diseases, must be dealt with. Some weeds, like some diseases may be prevented, others can be controlled, and others run their time until disposed of. The bulletin, therefore, is divided into three main sections:

Prevention--For all practical purposes, prevention includes the acts or means which create a condition under which weeds will not grow in such numbers to require significant costs for control or disposal.

Control--Where the prevention of weed growth is less than perfect, as it usually is, weeds grow. The practices necessary to kill the growing weed are termed control.

Disposal--The term disposal is used in this bulletin to describe all other practices required after prevention and control have not been successful in solving the weed problem.

PREVENTION

The prevention of weeds is the creation of an environment which is uninhabitable by a significant number of weeds. The development of equipment for preventing weed growths, particularly for seeding of steep slopes of canal, lateral and drain banks, has been much slower than the development of equipment for chemical and mechanical weed control and disposal. Possibly this follows because the results of chemical and mechanical weed control and disposal are immediate and the cost of special equipment will be returned within a few years. Mechanical and chemical methods of preventing weed growth, though necessary, must usually be repeated. Hazards of fire, pollution of water, and damage to adjacent crops also must be considered.

Establishment of Desirable Vegetation

On most sites, vegetation can be tolerated. Grasses are often beneficial in preventing erosion by wind and water and in some instances by traffic. The establishment of desirable vegetation can be the most important means of weed control on irrigation system rights-of-way, and desirable vegetation provides weed control with little maintenance.

Well sodded waterways are a protection against flashfloods, heavy runoff, and overflow-type canal breaks, in addition to protection against weed invasion. As illustrated in Figure 1, the grasses on the waterline, at center, held against the flooding water resulting from a canal break which cut into an unprotected bank.

Vegetation is established by sodding, by planting cuttings or whole plants or by seeding. The high cost of planting the living plants on steep slopes often eliminates all methods except seeding.

Fig. 1

The selection of species is governed by the local environment and its effect on the available or desirable species. Selection is further controlled by such other project conditions as the cropping pattern and the chemical weed control or disposal program. For example, Bermuda grass, a weed as well as a valuable forage crop in some locations, should not be used

even on a northern project if grass seed crops are to be irrigated with the project water supply. If 2,4-D herbicides are employed to kill annual weeds in the first 2 or 3 years to assist the development of perennial grasses, few of the desirable legumes will survive.

Selection of a desirable adapted species is a controlling factor in preventive weed control. Equipment for establishing this vegetation is adapted to the requirements of the species. If seed of the best species is bulky and offers problems in feeding through a grain drill, the drill will be modified to handle the seed.

The establishment of vegetation, although eventually resulting in a more permanent preventive means of weed control, may require 1 to 5 years to develop a stand which will resist the invasion of weeds.

The Bureau's Region 7 believes the best method of controlling weeds on irrigation systems in the Kansas and Nebraska areas of the Missouri River Basin Project is the planting of desirable adapted grasses. Experience under the climatic conditions in this area shows that 4 to 5 years after planting the grasses, weed control expenditures are at a minimum. During the 4 - to 5-year period that the grasses are becoming established, they must compete with weeds for nutrients, water, and light. Spraying with 2,4-D during that time eliminates most of the weeds and encourages more rapid development of the grasses. Studies of grass stands previously established have shown that for every dollar invested in seeding grasses, about $2.50 is saved in O&M costs. A good stand of grass on the banks of a canal on the Mirage Flats Project in Nebraska is shown in Figure 2.

In 1952, cost records were kept in planting work done on the Frenchman-Cambridge and Bostwick Divisions, Missouri River Basin Project. The costs ran from $6.60 to $13.76 per acre, depending upon conditions encountered and method of seeding used. In the same divisions, weeds were sprayed with 2,4-D using ground rigs, at costs ranging from $3.23 to $4.95 per acre. Mowing costs averaged about $2.45 per acre. However, mowing had to be accomplished two or three times during the season to give results comparable to those obtained with one 2,4-D spraying.

Much of the ditchbank seeding in Region 7 has been done under contract. To indicate how the work is done, an excerpt from a typical seeding specification is presented:

Fig. 2

"Spreading fertilizer and sowing grass seed. (a) General. --Areas of excavation surfaces, embankments, spoil banks, and drains, as shown on the drawings, or as designated by the contracting officer, shall be prepared for seeding and fertilized and seeded. All seeding operations shall be in accordance with the provisions of this paragraph.

"(b) Seedbed preparation. --The contractor shall compact or loosen the surfaces of laterals, drain ditches, embankments, and spoil banks as directed prior to seeding, in order to obtain a firm well-packed seedbed. Compaction for seeding may require two passes, but not more than two passes, with a packer and mulcher similar but not restricted to the 'Western Sprocket Packer and Mulcher' manufactured by the Western Land Roller Company of Hastings, Nebraska. No separate payment will be made for compacting or loosening areas to be seeded and all costs of seedbed preparation shall be included in the unit price per acre bid in the schedule for furnishing and spreading commercial fertilizer and furnishing and sowing grass seed.

"(c) Commercial fertilizer. --The contractor shall furnish a standard commercial fertilizer of 16 (nitrogen), 20 (phosphorous), 0 (potassium) formula, and shall uniformly broadcast or drill the specified fertilizer at the rate of 100 pounds per acre into the surfaces of the areas to be seeded unless otherwise directed. Fertilizer shall be applied to the prepared seedbed previous to seeding operations, or at the time of seeding if a grass drill with a fertilizer attachment is used.

"(d) Seeding. --The contractor shall furnish and sow a mixture of brome grass and wheatgrass on all the areas to be seeded, except that portion of Ayres Creek Channel Change from Station 34+00 to End Station 44+50. This mixture shall consist of brome grass (Bromus inermis), Lincoln or Achenback strain, at the rate of 14 pounds of pure live seed per acre and western wheatgrass (Agropyron smithii) at the rate of 4 pounds of pure live seed per acre. For that portion of Ayres Creek Channel Change from Station 34+00 to End Station 44+50, the mixture of grasses to be sown and the rates of seeding are as follows: (1) Brome grass (Bromus inermis), Lincoln or Achenback strain at the rate of 10 pounds of pure live seed per acre; (2) Rye (Secale cereale), at the rate of 20 pounds of pure live seed per acre; (3) western wheatgrass (Agropyron smithii), at the rate of 4 pounds of pure live seed per acre; (4) Sand lovegrass (Eragiostis trichodes), at the rate of 1 pound of pure live seed per acre.

$$\frac{\text{Pure live seed - percent of purity x percent of germination}}{100}$$

"The germination of brome grass and rye shall not be less than 85 percent, the germination of western wheatgrass shall not be less than 65 percent, and that of sand lovegrass not less than 75 percent. Seed shall contain no noxious weed seed or quackgrass (Agropyron repens) and shall contain not more than 4 percent of other weed seed. All grass seed shall comply with the seed laws of the State of Nebraska. The age of seed of the brome grass and rye shall not exceed 2 years. The sand lovegrass and brome grass seed shall have been produced in Nebraska, Kansas, or Colorado.

"The seed of brome grass, western wheatgrass, rye, and sand lovegrass shall be separately packaged and labeled so they can be uniformly and thoroughly mixed after they are received on the job. The mixture of grasses specified herein shall be uniformly distributed on the designated areas to be seeded by means of a hand seeder or grass drill. When seed is sown by means of a hand seeder, immediately after broadcasting, the seed shall be properly covered with soil to a depth not to exceed 1/2 inch by means of a spike tooth harrow, a treader (rotary hoe run backwards), or any similar implement acceptable to the contracting officer. If seed is sown with a grass drill, the drill shall be regulated so that the seed will be properly covered with soil to a depth not to exceed 1/2 inch. Seeding shall be done from February 1 to April 15 unless weather conditions, unfavorable soil moisture, or seedbed conditions are prohibitive to seeding, as determined by the contracting officer: Provided, That when moisture and seedbed conditions are favorable, the contracting officer may order the contractor to continue operations in a period other than that stated above.

"(e) Measurement and payment. --Measurement for payment for furnishing and spreading fertilizer and furnishing and sowing grass seed will be made of the areas actually prepared, fertilized, and seeded. The areas will be computed to the nearest one-half of an acre. Payment for furnishing and spreading fertilizer and furnishing and sowing grass seed will be made at the unit price per acre bid therefor in the schedule. The quantities as stated in the schedule for furnishing and spreading fertilizer and furnishing and sowing grass seed are estimates for the purpose of comparing bids and the contractor shall be entitled to no additional compensation above the unit price bid in the schedule by reason of any amount or none of this work being required."

Examination of the specifications will show that they meet several essential requirements needed to get the grass seeding done properly. First, the specification is written to enable Reclamation to make field changes in the seeding methods. For instance, it may be necessary to require the contractor to compact or loosen the ditch banks prior to seeding. Secondly, the specifications enable Reclamation to direct the contractor to seed miscellaneous spoil areas that are created during construction. In other words, if it is determined during construction that an additional bank will be constructed which is not anticipated in the original specifications for the canal or lateral, provisions are made in the contract that require the contractor to seed this additional area. Flexibility in the contract is also obtained by requiring the seeding of different species of grasses on different areas that are seeded. By going over such areas prior to preparing a specification, it can be determined what grasses are best adapted to the different soil types and drainage conditions encountered.

Seeding

Seeding may be accomplished by several types of equipment on irrigation systems, including seeders, drills, planters, and under certain circumstances by the use of aircraft. Part of the seeding operation requires that the planted seed be covered and this can be accomplished by harrows and weeders. From experience it has been found that some types of seeding and covering equipment have better qualifications for performance of the work than others and based upon this experience two tables have been prepared. Tables I and II on the following pages present the results that may be expected from the use of commercially available equipment for the planting and covering of seed.

Preparations for Seeding

Prior to seeding grasses on established canal banks, it is generally necessary to reshape the banks by filling in erosion cuts, and removing

TABLE I

Field Evaluation of Commercial Seeders in Weed Prevention on Irrigation Projects

Name	Type	Seed placement	Seed coverage	Soil compaction	Adaptation to steep slopes	Portability	Equipment cost
Drill	Single disk	Good	Fair	Fair	Poor	Poor	Moderate
Drill	Double disk press drill	Good	Excellent	Excellent	Poor	Poor	Moderate
Drill	Plow opener rangeland	Good	Excellent	Excellent	Poor to fair	Good	High
Seeder	Roller	Fair to good	Good	Excellent	Poor to fair	Poor to good	Moderate
Planter	Precision row	Excellent	Excellent	Excellent	Poor	Poor to good	Moderate
Seeder	Hand broadcast	Fair	None	None	Excellent	Excellent	Low
Seeder	Electric or gas engine broadcast	Fair	None	None	Excellent	Excellent	Low
Seeder	Strip broadcast	Excellent	None	None	Fair	Fair	Low
Seeder	Waterline dribbling	Good	None	None	Excellent	Excellent	Very low
Aircraft	Fixed wing or helicopter	Fair to good	None	None	Excellent	Excellent	Low

TABLE II

Field Evaluation of Commercial Seed Covering Equipment in Weed Prevention on Irrigation Projects

Name	Type	Seed coverage	Soil compaction	Adaptation to steep slopes	Portability	Equipment cost
Harrow	Spiketooth	Fair	Poor	Fair	Fair to good	Low
Harrow	Chain	Good	Poor	Good	Good	Low
Harrow	Disk	Good	Poor	Poor	Fair	Moderate
Harrow	Springtooth	Fair	Poor	Poor	Fair	Moderate
Weeder	Rotary hoe, treader	Good	Good	Fair	Fair	Moderate
Weeder	Finger	Good	Poor	Good	Good	Low

Fig. 3

Fig. 4

most of the weed vegetation. This may be accomplished simply by dragging or by hand removal of boulders and other easily movable debris. On one project, where it would have been a more difficult problem, a crawler-type tractor equipped with a special blade, as shown on Figures 3 and 4, has given good results.

The bank shaper on slopes pictured has been very efficient and was developed and constructed by maintenance personnel of the Tucumcari

Project, New Mexico. A similar and equally effective sloper is being manufactured commercially for mounting on a tractor or grader.

The first shaper developed by project forces and pictured was controlled entirely by the tractor operator by means of cables. However, to prevent the blade from "riding" in areas where a large amount of cut is necessary, the hydraulic actuating arm installed on the device has definite advantages for raising and lowering the blade in lieu of the cable control.

Drill-type Seeders

A commercially available grass drill attached to a tractor, as shown in Figure 5, is used in Region 5 in seeding all varieties of grass, either individually or in mixtures. The grass drill may be removed from the rig and attached to a conventional wheel-type tractor for use in seeding adjacent rights-of-way and reservoir areas.

Fig. 5

The side mounted grass drill is one of the very few pieces of equipment which does a job of steep-slope grass seeding, comparable to the seeding of the flatter range of cropland. Operation of this type of seeder is made more trouble-free on banks the slopes of which are 2:1, 3:1 or flatter.

The unit cost for seeding canals and rights-of-way with this drill has averaged about $10.00 per acre, exclusive of canal bank reshaping and cleaning.

The planting of fluffy seed is a problem which usually requires a local solution. Separate seed boxes may be used on the drill or the fluffy seed may be mixed with other grains such as rye, oats, or cracked corn to promote the feeding of the fluffy seed. Rice hulls, ground corn cobs, or sand also may be found satisfactory and occasionally another desirable grass can be added to the mix. Regardless of mechanical agitation or the type of additive, it is desirable to inspect the flow of seed frequently.

The drill described is used extensively for seeding canal and lateral banks and reservoir areas, and is equipped with large boxes for seeding trashy seed and small boxes for seeding small hard grass seed.

Drill disks have regulators to control depth of seeding and the drill has the advantage that any type tractor may be used for power.

A drill similar to that previously described in operation seeding grasses on the McMillan Reservoir area, on the Carlsbad Project in New Mexico, is shown in Figure 6.

The separate containers provided on the seeder for the large, fluffy seed (Western wheatgrass, grama, etc.) and the small hard seed

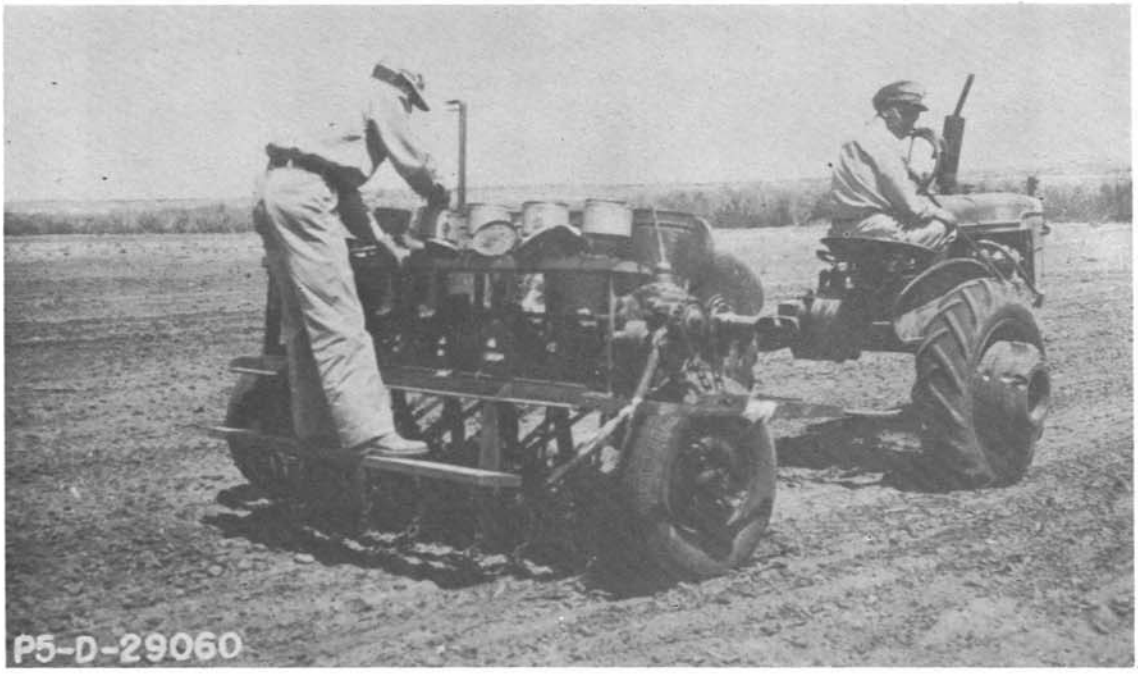

Fig. 6

(Bermuda, Lovegrass, etc.) are shown. A conventional car transmission is incorporated into the construction of the drill to facilitate changing seeding rates.

In Figure 7, there is shown a double disk opener, press wheel drill used for experimental seeding of various grasses and legumes on a ponded reach of a wasteway on the Columbia Basin Project, Washington. The wasteway was seeded prior to normal inflow to the channel. The press wheel drill provides adequate seed placement, covering and soil compaction even on the lighter non-tilled soils. This type of seeding equipment can seldom be used on steep slopes, or on rocky, or very heavy soils.

Fig. 7

Fig. 8

The seeding of a grass-legume mixture through non-disturbed annual grass range on the Columbia Basin Project, Washington, with a press-wheel drill is shown in Figure 8. The area, soon to be wet from impounded water was seeded to learn which species would survive for competition against noxious weeds and phreatophytes which occur where moisture conditions change from semi-arid to wet.