Department of the Interior

Bureau of Reclamation

OPERATION AND MAINTENANCE EQUIPMENT AND PROCEDURES

RELEASE NO. 2

January-February 1953

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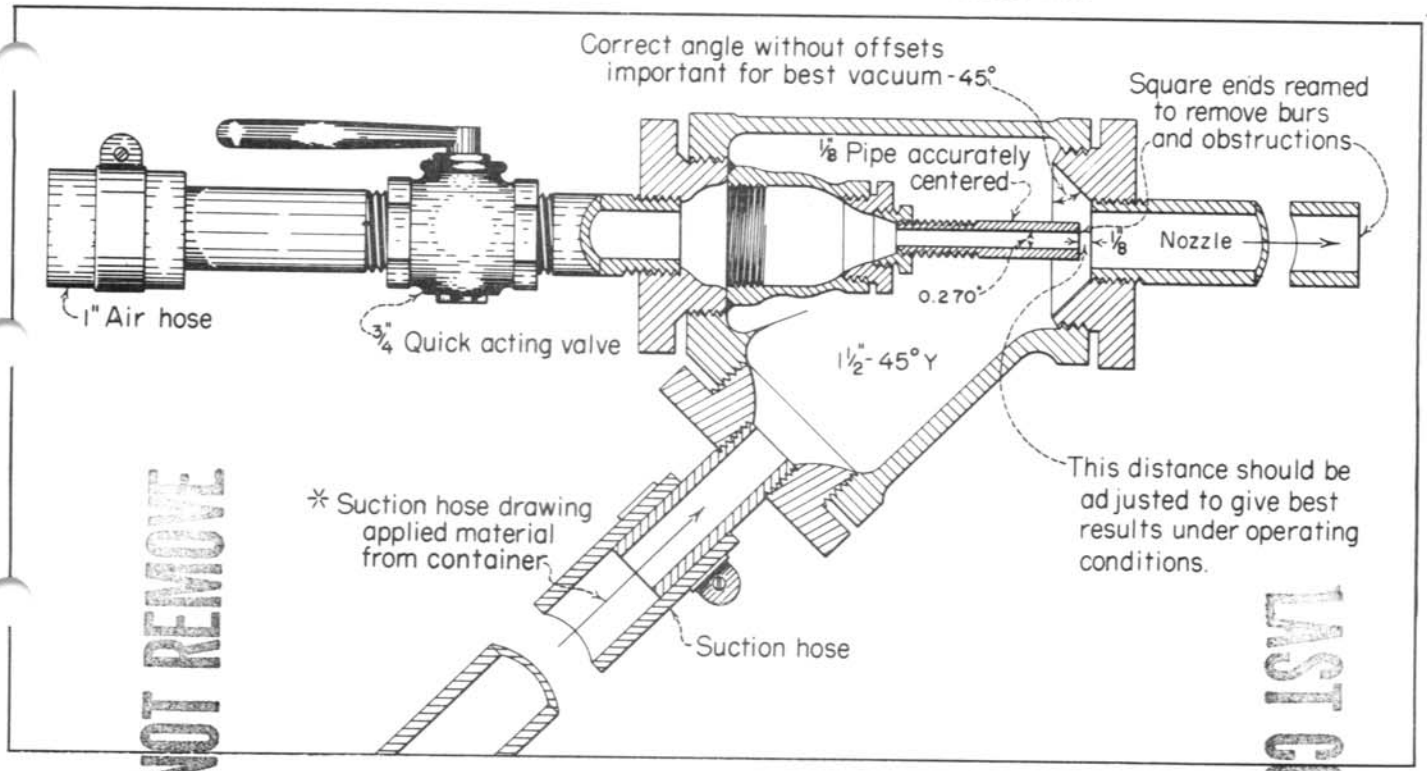

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INTRODUCTION

Here is Release No. 2 of the Operation and Maintenance Equipment and Procedures Bulletin which is being issued as a joint effort of the Divisions of Operation and Maintenance, and Design and Construction, of the Bureau. Since the issuance of Release No. 1, two months ago, except for some excellent material from Region 2, we have not had much response from you folks in the way of submitting material to be included in future releases. This bulletin will be only as good as you folks make it and we know that you field people have lots of good ideas that should be passed around, so please don't be stingy with them.

The November 1952 Reclamation Era carried an announcement of this series of bulletins and requested that suggestions relative to weed control equipment, as well as suggestions for other O&M improvements, be sent to the Commissioner, Bureau of Reclamation, Washington 25, D.C., attention Code 420. That address is correct for all suggestions related to weed control equipment but suggestions concerning other O&M equipment and procedures should be sent to Chief Engineer, Bureau of Reclamation, Denver Federal Center, Denver, Colorado, attention Code 206.

We hope to have the material for the weed control equipment issue of this bulletin in shape for release early in March. The material is being prepared by Mr. R. B. Balcom, Weed Specialist of the Washington Office, with the assistance of Mr. Curt Bowser of Region 3. If any of you have any good ideas on weed control equipment which you have not submitted, please get them to the Washington address given above.

* * * * *

A MANY PURPOSE AIR-SUCTION GUN

The air-suction gun shown on the facing page is a very useful addition to any project's tool kit. Developed by the Bureau of Reclamation laboratory shops at the Denver Federal Center, the "gun" has been a pattern for construction of similar devices used on many construction and operation and maintenance jobs for air-water jetting, wet and dry sandblasting, the application of plastic or dry mortar, and as a vacuum cleaner or low lift pump.

The photo, left, shows the "gun" being used to place cement mortar. It can be assembled, as shown on the facing page, from pipe and fittings to be found in most project warehouses or supply yards. A minimum amount of machine work is required.

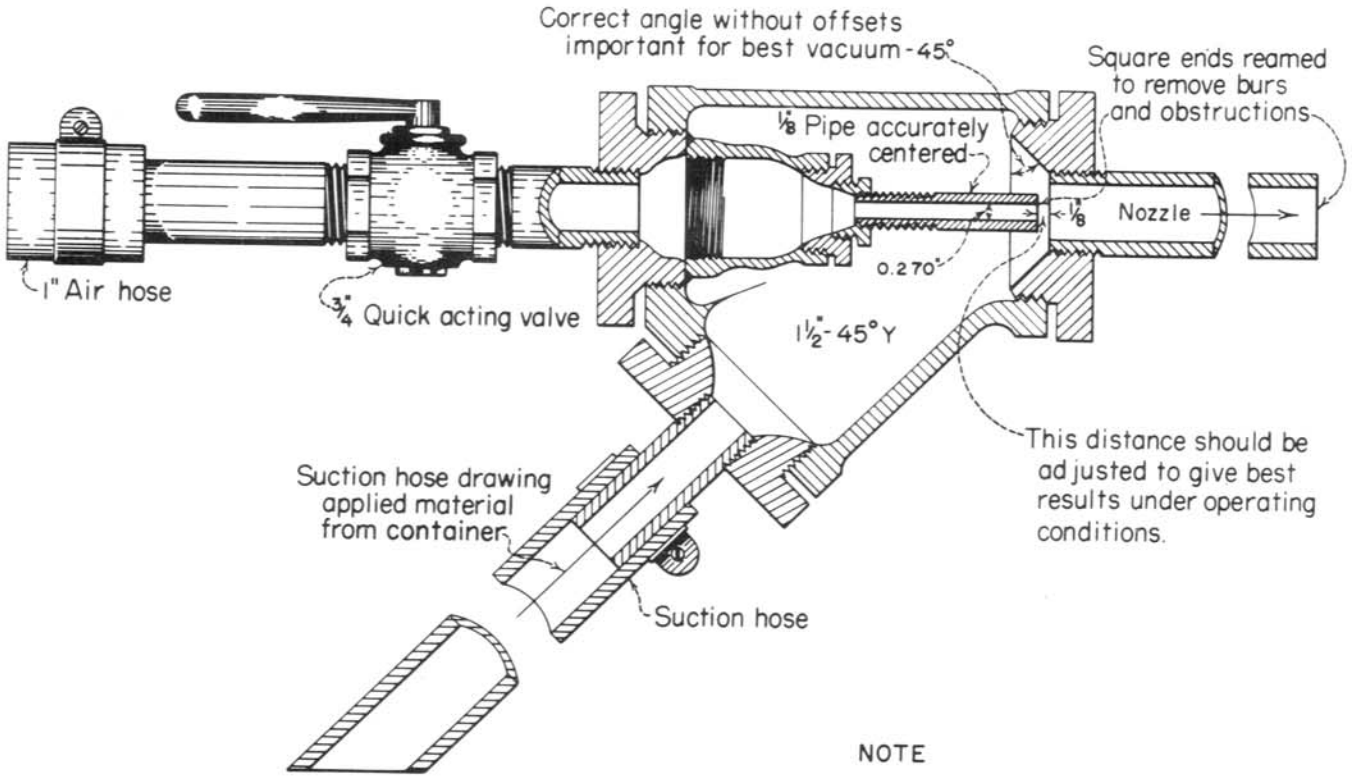
The "gun" is one of many useful tools and suggested methods of concrete repair to be found in the latest (5th) Edition of the Bureau of Reclamation Concrete Manual. One chapter of the manual is devoted especially to the repair and maintenance of old and new concrete by dry packing, mortar replacement, prepacked concrete, and other methods. The materials required, the repair procedure, and suggested inexpensive equipment that is obtainable or can be fabricated by project personnel are discussed.

The Why's and Wherefore's of good concrete construction are stated in a brief concise form, explaining that, although the steps are given for the accomplishment of good concrete work, it is equally essential that suitable materials, proper design, proper mixing and handling, and care in placement, protection and curing must be employed to secure durable, good appearing, and functional structures. Too much emphasis cannot be placed on the importance of these factors during original construction or repair. The Manual covers these factors in stressing the need for selecting suitable materials, the design of concrete mixes, the manufacture of fresh concrete, and its handling, placing, and curing.

Of additional interest is the portion of the Manual devoted to the application of special types of concrete and mortars, including: lightweight concrete, nailing concrete, prepacked concrete, various types of

SUCTION AND NOZZLE SIZES FOR VARIOUS USES OF SUCTION GUN

USE TO BE MADE OF GUN	1½ INCH 45° Y		NOTES
	SUCTION	NOZZLE	
Air water jet	¾"	¾" x 24"	Sizes are standard pipe sizes. Standard hose sizes for suction fit nipples of these pipe sizes fairly tightly. Suction hose should be of convenient length (6 to 10 ft.). For vacuum cleaning and dry material, 2-inch vacuum hose is preferable. Nozzle lengths shown have worked well. Other lengths may be better suited for other conditions. The nozzle may be fitted with elbow for buttering perimeter of "poured patch" with plastic mortar. A good nozzle for dry mortar is the rubber lined tip of a standard small gunite nozzle with an orifice of about ⅝" diameter.
Dry sand blast	1" to 2"	¾" x 24"	
Wet sand blast	¾" or 1"	¾" x 24"	
Plastic mortar gun (Mix 1:2 plastic)	¾"	¾" x 10"	
Dry mortar gun (Mix 1:4 damp)	1" to 2"	¾" x 10"	
Vacuum cleaner or low lift pump	1½" to 2"	1¼" or 1½" Hose to waste	



NOTE

Air pressure should be 60 to 80 p.s.i. measured about 8 inches back of Y with valve open.

* For air-water jet, suction may also be connected to water line. For wet sandblast, small streams of water can also be admitted through a proper attachment in nozzle.

AIR-SUCTION GUN FOR DRY SANDBLASTING, WASHING, MORTAR APPLICATION AND VACUUM CLEANING

floor finishes, pneumatically applied mortars, grouting mortars, and expansive mortar of concrete to secure water-tight patches. Many of the repair or construction procedures are illustrated and charts and tables are provided to simplify the design of concrete mixes and explain the effect and advantage of additives such as calcium chloride and air-entrainment agents. The importance of selecting the proper water-cement ratio and other factors for a given exposure condition to obtain maximum durability are also covered.

The Concrete Manual is available upon request and without cost to Bureau personnel. To others it can be made available at a cost of $1.75.

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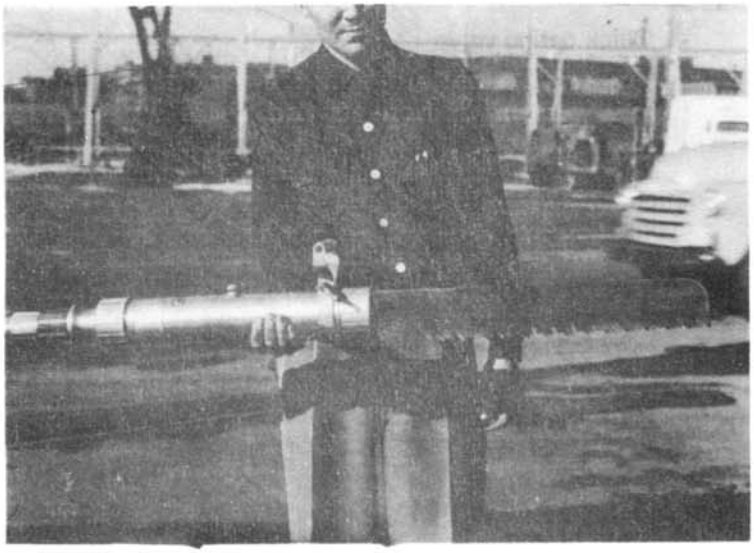
SOMETHING NEW IN A POWER SAW

The Wright Power Saw and Tool Corporation, 292 Longbrook Avenue, Stratford, Connecticut, has placed on the market the saw shown in the photograph below after having had it in service for 3 years of on-the-job testing.



Marketed as a truly portable precision power saw, the product is described as 10-20 times faster than handsaws, provides accurate line-of-sight sawing with a smooth cut 3/16-inch narrow kerf. Its versatility includes crosscutting, ripping, notching and framing of hard or soft woods, and being light in weight, 15 pounds, can be handled in any position and in many normally unaccessible locations.

The saw is simple in construction and blades can be sharpened like ordinary handsaws. Safety in operation is claimed because there is no kick-back or grabbing due to the opposed stroke of the twin reciprocating blades.

Model No. A-256 shown, has an over-all length of 46 inches, can make a cut 21 inches long with unlimited depth. The saw is pneumatically powered, consuming less than 60 cubic feet of air per minute at a pressure of 70 to 100 psi. The semicircular pistons are compactly fitted into the 3-1/4 inch diameter motor housing and operation is controlled by a safety throttle, which automatically stops the saw upon release.

The price of this implement is quoted as $365, fob Denver, Colorado, which includes one extra set of blades and a wooden carrying case. The saw is carried by the Colorado Builders Supply Company, Denver, Colorado.

* * * * *

CLEANING BOGGY DRAINS

Do you have a continual problem of keeping drains open, drains where the banks keep sloughing in about as fast as you can clean out the bottom with a dragline? Some of our operators have met such a problem by permitting the bottom of the drain to grow up in cattails and other vegetation so that the root mat serves to stabilize the material. A narrow trench is excavated out of the middle of the stabilized bottom of the drain with a clam shell bucket, care being taken not to disturb the vegatation on each side of the trench. Keeping the trench narrow is quite important since that leaves a maximum amount of root-bound material on each side, maintains an adequate velocity, and also, as the cattails grow up they shade the channel and prevent growth of moss and water weeds. Particular care should be taken to excavate the trench as straight as possible and along the true centerline of the drain in order to obtain best flow conditions.

* * * * *

PAINT AND PROTECTIVE COATINGS

Unless you are a paint specialist in your own right or an authority on protective coatings, you, or any other maintenance man, will welcome the Paint Manual, issued as a Specialist Supplement of the Reclamation Manual. Published in 1951 by the Bureau of Reclamation, the first edition provides information, advice, and instructions relating to paints and practices, as applied to Bureau Work.

The present pocket-size edition, replaces a tentative edition issued in 1941, and contains the comments and suggestions of field people like yourselves who have been called upon to provide information on the field application, performance and general value of the many products utilized over a period of many years for protecting surfaces from deterioration and corrosion. Also contained in the Manual, in the form of recommendations, specifications, etc. covering the composition and application of various paints, are the results of thousands of tests and investigations made by the Bureau Paint Laboratory. As pointed out in the Manual, there is considerably greater subject coverage that would be indicated by the title, which was selected for brevity. The term "paint" commonly applies to only a few of the coating materials used, but other materials which cannot technically be designated as paint are discussed. These include varnishes, lacquers, plastics, hot-applied bituminous products, cement-mortars, and others.

One chapter of the Manual is devoted to a general description of the types of coatings, rust preventative compounds and accessory materials, together with their composition and properties. The accessory materials include thinners, colors, stains, driers, puttys, and glazing compounds, caulking compounds, fillers, cements, and paints and varnish removers, etc. Another chapter discusses the painting of woodwork, with general comments, and applicable specifications references. Special emphasis is given the preparation of the surfaces before being painted, the preparation of the paint or covering material, its mixing, tinting, warming if necessary for best results, and its application.

The painting or application of protective coverings to metal work is covered in much the same manner. However, since a large portion of the protective coatings employed by the Bureau are for the protection of metal surfaces, the causes of deterioration and corrosion of metals are treated. This subject is discussed in considerable detail stressing the selection of the type of coating, which depends so much upon exposure; whether it be underwater, air and water, outside atmosphere, or special conditions such as exposure to excessive condensation, grease and oil, acid or alkali, and others. Many methods for the preparation of unpainted metals or their repainting are suggested and equipment and procedures are illustrated. Such paints as Coal-Tar Pitch, CA-50 Coal-Tar Paint, and CTP-3 Coal Tar Paint are discussed, giving the suggested use of each and their limitations or disadvantages.

Of especial interest to O&M personnel are the methods and pointers given for detection of early evidence of deterioration or corrosion. Advance

or early detection of coating failure can reduce maintenance considerably, if the failing coating is repaired without delay. This and such items as compatability of various types of covering materials play an important part in reducing the cost of preventative maintenance.

The preparation of concrete, plaster, and miscellaneous surfaces for painting, the suggested paints, their application and repair are treated. This includes such coverings as interior water paints, vinyl-resins, concrete floor paints; waxes for concrete, terrazzo, ceramic tile, linoleum, wood, etc.; and waterproofing and damp-proofing materials.

The proper methods of inspecting and sampling paints and coatings are presented and several pages are devoted to safety in painting operations. An appendix lists many specifications covering the paints, waxes, pigments, vehicles, removers, and other associated or accessory materials.

The Paint Manual has added to our general fund of information on the subject of protective coatings and as now issued represents the latest compilation of the best information available on the subject. Like the Concrete Manual, the Paint Manual is made available upon request and without cost to Bureau personnel. To others, the cost is $1.25.

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BUREAU WATER MEASUREMENT MANUAL GOES TO PRESS

No doubt many of you operators will be glad to know that the Bureau's Water Measurement Manual has been transmitted to Washington for printing by the Printing Office. If our friends in the Commissioner's Office of the Bureau exert the influence with the Printing Office which we hope they do, these handbooks should be available for your use during the coming irrigation season.

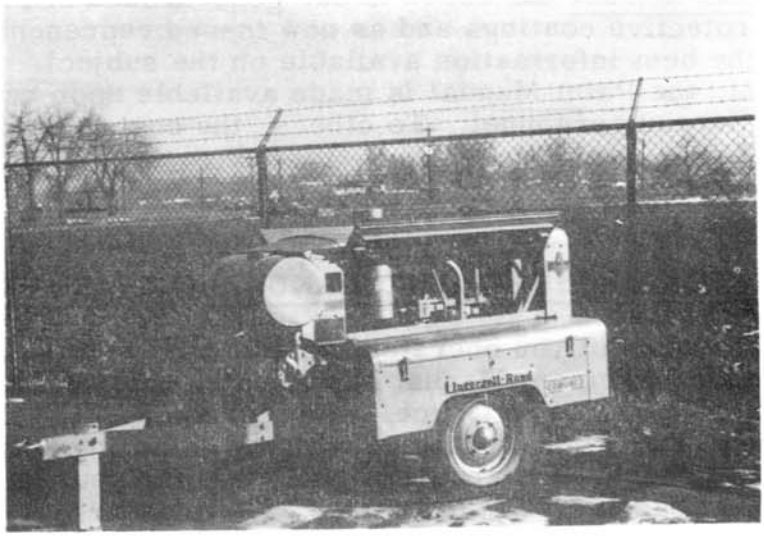
The last edition of this handbook was published in April 1947 under the title "Manual for Measurement of Irrigation Water." There was some dissatisfaction with this book on the part of operators in that they thought that it was too large for a ditchrider to carry in his pocket and it contained a lot of material that was of no use to ditchriders. In publishing the new handbook, therefore, a different plan is being followed. The new Water Measurement Manual will be a revision of the April 1947 edition with some material added and will be about that size. To take care of the ditchriders needs, the various rating tables and diagrams and other tables in the Water Measurement Manual, are being bound separately in a smaller volume, together with descriptions of the various measuring devices. This volume will be entitled "Irrigation Water Measurement Tables and Diagrams." This should provide the ditchriders with a handbook that is easy to carry but which contains all of the information they will need in making water measurements.

* * * * *

INGERSOLL-RAND 105 CFM ROTARY COMPRESSOR

The Ingersoll-Rand Company Gyro-Flo, Rotary, Mobil-Air Unit, described by them as the most revolutionary design change made during their 50 years of portable compressor history, is a 2-wheel, trailer type mounted unit. Weighing only 2, 630 pounds, ready-to-go, the new unit weighs 20 percent less than their similar capacity reciprocating compressor.

The use of a rotary sliding-vane compressor eliminates 80 percent of the wearing parts, such as valves, pistons, rings, rods, and clutch found in the reciprocating type compressors. Two stage compression, low operating temperature due to oil injection cooling, which also provides for copious lubrication, results in high efficiency. However, it is claimed that oil consumption is low, with 99.999 percent of the oil which mixes with the air during compression being removed by baffles and filter before entering hose lines. Air actually carries less oil than in many reciprocating-type compressors.



The Gyro-Flo 105 is available with either a General Motors Model 2-51, valveless, 2-cycle, 2-cylinder, diesel engine (parts replaceable with any GM series 51 engine), or a Continental Red Seal Model F-162, 4-cylinder, 4-cycle, L-head engine with individual porting for maximum power with standard grades of gasoline. Both motors are provided with push-button starting. The Diesel equipped unit weighs 3, 080 pounds, or 350 pounds more than the gasoline powered unit.

The ready-to-go unit has a length of 10 feet by 8-1/2 inches, a width of 4 feet by 9-3/4 inches, and a height with pneumatic tires of 5 feet by 3-1/4 inches. The unit also is obtainable with steel wheels and in either case has a track width of 45 inches.

The compressor is obtainable without running gear but shipped on skids for truck or stationary mounting. Mounted in this manner the length is 7 feet by 1 inch, width without hose reels, 2 feet by 8 inches, and height, 4 feet by 2-3/8 inches.

Two-hundred and ten and 315 cfm Rotary, Mobile-Air compressors similar to the 105 cfm unit and mounted on a 4-wheel running gear are also available. Information on any of the compressors can be obtained from Ingersoll-Rand Company distributors located in all large cities, or from 11 Broadway, New York 4, New York. Cost of the 105 is $3,500, fob Denver, where it is stocked by the Colorado Builders Supply Company.

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THE HYDROHOE--HYDROCRANE

A highly mobile, hydraulic controlled and operated, and easily convertible backhoe-crane rig is being produced by the Bucyrus-Erie Company under the trade name "H-3, Hydrohoe--Hydrocrane."

In either the Hydrohoe--shown above and called a drag-shovel--or the Hydrocrane, precise and simplified hydraulic control make operation much easier and inexperienced operators soon become adept at handling these machines. Without bails, sheave blocks or drag ropes and powered by the same engine that drives the truck upon which the rig is mounted, many wearing parts have been eliminated.

A telescoping, gooseneck-designed boom makes for less frequent truck movements and provides for greater digging depths with a shorter more easily handled boom and affords lower overhead clearance during travel or operation. Four outriggers which extend, retract and set hydraulically reduce the setting up and moving time, as well as increase the lift capacity. The handling of the outriggers from the operator's seat makes their use during all lifting operations practical and this in turn permits the mounting of the equipment on a relatively light truck chassis.

In addition to being easily convertible in the field from shovel to crane or the reverse, accessories for use with the crane include an 8-tine forked grab, a 3-tine grapple, a hook, 3/8-cubic yard clam bucket, a 1-cubic yard snow and trash bucket, a catch basin cleaning bucket, a 1/2-cubic yard materials handling bucket, all of which operate hydraulically, and a magnet. Both the 12-inch and 18-inch wide dipper buckets for use with the shovel are equipped with hydraulic ejectors which facilitate quick and clean dumping without hoisting the dipper.

Information and inquiry concerning the H-3, Hydrohoe--Hydrocrane can be obtained from the Bucyrus-Erie Company main office in South Milwaukee or from any of the many distributor and service offices located in most larger cities in the United States, and in many foreign countries. The Hydrohoe, mounted on a GMC Model FC-352 truck chassis, equipped with an 18-inch wide dipper, and with interchangeable 18-foot crane boom which extends hydraulically to 26 feet will cost $13,180, fob Denver, Colorado. One of the accessories, an 8-tine forked grab suitable for weed or trash removal will cost about $1,220. The cost of the Hydrohoe without crane boom is $11,390 plus $155 excise tax, fob Denver.

* * * * *

EXCAVATOR OPERATION AND MAINTENANCE HINTS

On the left, there is reproduced the cover page of an excellent 32-page bulletin issued by the Bucyrus-Erie Company, South Milwaukee, Wisconsin, pointing out that in excavator operation there are:

FOUR BASIC ELEMENTS
TO REMEMBER

1. To get the most out of your excavator or crane, you must have proper operating procedure. Consult operator's manual and keep such a manual available.

2. Complete knowledge of the "whys" and "wherefores" of lubrication will be one of the greatest contributions to the long life of your machine.

3. Basic maintenance rules will keep an excavator in shape. Refer to the operator's manual for your machine.

4. The amount of work you can get out of your machine and the ease with which you can operate it depends greatly on proper adjustments. These are easy to make--make them as soon and as often as necessary.

Included in the pamphlet are operating hints; tips, hows, and whys, to obtain maximum output, efficiency, and top performance; suggestions on preventative maintenance, including cleanliness, adjustments, lubrication, and repairs; and care of the power unit, the heart of the excavator.

Some worthwhile Safety Hints that should be called to the attention of operators and oilers are well put, as we start a New Year.

This bulletin is available without cost from the Bucyrus-Erie Company and their distributors.

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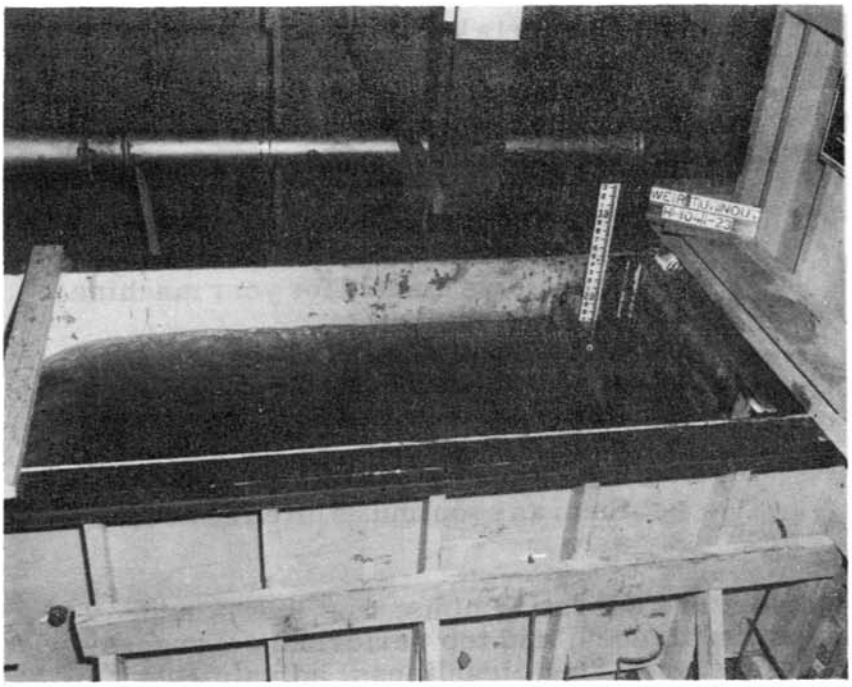
MEASURING IRRIGATION DELIVERIES WITH THE YAKIMA WEIR BOX

The Yakima Weir Box is a farm delivery measuring device in general use on the Yakima Project and, to a limited extent, in other areas of Region 1. Somewhat over a year ago, on the occasion of the Region 1 annual O&M tour, a number of these devices were observed in operation and their points of superiority over some other types of farm delivery measuring devices were noted. The operators who were using the weir boxes were very enthusiastic in recommending them to other projects. We felt, however, that there was some question as to the accuracy of the devices and that testing was in order since attempts to adapt this device to larger flows were not entirely successful. Accordingly, a full scale model was set up in the Denver Hydraulic Laboratory to determine the minimum dimensions permissable for the structure and, further, to check the accuracy of its measurement. The model is shown in the photo carrying 5 cfs of water discharging under 6 feet of head over the gate.



The weir box consists primarily of a relatively small baffled stilling box attached to the downstream end of the turnout pipe. The weir is located at the lower end of the box and the baffle is near the upstream end. Water leaving the turnout pipe is stilled in the box and measured over the weir.

The advantages of this measuring device over some of the others in use are that the stilling box does not readily fill with silt and so requires a minimum amount of cleaning, it is cheaper to build and flow through the structure stabilizes in a very short time so that measurement readings may be made rapidly.

The model was built with a 15 inch diameter pipe, controlled by a flat leaf gate, leading from the standpipe to the stilling box. Heads of from 6 feet to as little as a fraction of a foot, over the pipe, were used in the standpipe for various discharges and the baffling in the stilling box was varied to give the most desirable flow characteristics. With this arrangement flows up to 6 cfs, under 6 feet of head, were measured, the depth of water over the weir blade staying constant for a given discharge regardless

of the head. As a result of our testing and calibration we feel that we have an accurate measuring device which we are confident will give good performance.

One feature of the weir box is that a quiet pool for reading the gage height has been provided above the baffle so that accurate gage readings may be easily obtained.

Since the discharges did not agree exactly with the conventional Cippoletti weir rating, the weir box has been rated and a rating curve or table will be included on the design drawings of the device. It is planned to prepare standard drawings of the weir box in three sizes, the largest size being for 6 cfs capacity and the other two being smaller. The rating of the smaller sizes will soon be completed and it is hoped to have the design drawings completed for inclusion in the next release of this bulletin which we plan to have out early in March.

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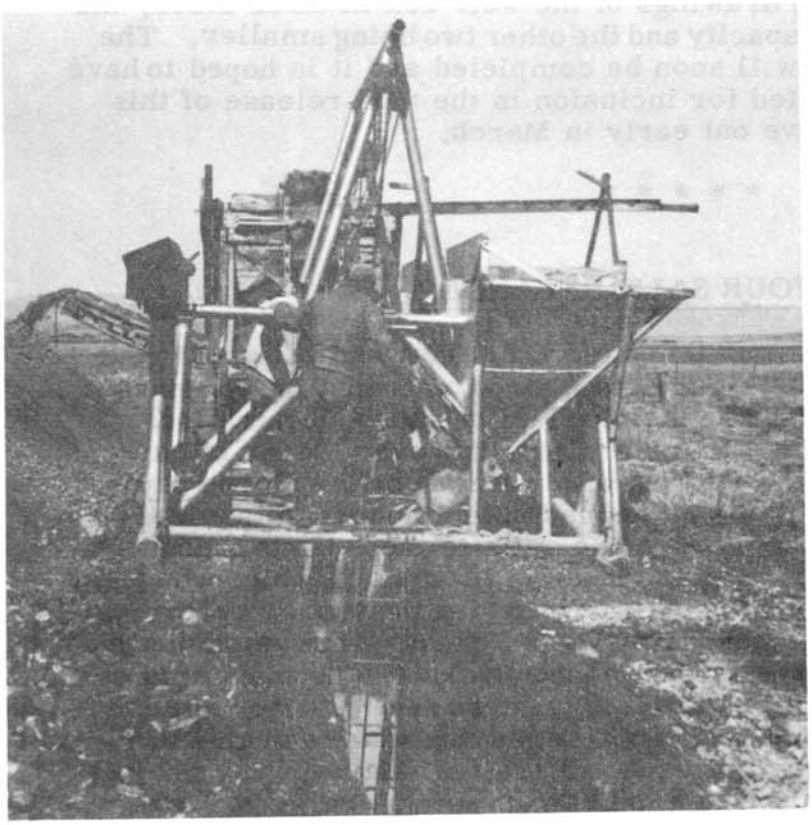
HOW IS YOUR SALT BALANCE?

We are thinking of your irrigated lands now and not about your individual physiques. On some projects where the irrigation water is extremely low in dissolved salts, the problem of salt concentrations building up is not too serious. Unfortunately, however, many of our projects are not blessed with that kind of a water supply. Those projects whose water supply contains an appreciable amount of dissolved salts, and who are thereby applying more salts to their lands than their drainage water is carrying away, are heading towards trouble. Just how serious this problem is may be determined by any project by recording the amount of salts leaving its lands by way of drains and comparing that with what is entering the lands in the irrigation water. To make this determination it is necessary to know the total acre feet of water applied to the lands and the total acre feet of water leaving via the drains together with the salinity content of each. If the salt leaving your project is more than that coming in through the canals and laterals, you are probably OK. If more salt is coming in via the irrigation water than is leaving through the drains, look out!

* * * * *

TRENCH SHIELD FOR LAYING DRAIN TILE

On a drainage system recently installed in the Big Horn District of Region 6, an attempt was made to develop a trenching shield to protect workmen placing drain tile and to place the gravel envelop for the tile at the same time. The equipment is shown in the accompanying photograph and it performed quite creditably; however, several difficulties were encountered which it was not practicable for those concerned to solve. An effort was made, therefore, to enlist the aid of the manufacturers of trenching equipment in perfecting this type of equipment.



One of the manufacturers' first concerns is of course, the matter of a market for the machine. Region 6 officials were able to convince the Barber-Greene people that the Missouri River Basin area will be a potential market of considerable magnitude as irrigation development proceeds; and that, of course, is correct. Consequently, the Barber-Greene Company have expressed themselves as being deeply interested and have turned the problem over to their factory engineers. We will hear more of this as they get into the problem.

A machine of this type, that is, a trench shield, was developed and used by the United Concrete Pipe Corporation and Vinnell Company, Incorporated, on a deep, closed drain job they had on the Bureau's Delta-Mendota Canal in California. This drain was placed 15 feet deep in saturated soil. The conditions there were much more severe than would ordinarily be encountered. The shield finally developed by the contractor was extremely heavy but it did a very creditable job. It was moved by power from a winch mounted on the trencher, and applied to a thirteen-part line anchored to two D-8 tractors, with their dozer blades set in the ground. It is our thinking that a lighter shield operating at lesser depths would have more general applications. What are your needs for this type of equipment? Let us have your ideas.

* * * * *

COMPACTED EARTH AS A CANAL LINING MATERIAL

More interest in the use of compacted earth as a canal lining material for the reduction of seepage losses from canals or laterals has led to the development of a "rating table" of suitability by the Chief Engineer's Earth Laboratory. A copy of the table will be found on the following page.

A variety of soils have been used in the successful installation of compacted earth linings in canals or laterals with the ideal being a gravel with sand-clay binder. The combination of reasonably well graded gravel and sand with plastic, cohesive clay provides for low permeability, high compacted density, good shearing strength, and erosion resistance.

Recently installed compacted earth linings have been competitive price-wise, with other lower-cost linings, and appear to be more successful in conforming to subgrade expansion or settlement, frost action, or hydrostatic pressures, than linings constructed of more rigid materials. Placed on 1-1/2:1 side slopes or flatter, depending primarily upon the conditions involved--ground-water table, hydraulics of the waterway or characteristics of the soils employed--compacted earth linings have a definite place in the canal lining program.

The column headed "Erosion Resistance" in the table is not only useful in selecting compacted earth lining materials, but also in selecting the most suitable soil for use as cover material for membrane linings. The "rating table" is also useful in the evaluation of stability and other qualities of existing soils in earth canal sections.

A paper "Construction of Compacted Soil Linings for Canals," is a recent contribution on the subject prepared for publication in the Proceedings, Third International Conference on Soil Mechanics and Foundation Engineering in Zurich, Switzerland in August 1953. Advance preprints of the paper are available and can be obtained by writing to the Chief Engineer's Office, Denver Federal Center, Denver, Colorado.

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Interior - Reclamation - Denver, Colo.

MAJOR DIVISIONS OF SOILS			TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	RELATIVE VALUES OF IMPORTANT PHYSICAL PROPERTIES			RELATIVE SUITABILITY FOR CANAL SECTIONS	
					PERMEABILITY	SHEARING STRENGTH	COMPACTED DENSITY	EROSION RESISTANCE	COMPACTED EARTH LININGS
COARSE GRAINED SOILS More than half of material is larger than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size (For visual classifications, the ¼" size may be used as equivalent to the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, gravel-sand mixtures, little or no fines	GW	14	16	15	2	—
			Poorly graded gravels, gravel-sand mixtures, little or no fines	GP	16	14	8	3	—
		GRAVELS WITH FINES (Appreciable amount of fines)	Silty gravels, poorly graded gravel-sand-silt mixtures	GM	12	10	12	5	6
			Clayey gravels, poorly graded gravel-sand-clay mixtures	GC	6	8	11	4	2
			Gravel with sand-clay binder	GW-GC	8	13	16	1	1
	SANDS More than half of coarse fraction is smaller than No. 4 sieve size	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, little or no fines	SW	13	15	13	8	—
			Poorly graded sands, gravelly sands, little or no fines	SP	15	11	7	9 coarse	—
		SANDS WITH FINES (Appreciable amount of fines)	Silty sands, poorly graded sand-silt mixtures	SM	11	9	10	10 coarse	7 Erosion Critical
			Clayey sands, poorly graded sand-clay mixtures	SC	5	7	9	7	4
			Sand with clay binder	SW-SC	7	12	14	6	3
FINE GRAINED SOILS More than half of material is smaller than No. 200 sieve size	SILTS AND CLAYS Liquid limit less than 50		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	10	5	5	—	8 Erosion Critical
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL	3	6	6	11	5
			Organic silts and organic silt-clays of low plasticity	OL	4	2	3	—	9 Erosion Critical
	SILTS AND CLAYS Liquid limit greater than 50		Inorganic silts, micaceous or ditomaceous fine sandy or silty soils, elastic silts	MH	9	3	2	—	—
			Inorganic clays of high plasticity, fat clays	CH	1	4	4	12	10 Volume Change Critical
			Organic clays of medium to high plasticity	OH	2	1	1	—	—
HIGHLY ORGANIC SOILS			Peat and other highly organic soils	Pt					
					Numbers above indicate the order of increasing values for the physical property named			Numbers above indicate relative suitability (1=best)	

Important Physical Properties and Uses of Soils for Canal Linings