Department of the Interior

Bureau of Reclamation

OPERATION AND MAINTENANCE EQUIPMENT AND PROCEDURES

RELEASE NO. 22

October, November and December 1957

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INTRODUCTION

"Maintenance Painting of Concrete" is the subject of the second article prepared by the Bureau's Paint Laboratory in the series of maintenance painting articles currently being published, and is included in this release of the bulletin.

This bulletin, published quarterly, is circulated for the benefit of irrigation project operation and maintenance people. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. Reference to a trade name does not constitute the endorsement of a particular product, and omission of any commercially available item does not imply discrimination against any manufacturer. It is hoped that the labor-saving devices or less costly equipment developed by the resourseful water users will be a step toward commercial development of equipment for use on irrigation projects in a continued effort to reduce costs and increase operating efficiency.

* * * * *

Division of Irrigation Operations
Commissioner's Office
Denver, Colorado.

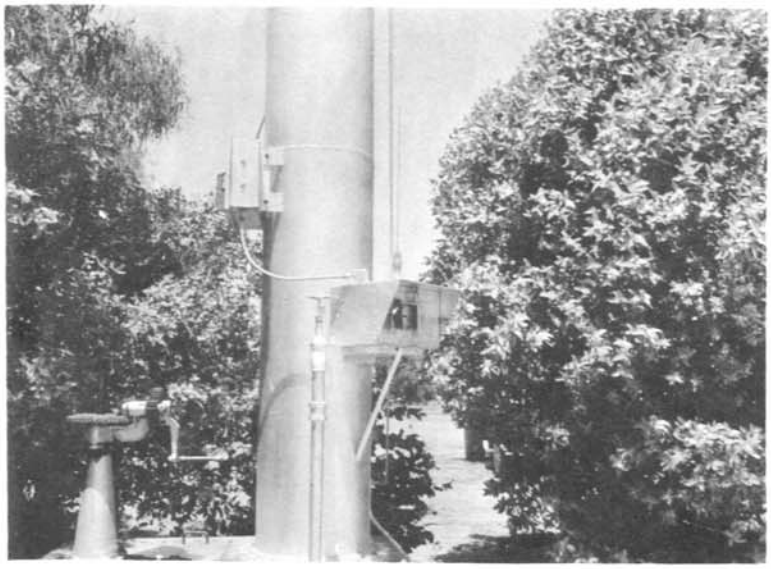
ELECTRONICALLY CONTROLLED DISTRIBUTION SYSTEM

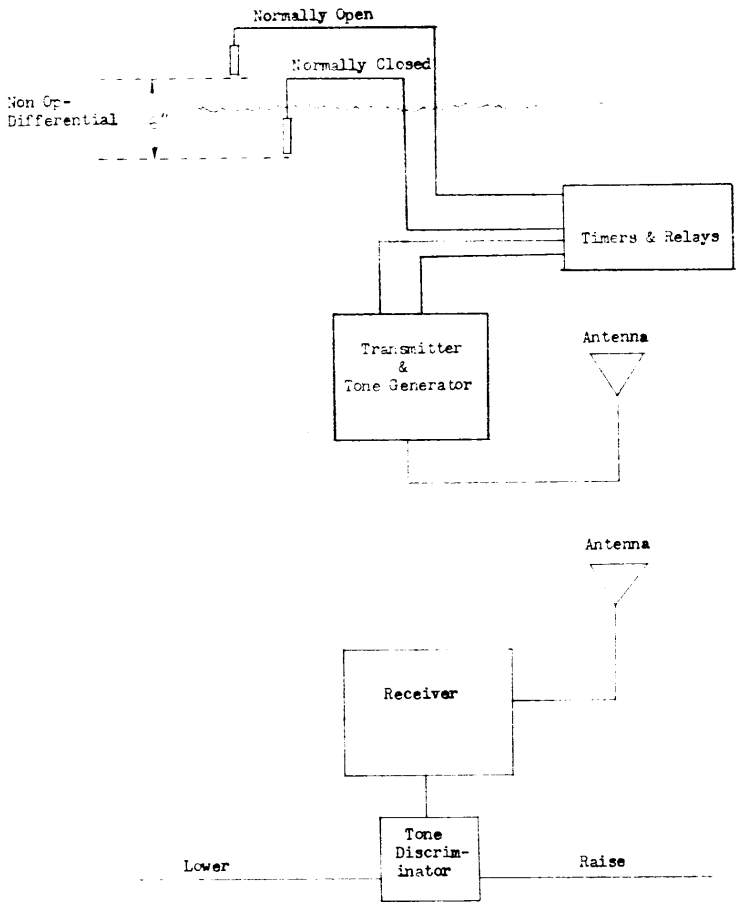
The Lindmore Irrigation District Distribution System of the Central Valley Project consists of 123 miles of gravity pipe lines which are comprised of four main feeder lines. The four main feeders receive their water from the Friant-Kern Canal through moss screen structures located adjacent to the canal, and from there the water is distributed through a network of junction boxes, laterals and sublaterals.

On a closed pipe gravity system it is imperative that the amount entering the line almost exactly match the amount being delivered out of the line. If this condition is not met, it of course would mean wasted water overflowing somewhere, causing damage or inconvenience, or there may be a shortage of water to one or several of the farmers on the line.

As is generally the practice, the ditchrider observes the level indicators on the standpipes, then drives up the line to make valve adjustments accordingly. This can be, and is, very time consuming. The Lindmore Irrigation District has solved the greater part of this problem on the First Avenue line which is most important to them, as they have no means of using spills from this line. The electronically controlled distribution system providing for better control and increased economy is described by the Bureau of Reclamation Engineer William G. Myer, Fresno Operations Field Branch, Central Valley Project, California.

A local electronics technician installed a radio transmitter on Junction Box No. 1, as shown in Figure No. 2 and the photograph below. In the initial installation, there was a 3-position toggle switch with "Off," "Raise," and "Lower" positions on the transmitter. The operator merely observed the level indicator, then put the switch to the raise or lower position. This keyed the transmitter to transmit a tone to the receiver upstream which received the tone, actuated relays, and thereby, operated the gate motor. When released the switch returned to the "Off" position. The receiver installation is shown in the upper photograph on page number 3. In general, the motor was "jogged" until the desired operating conditions were obtained. This saved a great deal of time.





SCHEMATIC DIAGRAM OF ELECTRONIC COMPONENTS

Figure No. 1

PROFILE OF RADIO OPERATED GATE

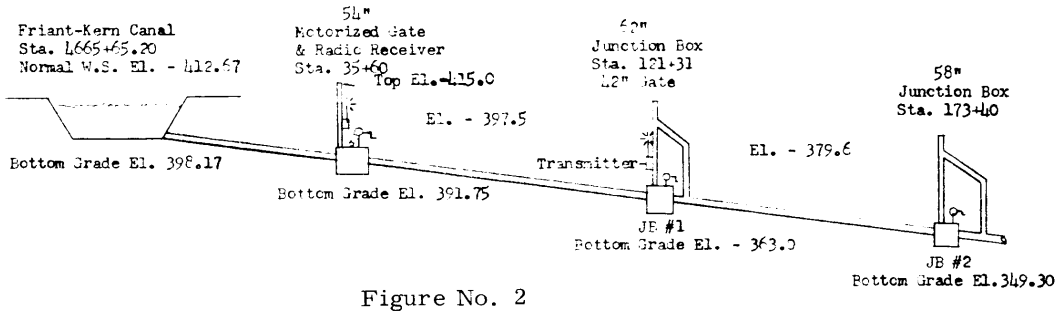
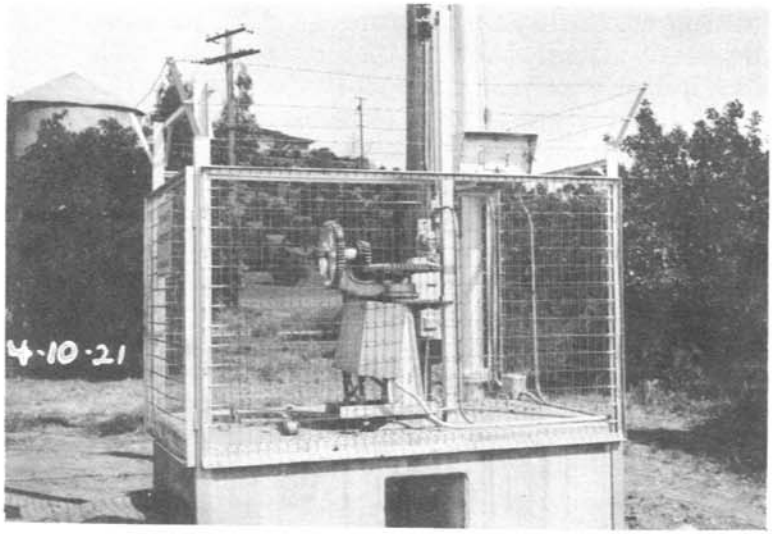
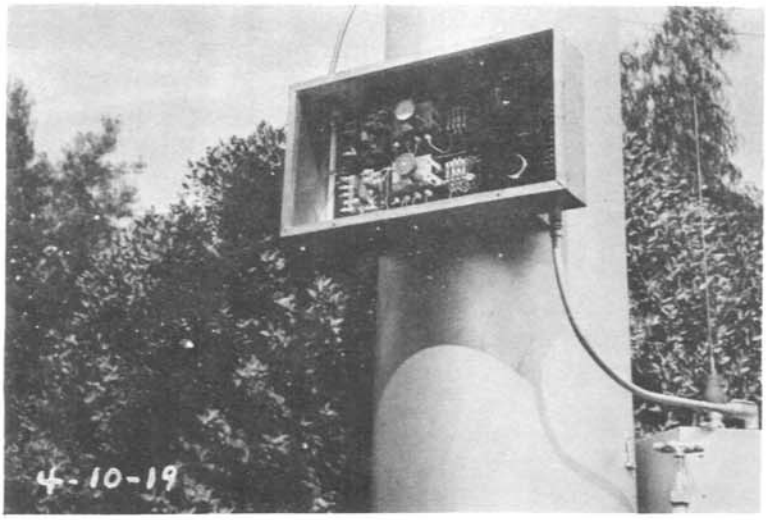


Figure No. 2

As time went by, the District began considering making the installation fully automatic. They again called upon the radio technician. Electrodes were installed in the standpipe to create an operating differential of approximately 6-inches. In other words, the upper electrode was set slightly lower than the overflow point so that when it became immersed it would, through a relay, start a timing device. The timing devices and relays are shown in the lower photograph. The timing device makes one revolution per minute, and its contacts may be set to be closed anywhere from zero to 30 seconds of each revolution, depending upon requirements. When the contacts of the timer are closed, the transmitter transmits a tone back to the receiver which detects that the tone is a "lowering" tone and begins lowering the gate. The gate is powered by a 1/2 H.P., 3-phase, 220 volt gear-motor. This will continue for the duration of the setting on the timer, at which time it will stop until the timer returns to the position where the contacts are closed again. Of course, it may be discontinued if the upper electrode is, in the meantime, no longer immersed.



The opposite situation, of course, would be when the lower electrode is no longer immersed. It then starts another timer, through a relay, which operates the transmitter when the timer contacts are closed. The receiver receives the transmitted tone, discriminates it as a "raising" tone, and through relays raises the gate to allow more water into the line. A schematic diagram of the electronic components is shown in Figure No. 1. Basically, the electrodes operate either one, but not both of the timers simultaneously, through its relay. The timer contacts close and the circuit is set up for the transmitter to



transmit the tone. The transmitter is always on, but will not transmit the tone until it receives the impulse through the timer. The tone is received in the receiver, discriminated, and the impulse is sent to the gate motor controls to raise or lower the gate depending on which tone it received.

An added feature in this system are the two indicator lights in the end of the box containing the relays and timers. These are visible in the photograph of the transmitter installation on page 1. The function of these lights is to indicate which direction the gate last moved. For example, if the lower light is on, that means that the gate was going down the last time it moved. The reason for this is that there is some slack in the gate. If the ditchrider is on his way to close the gate manually and the lower light is on, then he knows he need not allow for the slack. If on the other hand, the upper light is on, he knows that in order to close the gate he must first crank a few turns to take up the slack.

This automatic control has proven extremely reliable and relatively trouble free. The entire cost was near $1,500 installed, and it is anticipated that its life span will be 10 years. One may readily see that this step towards automation is definitely economically feasible.

* * * * *

STOP LOG HOLD-DOWN DEVICE

A device for holding stop logs in place in a check structure is shown in the drawing on the facing page. The check structures on the Courtland Canal, a part of the Missouri River Basin Project in Kansas, consists of a 12-foot wide radial gate and six bays of stop logs with the stop log bays being approximately five feet in width. The logs in these bays tended to float either resulting in a discharge of water through the openings between the logs, or in some cases, loss of the logs.

Randall W. Cleveland, Watermaster on the project unit, constructed the log wedging device shown, and it has performed in excellent fashion. The device is inexpensive, simple to construct and install. It also is simple to operate in the field, and makes the setting and pulling of the logs a less time consuming job. The device should last indefinitely.

Construction

Installed in one of the upper stop logs, the 1/2-inch rod is bent at an angle of 90 degrees so that the sharpened end of the rod lodges against the stop log guide.

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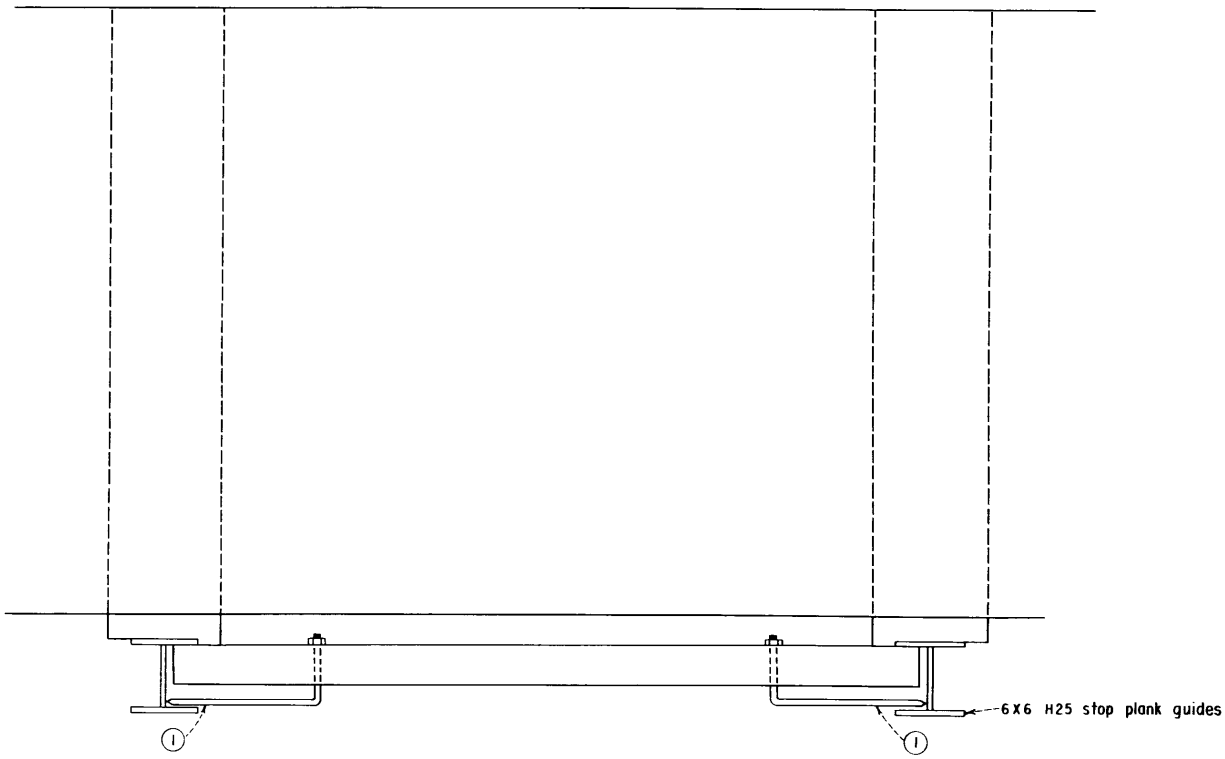
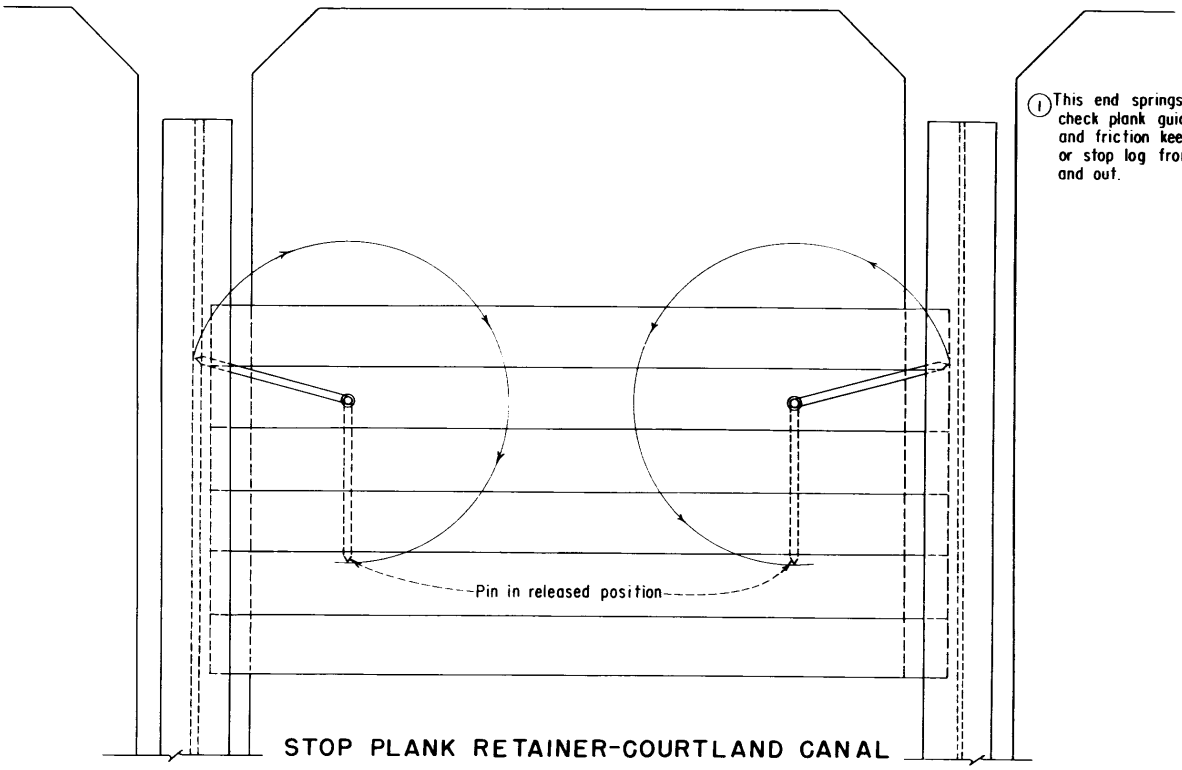




1 This end springs against the check plank guide or groove and friction keeps the plank or stop log from floating up and out.

STOP PLANK RETAINER-COURTLAND CANAL

TILT BED TRAILER

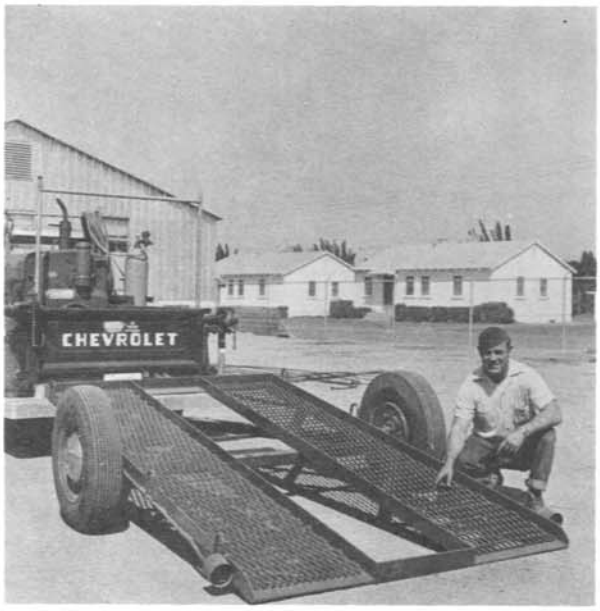
The trailer shown on the cover and below was constructed of scrap materials on hand and an extra pair of 16-inch wheels from an old house trailer by Clyde C. Wilson, Foreman, and Leland Willingham of the Lindsay Unit of the Central Valley Project, California. The loading of either a track laying or wheeled tractor is simplified and safe.

Formerly a tractor was loaded either into a dump truck or on a flatbed truck from a ramp in the project warehouse, and then unloaded at the job site wherever a suitable bank could be found to serve as a ramp. This was both unsafe and time consuming, as well as being more costly, including operation of a heavier dump or flatbed truck; the 1/2-ton pickup shown easily pulls the trailer.

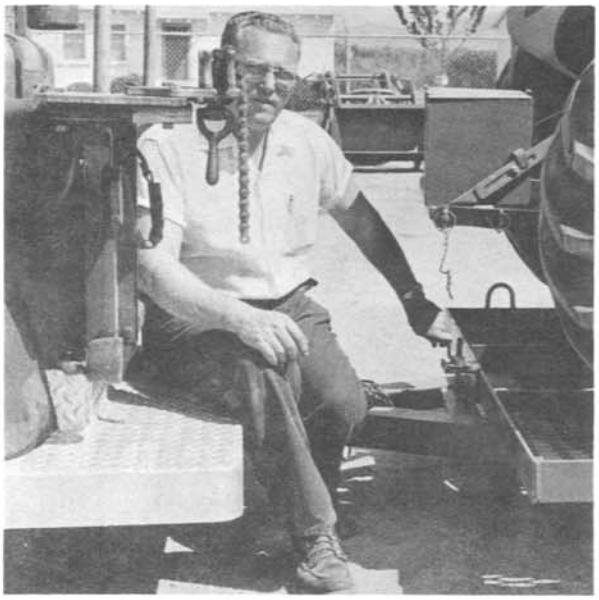
The trailer also contributes to more job efficiency. The tractor can be quickly loaded and unloaded, and moved from place to place with a minimum amount of delay and with a minimum amount of field assistance.

Construction

The trailer was constructed particularly for a Ford wheeled tractor and a Clark "airborne" track laying tractor. However, with modification of the bed the trailer can be adapted to any small tractor.



Details of construction are shown in the photographs at left. The 1/4-inch steel stretch plate used for the running strips of the trailer eliminated the accumulation of mud, etc. The hold down loops welded to the frame and the arrangement of the combination tail, stop and turning signal light are well designed and neat in appearance. The light circuits are provided with a connection to corresponding circuits of the towing vehicle. Note that the lights have been hooded with a piece of 4-inch pipe to prevent damage and breakage.



The quick acting "lock-down" latch which holds the tilting portions of the trailer in position for travel is shown in the lower photograph. The latch has been so constructed to eliminate the possibility of its slipping from the slotted metal bracket. However, when the latch is released with the trailer empty, the bed is so balanced on the pivoting axle so that is tips automatically, ready for loading.

For further details, contact the Fresno Operations Field Branch, Bureau of Reclamation, Fresno, Calif.

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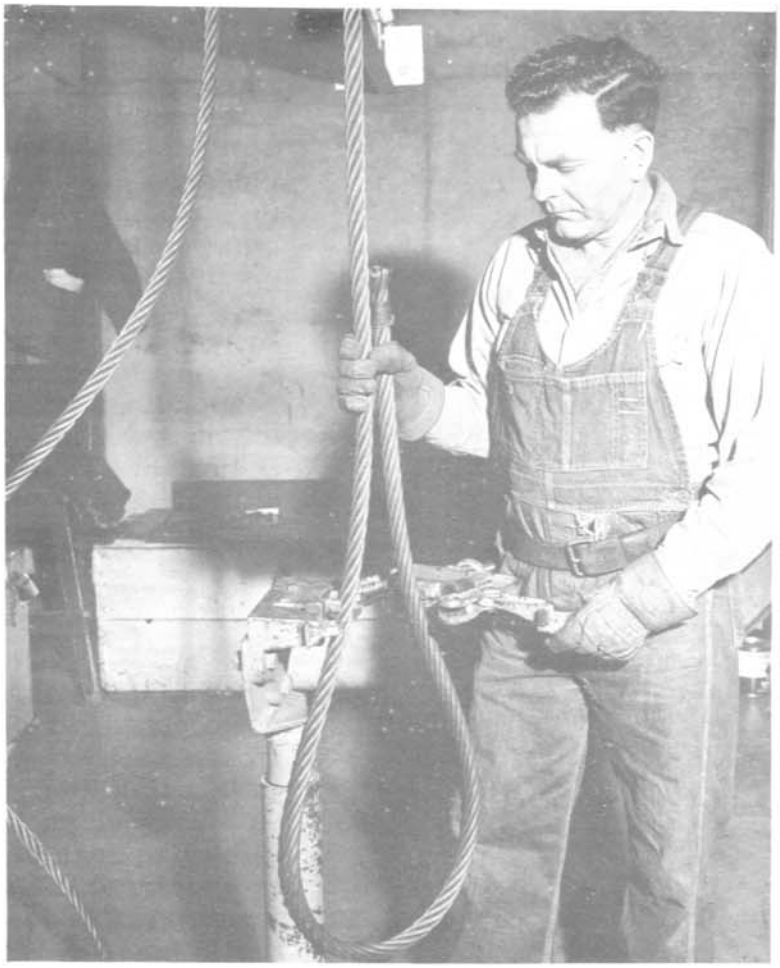
WIRE ROPE SPLICING

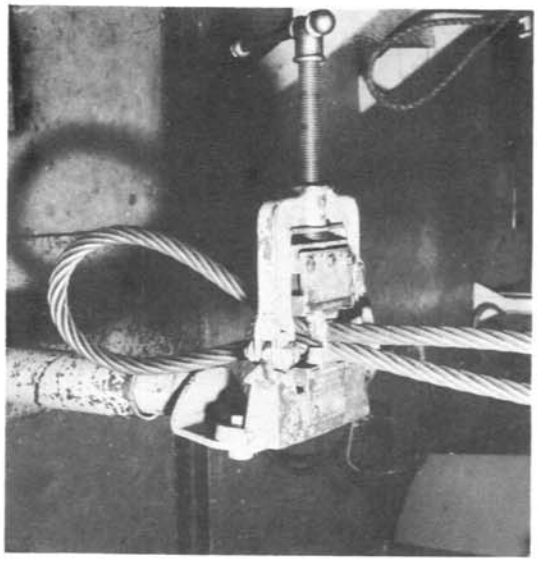
A pipe vise and attachments used by, and also designed and constructed by, riggers at Hoover Dam Power Plant to make eyes in wire rope, is shown below and in the photographs on the facing page. The vise and interchangeable blocks which can be easily attached to the vise are used to splice wire rope from 1/4-inch to 1-inch in size.

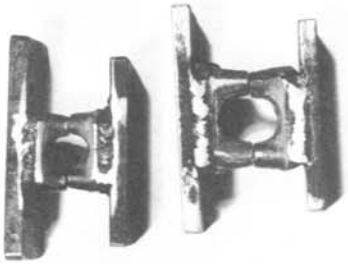


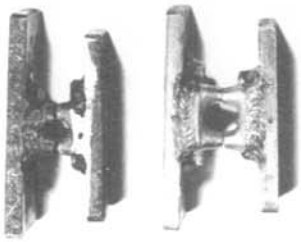
In the photograph above, one man is about to splice the eye in a 1-inch wire rope by use of the pipe vise, whereas the work involved in forming the eye in the rope without the device would normally require the services of an assistant. The device also enables the riggers to make a better splice because the strands of the rope are held in more exact alignment as shown in the photographs on the next page.

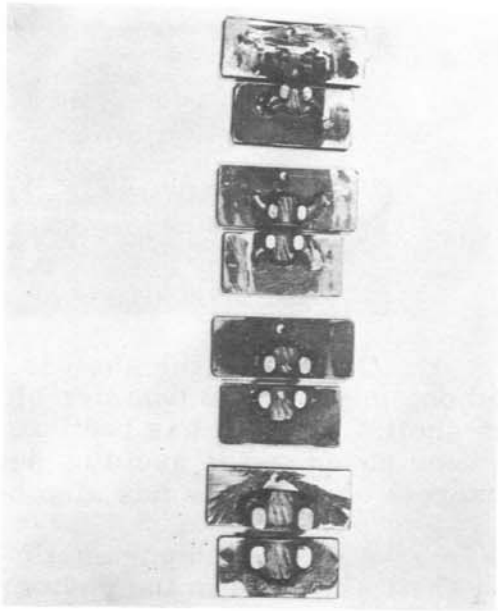
The block attachments and the manner in which these blocks are fastened to the pipe vise are shown below. The blocks are constructed of a piece of steel plate and cable clamps of the desired size. The clamps have been cut into two pieces with one piece being welded to each of the steel plates. A single screw in the block recess of the pipe vise makes changing the attachment blocks from one cable size to another possible in a matter of minutes.

The vise and blocks can be used in any rigging loft or shop where slings and cable splicing is required, and they make it possible to accomplish the task rapidly and efficiently.









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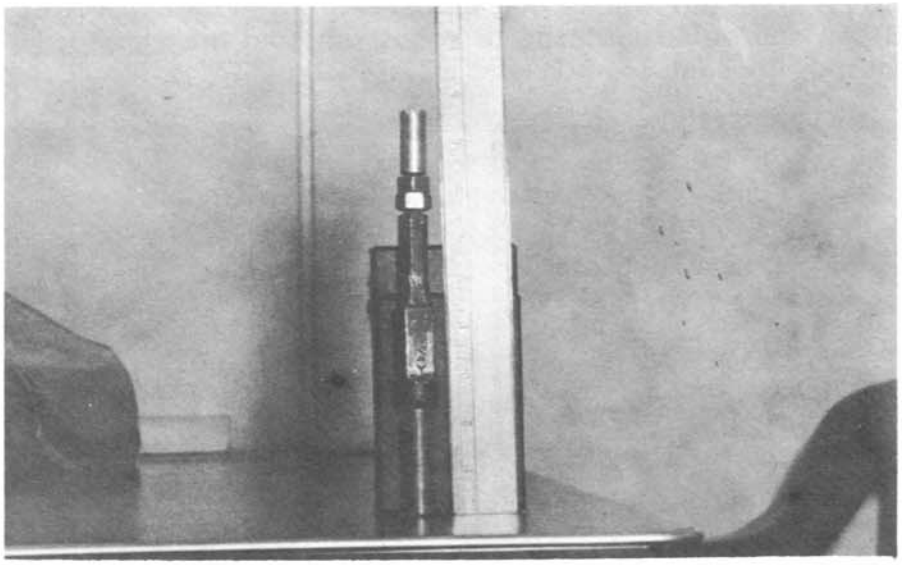
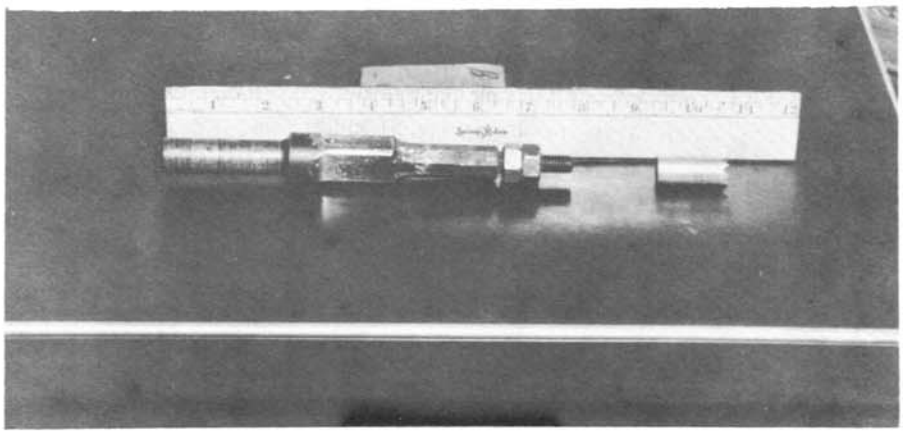
DRIVING SELF-DRILLING SHELLS INTO CONCRETE

The tool shown in the photograph, and the sketch shown on the opposite page, was suggested by John A. Sublett, Pumping Plant Operator, Tracy Pumping Plant, Central Valley Project, California, for driving Phillips Self-drilling shells into concrete with a pneumatic chipping gun.





Ordinarily the shell is driven into the concrete with a hammer and one misdirected hammer blow may seriously injure the hand holding the shell. The tool has been used with very satisfactory results, both in time saved and in avoiding serious injury. Setting cinch anchors in concrete under water has also been simplified with the tool.

A discarded pneumatic chipping gun bit was modified to hold the shell as shown in the photographs and sketch.

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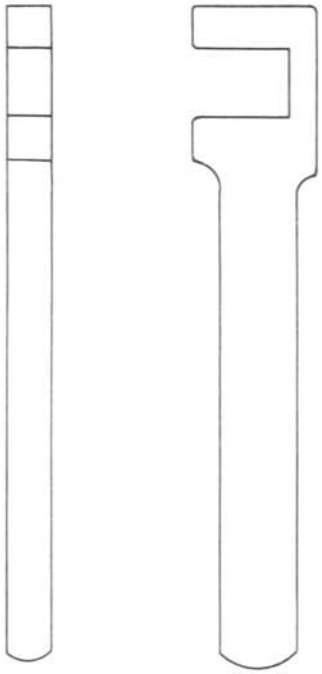
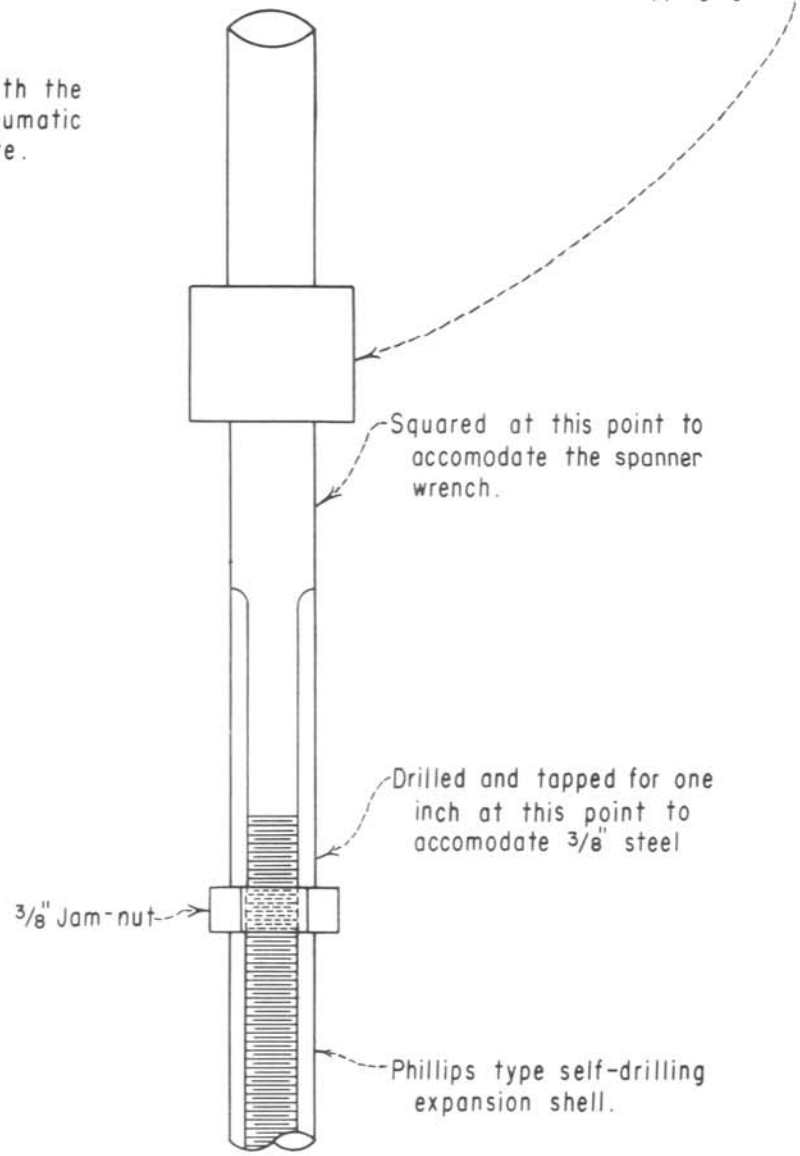
This tool was designed to be used with the Phillips self-drilling shell and a pneumatic chipping gun for drilling in concrete.



SPANNER WRENCH
For turning tool to keep from sticking.

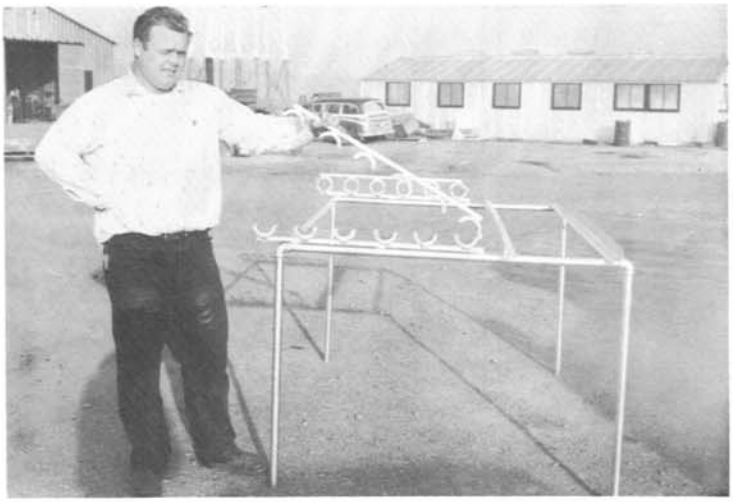


DRILLING TOOL

Sketch of Pneumatic Chipper for installing Phillip's self-drilling shells

METER CARRYING RACK

Prior to the design and fabrication of the rack shown in the photographs below, it was general practice to haul the irrigation meters about the Delta-Mendota Unit of the Central Valley Project, California, in the bed of a pickup truck. The meters are too long to lie flat in the bed of a pickup truck so this meant the end of the meter extended beyond the bed over the tail gate.



There was danger of losing the meter or of damage to the delicate gears, bearings, etc., due to jolting. With the rack suggested by Morgan H. Kenner, Meter Maintenanceman on the project, the meters are safely transported in individual rubber lined brackets free from excessive shock and jolting.

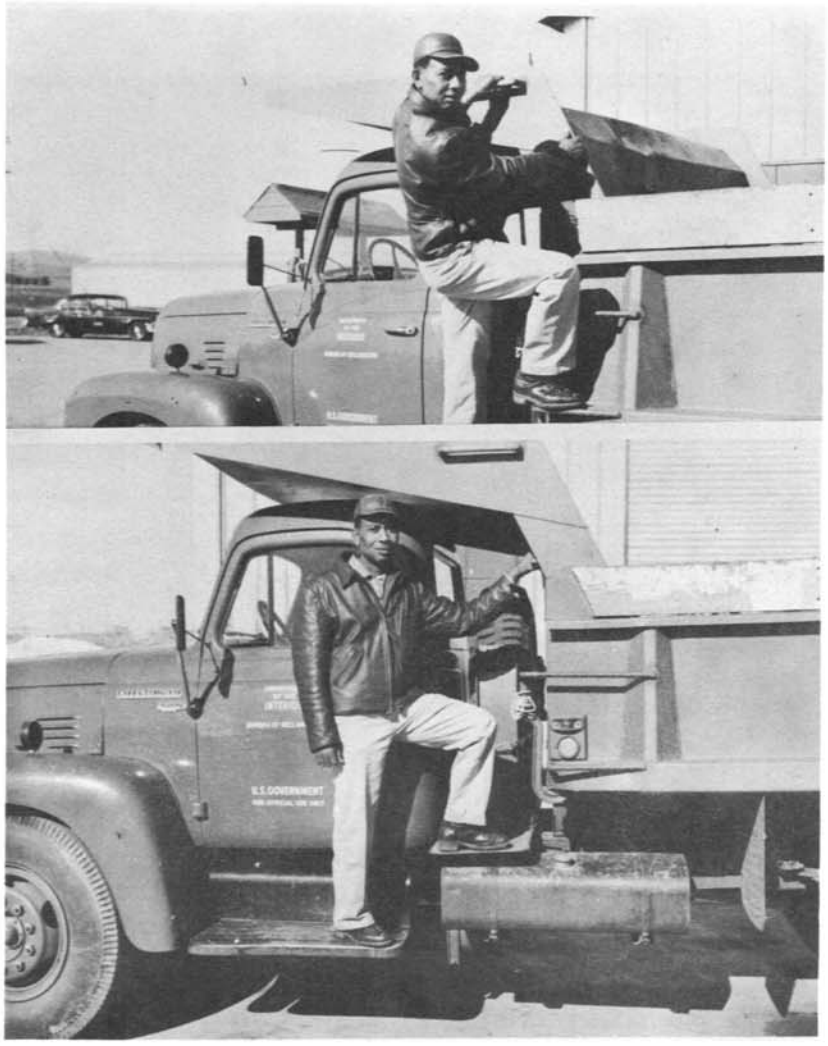
In addition to the meters, the rack provides for the carriage of a ladder necessary for the installation of the meters in the meter wells. The ladder can also be locked to the carrier when not in use.

Details of construction of the carrier are shown in the lower photograph. Materials common to most project shops were used in fabrication. Note that the rack can be easily and quickly placed on or removed from the pickup truck bed.

* * * * *

SAFETY STEPS AND HAND GRIPS FOR DUMP TRUCKS

An accident, fortunately not a serious one, on the Central Valley Project, California, led to the addition of safety steps, hand grips and splash plates to dump trucks, to eliminate future and more serious injury to the truck drivers. Canal maintenanceman Jack Thompson, of the Delta-Mendota Canal Unit, shown in the photograph below, suggested the safety devices, which are also shown.



The lower step and splash plate were made of 1/4-inch steel decking. The upper steps and hand grips were made of 5/8-inch or 3/4-inch reinforcing steel bars. The cost of installation is minor, especially if constructed of waste material, as those shown were. About $20.00 per truck was the estimated cost of the safety features on the Delta-Mendota Canal unit.

* * * * *

SCREW JACK FOR ELECTRIC DRILLS

To facilitate drilling in awkward positions where it is difficult and tiresome to exert pressure on the drill, the screw jack shown in the photograph below and in the schematic diagram on the facing page, is a useful idea. With it, overhead drilling and drilling in restricted and close quarters is made easier, less tiresome, faster, and more efficient.

The screw jack was designed and constructed by H. C. Lange, Equipment Operator Foreman on the Ysleta Branch of the Rio Grande Project, Texas-New Mexico. The jack can be constructed in any machine shop and is easily attached to an electric drill by one bolt.

In the photograph, the device is in use in drilling overhead holes in concrete for bolts to hold a top seal for stilling basin sluice gates. Much time and effort were saved in this operation.

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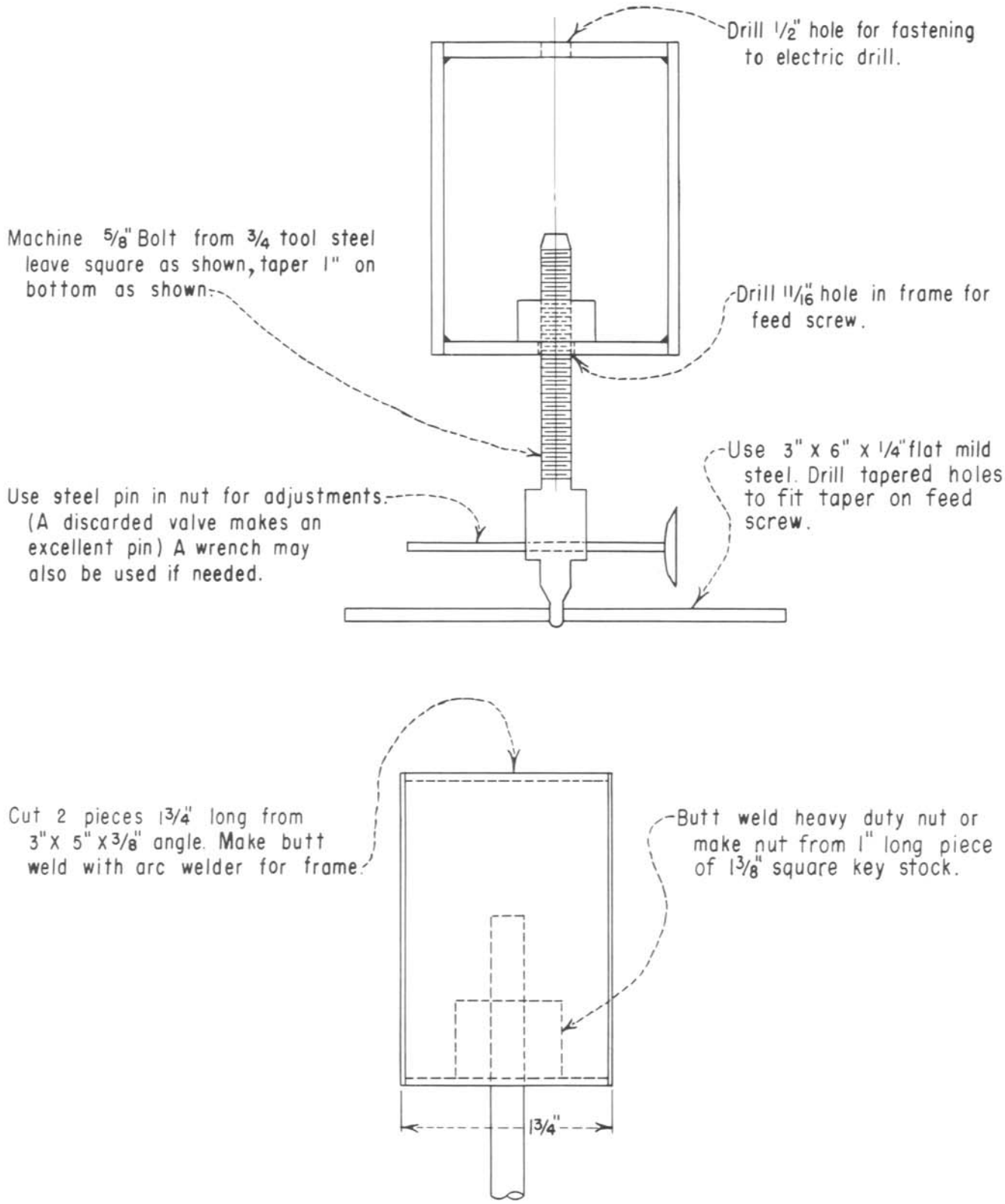


SCREW JACK FOR ELECTRIC DRILL

MAINTENANCE PAINTING OF CONCRETE

Concrete, among the most durable of all construction materials, slowly yields to the ravages of time. Cracks open, erosion begins, seepage increases, the structure begins to look forgotten and the time has arrived for maintenance. We note increasingly frequent references in inspection reports to structures where major maintenance action will soon be required to minimize future extensive damage. New construction also requires coating in some cases, usually for dampproofing, waterproofing, or decorative purposes. One method of slowing the process of deterioration of concrete is to coat the surface with a material which reduces the amount of moisture entering the concrete. Paint can be used for this purpose under some conditions, and the types of exposures and the appropriate coating selection are being discussed in this article.

Intended primarily as a guide, the Bureau's Paint Manual should be consulted for full treatment of individual coatings and procedures. The Denver office will be pleased to supply additional details and assist with any special problems which may arise.

Atmospheric Exposure

Concrete in the atmosphere of our northern states is exposed to the same severe freezing and thawing action that slowly erodes natural rock and similar effects observed on concrete in both large and small structures should therefore not be surprising. Generally, many years pass before the first small cracks appear in concrete structures, usually along parapets, posts and thin sections exposed to moisture from spray in the cold months. Occasionally, the attack will be accelerated by other forces such as alkali-aggregate reaction in the concrete. This reaction, being in turn aggravated by the increased supply of moisture available, is well illustrated below. Prompt action to seal the surface

against absorption of water is desirable in these circumstances. It is not intended to imply that a coating will halt progress of the alkali-aggregate reaction. Painting here will reduce the rate of deterioration on the surface and, insofar as it prevents permeation of water to the interior, will probably retard the reaction to some extent. In addition the appearance of the structure may be enhanced.

One method of coating concrete that has proved highly successful in reducing deterioration in atmospheric exposure is known as the Oregon State Highway (OSH) system. This treatment has been employed widely both by the Bureau and other agencies. It consists of one coat of raw linseed oil, thinned with equal parts of turpentine, applied at 175° F during a period when the weather is warm and the concrete as dry as possible. These conditions are most conducive to securing maximum penetration of the paint into the concrete and they apply also to the second coat of undiluted raw linseed oil applied at 175° F. Areas which by visual examination are very porous should be given an additional application of linseed oil. Two coats of a mixed pigment exterior oil base paint (such as required by Federal Specifications TT-P-102) complete the treatment. The first of these should be thinned with 2 quarts of turpentine and 2 quarts of boiled linseed oil per gallon and the second with about 1 quart of boiled linseed oil per gallon so as not to get a heavy pigment coat that will be susceptible to curling and peeling, but which will be heavy enough to brush out uniformly. Both coats may be tinted with lampblack and raw sienna ground in oil to give a concrete matching color if this is desired.

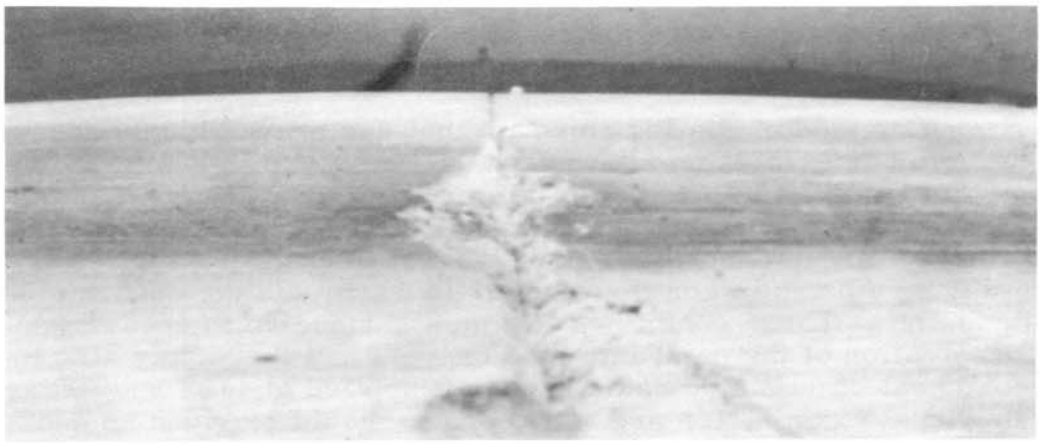
Concrete preparation for the OSH treatment requires removal of any contamination. Obviously, unsound concrete provides an unsuitable base for this preservative and must be removed and patched prior to painting. Cracks should also be repaired.

Roadways on the crest of dams often suffer the same exposure damage, but aggravated by traffic. Since the paint coatings mentioned above will not effectively withstand traffic damage, an asphalt seal coat with chips embedded has been satisfactory when maintained in the same manner as any asphalt road surface.

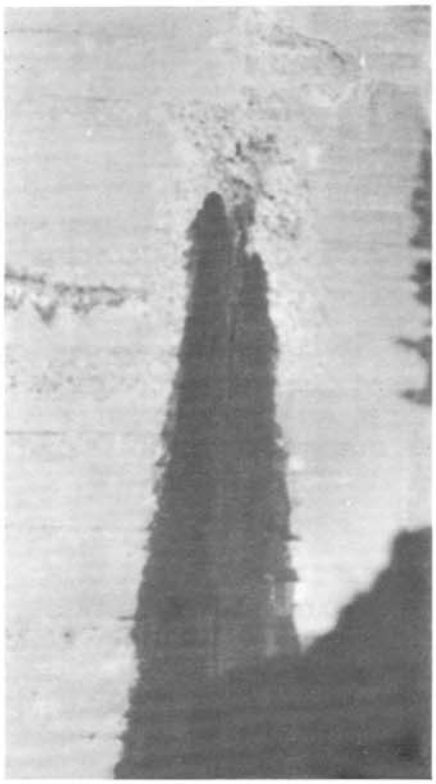
Upstream Faces of Dams

The upstream face of a concrete dam can present a variety of problems. First, certain portions of the dam are constantly under high hydrostatic head and slow water permeation may be objectionable. Another portion is alternately submerged; thus, during the atmospheric exposure, the scene is set for the most active wetting and drying, and freezing and thawing attack. Incidental ice and other abrasion may sometimes exist. And finally, small movements in the structure may create or increase seepage along construction joints. These joints constitute the most evident points of failure in northern areas. Looking

vertically down a joint in the upstream face of a dam, the view below shows typical spalling.



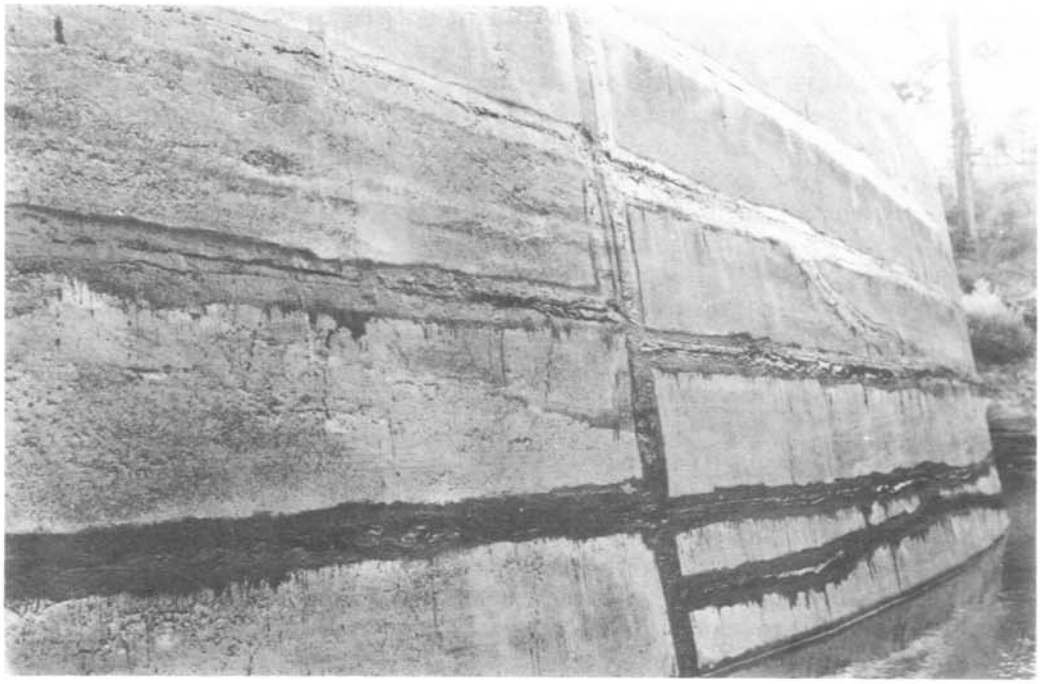
Seeps, at left below, produce spalling which may develop into the general condition, at right, on the downstream face.



Instances have also been noted where severe expansion by the alkali-aggregate reaction has caused major cracking in the face of the dam and admitted quantities of water to the interior. Here limiting the access of the water into the dam is essential. This would also be expected to

retard progress of the deleterious alkali-aggregate reaction to some degree and thus contribute to the fundamental soundness of the structure.

If the condition of the concrete is not so bad that complete resurfacing is necessary, a coating may serve a useful purpose. The function of a coating would be to provide a membrane with a negligible moisture transfer rate on the dam face. Such a membrane must accommodate slight movement in and around construction joints, effectively sealing against seepage. A neoprene brushing compound applied at Gerber Dam to certain upstream joints only, as shown below, so reduced seepage deposits on the downstream face that coating work was extended to other parts of the face in later years. This neoprene is available



from several manufacturers and the application instructions vary slightly with the various manufacturers. In general, an "accelerator," mixed into the paint, hastens the setting and shortens the curing period required to produce the necessary tough and rubbery, well-bonded film. Different combinations of primers and body coats, usually totaling between 4 and 6 coats, produce a minimum final dry film thickness of 30 mils. Strong emphasis is placed upon exact adherence to the manufacturers instructions for the application of the neoprene materials since failure to do so will markedly increase chances of a coating failure. In planning for this coating, the curing period available must conform to the manufacturers requirements both as to temperature and duration since a marked reduction in the curing rate occurs with decreased temperature.

Equally important are the vigorous surface preparation standards. Deteriorated concrete must be chipped out and patched, then old

and new surfaces roughened and cleaned of all surface contamination by sandblasting. Less thorough treatment will invite early failure.

Erosion of concrete has also been mentioned in recent annual inspection reports. Where such action threatens the soundness of a structure, and repair with concrete is not contemplated, neoprene may be applied as an erosion resistant coating. A special problem in some locations may be found in drying the concrete long enough to obtain the excellent adhesion mandatory in this exposure. Heat lamps or other means of accelerating curing may be practical for small areas.

Decorative Painting

It is sometimes desired to paint interior concrete walls to improve their appearance. Three types of coating materials are available for this purpose. Where the surface is aged and thoroughly dry, a varnish based paint permits a choice of flat, semigloss or gloss finish. Walls that are continuously slightly damp will show blistering and peeling of an oil base paint at an early age and selection of a latex based paint is indicated. Ease of application (a roller can be used) is a principal advantage of this latex base paint which conforms to Federal Specification TT-P-29. Also, it is not noticeably affected by alkali in the concrete, hence, removal of surface contamination (after filling pits if desired) is sufficient surface preparation.

A paint which has served well for lighting recesses is the VR-3, vinyl resin paint. The first of three coats should be thinned with equal parts of the special thinner provided by the manufacturer.

Exterior concrete may be painted with either oil based or portland cement paint. The former provides greater resistance to moisture absorption but preferably should be used where the concrete has aged. The cement paint can be applied to relatively new concrete, say 1 month old, with which it is perfectly compatible. Cement paint performs best on a rough surface and is often selected in order to provide a smoother appearance. Both paints require removal of surface contamination. The Paint Manual should be consulted for more detailed information. "Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces" (ACI-616-49, Title No. 46-1) discusses cement paint. "Guide to Painting Concrete" (Title No. 53-46), reported by ACI Committee 616, gives a comprehensive treatment of painting primarily for decorative purposes and is worthy of review where this type of painting will be performed.

Water Repellancy

It is sometimes desired to reduce the moisture absorption of exterior masonry such as building blocks, concrete, stucco, etc., without changing the appearance. Solvent and water based silicone solutions have been found to be quite effective. The latter is suitable only where a slight darkening will not be objectionable, but is believed to be slightly

more efficient. These silicones penetrate deeply into the surface, and, when the solvent evaporates, leave the pores and crevices coated with the water repelling compound. This material will not resist any appreciable water pressure; also, masonry once impregnated can only be coated with oil based paints thereafter. Copious application to surfaces free of foreign matter should be made in one coat; this is especially true if the water based material is selected, since no further absorption will occur when the first coat dries.

Dampproofing

Dampproofing of a concrete wall below grade is usually performed during the construction phase before backfilling operations commence and is done to prevent dampness from penetrating through to interior spaces. Occasionally this work may be required later when it is discovered that the dampness causes interior paint to peel or is otherwise objectionable. Asphalt emulsion when the concrete is damp at the time of painting, or coal-tar paint CTP-3 if it is dry, are suitable dampproofing compounds. Either of these should be applied to concrete from which dirt and other contamination has been scrubbed. Before application of the first coat of asphalt emulsion the surface should be watered down with a spray hose and free water allowed to drain off.

Surface Preparation

In the above we have mentioned surface preparation briefly to describe the kind of surface necessary for proper adhesion and performance of the coatings discussed. Ideally, any surface to which a coating is to be applied should be:

1. Free of all dirt, efflorescence, oil or any other foreign substance or contamination.

2. Free of any deteriorated concrete and patched to bring the surface to its original smoothness.

3. Free of any pits or depressions.

4. Aged sufficiently to eliminate excessive free alkali in the concrete.

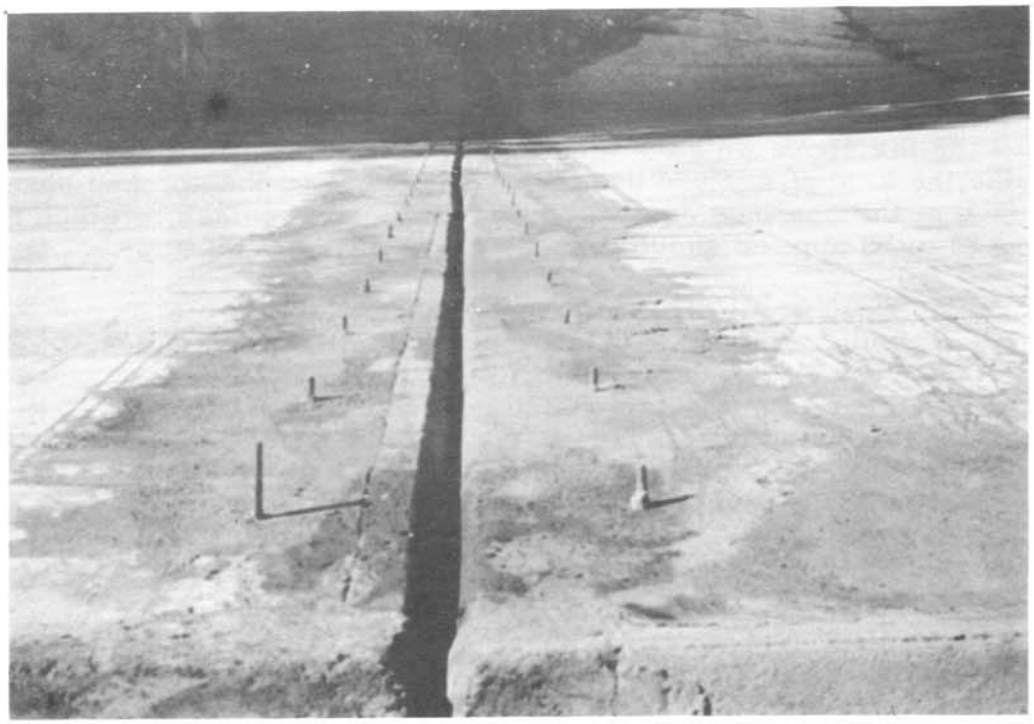
5. Roughened to an extent suitable for the particular coating.

Rarely do we approach this ideal in all respects. Actually, good results are often obtained by meeting only a few of these conditions, as was outlined with each coating discussed; however, the No. 1 condition above should always be met.

Several kinds of contamination are objectionable and different methods of removal are required for each. Dirt and loose materials

may be scrubbed and washed with brushes and a water jet. Oily depositions should be cleaned with solvent and rags. Efflorescence may be removed by scrubbing, but it is best removed with dilute hydrochloric (muriatic) acid followed by additional scrubbing and washing. The solution should be prepared by adding 1 part of acid to 4 parts by volume of water, and this solution may also be used for roughening (etching) a concrete surface.

Deteriorated concrete can be chipped out either by hand or using small chipping hammers. It is often found that this work is not carried far enough to reach fully sound concrete. Extreme importance is attached to a thorough job in this respect when high cost materials, such as neoprene, are employed in order to withstand a rugged exposure. Maximum stability of the concrete base is a prime requirement with this type of coating. Details of both removal of deteriorated concrete and patching are discussed extensively in the Concrete Manual. Completed work should be allowed to age at least 1 month before coating. The photograph below shows completed repair of the vertical joint like that previously shown in a badly spalled condition.



When the alkali in concrete will affect the coating to be applied (such as oil based paints), the surface should be neutralized with a zinc chloride-phosphoric acid mix (2 percent zinc chloride and 3 percent phosphoric acid) if the concrete is less than 1 year old. This pretreatment need not be rinsed from the surface.

Small pits and slight depressions will not be objectionable for most painting, however, where appearance is a strong consideration as in decorative painting, filling may be in order. A 1:1 sand-cement mortar, applied after the wall has been dampened, is suitable for this work.

Roughening very smooth masonry surfaces as part of the surface preparation will have the effect of lengthening the life of coatings applied to them. A smooth, glazed surface will provide poor tooth for mechanical adhesion. The degree of roughness should be fitted to the coating selected. Thin film coatings such as oil paints require only the slight texture provided by the zinc chloride-phosphoric acid etching to anchor the paint and promote appearance, while thick coatings like neoprene require a deep profile for maximum adhesion in severe service. Sandblasting is the most satisfactory and economical means for accomplishing this except on very small areas where chipping and vigorous wire brushing can be employed.

In general, much concrete painting will be limited to small areas for which hand cleaning methods will suffice, however, when any considerable areas must be treated, it may be economical to use sandblasting as the method of surface preparation. The advantages are twofold. First, large areas can be covered rapidly, and second, highly effective removal of surface contamination and deteriorated concrete can be accomplished along with roughening the surface. Thus, in nearly all large jobs and when equipment is at hand for small jobs, sandblasting should be considered as a most effective cleaning method.

Concrete curing compound merits special mention among the problems of concrete painting. Usually gone after a few years weathering, it may nonetheless hang on in sheltered locations. It should be removed before any painting will be satisfactory. Various methods including steam cleaning have proved unsatisfactory and sandblasting remains as the most effective method.

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CARE OF STORAGE BATTERIES

Most, but not all, of the stationary type of storage batteries in use by the Bureau of Reclamation are installed in power generating plants or other power facilities, for emergency use. We also have a number of storage dams, without power generating facilities, where storage batteries are installed to provide emergency power. It is of the utmost importance that these batteries receive proper care and maintenance so that they will be in operable condition when an emergency arises and they are needed.

With proper care a heavy duty storage battery of this type should remain in good serviceable condition for up to 20 years. These

batteries are guaranteed by the manufacturer to deliver 80% of their original capacity after 14 years of service if they have been properly cared for. In buying the batteries we buy extra capacity so that the full required voltage will be available when the capacity of the individual cells has been reduced to 80% of the original.

On some of the newer Bureau installations nickel-cadmium storage batteries are being specified and they should be cared for in accordance with their specific instructions. However, nearly all of the batteries presently in service in the Bureau are of the lead-acid type and the following comments are applicable primarily to these installations.

There are indications that in some past instances the detailed instructions for caring for the storage batteries have not reached the hands of the individuals who are actually responsible for carrying out this work on the job. It is not surprising then that some of our batteries are being mistreated, unknowingly, by the individuals caring for them. Also, that being the case, we should not be surprised if the batteries fail under emergency conditions or if we are faced with an expensive replacement long before it is due.

In a number of respects the care of heavy duty stationary batteries is different from that of the ordinary automobile battery so that special instructions are required. Lack of space prevents our dealing adequately with the details of the subject here but listed below are the names of two documents which tell how to take proper care of this type of lead-acid storage battery. They are:

Bureau of Reclamation Power O&M Bulletin No. 12, entitled, "Lead-Acid Storage Battery Principles."

and

"The Storage Battery, its Fundamentals, Use and Maintenance," available from The Electric Storage Battery Company, Philadelphia, Pennsylvania.

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