WATER OPERATION AND MAINTENANCE

BULLETIN NO. 101

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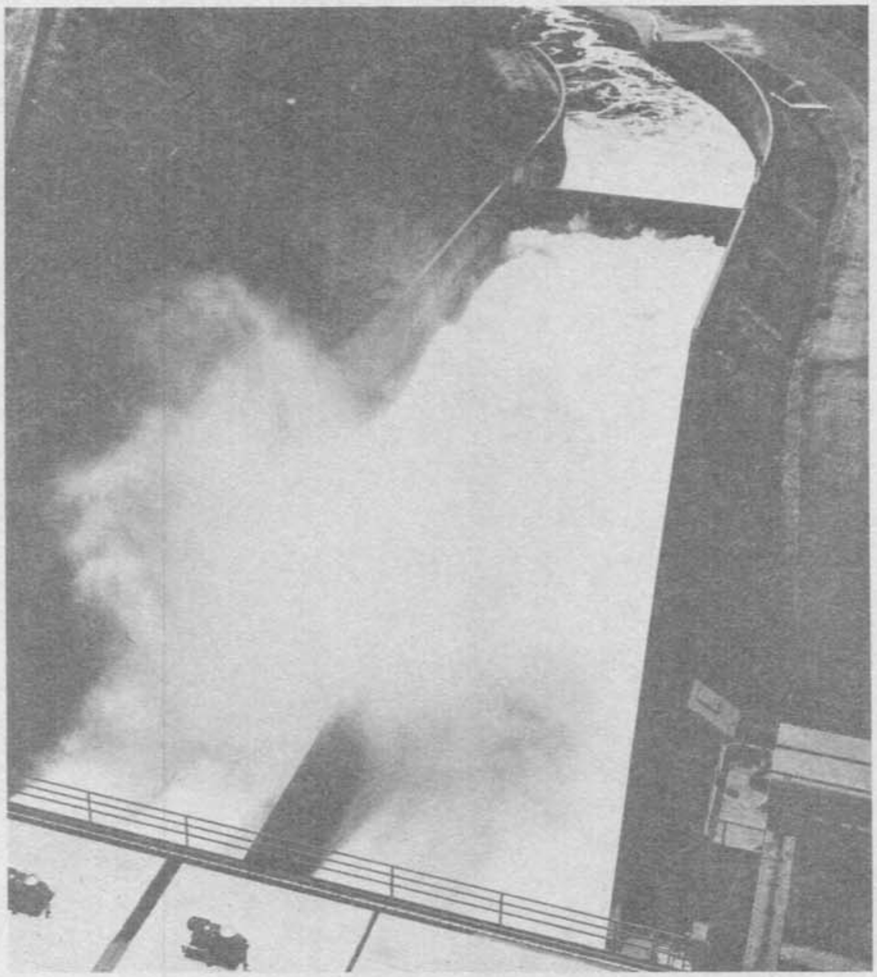

IN THIS ISSUE

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number as well as the person's name is given. All bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

Any information contained in this bulletin regarding commercial products may not be used for advertisement or promotional purposes and is not to be construed as an endorsement of any product by the Bureau of Reclamation.

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Division of Water Operation
and Maintenance
Engineering and Research Center
Denver, Colorado 80225

COVER PHOTOGRAPH:

Water for the Friant-Kern Canal being released from the headworks in the left abutment of the Friant Dam near Fresno, California. The water travels south for supplemental and new irrigation supplies in the fertile Fresno, Tulare, and Kern Counties in the San Joaquin Valley.

UNITED STATES DEPARTMENT OF THE INTERIOR   BUREAU OF RECLAMATION

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INTRODUCTION

"Concrete-Nylon Mat System for Erosion Control," beginning on page 1, describes the utilization of a nylon fabric mat filled with concrete grout as a new environmental erosion control system.

The article beginning on page 4 describes how leveling cropland to zero grade has shown promise toward improving irrigation efficiency and simplifying system automation.

In today's changing needs and increasing costs, operation and maintenance personnel must be aware of new advances and technology needed for most efficient project operation. The article on page 7 provides some insight on this subject.

A description of a simple water level indicator is presented in the article on page 10.

The article beginning on page 12 describes debut of the largest solar-powered irrigation system to date at the Gila River Ranch, Arizona.

The dangers of battery explosions and step-by-step procedures to connect jumper cables on a dead battery are presented on page 17.

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CONCRETE-NYLON MAT SYSTEM FOR EROSION CONTROL[1]

A new environmental erosion control system that utilizes a nylon fabric mat filled with concrete grout is gaining increased use by governmental bodies and private industry to protect shorelines, levees, ditches, reservoirs, and other areas subject to scouring, wave action, or erosion.

The patented system, which goes under the trade name Fabriform, makes use of pressure injection of a fine grain concrete into a flexible double-walled nylon fabric mat.

Figure 1. - Sand and silt that settle in the low pockets of the Fabriform mat can support vegetation growth. The cobblestone effect is caused by the spot woven filter points in the mat.

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[1] Reprinted by special permission of the Editor, from a recent issue of Public Works.

Dutch engineers have been using concrete in combination with various fabric forms to revet the erosion and scour-prone slopes of canals, waterways, and dikes for many years. However, it was not until development of a tough industrial product called Cordura that the Fabriform system could be economically applied.

The fabric forms are available in two types. The filter point system has filter points spaced 127, 203, 304, or 406 millimeters (5, 8, 12, or 16 inches). These filter points allow drainage of water from beneath the surface of the mat, which relieves hydrostatic uplift pressures. When inflated with concrete, the mat has a cobbled or waffled surface.

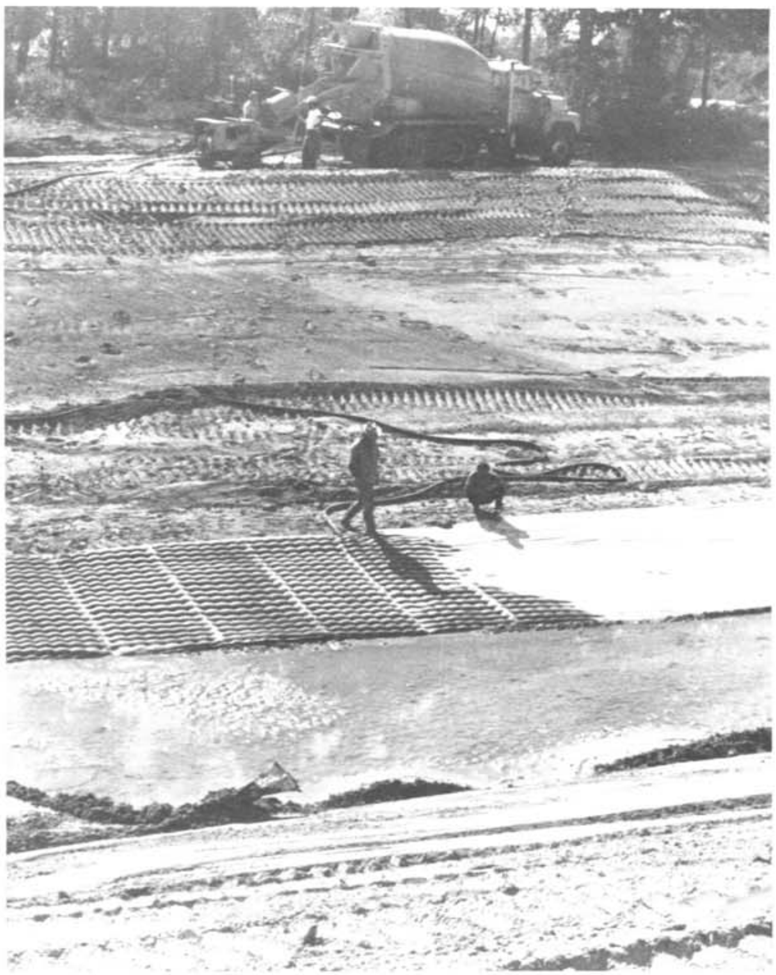

Figure 2. - A concrete mix is pumped into a nylon fabric mat, with filter points in the mat allowing drainage of water from beneath the surface to relieve uplift pressure.

The second mat type with uniform cross section has no filter points and produces a relatively flat surface. It is installed primarily where impermeability of the surface is desired, together with a low coefficient of hydraulic friction.

Engineers at Raymond International, a worldwide heavy construction, engineering, and manufacturing company headquartered in Houston, Texas, said the system's simplicity allows fast and economical installation for protection both above and below the waterline.

Users have described the system as not only quick and inexpensive, but esthetically pleasing when compared with normal concrete pouring using rigid forms that must be put in place.

First the slopes that require revetment are rough graded with a minimum of preparation. The fabric is delivered to the jobsite in panels that are easily handled. Once laid out on the surface, both above and below water, the mat is injected with concrete by a pressure hose in a sequence that first anchors the mat in place and then completes filling the fabric.

The mats can be laid below water without expensive drainage or removing existing water. And because the fabric is woven to a specified density, outside water will not readily pass through the mat to cause dilution or loss of strength of the concrete inside.

Also, without the need for extensive preparation and form setting, valuable construction time is saved. The faster installation allows work within short periods of good weather, avoiding delays that upset construction timetables and scheduling of materials.

Finally, the mats are a change from the usual concrete slab and can give a unique natural terrain appearance.

One recent Fabriform application was on part of a drainage ditch at The Woodlands, a "new home town" being constructed on 8100 hectares (20 000 acres) some 40 kilometers (25 miles) north of Houston. Fabriform was selected because it was the most economical, the easiest to install, and it eliminates the "concrete jungle look" of slab concrete. Sand and silt will settle in the pockets of the quilted filter point mat, allowing vegetation growth which will result in a more natural appearance.

* * * * *

AUTOMATION PROGRESSES AT WELLTON-MOHAWK[1]

More and more irrigators in Arizona and the Southwest are taking part in a trend that promises to improve irrigation efficiency, raise crop production, and simplify automating water distribution systems.

According to Leonard Erie and Allen Dedrick of the USDA/ARS Water Conservation Laboratory in Phoenix, that trend is to level cropland to zero grade - dead level.

According to Erie and Dedrick, the USDA is pursuing dead level irrigation as part of an overall program to reduce irrigation return flows. Return flows, they say, contain salt picked up from irrigated fields. That salt increases the salt load already existing in the river adding to the problems of downstream water users. Dead level fields produce no tailwater, minimizing the return flow problem. While deep percolation results from fields irrigated in excess of the evapotranspiration demand, less salt problems are associated with this type of irrigation.

Nearly 80 percent of this country's irrigated lands use surface-irrigation techniques. Most of that land is slightly sloped and is irrigated, using siphons or gated pipe, directing water to furrows. Excess amounts of water are usually needed to get water to the furthest end of the field to equalize infiltration. That excess water is collected as drainage and contains salt picked up from the soil profile.

In dead level irrigation, the idea is to get the water over the field quickly for even distribution and infiltration. The size of the stream available and the intake of the soil determines the size of the dead-level basins. Smaller streams mean smaller basins. In the Wellton-Mohawk Project, field sizes average about 4.05 hectares (10 acres), with stream sizes ranging from 0.425 to 0.566 cubic meters per second (15 to 20 cubic feet per second).

Jack-gates, so called because they are opened or closed by means of a jack-like device, are a means of turning the large irrigation streams on the fields.

Another means of handling the large streams is with the use of several tile outlets embedded along the concrete-lined supply canal.

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[1] Reprinted by special permission of the Editor, from a recent issue of the Arizona Farmer-Ranchman.

In the automated jack-gate system, the 26.30-hectare (65-acre) block was divided into eight level basins; four each on either side of a central supply canal. Jack-gates, one for each basin, were placed at the common corner of four of these basins. A jack-gate check was placed in the canal just beyond the first set of four gates to hold the water in the canal until the first four basins were irrigated. After completion of that irrigation "set," the jack-gate check was opened and the last of the first four jack-gates was closed, allowing water to pass on to the next set of four basins.

In modifying jack-gates for automation, a piston-type air cylinder is installed in place of the gate lifting mechanism. Air lines, one a low-pressure control-signal line and the other a supply line, are buried and run to the gates from a control shed. At the gates, the control line activates valves that send air to the bottom of the cylinder to open the gate, or to the top to close it.

Figure 1. - This photograph shows a jack-gate that has been automated in an irrigation system near Yuma. Air entering the bottom of the cylinder opens the gate while air entering the top of the cylinder closes the gate. Eight such gates irrigate 26.30 hectares (65 acres) in this plot - four gates to a "set."

Time clocks operate the system and are set to actuate turnouts and check gates for any predetermined length of time or gate combination. To properly operate the system as an irrigation management tool, the correct time of application must be known for each basin. Time of application is a function of basin size, size of irrigation stream, depth of application desired, and irrigation efficiency inherent in the system.

The tile-outlet system utilizes two types of air pillows to close or open the outlets. One is a pillow-type containing a valve stem and the other a bellows-type similar to air shocks found on large trucks. An air line is buried and run from a control shed to the valve stems in the "pillows."

Metal "collars" are grouted into the tile outlets in the irrigation canal to be used as a "seat" of what is essentially a 406.4-millimeter (16-inch) valve. Four "posts," welded equidistant around the periphery of the collar, are used to enclose a circular metal plate and the air pillow or bellows. Pressurizing the pillow through the air line forces the metal plate against the metal collar, and the outlet is closed off. Releasing air from the pillow or bellows by bleeding the line at the control shed opens the outlet.

This system can be operated automatically from the control shed in any combination just as the jack-gate system is operated.

Safety feactures to take care of overflow have been programed into the system.

* * * * *

AWARENESS - THE KEY TO SUCCESSFUL OPERATION AND MAINTENANCE[1]

Any successfully operated irrigation project must have as an essential part, a plan and budget for a progressive maintenance program. Economic, as well as policy changes make it necessary to continually educate water systems operators to keep them abreast of the changing times. If a district is going to survive, it must be responsive to the changing needs and opportunities that present themselves from day to day. Aggressive action is needed to seek out new approaches and ideas and for employing modern techniques and methods to provide more economical and effective operations over the life of the irrigation project.

In addition to encouraging personnel to develop new ideas and methods, it is also important to provide a means and opportunity to inform operating personnel of new technology and developments. A successful educational program allows them to utilize new ideas developed by others and stimulates their desire to be creative and innovative.

Recognizing the need to keep employees abreast of new techniques and developments, a Water Systems Management Workshop was initiated in the fall of 1961 by the Bureau of Reclamation, Division of Water Operation and Maintenance, located at the E&R Center, Denver, Colo. Since its inception, it has been attended by 1,740 individuals representing approximately 260 water user districts, 30 foreign countries, 20 colleges or universities, and 8 other Government agencies.

The objectives of this workshop are geared toward presenting up-to-date information which can be applied to the daily problems encountered in operating and maintaing water systems; for self-improvement; and for an interchange of experiences, ideas, and solutions to problems. The number of new ideas and methods which have been passed along at these workshops can only be estimated. It takes a lot more than luck to successfully operate and maintain an irrigation project of any size. Awareness of total irrigation operation and maintenance practices is the key to success.

With drought conditions very prevalent in the West and Midwest, it is incumbent upon everyone to emphasize water saving by improved operation and maintenance practices. To meet this need, the workshop offers a course on Water Management, which discusses the mechanics

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[1] This article was prepared especially for this publication by the Maintenance Branch, Division of Water Operation and Maintenance, E&R Center, Denver, Colorado.

of storing and moving water through carriage and distribution systems with a minimum loss to assure that adequate amounts are always available where and when needed.

Under the Water Management Course a session on Irrigation Management Services is presented. This session covers the conservation of water resources through optimum management and utilization. A program which provides in-the-field advisory services and timely data through careful measurement of local daily temperatures, wind, humidity, rainfall, and solar radiation is explained. With this information, an irrigation schedule (the time to irrigate and amount of water to apply) can be developed which is tailored to specific farm situations. The program further explains how water can be scheduled throughout the distribution system to the farm turnout with a minimum of loss and waste.

Also under "Water Management" a session is included on Water Systems Automation. Utilization of remote and automatic control devices to control the operation of pumping plants, bifurcation works, diversion works, canal checks, and other facilities should be considered to keep operational losses to a minimum.

Water measurement is vital to the irrigator and is included in the workshop. Through devices such as weirs, Parshall flumes, submerged orifices, and various kinds of meters, the rate of flow and the quantity of water required can be measured for irrigation, municipal, and industrial uses.

Other sessions covered in the 1-week-long Water Systems Management Workshop are:

"Project Management" which covers a number of activities in water systems management (organizational management, planning and budgeting, and records management).

" Management of Mobile Equipment" covers the selection, procurement, and use of mobile equipment, as well as equipment efficiency and operating costs.

"System Modernization and Rehabilitation" discusses the design considerations involved in replacing canal and lateral structures with modern facilities and other means of improving the operating and maintenance of an open or closed system.

"Concrete Construction and Repair" is aimed at the use of concrete in construction, maintenance, and repair of water system structures on a scale that can be accomplished by the normal operating organization using equipment available on an average project.

"Earth Construction Practices" covers the general soils engineering procedures from foundation considerations to soil selection and field procedures.

"Protection of Surfaces" discusses the utilization of coatings and/or cathodic protection for mitigating corrosion of metal surfaces and includes material selection, preparation and application, and cathodic protection.

The control of land and aquatic weeds receives primary attention in the course on "Weed and Other Pest Control." Emphasis is on the identification of weed problems, selection of methods of control (chemical, mechanical, or biological), Federal regulations pertaining to pest control, procurement of proper chemicals, and application.

Problems of seepage, design and building of drainage systems, and subsurface stratigraphic situations are covered under the sessions on "Drainage."

The subject of "Pump Maintenance" covers the mechanical maintenance considerations, types and design of pumps, and operation and maintenance problems or troubles commonly encountered in the various types of pumps, and repair or replacement or parts.

Electrical operation and maintenance considerations, primarily preventive maintenance practices, electrical installations found at water systems, and electrical equipment are covered under the session on "Electrical Maintenance."

The workshop has proven to be very popular and has been filled to capacity each year, indicating a desire by individual projects, water districts, and those individuals involved in different phases of water systems operation to keep abreast of the challenges of the changing times. The workshop has been unable to accommodate all the individuals who have applied for attendance. Attendance is arranged only through the Bureau's seven regional offices.

It is increasingly evident that the development, use, and management of our water supplies need to be given more attention than they have been given over the past decade. The Water Systems Management Workshop, as well as group training sessions or small workshops established among irrigation districts or individual projects, is a tool that can be utilized to spread the message of the importance of a sound management and maintenance program of our water systems. In your total operation and maintenance program, you should consider training sessions and workshops.

* * * * *

CLOSED LINE SYSTEM FOR LIQUID LEVEL INDICATION[1]

The sump pumps in the bottom of the dam at Glen Canyon had been controlled by float switches. The float switches were replaced by probe operated relays.

Sump water level indication at the pump control panels was desirable in order to check water level without going down the 200 steps to the sump.

Since a source of compressed air was not readily available in the dam, a "closed line" system (without air purging the pipe) was installed, and a "bell" shaped extension was added to the bottom of the pipe in the sump. The large diameter of the "bell" compared to the rest of the line confines the change in water level inside the pipe (due to the increasing pressure of the water) to the "bell" and error of the system is thus minimized. The low water level must be below the bottom of the "bell" to allow the air charge to be maintained.

Advantages of such a system are that there are no moving parts involved except the pressure gage and such a system is easily installed.

A sketch of the system is shown on the following page.

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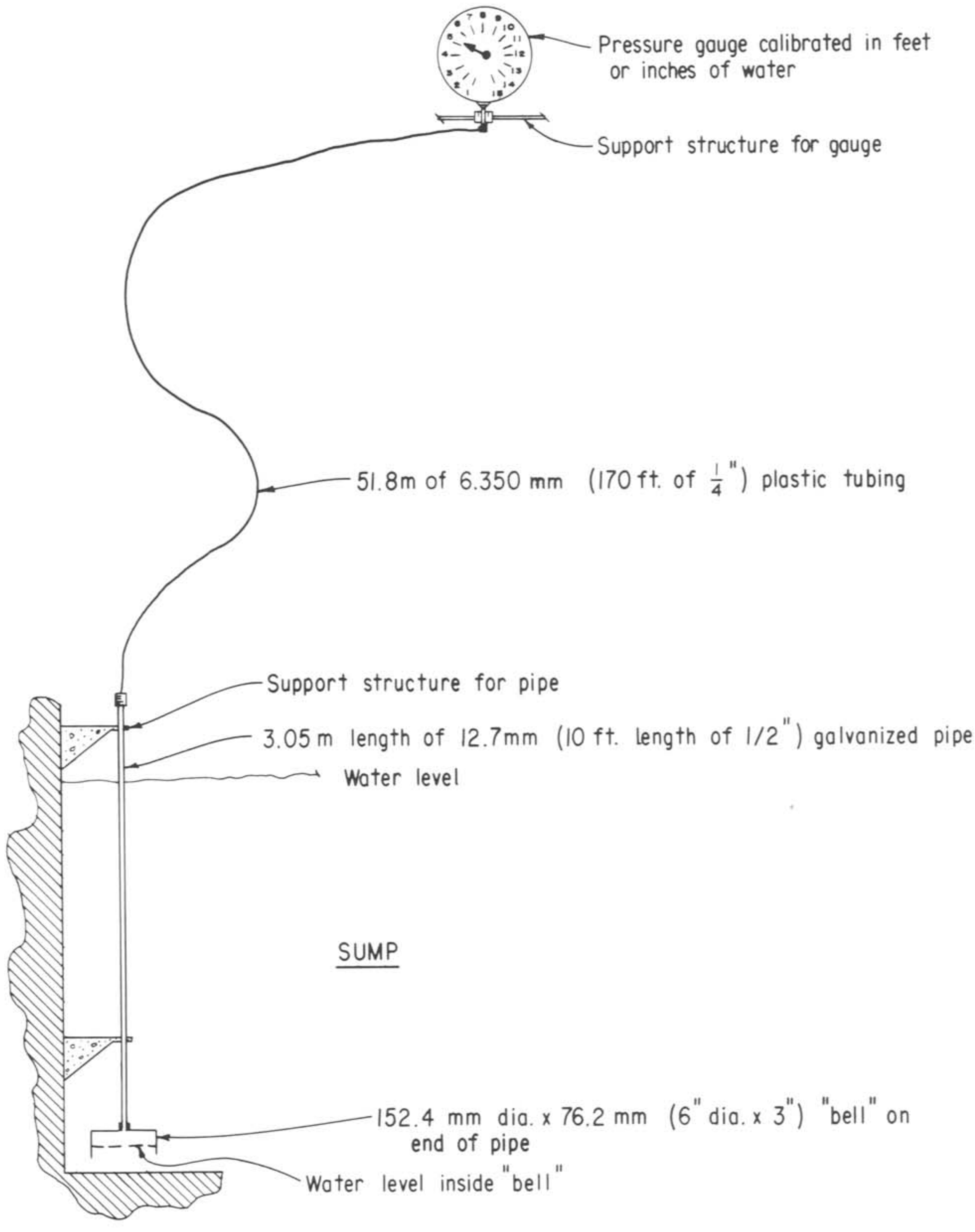
[1] Reprinted from information prepared by personnel in the Glen Canyon Field Division, Bureau of Reclamation, as Power Maintenance Instruction No. 57.



Pressure gauge calibrated in feet or inches of water
Support structure for gauge
51.8m of 6.350 mm (170 ft. of 1/4") plastic tubing
Support structure for pipe
3.05 m length of 12.7mm (10 ft. length of 1/2") galvanized pipe
Water level
SUMP
152.4 mm dia. x 76.2 mm (6" dia. x 3") "bell" on end of pipe
Water level inside "bell"

* * * * *

GILA RIVER RANCH DEBUTS SOLAR PUMP[1]

The largest solar-powered irrigation system to date made its debut April 25 at the Gila River Ranch 8.046 km (5 mi) west of Gila Bend.

There, rows of parabolic solar collectors power a 37 285-W (50-hp) pump capable of delivering up to 631 ℓ/s (10 000 gal/min) of irrigation water at peak operation.

Although the solar pump functions only as part of a tailwater recovery system, its designers hope to scale its capacity upwards to the 149 140- to 186 425-W (200- to 250-hp) level and pump water directly from the water table.

The Gila Bend unit is one of two such solar pump installations scheduled to serve Arizona. The other is a joint project between the Arizona Cotton Growers, the Federal Government, and the State of Arizona. They will attempt to design, construct, and test a solar-powered generator on the Coolidge farm of Dalton Cole.

Closed-loop System

The irrigation system at Gila Bend, which features 510.95 m^2 (5500 ft^2) of solar collectors, was developed as part of a cooperative program between Northwestern Mutual Life (NML), owner of the Gila River Ranch, and Battelle Memorial Institute, a nonprofit trust known for the development of the initial Xerox process in the 1950's for a small company then known as the Haloid Company.

Basically, the closed-loop solar-powered irrigation system at Gila Bend works like this:

> Water is pumped under pressure into the solar collectors. Solar energy from the collectors heats the water to a high temperature 93 to 149 °C (200 to 300 °F).
>
> The water then flows to a boiler where it heats liquid Freon until it changes to a gas. The Freon then drives a Rankine-cycle turbine at 30 000 r/min which operates the irrigation pump. The water, having heated the Freon, is then returned to the solar collectors for recycling.
>
> Freon gas exhausted from the turbine is then circulated through a regenerator heat exchanger and condenser (using actual pumped water) to convert it back into a liquid, ready to begin a new cycle.

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[1] Reprinted by a special permission of the Editor, from a recent issue of the Arizona Farmer-Ranchman.

Figure 1. - The irrigation tailwater flow down this ditch is 631 ℓ/s (10 000 gal/min). The solar powered irrigation pump located 4.27 m (14 ft) away delivers water from a tailwater pond to the ditch.

Figure 2. - The tallest object in this photo is a solar sensor which tells the unit when to operate and when to close down. Each night, the collectors rotate downward to protect them from damage and high wind.

BASIC COMPONENTS AND OPERATION OF THE NORTHWESTERN MUTUAL/BATTELLE SOLAR-POWERED IRRIGATION SYSTEM

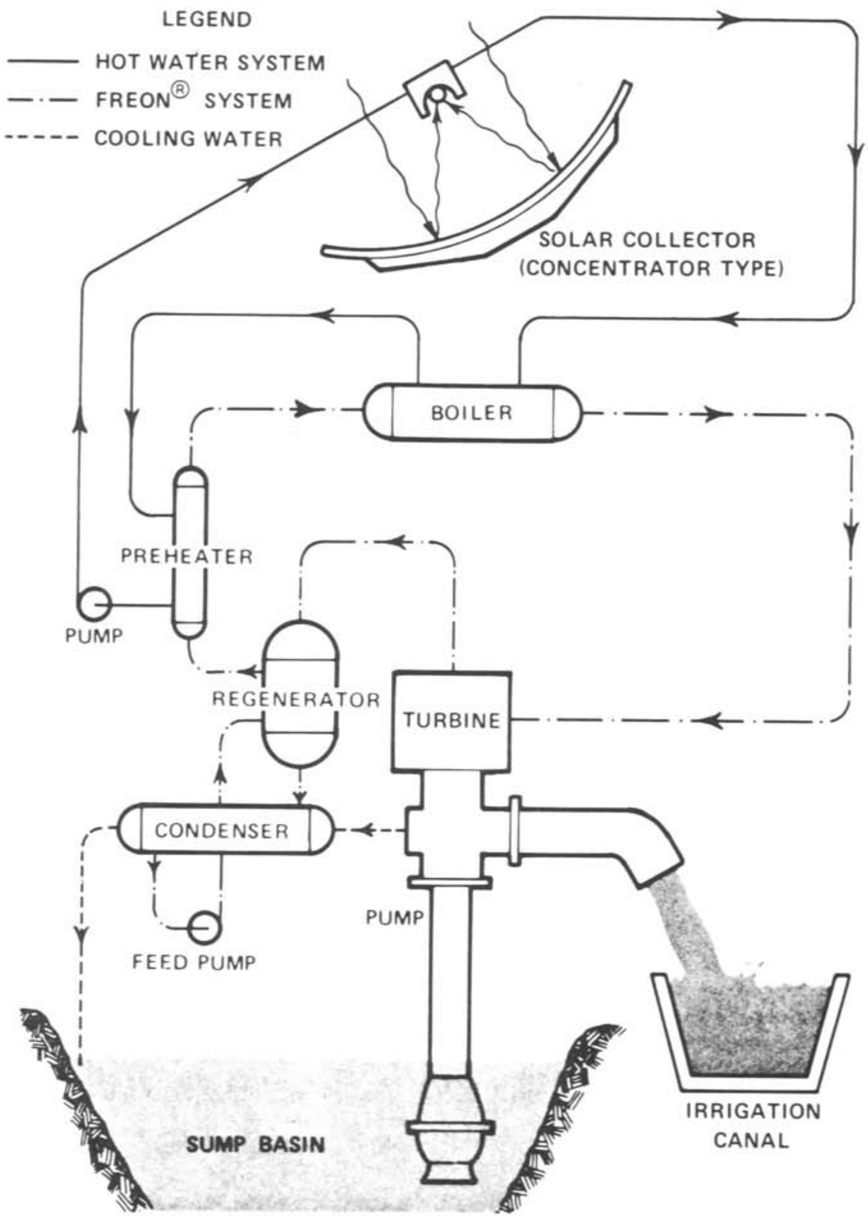

Figure 3. - The Gila Bend solar pump uses two fluids to power its water pump as this drawing attests. The heating fluid (water) is circulated through the solar collectors to heat and expand Freon and thus operate the Rankine-cycle turbine.

At Gila Bend, the solar-powered system pumps water from a tailwater basin 4.27 m (14 ft) to an irrigation canal where it is recirculated to the fields.

Figure 4. - Tailwater pumped into the irrigation ditch is delivered via this metallic pipe connecting the ditch with the solar pump.

Sensors mounted above the collectors "wake them" in the morning and aim them at the sun. Throughout the day, the sensors will keep the collectors pointed at our largest source of renewable energy as it moves across the sky.

The same sensing devices also rotate the collectors to a storage position at night or during storms. This is done to lessen the chance of damage to the reflective surfaces of the collectors. A backup control system is available for emergency situations.

In June, during the longest days of the year, the system can deliver up to 21 200 m^3 (5.6 million gal) of water over a period of 9-1/2 hours. While there is presently no provision for energy storage to allow for longer periods of operation, this feature can be incorporated if desired, say the designers.

Although the existing system uses electric power to operate auxiliaries, the design is adaptable to a totally unattended and isolated operation where no external power source is available. The system is completely nonpolluting and environmentally safe since both the heating (water) and working (Freon) fluids are contained in sealed systems.

Figure 5. - The solar concentrators shown in a "stowed" position. During hours of calm weather and daylight, the collectors are faced upward where they track the sun across the sky.

According to the designers, the 37 285-W (50-hp) pump size was chosen because it is large enough to provide a meaningful demonstration of commercial size.

The impetus for development of the solar-powered irrigation system came from rapidly increasing energy costs at NML's ranch during the oil embargo of 1973. The ranch is totally dependent upon intensive irrigation to produce cotton and a variety of food crops.

Both NML and Battelle see widespread long-term potential for solar-powered irrigation systems. With energy costs escalating annually, with quotas being placed on energy consumption in some areas, and with peak load restrictions being mandated in certain parts of the country, the need for alternative power sources is readily apparent.

Energy costs for farm pumping of irrigation water in the 17 Western States during 1977 are estimated to exceed $700 million. Hundreds of thousands of irrigation wells are used in this region which accounts for about 88 percent of the irrigated acreage in the United States.

Irrigation pumps in the region operate on a variety of energy sources. In Arizona, for example, about 70 percent of the pumps are electrically powered; in California, the figure is about 98 percent. On the other hand, in Texas, natural gas is used to operate about 65 percent of the pumps; while in Nebraska, diesel fuel is used for nearly 25 percent of the pumps.

* * * * *

EYE INJURIES FROM CAR BATTERY EXPLOSIONS[1]

Eye injuries related to car batteries nearly tripled from 1973 to 1976, according to the National Society for the Prevention of Blindness. Among the reasons cited for the sharp increase are public ignorance of the explosive nature of the car battery and lack of proper instructions for the use of jumper cables.

Battery explosions may result from improper connection of jumper cables, accidental shorting or sparking, or examining a battery with an open flame. These explosions can result in severe eye injuries, even blindness.

In a recent report, eye specialists Drs. T.L.R. Holekamp and Bernard Becker of the Department of Ophthalmology, Washington University School of Medicine, St. Louis, attributed the increase in eye injuries related to car batteries to the large number of unwary or careless individuals servicing their own cars. Many drivers are unaware that a car battery can become a highly explosive bomb!

[1] Reprinted from the April 1977, National Safety News.

Car batteries are filled with a mixture of water and sulfuric acid, which under certain conditions, as during rapid charging, can generate hydrogen and oxygen gases. A spark or open flame can ignite this highly explosive mixture, producing a blast forceful enough to send battery acid and fragments flying. Many battery explosions are triggered by using a match flame to see into filler ports.

The eye specialists' report also cited a little publicized source of battery explosion - ignition of the gas by internal sparking in old batteries, which can occur when conductors between cells become cracked. Corrosion deposits on terminal posts present an additional hazard if fragments scraped or chipped off them get into the eye.

In an effort to minimize the risk of injury and loss of sight from improperly connected jumper cables, the National Society for the Prevention of Blindness recommends this step-by-step procedure:

1. Extinguish all cigarettes, matches, and lighters

2. Turn off the ignition in both cars and make certain the vehicles are not touching each other

3. Remove the caps from both batteries to vent dangerous gases

4. Connect one clamp of the jumper cables to the positive (+) pole of the dead battery

5. Connect the other end of the same cable to the positive (+) pole of the booster battery

6. Connect the second cable to the negative (-) pole of the booster battery

7. Finally, clamp the other end to the engine block of the vehicle with the dead battery, on the side away from the battery

After starting the disabled car, remove the cable from the engine block first, then remove the other end of this cable from the booster battery. Now disconnect the other cable, first from the recharged battery, then from the booster battery. Finally, replace all battery caps.

Protective eyewear is recommended for anyone working around batteries.

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GPO 842-276

The purpose of this Bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin! So let us hear from you soon.

Prospective material should be submitted through your Bureau of Reclamation Regional office.