WATER OPERATION AND MAINTENANCE

BULLETIN NO. 127

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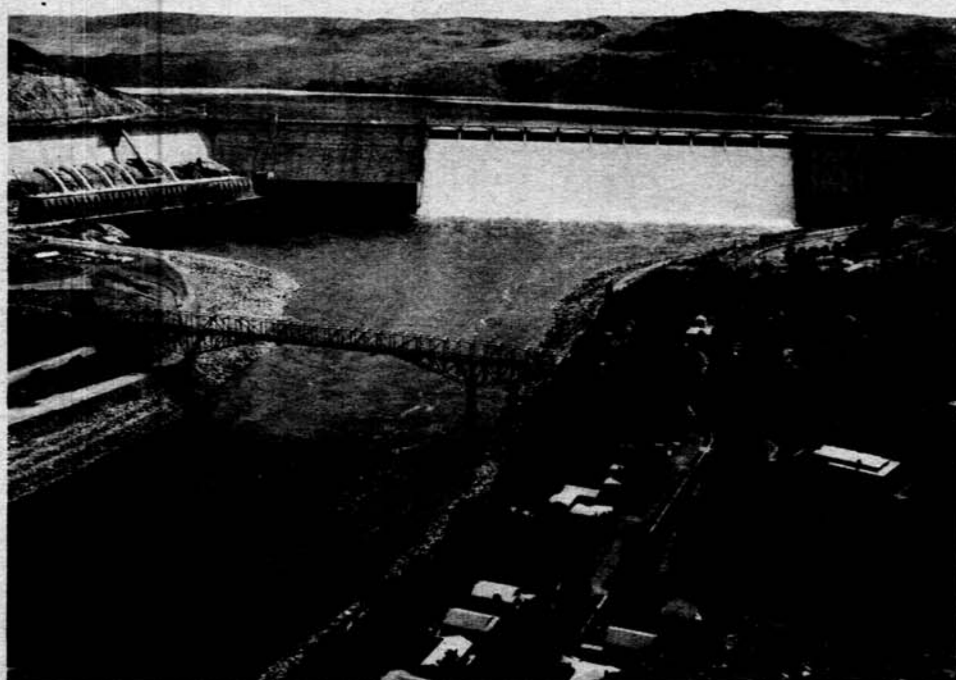

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UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

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.

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Division of Water and
Land Technical Services
Engineering and Research Center
P O Box 25007
Denver CO 80225

Cover Photograph:

Grand Coulee Dam and the Third Powerplant as seen from Crown Point vista area, Washington .

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WATER OPERATION AND MAINTENANCE
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INTRODUCTION

The operation and maintenance staff of the Alberta Department of Environment was faced with a formidable challenge when a primary shut-off valve cracked through the downstream flange and body. The article beginning on page 1 details how they were able to solve the problem.

A new method for construction of concrete gravity dams, RCC (roller-compacted concrete), will provide substantial savings and time. This article on page 8 is an excellent example of technology transfer from the laboratory to the field.

Rodent control should not be measured by the number of rats and mice killed but by the number allowed to live. A five-step integrated pest management program was developed by the University of Nebraska for rodent control. See page 13.

Photographs on pages 15 and 16 illustrate a simple method of catching metal filings before they can do damage to equipment or machinery.

Those pretty rings are a hazard. See page 17.

SHUT-OFF VALVE REMOVAL – UNDER PRESSURE[1]

Synopsis

In mid-1983, a piping and valve modernization program was undertaken at the Waterton and St. Mary Reservoirs in Canada. Piping changes consisted essentially of replacement of existing manually operated gate valves with modern ball valves in a 12-in (300-mm) main flow bypass line. The valve room is located approximately at the midpoint of a 2000- to 2500-ft (609.6- to 762-m) conduit conveying the riparian river flow from the reservoir.

During the course of removal of "pipe to be replaced" from the primary shut-off valve, excessive stresses were inadvertently applied, and the valve cracked through the downstream flange and body, rendering it unsuitable for future use.

Repair or replacement of this particular primary shut-off valve under approximately 175 ft (53 m) of head represented a formidable challenge to the operation and maintenance staff of the Alberta Department of Environment.

The following report deals with the solutions to the problem and the results that were obtained.

Report

A piping and valve modernization program was initiated in the early summer of 1983 to replace most of the downstream 12-in (300-mm) riparian flow piping at the St. Mary Reservoir. This piping had been in operation since construction of the reservoir in the early 1950's.

The St. Mary Reservoir dam is located on the St. Mary River approximately 35 mi (56 km) upstream of the city of Lethbridge, Alberta. The dam proper is a zoned earthfill structure some 2530-ft (771-m) long at the crest, with a maximum height above the St. Mary riverbed of 193 ft (58.8 m). The dam and appurtenant structures were designed by the PFRA (Prairie Farm Rehabilitation Administration), and contains approximately 3 850 000 yd^3 (2943 x 10^3 m^3) of material. Reservoir storage capacity is around 321 000 acre-feet (395 x 10^6 m^3) in total. This is the largest reservoir on a system that supplies water to over 400 000 acres (161 880 ha) of irrigated land.

During initial construction, a diversion tunnel was provided through a dam abutment to divert the riverflow from a cofferdam in the reservoir to a point downstream of the earthen fill. The diversion tunnel is circular, concrete-lined, with a length of about 2120 ft (646 m) through bedrock, and 20 ft (6 m) in diameter.

Prior to reservoir commissioning, the diversion tunnel was sealed at its approximate mid-length by means of a keyed concrete plug 20 ft (6 m) in length. A cross section diagram of the diversion tunnel at the plug is shown in figure 1.

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[1] This article was written for this bulletin by Arthur D. Adams, Field Engineer, Alberta Department of Environment, Lethbridge, Canada.

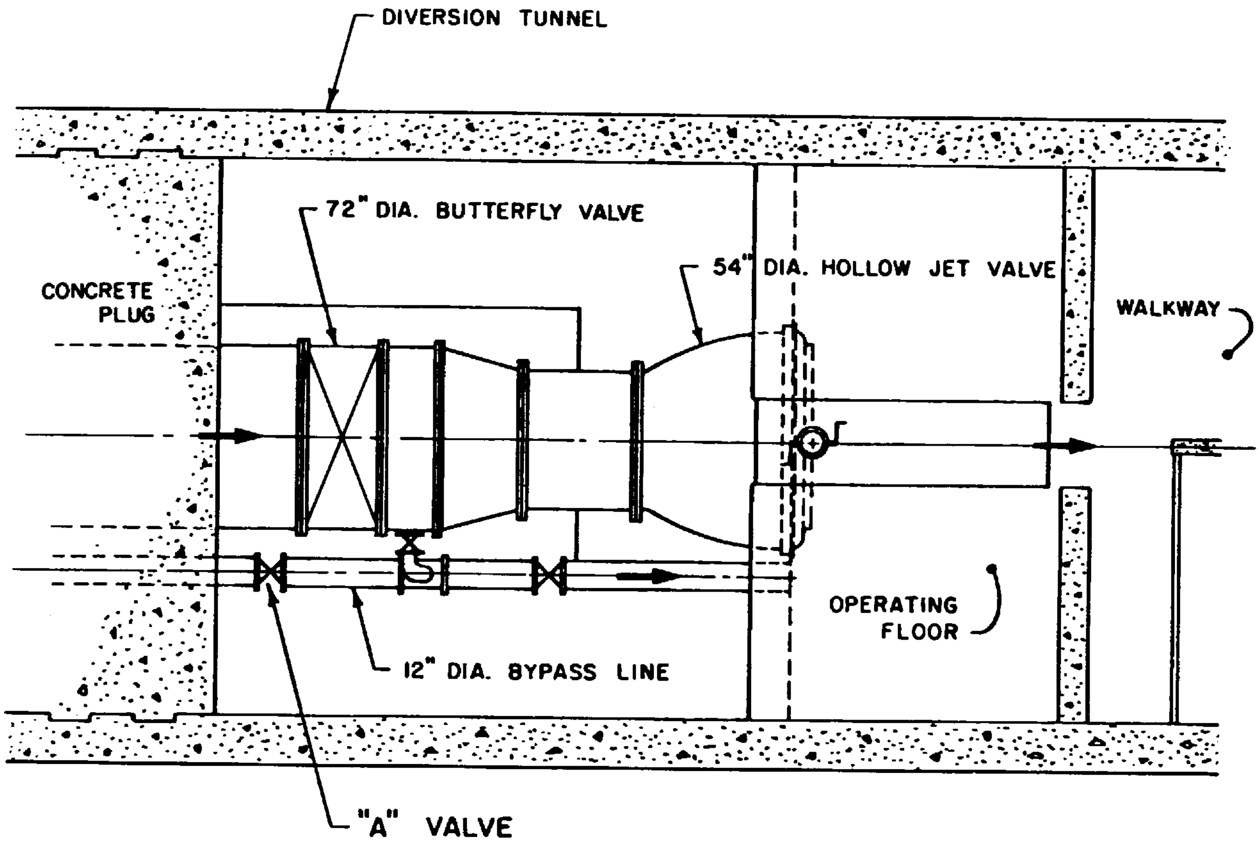

Figure 1.–Diversion tunnel/valve room plan view.

As shown in the figure, 72-in- (1828.8-mm-) diameter steel pipes are embedded into the lower half of the plug. These lines, through appropriate valves, provide for reservoir control and riparian flows. The riparian flow can be governed by two 12-in (300-mm) gate valves with a capacity of 30 ft^3/s (0.849 m^3/s). Some reservoir control and riparian release can be accomplished through the 72-in (1828.8-mm) line, butterfly valve, and hollow jet control valve. The maximum discharge through this line is 1130 ft^3/s (32 m^3/s) with a normal head of 173 ft (52.7 m).

The piping modernization program to be implemented in 1983 consisted primarily of utilizing the first valve (shown as "A" in fig. 1)* in a shut-off role and adding new Grove ball valves on either side of the branch line connecting the 12- and 72-in (300- and 1828.8-mm) lines. Valve "A", as well as the other valve in the 12-in (300-mm) line was 200 lb (90.7 kg) WOG (water, oil, gas) cast iron gate valves.

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* Measurements used in the figures in this article are not converted to the metric system.

The piping modification program was initiated by closing both valves and the branch valve, thus pressure-isolating all the remaining downstream 12-in (300-mm) piping. Unfortunately, during dismantling, excessive forces (stresses) were applied through the flange of valve "A" and a crack developed in the downstream flange and partially into the body.

Because of the position of this valve in the system, its removal or replacement was initially considered impossible, short of draining the reservoir or possibly employing underwater divers to seal the 12-in (300-mm) line entry at the upstream diversion tunnel plug face. Divers, if employed, would contend with very limited times underwater at the necessary depth and must negotiate an underwater trashrack and some 1200 ft (365.7 m) of conduit before reaching the face of the plug. Facing this, it was obvious that other options would be required.

Recent metallurgical developments in the repair of cast iron led the Alberta Environment staff to attempt an in-place repair with special electric arc welding rods and techniques.

Space does not permit a full written assessment of the attempted weld repairs – suffice it to indicate that sound repairs were made in areas which could be rendered water free (flange), and in other areas which could not (body), and the electric arc weld repair attempt proved unacceptable.

Following unsuccessful attempts at weld repair, other possible solutions were sought, and finally a device was conceived which would offer the possibility of sealing the line upstream of the damaged valve by passing a plug through the valve and into the upstream piping. On most full opening gate valves, passing a plug through the valve would not represent a major problem; however, measurements of the valve in question indicated only an 11-5/16-in- (287.3-mm) diameter plug would pass through. The upstream piping inside diameter was determined to be approximately 12 in (300 mm), leaving a possible gap of 11/16 in (17.5 mm) (diameter). This problem was corrected by providing the plug with an expanding seal which would pass through the valve, and then, when in position, expand to sealing diameter actuated by a controlled pressure differential across the plug.

Figures 2 and 3 provide details of the device. Figure 2 details the plug advancing component; and figure 3, the special plug itself. The key to the expanding seal is the eight 1-1/8-in- (28.6-mm) diameter pistons which operate as inclined planes to eight radial push rods. These rods expand twin rows of 1/4-in- (6-mm) thick segmented teflon sealing strips. Seal segment ends were staggered to eliminate some leakage path. The eight small pistons on the plug are capable of exerting a total radial seal expansive force of approximately 1040 lbs (4626 N) at full pressure differential across the plug. At zero differential, the piston springs and "O" rings return the seal to the retracted position.

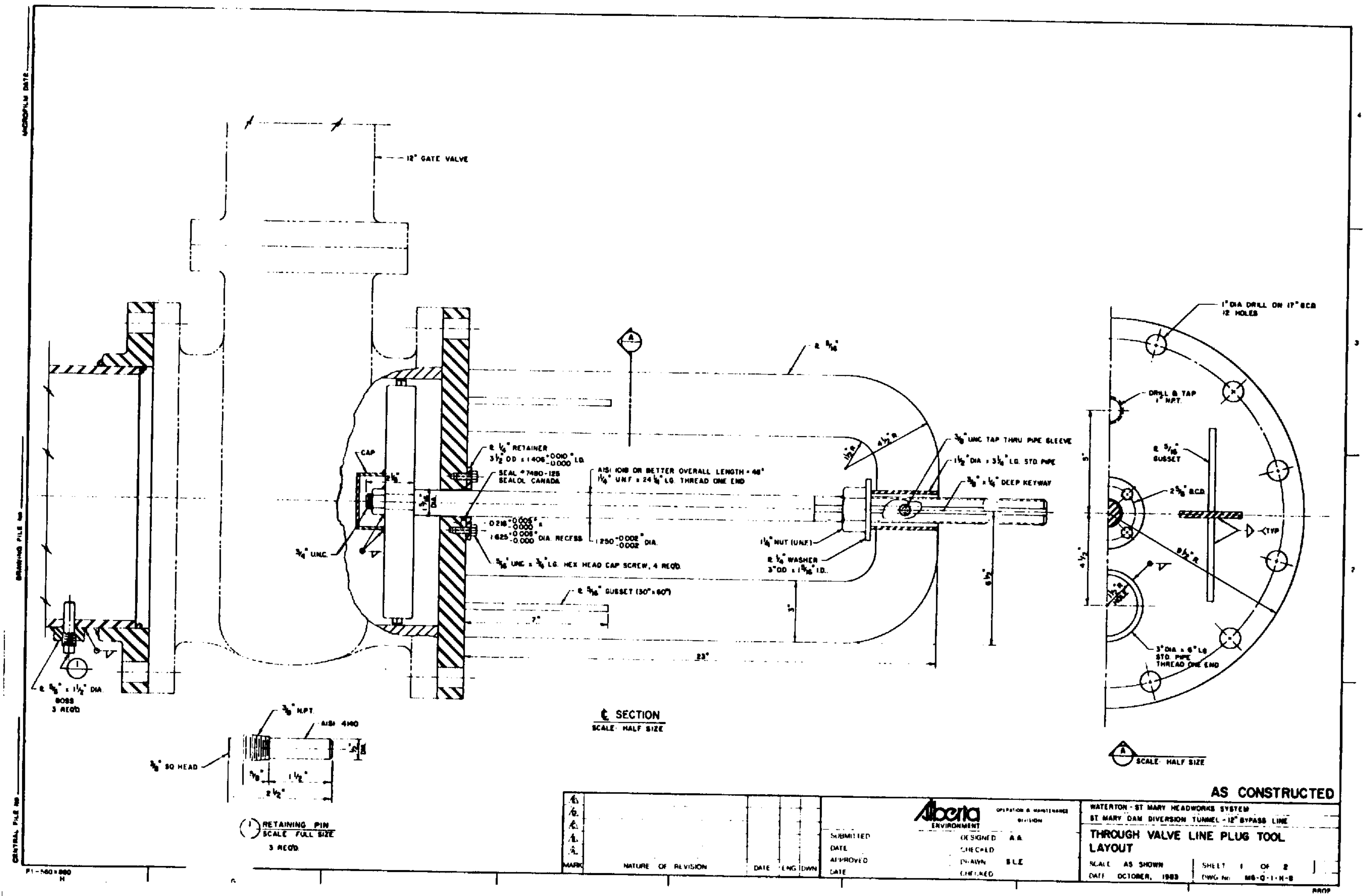

Figure 2.–Through valve line plug tool layout.

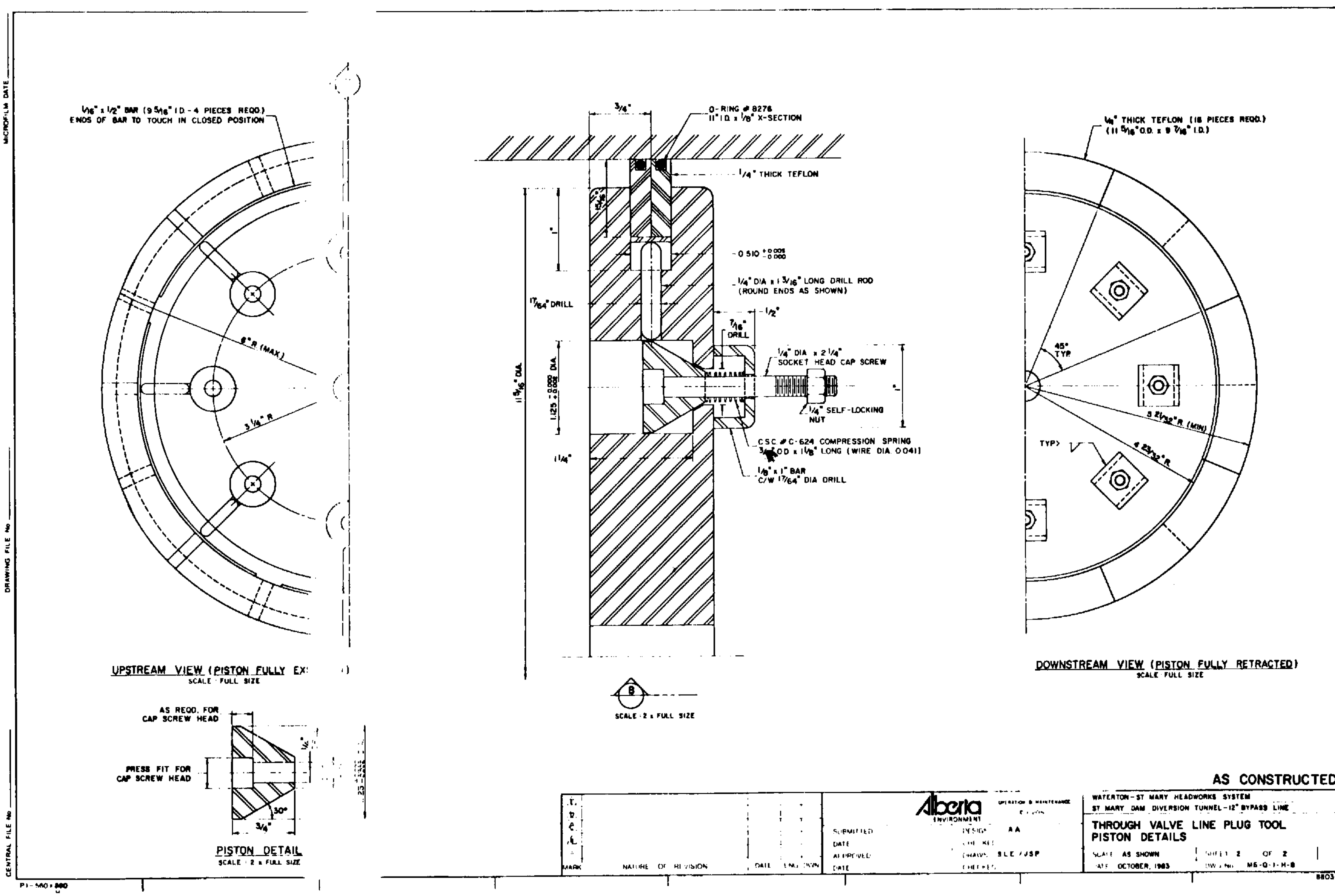

Figure 3.–Through valve line plug tool piston details.

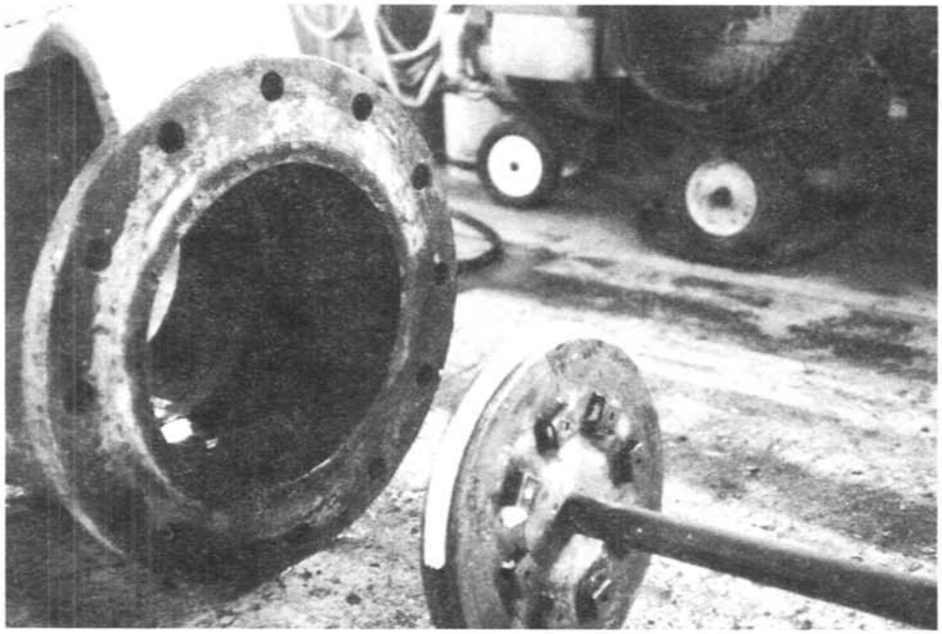

Figure 4.–The downstream face of plug, piston guides, and shaft. Expanding teflon segments partially removed for clarity.

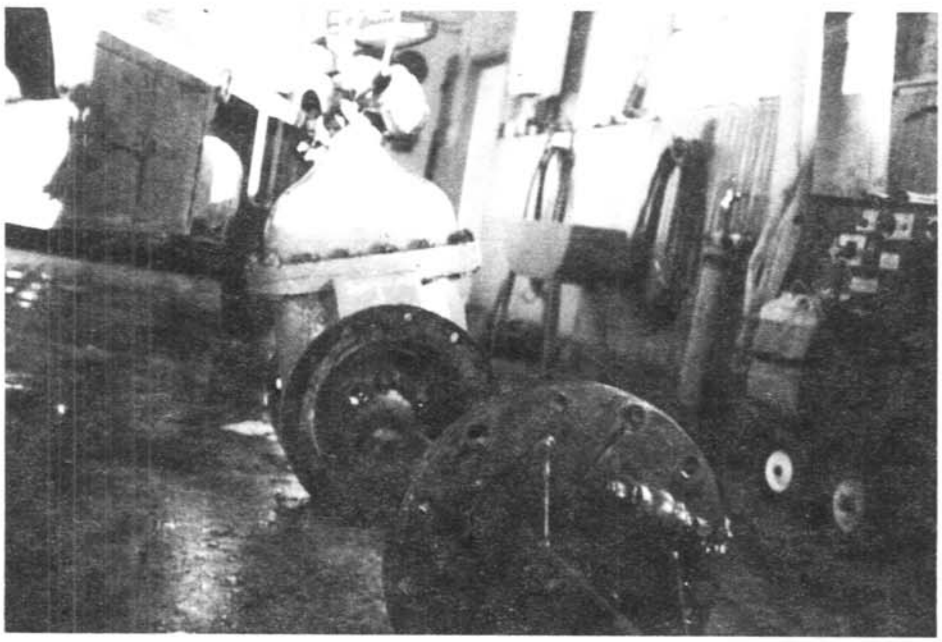

Figure 5.–The plug shown partially inserted in valve with position control device in foreground.

When placed in service, the tool flange was bolted to the damaged valve flange, thus effectively sealing the valve, allowing it to be fully opened. Balance pressure was admitted to the downstream side of the plug through the 1-in (25-mm) NPT connection, thus retaining the plug seal in the retracted position. The plug was then advanced the full travel length through the gate valve and into the upstream piping. Pretapped bosses were positioned and welded to the upstream piping 120° apart and as close to the flange as possible. After the plug was positioned in the upstream line beyond the retaining pin location, the balance valve was closed and the pressure relief valve (drain) opened, thus providing a pressure differential across the plug. This differential was necessary to expand the seal and allow the retaining pin holes to be completely drilled through the piping. The retaining pins were then screwed into position. Thrust loading was transferred to the retaining pins by retracting the plug into the pins.

With the plug safely locked in position and the seal forcefully extended against the inside of the upstream piping, the damaged valve was then removed from service and a replacement valve assembled in place.

Removal of the plug through the new 12-in (300-mm) gate valve took place in reverse order except that ordinary pipe plugs were installed in the three welded bosses following thrust transfer to the central threaded shaft.

The results with this single application of the plug device were very good, considering other available options. Certainly, if a problem were to appear again at this location, our people would approach it with a high level of confidence if another primary shut-off valve required removal.

* * * * *

ROLLER COMPACTED CONCRETE[2]

In the past 3 years, many of the resources of the Concrete and Structural Branch have been devoted to investigations of a new method of construction of concrete gravity dams called RCC (roller compacted concrete). RCC combines the basic building material of the concrete dam with the high volume construction methods of earth and backfill dams. The technique involves placing a lean, dry concrete in horizontal layers (fig. 6) and compacting the concrete with a vibratory roller (fig. 7). The Bureau plans to place the RCC within facing elements or "curbs" which are slip-formed horizontally by a laser guided paving machine (fig. 8). The facing elements, similar to highway median barriers, serve as the upstream and downstream faces of the dam. The RCC is placed without the use of artificial cooling pipes, which would drastically slow down the rate of placement.

Figure 6.–The dry RCC is spread in horizontal layers with a dozer. The blade is controlled for grade by laser receivers. Notice the upstream and downstream facing elements which serve as the forms to contain the RCC.

Figure 7.–After being spread into horizontal layers, the RCC is compacted by a smooth drum, vibrating roller. The roller can compact the RCC directly against the facing elements.

Roller compacted concrete was first proposed as a means of rapid concrete construction in the early 1970's. Test placements by the Corps of Engineers and Tennessee Valley Authority indicated that the concept was a viable means of construction. The use of over 1 307 800 yd^3 (1 000 000 m^3) of RCC for emergency repairs of an outlet works structure and spillway stilling basin at Tarbela Dam in Pakistan proved that large quantities of concrete could be placed in a short time span. As much as 26 160 yd^3 (20 000 m^3) of RCC was placed in 1 day, a placement rate which would allow the completion of a structure the size of Grand Coulee Dam in less than 1-1/2 years. The Corps of Engineers recently completed Willow Creek Dam, an RCC flood control structure.

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[2] Article written by Timothy P. Dolen, Division of Research and Laboratory Services, Engineering and Research Center, Bureau of Reclamation, Denver, CO.

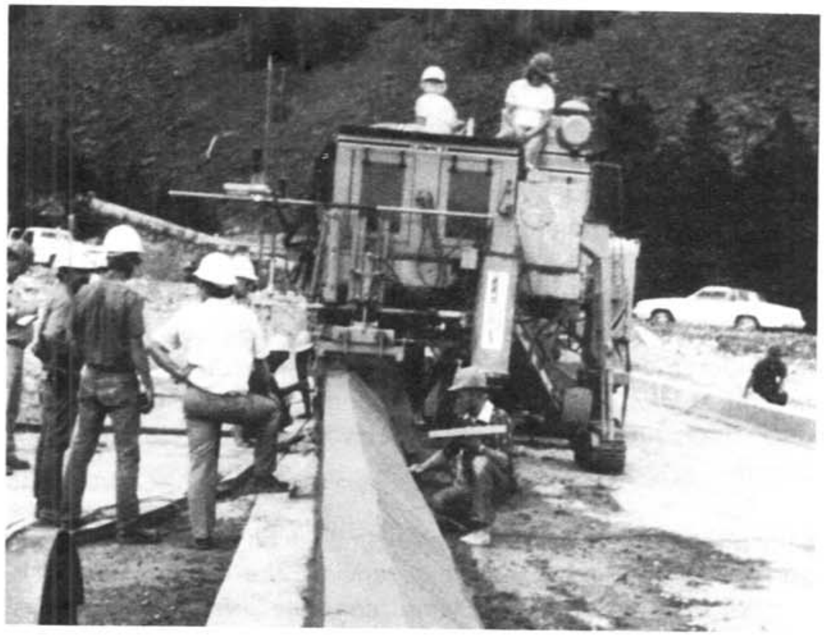


Figure 8.–The upstream facing element or "curb" is continuously slip-formed in a horizontal direction by a laser controlled paving machine traveling 1.6 ft/min (0.5 m/min). The paver is capable of slip-forming the vertical face without slumping.

In 1984, the Bureau will apply the RCC technique in the construction of Upper Stillwater Dam, a 1 307 800 yd^3 (1 000 000 m^3) RCC gravity dam which will be one of the principal storage reservoirs of the Central Utah Project. The dam, located in the Uinta Mountains of north-central Utah, will be the first RCC dam built by the Bureau and will be the first dam of its kind in the world to be used for water storage.

The use of RCC at Upper Stillwater Dam will yield a cost savings over conventional concrete or earth and rockfill dams. This savings is achieved by: (1) less costly methods of concrete placement, (2) a shorter construction time for the dam, and (3) reducing the volume of materials in the dam. The cost of RCC concrete placement is approximately one-half the cost of conventional mass concrete due to the elimination of time-consuming and labor-intensive form work. The use of earthmoving equipment increases concrete production and will allow the dam to be completed in only two construction seasons as compared to three or four seasons for any other structure. This will provide substantial time and money savings for both the Government and the Contractor. The construction of a concrete dam with the overflow spillway will use only one-third the volume of materials of a rockfill dam and eliminates the need for a conventionally formed spillway.

The Bureau's involvement with RCC for Upper Stillwater Dam began with preliminary design and laboratory studies in 1980. The program has progressed through laboratory studies and the construction of an RCC test section in Utah in 1981. The final specifications were issued in July 1983. Design of the dam required extensive laboratory testing to determine the properties of concrete, including workability, strength, thermal properties, and durability of both fresh and hardened concrete.

The use of this new concrete construction method has presented numerous challenges to Branch personnel. Design of the dam and the severe climatic conditions at the damsite (average daily temperature 36 °F (2 °C) required significant changes in the mix design which was developed in the laboratory. The design tensile strength of the concrete of 26 100 lb/ft^2 (1250 kPa) required a relatively high cementitious materials content for the mix. However, with no artificial cooling of the dam, the heat generated would produce thermal cracks due to the hot interior and cooling of the exterior of the dam. To achieve high strength and lower the heat generation, 70 percent of the cement was replaced with fly ash, a byproduct of coal-fired powerplants. By reacting with water and the free lime generated by cement hydration, fly ash produces cementing properties in concrete while generating only half of the heat of an equal amount of cement. Though fly ash has been used in Bureau structures for many years, it has never been used in such large quantities. Since normally fly ash cannot react until cement hydration has begun, the early strength is lowered; thus 28-day strengths are only one-third of the 7×10^5 lb/ft^2 (35 MPa) 1-year strengths. This is substantially different from the strength development and heat generation of conventional concrete.

In addition to evaluating the properties associated with the high fly ash content, high volume production and "no slump" workability of the concrete have required the development of new test methods for evaluating the quality of both fresh and hardened concrete. New test methods were developed to evaluate the workability of the "no slump" concrete using a consolidation test on a vibrating table (fig. 9). New procedures were required to fabricate test specimens due to the stiffness of the mix. Research has progressed on the measurement of the in-place density of RCC using a nuclear density gage (fig. 10). New methods of accelerated curing of the RCC to predict the ultimate strength potential of the RCC at early ages are being evaluated. This is particularly important because it is estimated that over 196 000 yd^3 (150 000 m^3) of RCC will be in place in the time span it takes to produce the 28-day standard-cured compression test. Because of the large surface area of concrete exposed with this method of construction, considerable research was devoted to evaluating the mix design parameters which affect construction joint bond strength.

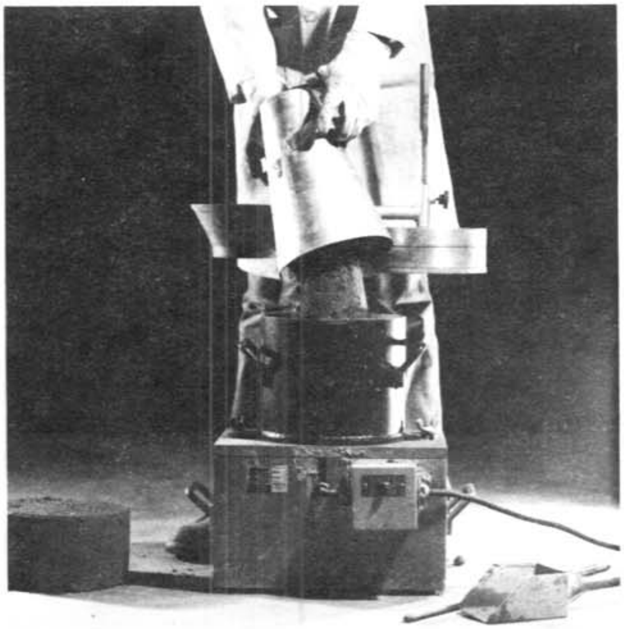
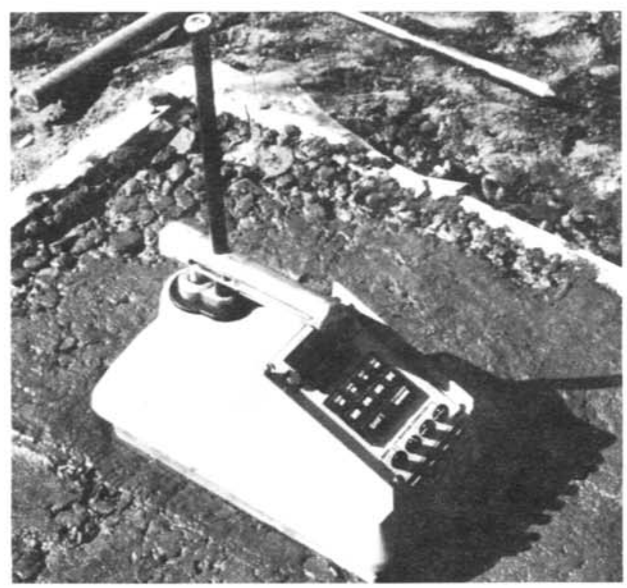


Figure 9.–The workability of RCC is determined by a Vebe vibrating table. "No slump" RCC is vibrated under a surcharge weight until full consolidation is achieved. The time to consolidate the sample gives an indication of the compactability of the RCC. To the left is a fully consolidated "fresh" RCC sample.

Figure 10.–To maintain quality control during construction, a nuclear density gage will be used to evaluate the compaction of RCC. The gage is capable of detecting voids below the RCC surface which would result from incomplete compaction.



This new concrete technology has generated considerable interaction between the design, research, and construction offices, which will continue through completion of the dam. The designer has had to analyze the dam for both the stresses resulting from a steeper downstream face and reduced cross section and from one of the most severe climatic conditions ever experienced by a Bureau dam. The research has been faced with developing test procedures and evaluating the properties of a new material which differs significantly from conventional concrete. Perhaps the greatest challenge will be faced by construction forces who will have to learn new quality control procedures and construction techniques for constructing a dam with RCC. They will be faced with the possibility of 4 to 6 months of virtually continuous concrete placement in a remote location. The design and research personnel have tried to prepare the construction forces by anticipating conditions which are likely to occur. Concrete and Structural Branch personnel will closely monitor the progress of the dam and will follow up with a coring program to evaluate the hardened concrete properties upon completion of the structure. This program has allowed the Bureau to make significant advances in the evolution of concrete dams and their construction.

* * * * *

MAKE THINGS TOUGH FOR RODENTS[3]

Farm rodent problems often become noticeable with the return of harvesting and cool weather. Every fall, rats and mice are driven by the coming winter into machine sheds, bins, barns, and other buildings in an attempt to seek food and shelter.

The damage these rodents cause varies from farm to farm, but the USDA (U.S. Department of Agriculture) estimates each rat on your farm costs $25 per year in contaminated and consumed grain and feed, in building damage, and in spreading livestock disease, such as bloody scours in swine.

Extension specialists recommend rodenticides and traps as cost-effective rodent control, but are recommending that you take a longer view of your control strategy.

Dr. Robert Timm, Vertebrate Pest Specialist with the University of Nebraska, says rodent control should not be measured by the number of rats and mice killed, but by the number allowed to live.

The main mistake farmers can make in rodent control is in not taking action until they already have a serious problem. The most cost-effective control is using an IPM (integrted pest management) approach to achieve population control and prevention.

Timm says the University of Nebraska has developed a five-step IPM program for farm rodent control:

1. Clean up.–Timm says to make life as tough as possible for rodents by denying them shelter and security. Mow or spray weeds along buildings, clean up wood and refuse piles, and cover garbage cans. Eliminating puddle areas, leaking faucets, and other water sources will help control rats.

2. Single-dose poisons.–Heavy rodent infestations (common daylight sightings) can be quickly reduced if necessary with single-dose poisons, such as zinc phosphate and strychnine. Limit use of of these poisons to avoid "bait shyness." Prebaiting with a nontoxic bait is recommended to improve acceptance. Applications should be made by experienced persons.

3. Multiple-dose (anticoagulant) baits.–Anticoagulant baits are fed upon for several days before killing rodents by thinning out their blood. This slower action and antidotal qualities provide a margin of safety to nontarget animals. Anticoagulants may be used throughout the year to minimize rodent numbers. Commercially available anticoagulant baits are formulated to offer weather resistance, convenience, and a high degree of acceptability to rats and mice. When using a bait around feeds or grains, bait acceptance is critical.

   Place rodenticides near rat burrows, nests, feeding sites, and other areas of activity. Use tamperproof bait stations wherever children, pets, or livestock would have access to the bait placement. Bait stations for mice should be no further than 10 ft (3 m) apart, and 30 to 40 ft (9 to 12 m) apart for rats.

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[3] Reprinted by permission of the Editor, Colorado Rancher and Farmer.

4. Traps.–Snap traps and glue boards can be effective for controlling small numbers of rodents. Trapping takes more time, however, and a greater amount of skill than using rodenticides. Using too few traps can also result in poor control. Glue boards cannot be used near heat or dust.

5. Rodent-proof buildings.–On some new buildings, rodent-proof designs can be specified. On existing buildings, modifications can make it difficult to impossible for rodents to enter. Seal openings larger than 1/4 in (6 mm) across to prevent access by mice, and 1/2 in (12 mm) for rats. Plug holes with concrete, steel sheeting, or heavy wire mesh. Make sure doors and windows fit tightly. Floor drains should have metal covers, and don't forget openings where powerlines enter structures. "Building out" rodents can be expensive and time consuming, but it also provides the most permanent form of rodent control.

Rats like to burrow beneath grain bins, Timm says. Use baits or gas cartridges to get rid of any rats beneath the structures, he advises, and then dig a 6-in-deep and 18-in-wide (152-mm-deep and 457-mm-wide) trench around the bin. Fill this trench with coarse gravel, 1 in (25 mm) diameter or larger. While the barrier may not prevent a new infestation, it will discourage rodents from digging and will make any new infestations readily visible. Filling the bottom of the trench with plastic sheeting will also control weeds. Rats will enter bins through aeration and drying equipment, so when equipment is not being used, close the housings with steel covers.

For more information on rodent control, contact your county extension service, farm supply dealer, or land grant university.

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FILINGS[4]

When drilling into metal plates or walls, have you wondered where the filings were falling? Machinery and equipment have been damaged in some cases because of metal filings falling into their systems. Using a magnet simplifies catching the filings (see figs. 11, 12, and 13).

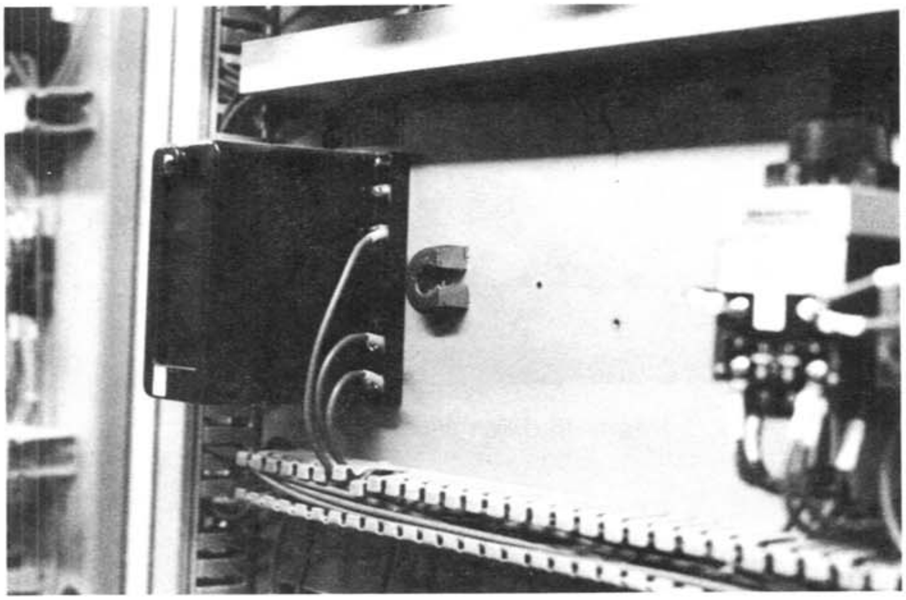

Figure 11.–Magnet attached to wall.

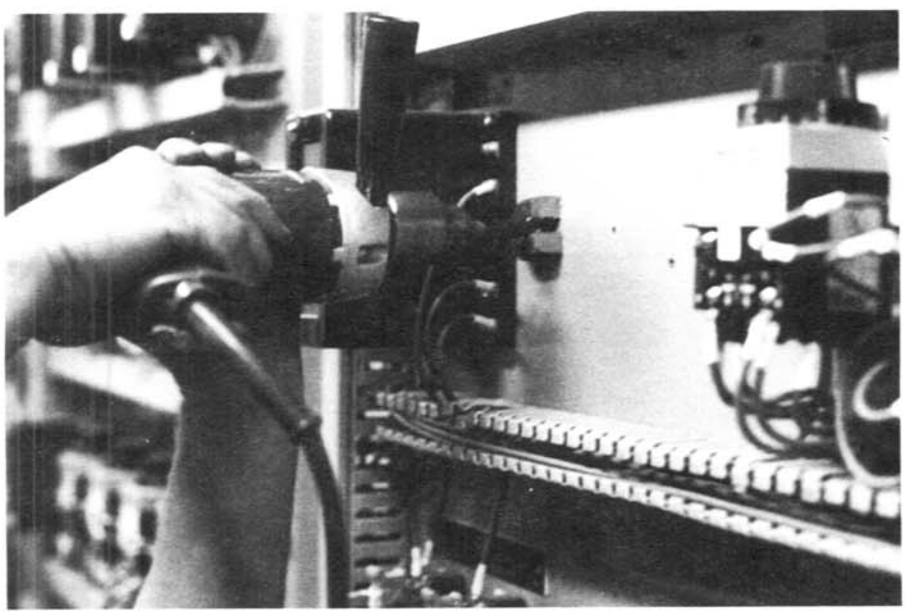

Figure 12.–Drilling through opening in magnet.

[4] Article provided by Gordon Johnston, Sacramento, California.

Figure 13.–Filings attached to magnet.

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THE TROUBLE WITH RINGS[5]

A finger may be torn off if a ring catches on a moving machine part, or on a fixed object when the body is moving rapidly.

A ring is not just a circle of metal worn on someone's finger for any number of reasons; it's also a potential cause of serious injury to the wearer in many situations. Many ring injuries occur in day-to-day occupations. The victims might include a man who jumps off the back of a truck and catches his hand on a projection, or a woman who strains to reach something on the top shelf and comes to grief on an unseen nail.

One plastic surgeon has treated no fewer than 21 cases of ring avulsion (avulsion is the tearing away of a body part). That surgeon emphasizes the seriousness of such an injury by explaining that the destruction of soft tissue may be so extensive that the small vessels supplying nourishment to tendon, bone, and nail cannot be restored.

Even if a finger can be restored, its appearance is often a bitter disappointment to the patient.

Another surgeon explains that the surgical procedures necessary to restore a severely damaged finger may include bone grafts, skin grafts, and skin flaps. The result may often be a stiff and bulky finger that is very unattractive to the patient.

One good way to prevent ring injuries is to use a breakaway ring that under stress will open and release the finger. A jeweler, or somebody with the necessary skill and a jeweler's saw, can make one. Here's how:

> A slit is cut obliquely clear through the ring (from the inside) at the 6 o'clock position. (The crest or stone is the 12 o'clock position.) Then, also from the inside, slots are cut (about two-thirds of the way through) at the half past 9 and half past 2 positions.

In case of a violent tug, the ring will open at the 6 o'clock position, with its two lower parts hinging at the half past 9 and half past 2 positions. The finger should be released unharmed. It's very important, though, to keep in mind that the partial cuts in the ring are as necessary as the complete one. The ring can't be relied on to open properly without all three.

Some people may feel a reluctance, based on sentimental attachment to a ring, to make the necessary alterations in a ring to prevent ring injury. But a ring can be repaired at moderate cost, while the restoration of proper finger function (even when it works) can cost a lot of money. And, of course, you can't wear a ring on a missing finger.

According to the plastic surgeon who has treated so many ring avulsions, one possible alternative to the slit and slotted ring is the hinged ring for arthritics that can be obtained through jewelers. Although designed primarily for persons with enlarged joints, it could be a fingersaver in case great stress were put upon it.

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[5] Reprinted from Today's Supervisor (November 1983), publication of the National Safety Council.

Supervisors in every industry have a strong interest in preventing ring injuries to themselves and those whom they supervise.

Writing in the July 1981 issue of National Safety News, James D. Woodward (Supervisor of Safety, Oldsmobile Division, General Motors Corp., Lansing, Michigan) had this to say:

"In describing just what a ring is, we felt that the best approach would be to demonstrate that a ring is simply a band of metal which, in most cases, is extremely dangerous because of its inherent strength. To illustrate this, we took a familiar gold wedding band and pulled it to destruction. Would you believe that it took 1670 lbs (7 428.5 N) of pull to separate the ring? To illustrate this best, we then compared that weight with the weight of some common auto components familiar to our employees, such as 1670 lbs (757.5 kg) is equal to 48 wheel and tire assemblies, 8 rear axle assemblies, 34 finished V-8 engine crank shafts, 5-1/2 big car frames, or 3-1/2 complete 350-in^3 (5.7-L) V-8 engines. That is a lot of weight to hold up with one finger.

"The (safety) program's second point approached by the joint committee was a listing of reasons why people wear rings and why they are reluctant to remove them. They include:

- "To beautify the hand—a diamond dinner ring, or any precious metal or jewel setting;
- "To show a status in life—a 25-year service ring, high school or college, fraternity, lodge;
- "Sentimental or religious reasons, promises, and vows—a wedding ring would be the prime example; other reasons include heirloom or gift rings.

"We answered each of these arguments with counter-arguments and, in the case of religion, with statements from a Catholic bishop and a rabbi."

Of course, the best way to prevent a ring injury is not wear one at all. But if you do wear a ring, alter it as described earlier or wear an alternative form (as for arthiritics).

Necklaces, key chains, and watch chains also constitute hazards near moving machinery.

So much for rings. What about the safey aspects of jewelry in general? The work rules of most industries advise against the wearing of bracelets, neck ornaments—in fact, all jewelry.

A manufacturer of electric typewriters has affixed a sticker inside the hood of its machines warning users to keep jewelry, as well as fingers and hair, away from this area. And some auto makers remind owners that metals are electrical conductors and that bracelets, watch bands, and all jewelry should be removed before working on a battey or spark plugs.

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