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LABORATORY TECHNIQUES FOR DETERMINING CORROSIVITY OF WATER TO ASBESTOS-CEMENT PIPE

by

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INTRODUCTION

The Drinking Water Research Division (DWRD) of the U.S. Environmental Protection Agency has been researching Asbestos-Cement (A/C) pipe corrosion and corrosion control for a few years. This phenomenon is called corrosion because the cementing materials are being dissolved, rather than a physical wearing of the pipe. A/C deteriorates when certain aggressive water quality conditions exist and asbestos fibers are loosened and can be released into the water. These aggressive waters attack most other piping materials as well.

A/C pipe resistance to chemical attack has been evaluated by use of an index comprised of the pH, alkalinity and calcium factors in water.(1) This index does not work in all cases. Some waters determined by the index to be non-aggressive may attack A/C pipe while some determined to be aggressive may not. Iron, manganese, zinc and silica are examples of substances found in water that can protect A/C pipe, even when the water is aggressive according to the calculations. The goal of the DWRD was to develop an experimental technique for evaluating these factors.

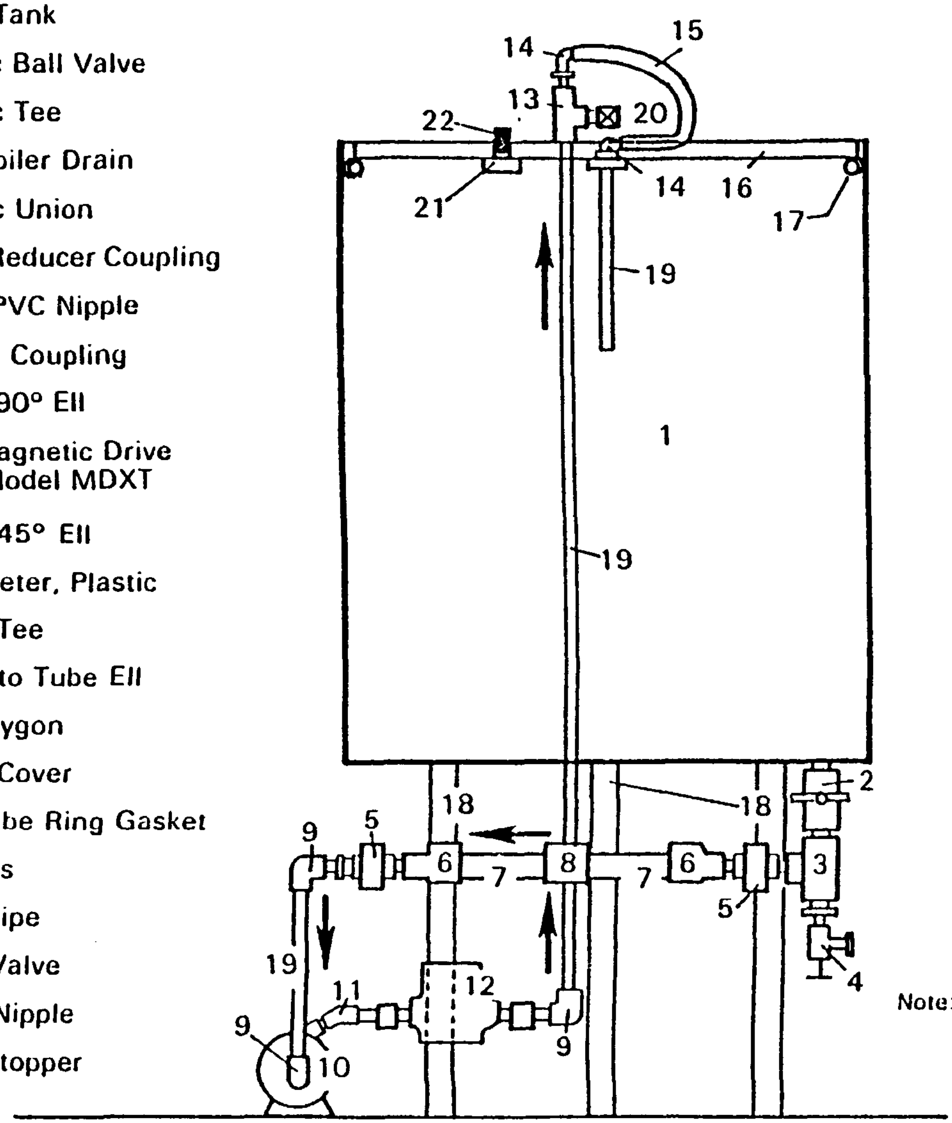
The first experiments were done with large recirculation systems and full lengths of 4 in (10 cm) and 6 in (15 cm) diameter A/C pipe assembled in approximately 90 ft (27 m) loops. These experiments were not successful. Small scale tests using a coupon of A/C pipe in a recirculation system were then investigated. The equipment used in the experiments and the reason for certain techniques will be described.

EXPERIMENTAL APPARATUS

Figure 1 identifies the parts in the recirculation system used in the small scale A/C pipe experiments. It also shows the flow path of the recirculated water. Some of the more important aspects of this arrangement will be discussed. The water is pumped out of the bottom of the tank by the recirculating pump (Part No. 10). The water flows past the A/C pipe coupons placed in PVC pipe nipples (Part No. 7 and Figure 2) on the way to the pump. The volume of water pumped through the system is recorded by a meter (Part No 12) before returning to the tank.

The most important items in controlling the water quality during an experiment are the floating cover (Part No. 16 and Figure 3) and the Tygon type plastic tubing circular gasket (Part No. 17). Fabricating the floating cover to fit the tank closely is better than

Part No.	Description
*1	100 gal. Tank
2	1" Plastic Ball Valve
3	1" Plastic Tee
4	Plastic Boiler Drain
5	1" Plastic Union
6	1½"x1" Reducer Coupling
**7	1½"x6" PVC Nipple
8	1½" PVC Coupling
9	½" PVC 90° Ell
10	Pump-Magnetic Drive March Model MDXT
11	½" PVC 45° Ell
12	Water Meter, Plastic
13	½" PVC Tee
14	½" Pipe to Tube Ell
15	½" I.D. Tygon
***16	Floating Cover
17	Tygon Tube Ring Gasket
18	Tank Legs
19	½"PVC Pipe
20	Sample Valve
21	¾" PVC Nipple
22	Rubber Stopper



* 100 gal. tank can be stainless steel or plastic.

** Part #7 serves as the A/C pipe coupon holder.

*** Floating cover made from ⅛" sheet PVC. 1" strip of PVC cemented around edge of disc to form floating pan. Threaded fittings in cover require build up of PVC.

Note: Pipe bushings and nipples required to make connections are not numbered and described.

Asbestos-Cement Pipe Small Scale Corrosion Experimental Set Up

Figure 1.

purchasing a ready made cover that is poor fitting. The plastic tubing circular gasket is fitted so that it wipes the sides of the tank as the water level in the tank drops. The purpose for the cover and gasket is to prevent exposure of the water to the atmosphere.

If the seal is not substantially complete, the pH of the water will be difficult to control and require frequent adjustment as carbon dioxide from the air causes it to change. Alkalinity control can also be a problem in systems open to the atmosphere. Water in the systems tends to establish equilibrium with its environment and if exposed to the atmosphere will seek equilibrium with it. Experience with open tanks found frequent pH adjustment required, at least daily. Further, a closed system is more representative of an actual distribution system.

Figure 2 pictures an A/C pipe coupon being inserted in the PVC coupon holder. The coupon is small relative to the recirculation water volume. The intent of this size ratio between the coupon and water volume was to permit long runs without the need to change water because of large increases in ion concentrations in the water caused by dissolution of materials in the coupon. At the same time the coupon is large enough to contribute measureable changes in the water quality under aggressive water situations. Large size pipe materials other than A/C can be cut into coupons and handled in this same manner.

Figure 3 is a view of a floating cover fabricated from a disc of 1/8" (2.3 mm) PVC sheet with a strip of PVC solvent welded around the edge to produce the pan. The Tygon ring underneath the cover fills in the gap between the cover and the sides of the tank. When threaded fittings are attached to the cover a built-up section is usually needed because 1/8 inch (3 mm) PVC is too thin to thread. Use of bulkhead fittings would eliminate the need for this reinforcement. Additions of chemicals for controlling or adjusting water quality when the system is in operation are made through the stoppered hole in the floating cover.

Figure 4 shows the actual arrangement of the parts of a recirculation system. The tanks being used are stainless steel because these tanks had been used for previous research and were available. Plastic or fiberglass tanks can also be used and would be preferable for metal corrosion studies. All of the equipment is essentially located underneath the tank in order to conserve space and protect the equipment from being bumped. The pump, mounted on a piece of plywood that rests on the floor, recirculates water at 2.3 (9 L/min) to 3 gpm (11 L/min). The pump requires only 25 watts and therefore does not impart sufficient energy to the system to cause significant heating of the water in either stainless steel or plastic tanks.

At the top of the tank in Figure 4 the water sampling arrangement is teed off the recirculation line. The size of the sample line is kept small to minimize flushing needs before sample collection. The volume of water for samples is also minimized. Conserving sample water allows the operation of a system for 6 months without the need for make up water.

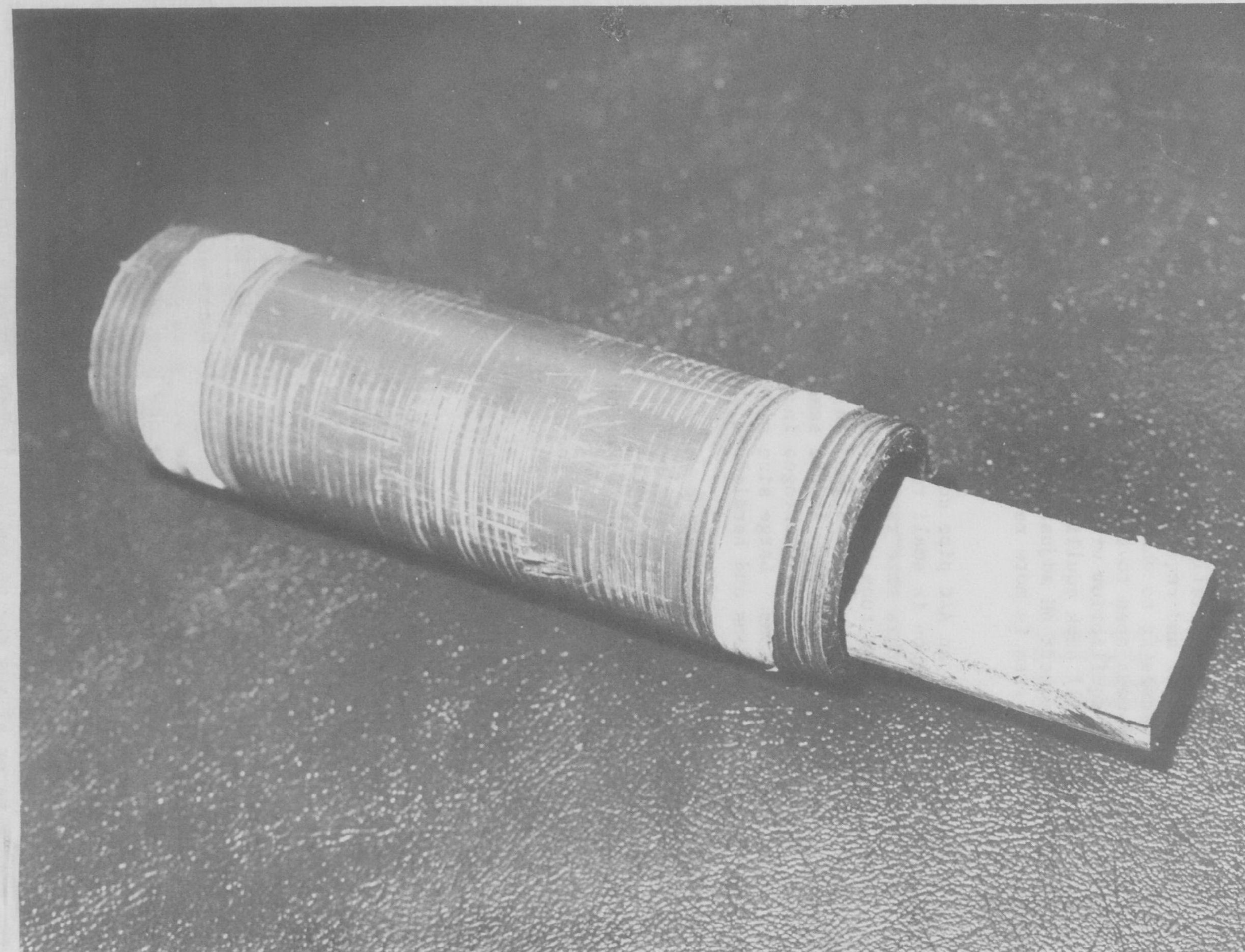


Fig. 2. Coupon Holder & Coupon

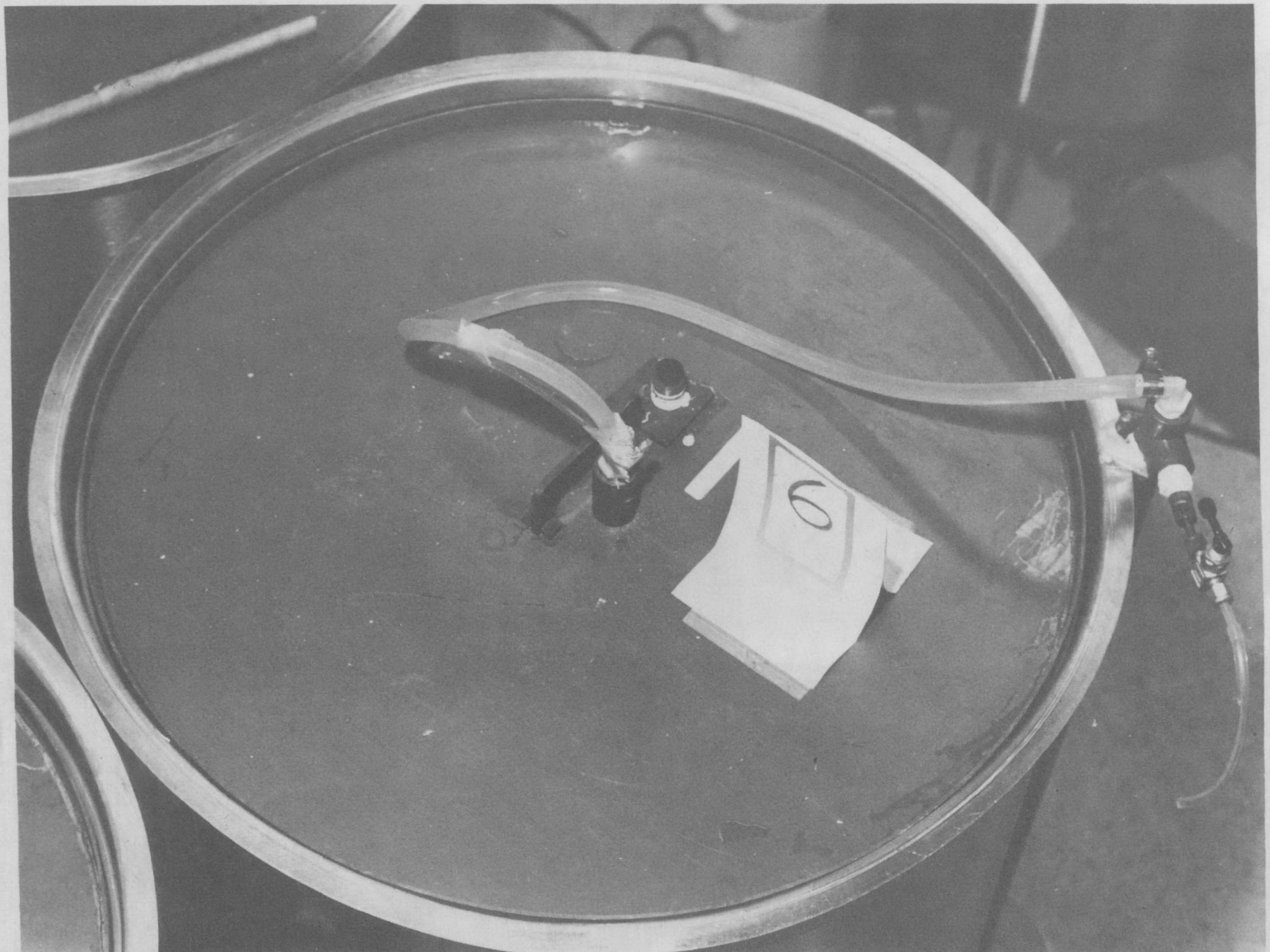


Fig. 3. Floating Cover

Fig. 4. Recirculation System

Figure 5 is a photo of a section of lead pipe installed in the recirculation line following the pump. Pipe materials of small diameter can be placed in the system in whole sections.

OPERATING PROCEDURES

After choosing the materials to be tested and the water quality conditions to be used in the test, the material to be tested is mounted in the system. The recirculation tank is then filled with water and adjusted to the desired quality. The first step in water quality attainment can be accomplished with a blend of tap water and deionized or distilled water. This blend then can be further adjusted to provide the desired alkalinity, pH, and so forth. If one desires to test a natural water for its corrosive tendencies, this water can be used "as is" and weekly chlorination and pH adjustments (described as follows) are all that is needed to maintain this water quality close to original conditions.

After the tank is filled, the floating cover is put in place, the recirculation tubing connected, the valves opened and the pump started. Analyses of the water quality will determine what chemical additions are necessary. Chemical additions are made easily while the system is in operation by removing the rubber stopper in the cover and pouring the necessary amount through the opening.

Following the initial water quality adjustment, analysis of the water quality need only be done once a week. The analysis should include the parameters related to the aggressive nature of the recirculation water, the residual chlorine concentration and chemicals that would be contributed to the water by the pipe material being tested. When testing A/C pipe the parameters measured are temperature, pH, and concentrations of calcium, alkalinity, residual chlorine, total dissolved solids, and any corrosion control substance being used.

The need for testing only once a week results from sealing the system. Without the floating cover and tube ring seal, the pH would require adjustment more than once a day when using an unstable water. Usually the pH varies only hundredths of a unit during a weeks time under sealed conditions. The weekly addition of chlorine, needed to prevent growth of organisms, influences the pH more than anything else. The pH is usually raised by adding sodium hydroxide and lowered by adding hydrochloric acid.

EVALUATION OF EXPERIMENT

During an experiment, changes in the concentrations of substances in the water that are contributed by the material being tested indicate whether or not corrosion is taking place. When testing A/C pipe if the calcium concentration in the water increases only 1 to 4 mg/L as $CaCO_3$ over a 6 month period then the A/C pipe has not been attacked and softened. If the calcium concentration in the water increases continually during a 6 month run and increases 8 to 10 mg/L as $CaCO_3$

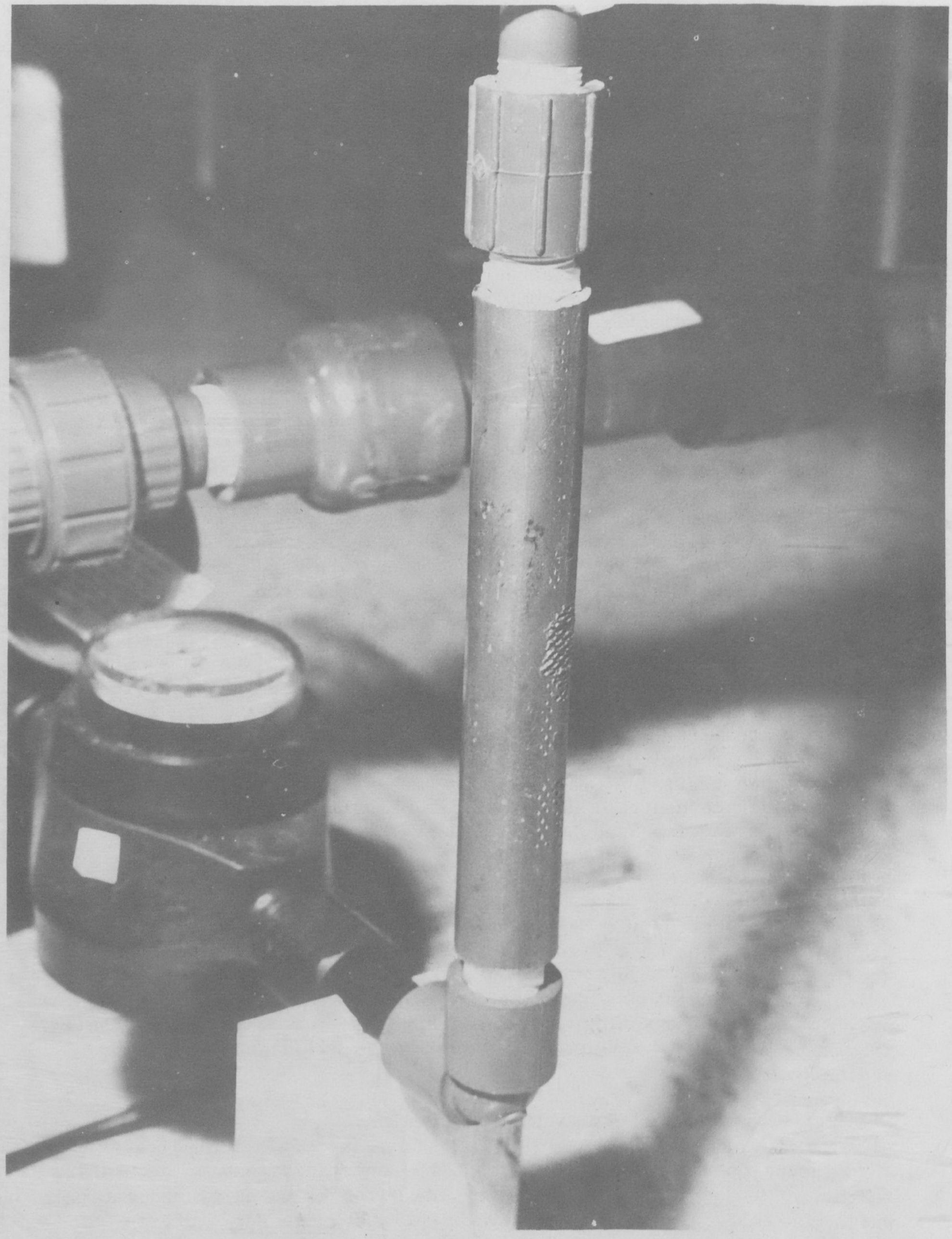


Fig. 5. Small Diameter Pipe Testing

total during this time, then the A/C pipe has been softened on the surface and is being attacked by the water. Figure 6 is an example of both situations.

At the end of an experimental run a physical examination of the the coupon reveals whether the A/C has been softened or not. Photographs of the pipe surface by a scanning electron microscope show whether the surface is protected by a coating or is being attacked. Information regarding some of the early experiments performed with this equipment and other A/C pipe performance information is available in the Journ. AWWA.[2]

An important side development that resulted from use of sealed recirculation systems was the devising of a reliable pH measuring procedure. Unless the sample is sealed from contact with the air when pH is being measured in a sample water that is not stable, the pH will change considerably during measurement. Figure 7 pictures the arrangement for measuring pH under sealed conditions. Essentially this requires the boring of a stopper with a hole that will accept the pH electrode and fit the sample container. This procedure has been explained in detail in a paper that has been submitted to Journ. AWWA for publication.[3] Pre-publication information about the method can be obtained from U.S. EPA, Drinking Water Research Division, 26 W. St. Clair St., Cincinnati, Ohio 45268.

SUMMARY

Many studies over the past 18 months with both metal and A/C pipe have shown that the technique described herein permit reliable small scale corrosion and corrosion control experiments. Utilities interested in the corrosivity of their own water should consider using this method for evaluation.

REFERENCES

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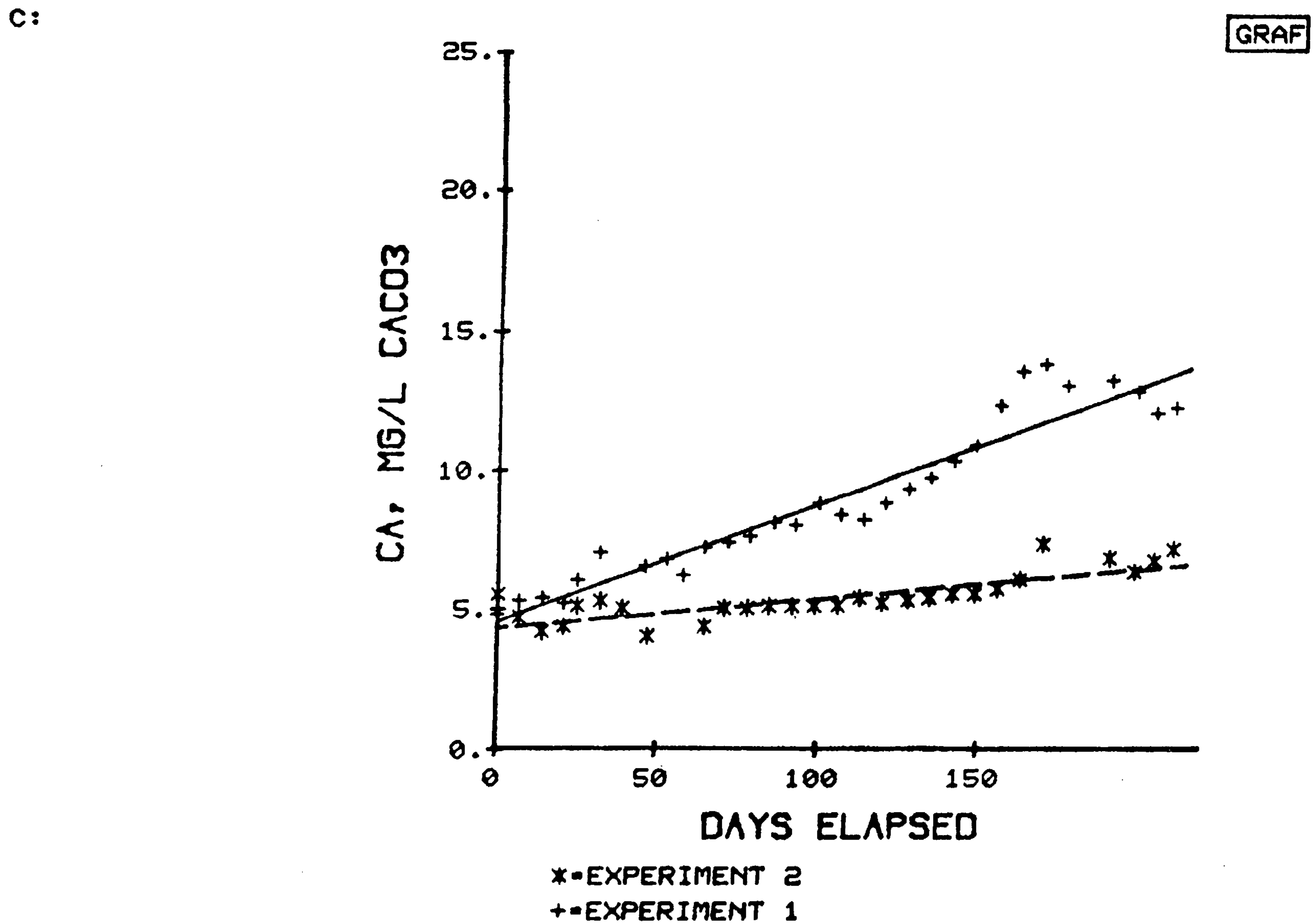

Fig. 6. Calcium Concentration Increase During Experiment

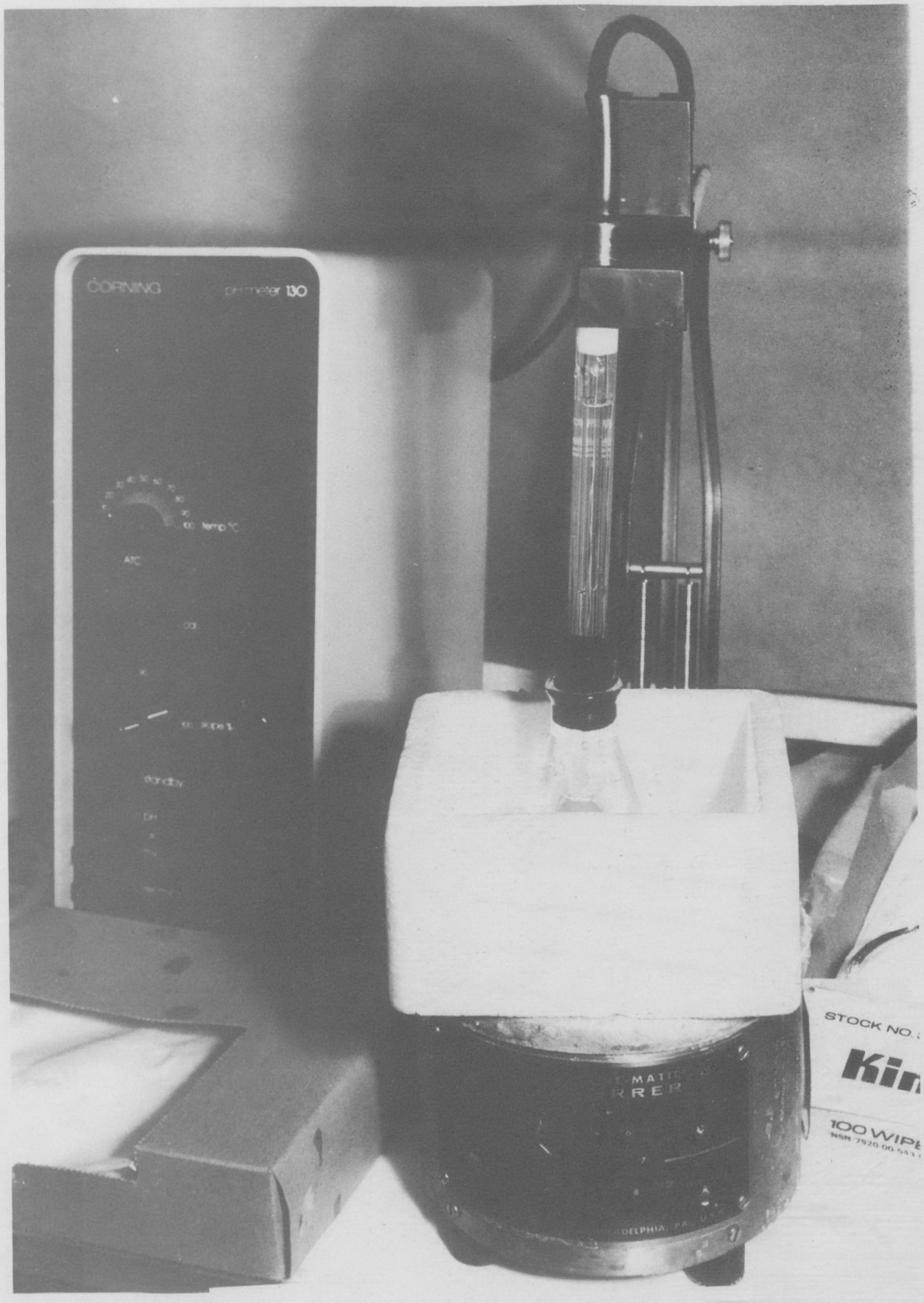

Fig. 7. Sealed P^H Measuring Unit

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