The Corrosometer as a Tool in Measuring Corrosion

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CORROSOMETER METHOD

The corrosometer method for measuring corrosion involves insertion of a special probe into the corrosive environment to be studied, and following the progress of corrosion on the probe electrically by means of a special meter.

This meter is designed for general use in either field or laboratory. It may be operated directly from AC line or from batteries contained within the meter; with either battery or line operation, alternating current is used on the probes. The meter reads corrosion on probes containing sensing elements having any shape (flat, round, tubular) and may be used with any solution. Corrosion is indicated directly in microinches of metal lost.

The operation of the corrosometer is based on the fact that the electrical conductivity of most metals is very great, while the conductivity of nonmetals is negligible by comparison. As the corrosion process converts metal into nonmetal, the electrical resistance of a piece of metal thus increases. The corrosometer circuit utilizes this change of resistance to indicate the extent of penetration on an exposed metal speciman as corrosion proceeds on its surface.

The resistance of this exposed specimen is not measured directly by the corrosometer circuit, however. Instead, a second specimen, made from the same metal or alloy, is connected in series with the first and the two specimens are made part of a bridge circuit. The second specimen is covered with a highly corrosion resistant coating and so retains its original cross section and resistance. The ratio of the resistance of the exposed specimen to that of the covered one is then determined. Changes in this resistance ratio are translated directly into units of corrosion by the meter circuit.

By using a circuit which measures only the ratio of the two resistances, the measurements are made essentially independent of the current used to energize the bridge. Likewise, because temperature changes affect the resistance of both exposed and covered elements in the same manner, the resistance ratio and the meter reading are independent of the temperature of the environment.

Reading Corrosion

Reading corrosion is a matter of turning on power, setting probe type, voltage, null and turning corrosion dial until indicator needle reaches the null position. The numbering on the dial runs from 0 to 1000 with 100 divisions per turn. Dial divisions are in units of microinches X probe multiplier. Because corrosion of probe specimens of all sizes is read from a single scale on the corrosion dial, each probe has associated with it a certain multiplier which is applied to the dial readings to convert to absolute penetration units. The multiplier is part of the company designation for the probe element type, being added after an "X" following the element diameter or thickness. Thus, S4 X 1 designates a flat strip 4 mils thick, for which the multiplier is 1.

Coupons have been used as a control measure rather than an indication of absolute corrosion rates, and corrosometer probes should be used in the same manner. Thus, although the corrosion rate indicated by a probe may not correspond exactly to the average corrosion rate of the system, any percentage change detected by the probe is likely to reflect the percentage change in corrosion of the system as a whole.

It is the purpose of this paper to compare corrosion rates obtained from probes and coupons in pumping wells and a water flood in West Texas. In most of these field tests, coupons were placed in the system near a probe, and coupons and probe were installed and removed at the same time.

The coupons used were made of 1020 mild, sand blasted, steel measuring 1-1/4 by 5 by 1/16 inches. The net area for corrosion (total area less holder contact area) is 12.4 in.^{2} The term Mils Penetration per Year (M.P.Y.) expresses the depth of surface, in thousandths of an inch, which would be removed in a year if the corrosion had occurred evenly over the entire surface.

$$\text{M.P.Y.} = (\text{Gm. wt. loss}) \frac{(1)}{\text{Density}} \frac{(\text{Inches})}{\text{CC}} \frac{(1)}{\text{Area}} \frac{(365)}{\text{Days of Test}} (1000)$$

Experience has shown that most systems are not corroding or are under control if the MPY is 1 or less.

The exposed specimen, on all probes used in this work, were of mild steel. Because the corrosion dial indicates penetration, rather than wall thickness, readings will increase as corrosion proceeds. In general, it is not recommended that corrosion rates be calculated by taking individual differences between each successive pair of readings. This method of treating data tends to magnify small deviations out of proportion to their true significance. Instead, the individual readings should be plotted against time. After a number of points have been plotted, the best smooth line is drawn through the points and the corrosion rate calculated as the slope of this line at any point.

Inhibitor Treatment

Fig. 1 illustrates a pumping well in which a wire type probe was installed. The corrosometer shows that corrosion was eliminated when the inhibitor treatment was changed. The coupons revealed con-

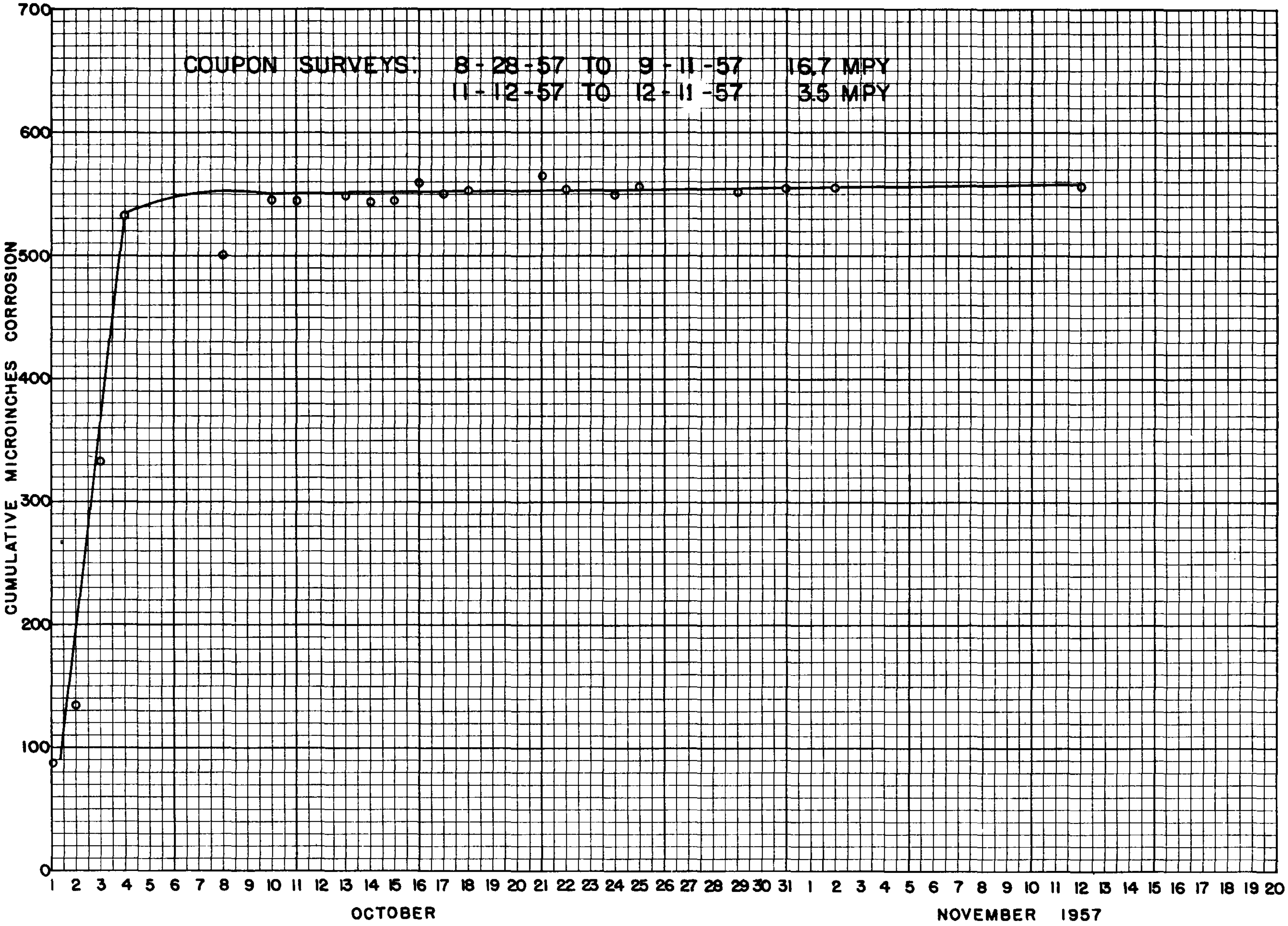

COUPON SURVEYS: 8-28-57 TO 9-11-57 16.7 MPY
11-12-57 TO 12-11-57 3.5 MPY
CUMULATIVE MICROINCHES CORROSION
0
100
200
300
400
500
600
700
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
OCTOBER
NOVEMBER 1957

Fig. 1

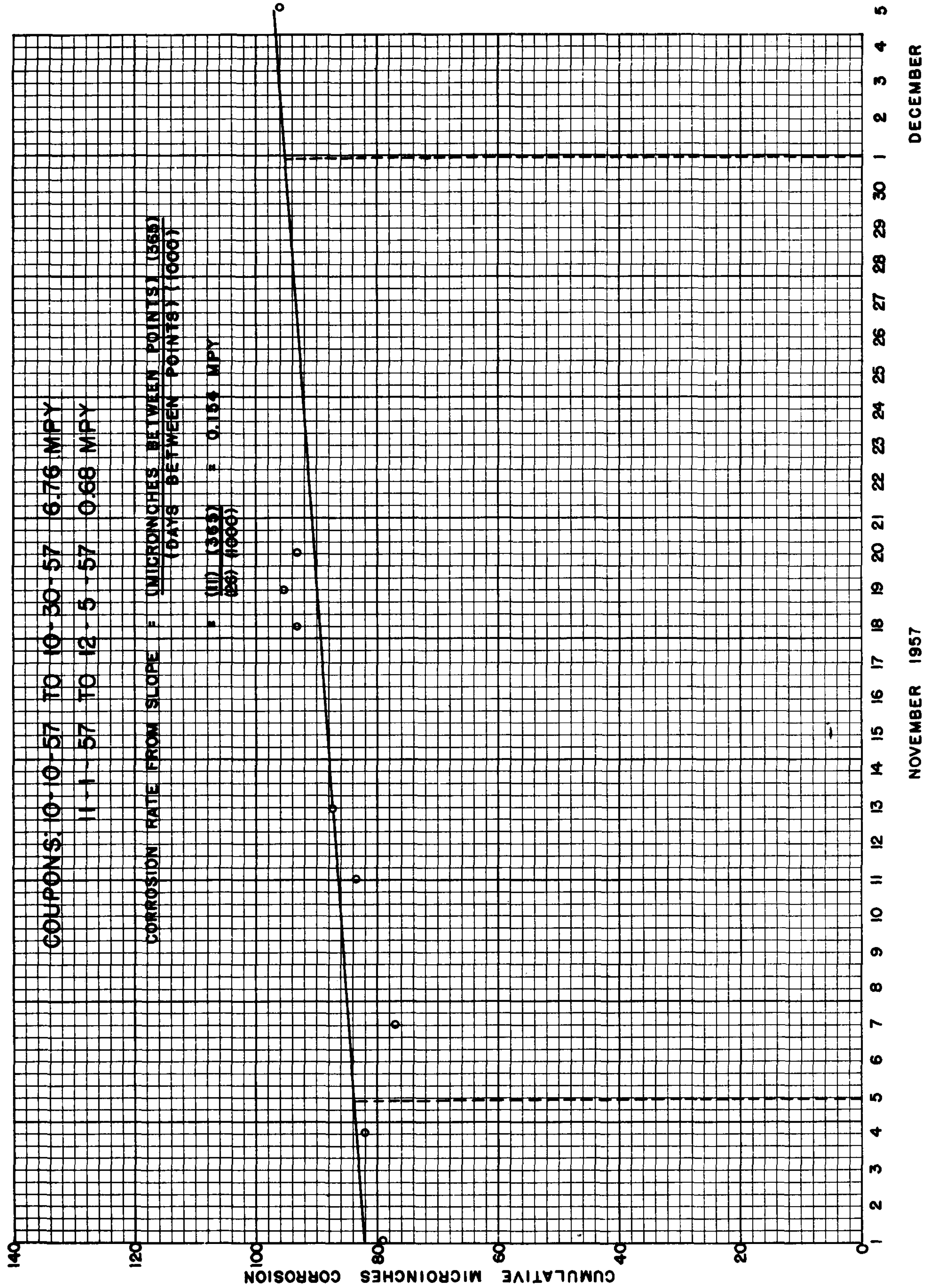

COUPONS: 10-10-57 TO 10-30-57 6.76 MPY
11-1-57 TO 12-5-57 0.68 MPY
CORROSION RATE FROM SLOPE = (MICROINCHES BETWEEN POINTS) (365) / (DAYS BETWEEN POINTS) (1000)
= (11) (365) / (26) (1000) = 0.154 MPY
CUMULATIVE MICROINCHES CORROSION
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
1
2
3
4
5
NOVEMBER 1957
DECEMBER

Fig. 2

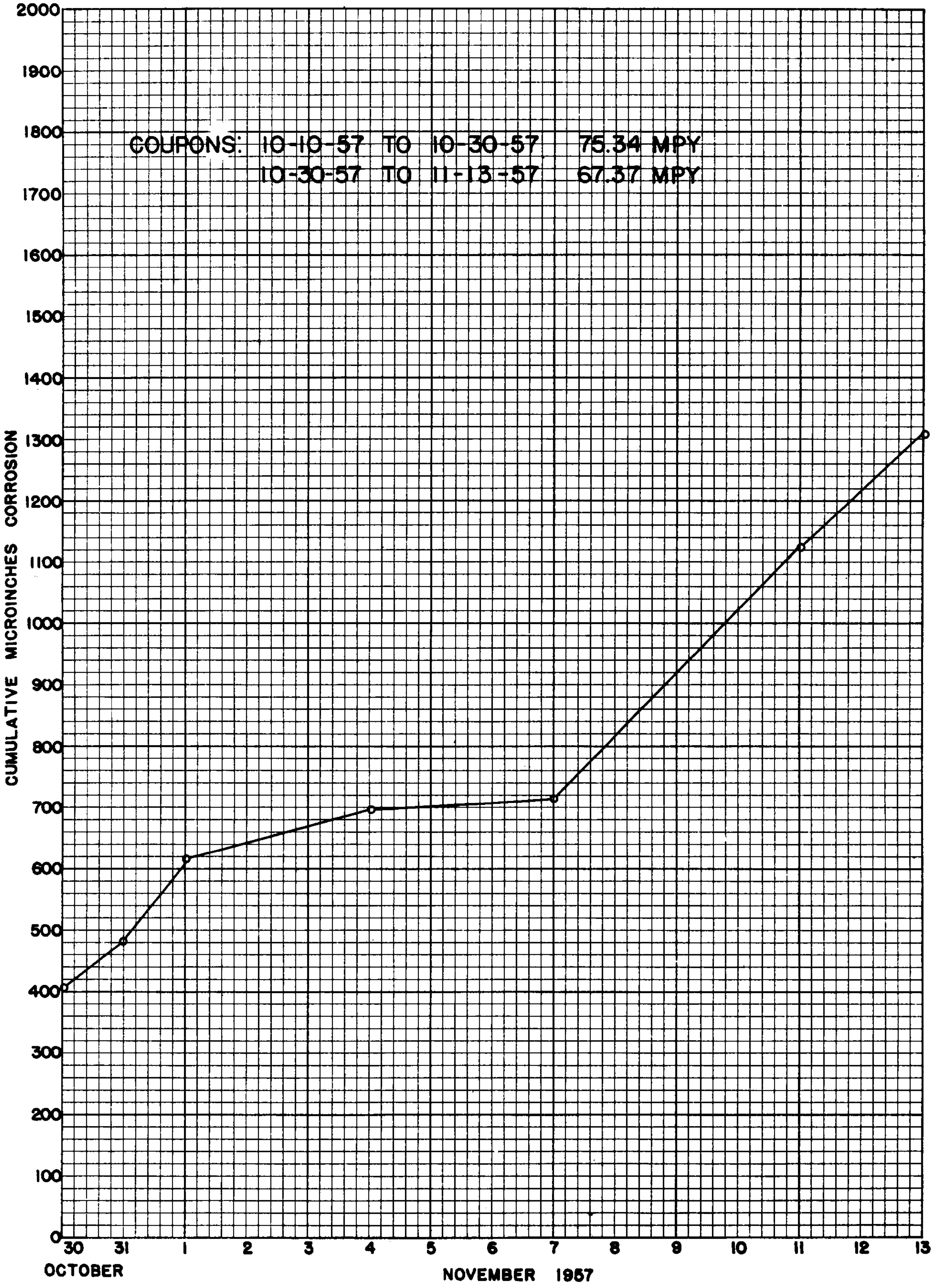
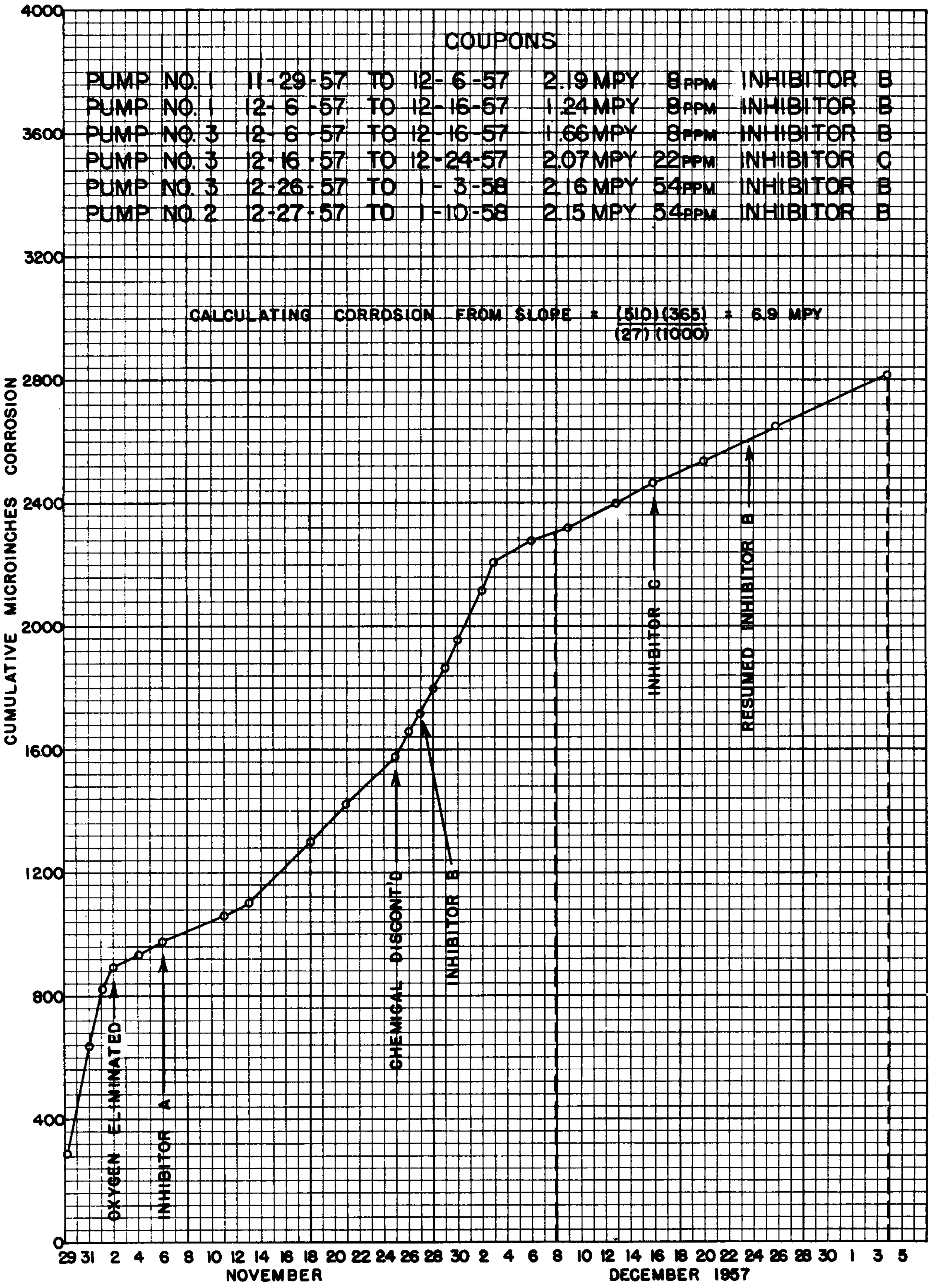

COUPONS: 10-10-57 TO 10-30-57 75.34 MPY
10-30-57 TO 11-13-57 67.37 MPY
CUMULATIVE MICROINCHES CORROSION
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
30
31
1
2
3
4
5
6
7
8
9
10
11
12
13
OCTOBER
NOVEMBER 1957

Fig. 3



COUPONS

PUMP NO. 1	11-29-57	TO	12-6-57	2.19 MPY	8 PPM	INHIBITOR	B
PUMP NO. 1	12-6-57	TO	12-16-57	1.24 MPY	8 PPM	INHIBITOR	B
PUMP NO. 3	12-6-57	TO	12-16-57	1.66 MPY	8 PPM	INHIBITOR	B
PUMP NO. 3	12-16-57	TO	12-24-57	2.07 MPY	22 PPM	INHIBITOR	C
PUMP NO. 3	12-26-57	TO	1-3-58	2.16 MPY	54 PPM	INHIBITOR	B
PUMP NO. 2	12-27-57	TO	1-10-58	2.15 MPY	54 PPM	INHIBITOR	B

CALCULATING CORROSION FROM SLOPE = $\frac{(510)(365)}{(27)(1000)}$ = 6.9 MPY

Fig. 4

siderable corrosion as did the probe, prior to making the change in treatment, and these plates show a 79 reduction in attack. Coupons were not in the well at the same time as the probe, but were run prior to and after its removal.

Fig. 2 illustrates a pumping well in which coupons were installed simultaneously with a strip type probe and removed at the same time. The corrosion rate from the curve obtained by plotting probe readings is 0.154 MPY as compared to 0.68 MPY by coupons.

Fig. 3 reveals the corrosion on another pumping well in which coupons and a wire type probe were installed simultaneously for the same period of time. While the corrosometer doesn't reveal corrosion as severely at any part of the period as the coupons, it does show a severe attack. This particular well was not produced regularly during the test, due to over production and full stock tanks; therefore, dial readings did not increase uniformly.

Fig. 4 is the plot of data obtained with a wire type probe installed in the water discharge line of a water flood. Three different inhibitors were used during the test. Observe that soon after this work was begun, a leak was found where oxygen was entering the system. Immediately after eliminating the oxygen, the corrosion rate was reduced. Removing the probe required a complete plant shutdown which the company did not like to do. Therefore, the probe was not cleaned when any change in chemical was made.

On November 27th, a test with inhibitor B (a concentrate) was initiated and corrosometer readings indicated an increase in corrosion. By December 6th the corrosion rate had decreased while the amount of concentrated inhibitor consumed had been held constant. This can be explained by the detergency action of the inhibitor, whereby accelerated corrosion was encountered until the metal surfaces were cleaned up. Soon after the use of the concentrated inhibitor was undertaken, coupons were installed in the suction lines of the pump. These were 200 feet from the probe. They have revealed good protection in this very corrosive system of from 1 to 2.6 MPY. The slope of the curve obtained by plotting the corrosometer readings, for the same period that coupons were studied, reveals 6.9 MPY.

PROBE INFORMATION

Selection of the correct metal or alloy for the specimen composition is straight forward, but choice of specimen shape, protective coating material, and housing, require more thought. For short term testing with the highest sensitivity, strip specimens are required, whereas for long range testing, wire specimens are needed.

A probe requires cleaning when it is moved from one test location to another to remove corrosion products, paraffin, scale, or an inhibitor film. This may be done by mechanical, chemical, or electrochemical means. Mechanical methods involving abrasives are preferred over other methods for cleaning and activating metal surfaces. When properly used, mechanical methods can give a surface completely free of contamination and are the only sure methods of removing a strongly bonded inhibitor. The surface is rubbed with garnet paper or emery cloth to get a bright finish. It is then degreased with carbon tetrachloride (or similar solvent), rinsed with water and dried.

Electrochemical methods involve immersing the metal in an electrolyte and passing electric current between the specimen and an auxiliary electrode by means of an external circuit. This method is least preferred since it leaves the surface in a passive state; that is, a hydrogen film is left on the surface as a protective film. Acid treatment should follow to remove this.

CONCLUSION

1. Corrosometer probes do correlate closely with results obtained by coupons in pumping wells.
2. When reading a probe in a system where various changes in inhibitors are made without removing the probe, detergency of chemicals must be considered, and representative results cannot be obtained in hours or a few days.
3. Handling, cleaning, and storing probes is to be considered if the engineer desires to move them from well to well or field to field.
4. The company manufacturing the probes should make it possible for the engineer to replace the exposed specimen; this would provide another simple and economic tool for the corrosion engineer.

Much of this work was done with a spiral wire, and mechanical cleaning was not possible. The hard, greasy deposits were removed by boiling in 10% sodium hydroxide solution. The probe was then immersed in concentrated hydrochloric acid and the meter unit attached to check on the dissolution of base metal. No more than 100 microinches were dissolved during the cleaning. Inhibitor films are removed only slowly, even in strong acid solution. After cleaning in acids, the surface should be rinsed in fresh water, carefully dried and stored in a clean dry place, preferably in a closed container with a desiccant.