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PRESSURE TESTING

CONSTRUCTION, USE AND MAINTENANCE OF

ALCOHOL MANOMETERS

CONTENTS

1. EXPERIMENTAL ALCOHOL TYPE MANOMETERS

1.01 Considerable experimental work has been done with alcohol manometers to provide more sensitive pressure measuring instruments than those now available for standard use. Preliminary data covering such instruments and their use are included in this practice for possible utilization under proper supervision of Division or District representatives, where adequate results cannot be secured using standard instruments. Development work still remains to be done before the alcohol type manometers (or alternative sensitive measuring apparatus) can be standardized.

1.02 The pad manometer is intended, primarily, for securing pressure measurements in gas leak location work where extreme accuracy is essential, and where the pressure drop between adjacent valves is very small. Its sensitivity is about .0015 pound per square inch for each division on the scale, as compared with .02 per scale division for the mercury manometer. It provides a means of securing data for leak gradients on relatively small leaks in high resistance quadded cables or for leaks in low resistance cables such as coaxials, particularly where it is desired to dig and expose the cable for repairs and it is important that the digging work be kept to a minimum.

1.03 The inclined tube manometer is intended, primarily, as a direction of flow indicator. It is visual, quantitative and its sensitivity can be varied by changing the inclination of the manometer from a vertical position to a nearly horizontal position; in a vertical position its sensitivity to pressure differences is about .0015 pound per square inch for each division, and this sensitivity is greatly increased with inclination of the instrument from the vertical. It can also be used to detect stoppages in cable or splices, by comparing the drop across a section of good cable with the drop across a section of the same length containing the suspected stoppage.

2. PAD TYPE MANOMETER

(A) Description of Pad Manometer

2.01 The pad manometer consists of two parallel 36-inch lengths of glass tube, joined at one end by a glass valve (pressure stopcock). One of the open ends of glass tube is connected to a pressure pad (one quart highly evacuated vacuum bottle) and the other is equipped with a long hose and a snap-on chuck for attachment to valves on the cable. Alcohol (colored with red vegetable dye) is used in the tubes as the measuring medium. A graduated scale is placed under the tubes so that reading of the height of the alcohol columns can be observed and recorded. The entire unit is mounted on a wood framework. Figures 1 and 2 show pictures of the completed instrument.

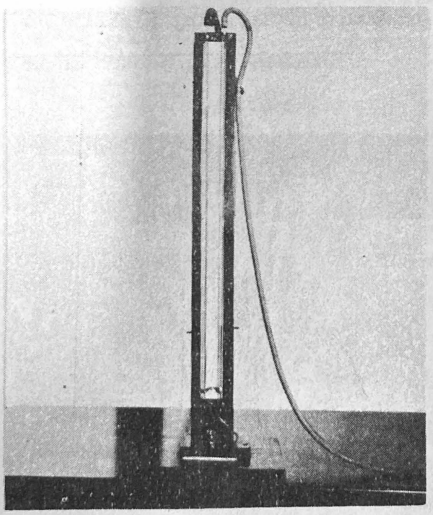


Figure 1

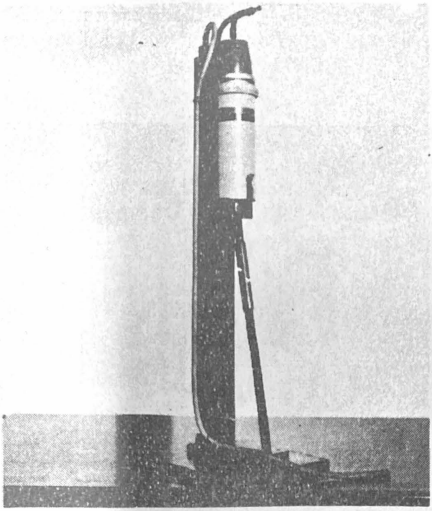


Figure 2

(B) Construction of Pad Manometer

2.02 The glasswork for the pad manometer may be obtained locally or it can be ordered from Eck and Krebs, 131 West 24th Street, New York City, at a cost of approximately $8.50. A spare unit should be available for replacement in the event of breakage. The order should read as follows:-

> Furnish (number) manometer complete, consisting of a No. 5150 straight bore pressure stopcock, made of Pyrex (3 mm bore) to which two parallel 36-inch lengths of 3 mm bore Pyrex tubes are attached and spaced 1-1/8 inch between centers. Grind the stopper into the body of the stopcock, for a ground glass fit, after attaching the tubes. Working parts of the stopcock should be given a liberal uniform coat of "Yale Stopcock Grease" (manufactured by Eimer and Amend).

NOTE:-

It should be observed that the order specifies securing a ground glass fit between the stopper and the body of the stopcock after the tubes are attached. This is important since it has been found that the heat necessary to attach the tubes to the stopcock and to bend the tubes into proper shape to make them parallel, causes sufficient distortion to allow alcohol to seep into the joint and dissolve the grease, resulting in leakage and a "freezing" of the valve.

2.03 The insulated pad used should, preferably, be a high-vacuum one quart glass vacuum bottle. However, at the time this is written, difficulty may be experienced in securing such a bottle. Pending the availability of the high-vacuum bottle, it will be satisfactory to use any commercial one quart size glass type vacuum bottle, improving the vacuum locally, if practical. Because it is not known what type vacuum bottle can be obtained, it is not possible to describe, in detail, the method of sealing the mouth of the bottle. Generally, the bottle can be sealed with a rubber stopper which has been formed so that it has a shoulder which rests on the top of the bottle and a section which extends into the mouth of the bottle snugly, but not tightly. It is not practical to force a stopper into the bottle in a normal way, since the strains set up may result in shattering the bottle when placed under pressure. A hole should be drilled through the center of the stopper, into which a four inch section of 1/8-inch inside diameter threaded pipe can be inserted, extending 1/4-inch beyond the small portion of the stopper; place washers and nuts on each side of the pipe and tighten against the stopper to secure a seal. Connect a 1/8-inch pipe T to the long end of the pipe and place F pressure testing valves with cores removed into the two remaining ends of the T. All threaded joints should be coated with thread lubricant (Pipetite-Stick joint compound) to insure against leakage. The

stopper is now ready for insertion into the bottle. Arrangements must be made for applying top pressure to the stopper, so that the pressure seal is secured between the top of the bottle and the shoulder on the stopper rather than by the portion which enters the neck of the bottle. Thread lubricant on the stopper will be of assistance in securing a seal. As an alternative, adequate seal can frequently be secured by wetting the stopper with saliva before placing it in the bottle, deterioration of the surface of the rubber causing a seal to the glass after a short time. Insert cores in valves on T, charge pad to ten pounds and check for leakage. Remove valve cores.

2.04 A measuring scale is required for mounting under the tubes. A satisfactory scale can be constructed using 20 division-to-the-inch cross-section paper, two inches wide and 30 inches long. The scale should have a column of figures along the centerline with zero at midscale and marked consecutively in each direction for each ten divisions from zero to 300 divisions. After the scale has been prepared, cover it with a two-inch wide strip of transparent cellulose tape or equivalent on each side to protect it against mutilation or moisture.

2.05 Colored alcohol for use in the instrument can be secured in most drug stores. It should be tinted with a red vegetable dye which will completely dissolve in the alcohol; coloring materials which leave a residue should be avoided because they cloud the column of liquid and clog the valve. It is important that a good grade of alcohol be used; rubbing alcohol is not satisfactory for this purpose since it contains only about 20 per cent alcohol. Gauge oils have not been found to be very satisfactory because of the appreciable movement of the liquid columns which discolors the tubes and requires a considerable period of time before the glass clears and readings can be taken.

2.06 Thick wall, pure rubber hose 1/2-inch O.D. and 1/4-inch I.D. should be secured for making connections and for the extension from the instrument to the cable valve. This hose is

frequently found to be porous and should be checked under water with a pressure of 15 pounds. Such porosities are frequently minute, so that no continuous stream of bubbles arises, but beads appear on the hose which can be wiped off and then observed for reforming. Porous sections of hose should be discarded or cut out, using only tight hose. About 12 feet of good hose is generally required.

2.07 The wood framework can be constructed locally, see Figures 1 and 2. The vertical section consists of a two by four inch piece of hard wood about 40 inches long, recessed about 3/4-inch deep on one face to mount the tubes below the face level of the piece; this recess is provided so that a cover (not shown in figures) can be placed flush over the tubes when the instrument is not in use, to protect the glasswork from breakage. Near the base a large hole is drilled through the vertical piece to admit the body of the glass stopcock. The base consists of two pieces of one-inch thick hard wood; one is 12 inches square and the other six inches square. A small shelf is attached to the vertical section at a height which will bring the top of the pipe extending from the vacuum bottle level with the top of the glass tubes. A brace and strap are provided for mounting the vacuum bottle on the shelf. One inch wide strap metal, 1/8-inch thick is installed from the shelf to the base to act as a stiffener for the vertical member. Also half round wood carrying handles are attached to this strap at the balance point to simplify carrying the instrument. Clips mounted on the back of the vertical section permit coiling the hose when not in use.

2.08 Miscellaneous parts necessary, in addition to those described above are:-

(a) Stranded lashing wire (picture frame wire) for lashing all hose connections.
(b) Rubber grommets and brass clips for mounting glasswork on wood framework.

(c) A good level which will mount on a flat surface.
(d) "C" pressure testing valve for gas admission to the pad.
(e) A snap-on air chuck.
(f) Two hose pinch clamps (Fisher Castaloy Hose Clamps S-847-40 or equivalent). Only one required - other is a spare.
(g) Clip for rigidly attaching hose to vertical wood section to take weight of hose from connection to glass tube.
(h) Miscellaneous screws and tacks for assembly and mounting.
(i) Enamel, Dulux Green, No. RR-83546 - one pint for painting woodwork.

2.09 Construction of wood framework should not be started until the glasswork and vacuum bottle are available. Detailed dimensions of the woodwork will depend upon the type and dimensions of the vacuum bottle and minor variations in the shaping of the glasswork.

2.10 Assembly of the parts should be done as follows:-

(a) Attach the vertical portion of the woodwork to the two pieces comprising the base. Then install the vacuum bottle shelf and bottle mounting details, the stiffener brace and the hose coiling clips.

(b) Place the glasswork temporarily in the recess on the upright and center the scale under it so that the figures are midway between the two glass tubes; lengthwise the scale should be centered on the straight portions of the tubes. Fasten the scale in place with small tacks.

(c) Install the glass manometer, mounting it with two brass clips over rubber grommets at the top and two at the bottom, i.e., two mountings for each tube. Care should be

exercised to insure that the glass valve is centered in the hole through the vertical wood member and has ample freedom for movement without touching the woodwork.

(d) Open the glass valve and place a one inch length of rubber hose on the end of one of the glass tubes. Thread a fine wire through this tube and extend it into the glass tube as far as it will go (to the valve at the bottom of the glass tube). With a medicine dropper, place colored alcohol into the manometer, through the rubber tube reservoir, and work the wire back and forth to eliminate air bubbles. Continue filling until both glass tubes are level at, or close to, the midscale zero. If necessary, transfer the wire to the other glass tube to remove any bubbles which may be present. Remove the one inch length of rubber hose and the wire.

(e) Mount the level on the base directly below the glass valve. Level the instrument laterally with wedges until the level of liquid in both tubes falls on the same horizontal plane of the scale. Then shim up the level with the bubble in the center and tighten it in place. Close the glass valve.

(f) Mount the vacuum bottle with one of the valves in the T pointed toward the ends of the glass tubes at the top of the manometer. Cut a length of rubber tubing just long enough to extend from the end of one of the glass tubes to the valve in the T closer to the tubes. Wet the end of the glass tube and the valve and connect them with the rubber hose, lashing the connections; care should be exercised not to break the glass in

tightening the lashing wire.

(g) Cut a two-inch length of rubber hose and install a C valve in one end. Place the other end over the remaining valve in the T and lash both hose connections.

(h) Install a snap-on hose chuck in one end of a 10 to 12 foot length of rubber hose, and place the other end of the rubber hose on the top of the glass tube of the manometer, lashing both securely. Install the clip on the rubber hose near the top of the manometer, fastening it to the woodwork with a slack loop in the hose, to remove the weight of the hose from the glass tube and to avoid hose kinking.

(i) The protective cover should be constructed so that it covers both the glass tubes and the valve, and may be attached to the framework with hooks and eyes for ready removal.

(j) Place a hose pinch clamp on the long rubber hose adjacent to the snap-on hose chuck, but do not tighten it to restrict the hose.

(k) Charge the pad from the C valve and the long hose from the snap-on chuck to ten pounds from a nitrogen cylinder and regulator, closing the hose pinch clamp before disconnecting from the charging source. Open the glass valve slowly to be sure fluid levels reach equilibrium. Soap all connections carefully, observing for minute leakage. Allow unit to stand for a considerable period to indicate any loss of pressure on either the pad or hose side. as shown by change in the fluid levels. Close glass valve and release pressure in pad and long hose.

(C) Preliminary Work on Gas Section Before Use of Pad Manometer

2.11 Before satisfactory results can be secured with the pad manometer, a certain amount of preliminary work on the cable gas section is necessary. Leak gradients should be secured with the pressure testing manometer from 3,000 feet spaced valves to get a tentative leak location. Then three auxiliary valves must be placed in the cable on each side of this tentative leak location, spaced at about 500 foot intervals (or in manholes on underground cable). The workable range of the pad manometer is about 1/2 pound, so that if pressure gradients show drops in excess of this over the range to be covered by the temporary valves, it should be possible to secure sufficiently accurate results with the pressure testing manometer without resorting to the use of the pad manometer (or else the temporary valve spacing must be still further reduced). When cable is in conduit containing water, the temporary valves should be brought to the neck of the manhole with rubber hose or lead pipe; this eliminates the need for pumping manholes to secure readings and possibly changing the gradient. Where there are two or more cables forming a circular gas section, connect them together with a rubber hose by-pass beyond the location of the temporary valves on each side of the leak, using existing 3,000 foot valve locations. Allow the plug section to equalize (or charge it and then remove all nitrogen cylinders and allow equalization to take place) over a period of about one week. No pressure measurements or work should be done on any part of the plug section during this interval, unless, of course, contactor operation or trouble necessitates entering the cable, thus deferring the pad manometer tests.

2.12 In general, it is inadvisable to secure an exact leak location and clear section troubles on cable in conduit where known electrolysis conditions exist. Such sections should be replaced unless special conditions warrant, such as deferring replacement due to K

circuits in cable and probability of rebalancing cable after section replacement, etc.

2.13 Pad manometer tests should not generally be used on aerial cable, due to temperature fluctuations and difficulty of securing complete equalization. Also tests using the pad manometer on underground or buried cables, should, if possible, be made during periods of stable temperature conditions both on the cable and above ground; the latter to insure minimum temperature change of the pad.

2.14 Where an appreciable change in elevation, in excess of about ten feet, occurs over the terrain where the temporary valves are installed, correction of readings must be made for change in elevation. Elevations for all valves to be read can be secured from known records or by using a hand level. Correction of readings to reflect changes in elevation (i.e., differences in the weight of the nitrogen column due to change in elevation) should be determined as outlined below:-

Consider the valve reading at the lowest elevation as satisfactory and correct readings for all other valves at a different elevation as follows:-

(1) When fluid on pad side of manometer is high (pad pressure low) - Add correction of one division for each two-foot change in elevation.

(2) When fluid on pad side of manometer is low (pad pressure high) - Subtract correction of one division for each two-foot change in elevation.

This will be outlined more fully below under the tabulation of data.

(D) Taking Measurements with Pad Manometer

2.15 The procedure to follow in securing a set of pad manometer readings is outlined below:-

(1) Using a pressure testing manometer, secure a pressure reading on the leaky cable at a point beyond the location of the temporary valves.

(2) With the pad manometer valve closed, charge the pad and the ten-foot hose to the pressure found in (1) above, closing the hose pinch clamp adjacent to the snap-on chuck before removing it from the nitrogen cylinder charging source. Prior to the tests, the pad manometer and nitrogen cylinder should be stored at a point where they will assume as nearly as possible, the temperature conditions of the atmosphere which will prevail during the taking of readings. (Do not bring pad manometer and nitrogen cylinder from hot storeroom to the job on a cold day and start tests).

(3) Set up the pad manometer and level it with a wood wedge under the base, at the third temporary valve from one side of the leak. Lateral leveling only is necessary.

(4) Open the glass valve carefully to be sure that pressure on hose side is same as pressure on pad side, or nearly so. If major changes are observed, repeat step (2).

(5) Close glass valve and connect snap-on chuck to cable valve at set-up point indicated in step (3). Soap valve connection to eliminate any possible leakage. Open hose pinch clamp.

(6) Open glass valve very carefully, just enough to observe that pad pressure is higher than cable pressure; then close valve. Bleed a small amount of gas from C valve at pad and repeat above observation. Continue this procedure

until fluid in tubes stabilizes with the glass valve open and with the pad pressure about 400 divisions less than the cable pressure (fluid on pad side 200 divisions above zero in its tube and fluid on cable tube side 200 divisions below zero. Each division on the scale represents a pressure difference of .0015 lb/sq. in.). Restore cap in C valve and use this pad pressure throughout balance of test.

(7) Observe pressure levels of both tubes to be sure that they are stable.

(8) An accurate record of time - to the nearest quarter minute - should be kept. When fluid in tubes is stable, close glass valve at nearest quarter minute as announced by the timekeeper. Read and record the time and fluid level of each tube, using a data sheet similar to the one shown in Figure 3. Pressure readings above zero on the scale are recorded to the nearest half division, as plus and pressure readings below zero as minus.

DATA SHEET

Cable_____
Date_____
Observers_____

Reading Set No.	Time	Reading Pad	Reading Cable	Reading Total	Pad Pressure	Elevation Correction: Elevation Difference Feet	Elevation Correction: Pressure Correct. Div.	Corr. Total Read.	Remarks
			VALVE NO. 1						
1	9:50:00	+205	-195	400	L	8	+4	404	
2	10:29:15	+194-1/2	-197-1/2	392	L			396	
3	11:11:15	+183	-201-1/2	384-1/2	L			388-1/2	
4	12:10:00	+169-1/2	-206-1/2	376	L			380	
			VALVE NO. 2					Lowest Valve	
1	9:54:30	+197	-189	386	L	0	0	386	
2	10:33:45	+186-1/2	-192	378-1/2	L			378-1/2	
3	11:15:30	+176-1/2	-195-1/2	372	L			372	
4	12:15:30	+162-1/2	-211-1/2	374	L			374	
			VALVE NO. 3						
1	10:00:00	+182	-175	357	L	12	+6	363	
2	10:39:30	+171-1/2	-178-1/2	350	L			356	
3	11:21:00	+161-1/2	-181-1/2	343	L			349	
4	12:22:00	+147-1/2	-188-1/2	336	L			342	
			VALVE NO. 4						
1	10:01:45	+182-1/2	-169	351-1/2	L	16	+8	359-1/2	
2	10:41:45	+168	-176	344	L			352	
3	11:22:00	+158-1/2	-180	338-1/2	L			346-1/2	
4	12:24:00	+144	-186	330	L			338	
			VALVE NO. 5						
1	10:06:45	+188	-184	372	L	22	+11	383	
2	10:47:15	+177-1/2	-187	364-1/2	L			375-1/2	
3	11:28:00	+167-1/2	-190-1/2	358	L			369	
4	12:29:30	+153	-197	350	L			361	
			VALVE NO. 6						
1	10:10:30	+198-1/2	-195	393-1/2	L	14	+7	400-1/2	
2	10:51:15	+187-1/2	-198-1/2	386	L			393	
3	11:32:30	+181	-199	380	L			387	
4	12:33:45	+163	-208	371	L			378	

NOTES: + Indicates readings above zero on the scale.
- " " below " " " " .
H " pressure of pad higher than that of cable.
L " " " lower " " " " .

Physical Layout of Plug Section in vicinity of leak

	RV	TV	TV	RV	TV	TV	TV	RV
Cable B	A	1	2	3	4	5	6	B
Cable A	RV	503.2 Ft.	487.3 Ft.	500.1 Ft.	520.6 Ft.	485.7 Ft.		RV

RV = Regular 3000' Spaced Valve. TV = Temporary Valves.
Plug Section = 51,897 ft. of _____ cable and 51,886 ft. of _____ cable.
Pad Manometer Gradient shows leak 260 ft. N. of TV_3 (between RV_3 and TV_4)

Figure 3

(9) Close hose pinch clamp and remove snap-on chuck from valve, exercising care to avoid loss of gas from cable. Restore valve cap.

(10) Move to next short spaced valve, toward the leak. Place snap-on chuck on valve, check for leakage with soap solution, open hose pinch clamp, open glass valve and then repeat steps 8 and 9.

(11) Make similar readings at the remaining four temporary valves, reading them in order to the end of the section.

(12) Make three more such sets of readings of the six temporary valves, taking the data in the same direction as the first set.

(13) Readings should be taken as rapidly as possible, consistent with accuracy, to keep the overall time to a minimum and thus reduce temperature change of pad.

(14) The total column indicates the total number of divisions between the levels of the two tubes.

2.16 Change in elevation measurements, where required, (more than about 10-foot change) should be made, either before or after making pressure measurements, and recorded on the data sheet. Correct pressure measurements for elevation differences.

2.17 Cable distances between reading valves, used in plotting the leak gradients should be measured. Do not utilize existing record data.

2.18 Precautions to be observed before and during tests are outlined below:-

(1) Do not overcharge pressure pad. Pressures in excess of 15 pounds may shatter the bottle or break the seal.

(2) Keep pad manometer sheltered from the sun, except where this is impractical during the taking of readings.

(3) Secure data as rapidly as possible in a continuous operation.

(4) Make tests, if possible, when temperature conditions are stable.

(5) Lubricate glass valve before each day's use to avoid "freezing".

(6) If severe leakage occurs during a test at one or more valves, discontinue test until a later date when equalization is again established.

(7) In the event a leak is of such magnitude that the readings go beyond the range of the instrument during a test, take a reading (after closing the glass valve) at a given valve location within the range. Then bleed the C valve on the pad very slightly, open the glass valve and allow columns to stabilize. Take a second set of readings. Determine the difference between the two sets of readings, in total divisions and correct all previously made total readings by this amount. Subsequent readings are recorded as read. Indicate this action in the remarks column.

2.19 In plotting time-pressure curves and leak gradients, use large sheets of graph paper and select a desirable scale. See attached Figures 4 and 5 - showing plotted curves for data in Figure 3.) Connect all points with straight lines. By comparing the shape of the time-pressure curves, any obvious errors in taking readings can be corrected. In the event the pad pressure becomes higher than the cable pressure during the taking of

data (either due to the magnitude of leak or from temperature changes of the pad), the graph paper pressure coordinate should be laid out to show divisions above zero and divisions below zero, plotting the "pad pressure high" values above zero and the "pad pressure low" values below zero. For example, from Figure 3, if the leak was large enough or the pad temperature increased so that the fourth set of readings showed "-" pad values and "+" cable values, the total column would still be the sum of the two, but the "Pad Pressure" column would indicate "H". The pressure coordinate would provide space for such plotting as indicated below:-

200	100	0	100	200	300	400	500
Pad Pressure High						Pad Pressure Low	

Pad Manometer Readings - Divisions

In addition to plotting leak gradients for a location, a method has been devised for calculating a leak location using the "simultaneous equivalent data" taken from the time pressure curves. Using the layout shown in Figure 3 and the simultaneous pad readings for the two valves on each side of the low point in the gradient, tabulate the data as follows:-

Distances	Pressure Readings
TV 2 to RV 3 = 487.3 ft. (A)	TV 2 = 371
RV 3 to TV 4 = 500.1 ft. (B)	RV 3 = 349
TV 4 to TV 5 = 520.6 ft. (C)	TV 4 = 346.5
	TV 5 = 370

Pressure Difference TV 2 to RV 3 = 371-349 =22 (X)

" " RV 3 to TV 4 = 349-346.5 = +2.5 (Y)

" " TV 5 to TV 4 = 370-346.5 = 23.5 (Z)

(NOTE) When pressure at TV 4 is greater than at RV 3 the resultant will be negative.

Applying the values indicated above by the bracketed letter in the formula

$$D = \frac{(BZ \pm CY)\ A}{CX + AZ}$$

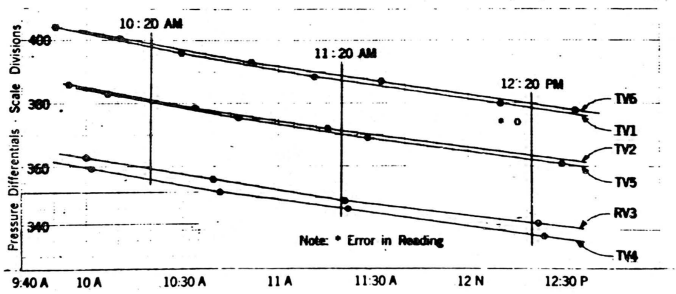
where D is the distance from RV 3 to the leak

$$D = \frac{[(500.1 \times 23.5) + (520.6 \times +2.5)]\ 487.3}{(520.6 \times 22) + (487.3 \times 23.5)}$$

$$= \frac{(11752.35 + 1301.5)\ 487.3}{11453.2 + 11451.55}$$

$$= \frac{13053.85}{22904.75} \times 487.3$$

= 277.72 ft. from RV 3 toward TV 4 leak location.



SIMULTANEOUS EQUIVALENT READINGS			
Valve No.	10:20 A	11:20 A	12:20 P
TV 1	398	387	378.5
TV 2	382	371.0	363.5
RV 3	359.5	349	342
TV 4	356	346.5	338.5
TV 5	380.5	370	362
TV 6	399	389	380

Cable _____
Date _____
Observer _____

Figure 4
(Drawing S-9799-143)

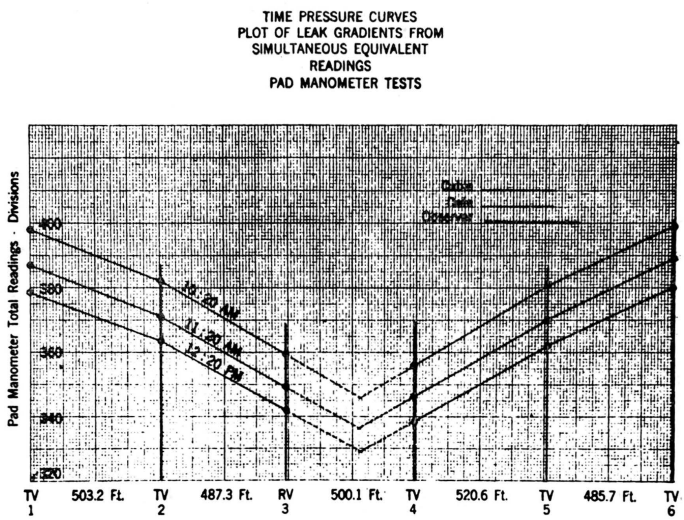


Figure 5
(Drawing S-9800-143)

(E) Pad Manometer Data Analysis

2.20 Analysis of the leak gradients (taken from simultaneous equivalent values on the time pressure curves) will afford information as to whether good data have been secured. The leak gradients should follow the pattern of a normal leak gradient, i.e., slightly concave down toward the leak on both sides. Three readings are taken on each side of the leak so that enough of the gradient can be plotted to show this condition. Irregularities in the leak gradients or non-parallel time-pressure curves indicate improper conditions, either in the securing of the data or in the cable itself. As an example, irregular leak

gradients will result if there is a splice with a stoppage between reading valves. Its location can be determined, roughly by inspection of the leak gradients. Time-pressure curves frequently do not assume a nearly straight line (due primarily to change in pad temperature and loss of gas through leak during the period readings are taken), but may be curved at one or both ends, or may assume an arc. Such curves are satisfactory, provided all of the curves assume the same pattern and are roughly parallel.

2.21 Splices suspected of containing a stoppage can be checked by the use of an inclined tube manometer (described in Part 3 of this section) by comparing, quantitatively, the drop across a good section of cable with that across an equivalent length of cable containing the suspected stoppage. Where an excessive drop across a splice is found, it can be by-passed by removing valve cores from the reading valves and installing a length of rubber hose between the valves. Another set of pad manometer readings can then be taken after cable has equalized. If experience indicates trouble in the cable under test from splices with stoppages, this by-passing may be done before the pad manometer tests are started.

(F) Maintenance of Pad Manometer

2.22 Maintenance procedures for the pad manometer are outlined below:-

(1) Keep screws in woodwork tight.

(2) Check setting of level as outlined in 2.10.

(3) Remove and clean core of glass valve.

(4) Clean tubes with alcohol, removing any accumulated grease from the body of the glass valve where tubes are attached. Use piano wire with a small alcohol saturated pad.

(5) Reassemble valve, applying a liberal uniform coat of Yale Stopcock Grease. Work core in body of valve to get uniform distribution of grease, as indicated by disappearance of the hazy film between core and body of valve.

(6) Refill manometer with colored alcohol as outlined in 2.10.

(7) Check long hose, under pressure, for leakage.

(8) Restore and lash all hose connections, checking for leakage.

(9) Charge pad and long hose, equalize pressures, open glass valve and observe for any evidence of leakage or loss of insulating qualities of the pad. It would be desirable to record time and tube fluid levels over several hours, under stable temperature conditions.

3. INCLINED TUBE MANOMETER

(A) Description of Inclined Tube Manometer

3.01 The inclined tube manometer consists of two parallel 12-inch lengths of glass tube, joined at one end by a glass valve (pressure stopcock). The open ends of the tubes are connected to lengths of soft rubber hose, equipped at their other ends with snap-on chucks for attachment to valves spaced several feet apart on the cable. Alcohol (colored with red vegetable dye) is used in the tubes as the measuring medium. A graduated scale is located under the tubes so that the height of the alcohol columns can be observed. The glasswork is mounted on a base which is hinged to a second larger base so that the tubes can be adjusted from a vertical to a horizontal position in graduated steps. Figures 6, 7 and 8 show pictures of a completed model instrument. Parts and assembly details are shown in

Figures 9 and 10. The standard instrument, which will be available shortly, will be similar, with minor changes in materials used for the mounts.

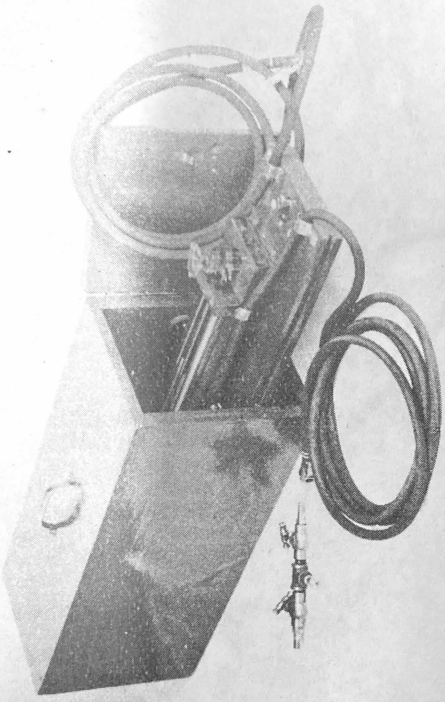


Figure 6

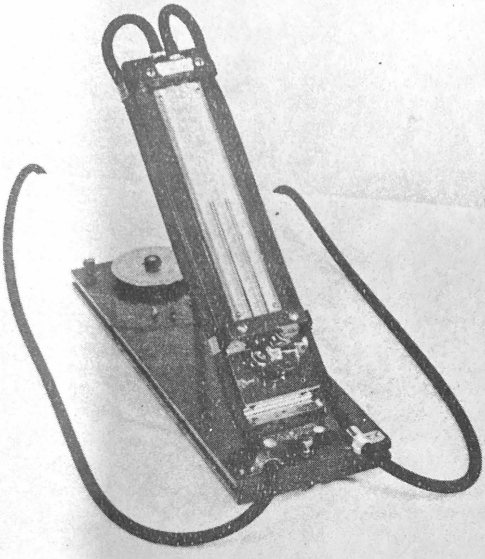


Figure 7

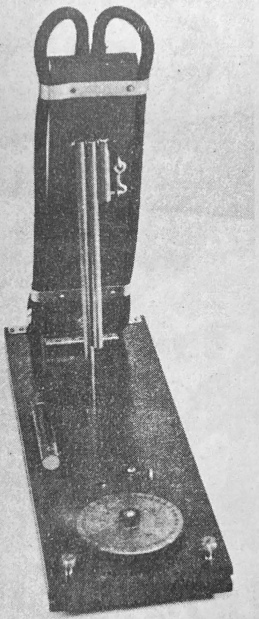


Figure 8

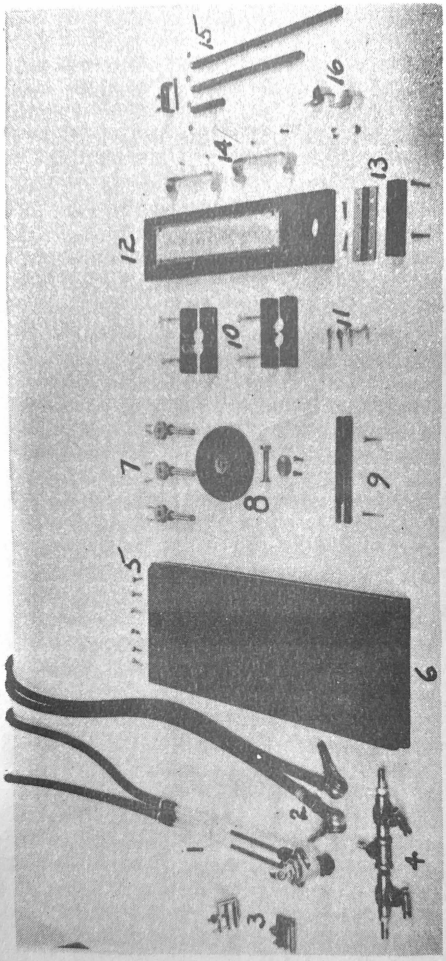


Figure 9

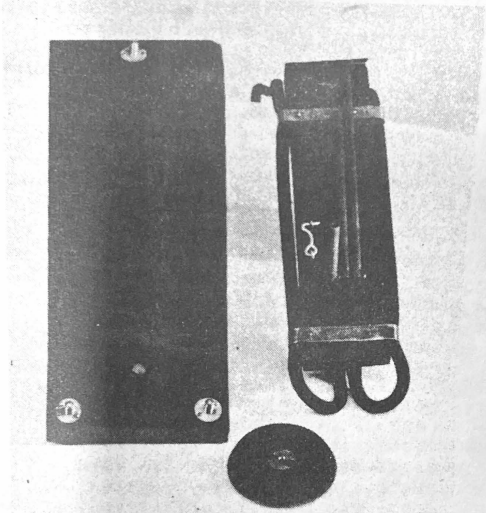


Figure 10

(B) Charging Manifold

3.02 A charging manifold (Item 4 on Figure 9) is necessary for securing uniform pressure on both sides of the manometer. This consists of: (1) an eighth inch pipe T (with two male ends in line and one female end at right angles to the other two or with all female ends and 1/8 inch pipe nipples installed in the two ends which are in line); (2) two brass needle valves with female ends, tapped for 1/8 inch pipe; (3) three F pressure testing valves. Connect the needle valves to the pipe T by screwing them on the ends which

are in line. Install the pressure testing valves in the open ends of the two valves and in the open end of the T. The handles of the valves should be in line and 180° from the valves in the T. Remove the cores from the two F pressure testing valves installed in the needle valve outlets. Thread lubricant (Pipetite-stick joint compound) should be used in making all connections.

3.03 Adjusting Levels and Test

(a) Set the instrument on a level surface and with a good auxiliary level placed on the lower base, adjust the leveling screws until the lower base is about level. The glass valve must be closed.

(b) Place a flat piece of material longitudinally, resting on both glass tubes; on this put a good level and adjust the vernier dial until the level bubble centers; then shim up the instrument level mounted on the lower base until its bubble shows in middle position. Place washers over the vernier bolt so that the vernier dial will be at its lowest position when the tubes are level, rechecking with the auxiliary level to insure correct shimming. Thereafter when the instrument mounted level is centered and the vernier is in its lowest position, the tubes will be horizontal.

(c) The vernier leveling disc should next be calibrated for a minimum setting of one degree from horizontal. With an 11-inch swing from the adjustable base hinge to the center of the vernier screw, a full 360° swing of the adjustable base at the vernier point would be 34.6 inches or about 0.1 inch per degree. The leveling screw with 28 threads per inch rises .0356 inch per revolution. Therefore, a 1 degree rise of the adjustable

base requires $\frac{0.1}{.0356}$ or about 3 complete turns of the vernier dial.

(d) With the vernier set at 1° from horizontal, open the glass valve and observe the fluid levels in the tubes; slightly readjust the three main leveling screws so that the two tube levels are at the same scale reading and the instrument level bubble is centered. Then close the glass valve, attach the snap-on chucks to the manifold, and with the manifold valves open, charge both tubes to about cable pressure. Close both manifold valves simultaneously, then place a hose pinch clamp on each rubber hose adjacent to the chucks. Raise adjustable base to vertical and carefully open the glass valve; if fluid levels are about equal, lower adjustable base to 1° position and note the reading; let stand for about 15 minutes to check for any leakage, which would be indicated by a change in the readings of the fluid levels in the tubes. If they remain stable, the instrument is ready for use.

3.04 Carrying Case

(a) When placing the instrument in the carrying case, the adjustable base should be elevated on the shortest leg and the hook and eye must be engaged. The glass valve must be closed. Wind one hose around the instrument, looping at the hinge on one end and behind the adjustable base at the other end. Then slide the instrument into the case and drop the eccentric latch. Feed the other hose into the cavity under the instrument and also place the manifold into this area. Close the lid, engaging the snap latch.

(b) The instrument must lie relatively flat in transport. Do not up-end it.

(C) Preliminary Work on Gas Section Before Use of Inclined Tube Manometer

3.05 Two valves must be installed in the cable sheath, spaced as far apart as practical. In manholes, the spacing is limited to points just inside the end walls. On buried cable, the hose lengths on the instrument establish the maximum limits. Satisfactory results have been secured with two feet between valves, but longer lengths are desirable. At least two such measuring points should be established, one on each side of the leak location determined by other measurements. Pressure drop between the two valves is read, drawing no gas from the cable, as contrasted with the phenolphthalein type flow indicator, which by-passes the gas from one valve, through the instrument and back into the cable on the other side. Readings should not be made immediately after valves are installed; sufficient time must be allowed for normal flow toward the leak to be reestablished. When cable is in conduit containing water, the temporary valves should be brought to the neck of the manhole with rubber hose or lead pipe; this eliminates the need for pumping manholes to secure readings and possibly reversing the gas flow due to temperature changes.

(D) Taking Measurements with Inclined Tube Manometer

3.06 The procedure to follow in securing readings is outlined below:-

(1) Using a pressure testing manometer, secure a pressure reading on the cable at a point about 1000 feet beyond the location of the temporary valves.

(2) Set up the instrument in such a manner that the weight of the lengths of hose will not tend to move it, i.e., tie the

hoses so that only a sufficient length of slack loop to permit swinging the glass-work from vertical to horizontal will be acting on the end of the glass tubes.

(3) Place the manometer horizontal, turning the knurled knob all the way down, which makes the glass tubes horizontal; then turn the knurled knob up three full turns, (See Paragraph 3.03) which places the glass tubes at an angle of about one degree from horizontal; shield snap-on chucks from wind or other air currents. Using the leveling screws, center the bubble on the level mounted on the base; then open the glass valve and use the fluid in the tubes for cross-leveling (i.e., get the tops of the columns of fluid on the same line on the scale); readjust leveling screws until the instrument is level in both directions. This leveling operation is called "zeroing the instrument". Close glass valve.

(4) Set nitrogen cylinder regulator to pressure measured in step (1), measuring it with a pressure testing manometer. Attach snap-on chucks on rubber hoses to the two F pressure testing valves on the brass needle valves of the manifold, checking to insure that the brass needle valves are open. Attach the nitrogen cylinder to the F pressure testing valve on the T and allow pressure to equalize on both sides of the manometer. Turn off both brass needle valves simultaneously. Install hose pinch clamps on both manometer hoses adjacent to the snap-on chuck. Remove manifold and charging source.

(5) Raise the tubes to vertical and open the glass valve slightly to see that

pressures are approximately equalized. Gradually lower the manometer to one degree from horizontal, observing fluid as manometer is lowered. Leave instrument in this position and observe for any change in fluid levels, which might be caused by slight leaks or temperature equalization.

(6) When fluid in tubes is stable indicating there are no leaks in the setup, close glass valve.

(7) Attach snap-on chucks to cable valves and soap to detect leaks. Open hose pinch clamps.

(8) Raise manometer to vertical, open glass valve and observe fluid deflection. Move manometer toward horizontal until good deflection is obtained on tubes, but not lower than 1 degree above horizontal.

(9) Watch fluid levels in tubes until they stabilize, then read and record positions.

(10) Close glass valve and hose pinch clamps. Interchange snap-on chucks on the cable valves and repeat steps 7 to 9 inclusive. This should produce a reversal of the fluid levels in the tubes, but may not result in identical values, since small changes due to hose expansion, etc. cause considerable change in the readings.

(11) The magnitude of the readings is not significant, but visual reversal of fluid levels in tubes with reversal of snap-on chucks affords positive indication of direction of flow, the lower level tube indicating the side of the higher pressure. If direction of flow reverses, due to temperature change

or other causes while the instrument is connected to the cable, this will be reflected by a reversal of the fluid levels in the instrument.

(E) Stoppages

3.11 Stoppages in splices or a portion of the cable can be determined by comparing the pressure drop across a good section of cable with that across a splice, using the same spacing between valves. Under these conditions, it is necessary that leveling and duplication of the angle of inclination be done carefully since the magnitude of deflections is compared directly and they depend upon the angle of inclination of the manometer as well as the difference in pressures which exist at the valves on the cable. For these measurements the 3 angle setting legs on the manometer may be required.

(F) Precautions

3.12 Precautions to be observed before and during tests are outlined below:-

(1) Exercise care in leveling the instrument.

(2) Keep hose lengths the same.

(3) Make tests when cable temperatures are stable (do not pump manholes when cable is in conduit).

(4) Lubricate glass valve before each day's use to avoid "freezing".

(5) If severe leakage occurs during a test at one or more valves, discontinue test until a later date when equalization is again established.

(6) Wait until fluid levels stabilize, both in preparation and during tests. The

hoses lying on a hot sidewalk will change pressures during the preparation work and tests should not be started before stabilization is attained. In making tests where the flow is very slight, a considerable interval (up to 15 minutes) may elapse before stabilization occurs; watch the tubes so that angle of inclination can be changed if range is inadequate.

(7) Tie up the rubber hoses so that their weight does not suspend from the glass tubes.

(8) In interchanging snap-on chucks on the valves, or in moving the manometer tubes from vertical to inclined angle, exercise care so that the level will not be disturbed.

(9) Set instrument on a hard surface for leveling. Do not set it up on a macadam or other soft surface where the level might change during the taking of readings.

(G) Maintenance of Inclined Tube Manometer

3.13 Parts 1-8 of Section 2.22 covering the pad manometer apply equally well for the inclined tube manometer:

(a) Charge both hoses, using the manifold and check for leakage at a setting of about one degree from horizontal. It would be desirable to record time and tube fluid levels after several hours under stable temperature conditions.