Level Measurement

I. Displacers
II. D/P Cells
III. Bubblers
IV. Floats
V. Float and Tape
VI. Ultra Sonic
VII. Capacitance
VIII. Radar
IX Nuclear

Level measurement is important for many plant operations ranging from accounting-type transfer of product (referred to as custody transfer) between seller and buyer to high or low level detection in tanks or vessels to facilitate normal plant operations.

As with other kinds of measures, there are a variety of techniques to measure level depending on process fluid, environment factors and control requirements. In this course, we will focus on the following

1. Displacers
2. D/P Cells
3. Bubblers
4. Floats
5. Float and Tape
6. Ultra-Sonic
7. Capacitance
8. Radar
9. Nuclear

The above types account for most installations the instrument engineer will find in the typical petrochemical plant.

I. Displacer

One of the most frequently used level measuring devices is the displacer float shown in Figure 10-1. Figure 10-1 shows a pneumatic level controller, which is used to measure level and provide pneumatic measurement or control signal outputs. Although the device shown is pneumatic, electronic level devices are also available. A float-supporting tube called a torque tube is subjected to torsion by the weight of the float. As the float is covered by the fluid, its apparent weight changes by the amount of fluid displaced by the float. The torque tube senses the changing weight of the float in terms of an increase or decrease in rotation. This rotation (and the pneumatic output derived from it) is proportional to the fluid level change. Figure 10-2 describes the components of the displacer shown in Figure 10-1. The displacer controller incorporates an intermittent bleed relay actuated by a conventional primary orifice system and a pneumatic proportional band adjustment.

The operation of the displacer is as follows:

Operating air is cleaned and reduced to 20 psi by the combination filter regulator and is then sent to orifice "J", into relay diaphragm chamber "L", through small tubing "D", inside the Bourdon tube and to nozzle "A". The nozzle "A" when not restricted by flapper "B", is large enough to bleed off all the air coming through orifice "J" and the pressure difference will be zero between the orifice and the nozzle. When the nozzle is restricted by the flapper due to a rise in liquid level, pressure is built up in the system between "A" and "J". Thus any change in the liquid level results in a pressure change in the chamber "L".

The intermittent bleed pneumatic type relay wastes air only when pressure to the diaphragm motor valve is being reduced. The double diaphragm assembly with exhaust ports between diaphragms "M" and "P" is free floating and always pressure balanced. If there is an increase in pressure chamber "L" the diaphragm assembly is pushed downward, and the inlet valve "O" is pushed open. This allows supply pressure to come into chamber "N" until it pushes the relay diaphragm assembly back into its original position and the inlet valve "O" is closed again. A decrease in pressure in chamber "L" will cause the diaphragm assembly to move upward and to open exhaust valve "K", allowing pressure under small diaphragm "P" to bleed out until the diaphragm assembly again returns to its original position and exhaust valve "K" is closed.

The ratio of the two diaphragm areas in the relay is 3 to 1, or such that a 5 pound change on large diaphragm "M" results in a 15 pound change in pressure to the diaphragm valve.

The third part of the pilot assembly is the proportional band adjustment mechanism, which consists of a 3-way assembly "H" in a branch from the diaphragm motor valve supply line to the compensating Bourdon tube "C". The 3-way valve "H" is manually positioned between the inlet port 'I" and the exhaust port "G". When the valve is seated against exhaust port "G", all of the diaphragm pressure is transmitted to the Bourdon tube "C". This causes the Bourdon tube to "back away" and the flapper has to move a relatively large distance to close the nozzle. On the other hand if the valve is seated against the inlet port "I", no pressure is transmitted to the Bourdon tube with the result that a very small flapper movement is all that is necessary to close the nozzle. Intermediate positions of the valve, of course result in intermediate pressure to the Bourdon tube.

Assuming the pilot and the diaphragm motor valve are both direct acting as shown in the schematic drawing, the operating cycle of the complete level controller is explained as follows:

Figure 10-1
Level Displacer With Controller

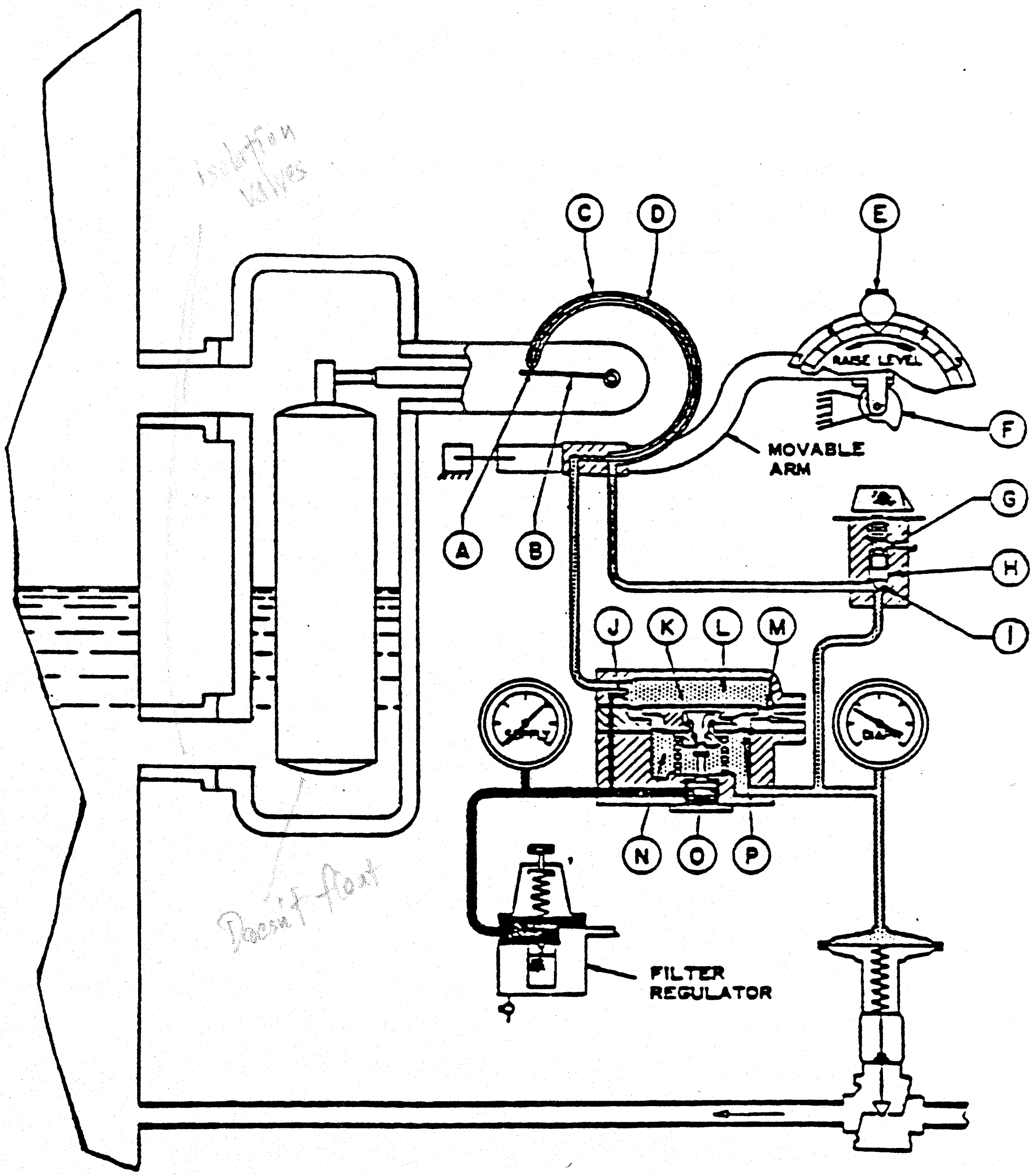


Figure 10-2
Components Of Level Displacer

ITEM	MAJOR COMPONENT DESCRIPTION
A	NOZZLE
B	FLAPPER
C	BOURDON TUBE
D	TUBES
E	SET POINT
G	EXHAUST POINT
H	3 WAY VALVE
I	INLET POINT
J	RESTRICTION
K	EXHAUST POINT
M	DIAPHRAGM
O	RELAY VALVE
P	DIAPHRAGM

Consider the level in the vessel at a point midway in the travel of the displacer, and the pilot is adjusted to give 9 pounds on the diaphragm of the control valve. Inlet flow to the vessel equals outlet flow and everything is in equilibrium. Now if there is a decrease in outlet flow, the level and the displacer will rise. The rising displacer causes the flapper "B" to move toward the nozzle "A". This will build up pressure in the relay chamber "L" and the relay diaphragm assembly will move downward opening relay supply valve "O". Air then flows into chamber "N" until the relay diaphragm assembly is pushed back into its original position, and valve "O" is closed again. The pressure in chamber "N" is transmitted to the diaphragm of the motor valve causing it to move toward its seat.

At the same time, the pressure in Bourdon tube "C" is being increased through the 3-way vale assembly "H" which causes nozzle "A" to move away from the flapper, thus stopping the pressure build up in chamber "L". The unit is again at equilibrium with the level at a higher point, and the diaphragm motor pressure is increased to partially close the motor valve so that inlet flow again equals outlet flow.

If an increase in outflow takes place, the reverse of the above cycle will occur, with a decrease in liquid level causing an increase in motor valve opening. This device is generally mounted in an external piping bridle and attached to the process vessel, as shown in Figure 10-3, so that it can be isolated form the vessel for repairs.

Figure 10-4 shows a cut-away drawing of the internals of a displacer and torque tube arrangement.

Figure 10-5 shows the two types of connections that are typically found for displacers. Only the side and side connections are recommended. This is because top and bottom connections often result in introducing errors due to condensation of the vapor components of the tank. This is especially true when H_2O is being measured in an atmosphere of hydrocarbons. Figure 10-6 shows how the collected condensate can affect readings and make the level read lower toward the high end and higher toward the low end of the range. This problem is less likely to occur in side and side connections because any condensed hydrocarbons are more readily flushed out of the displacer as the level changes.

Figure 10-7 shows how the displacer might be externally connected along with sight glasses. Note that drain valves are shown and these are required on all installations. Note also the side and side arrangements is not shown in this figure, but is recommended. Figure 10-8 and 10-9 show other arrangements. Note when installing the displacer in a boot at the bottom of a vessel (Figure 10-8) that you leave enough room for the displacer and any accessories.

Figure 10-3
Displacer Attached To Vessel

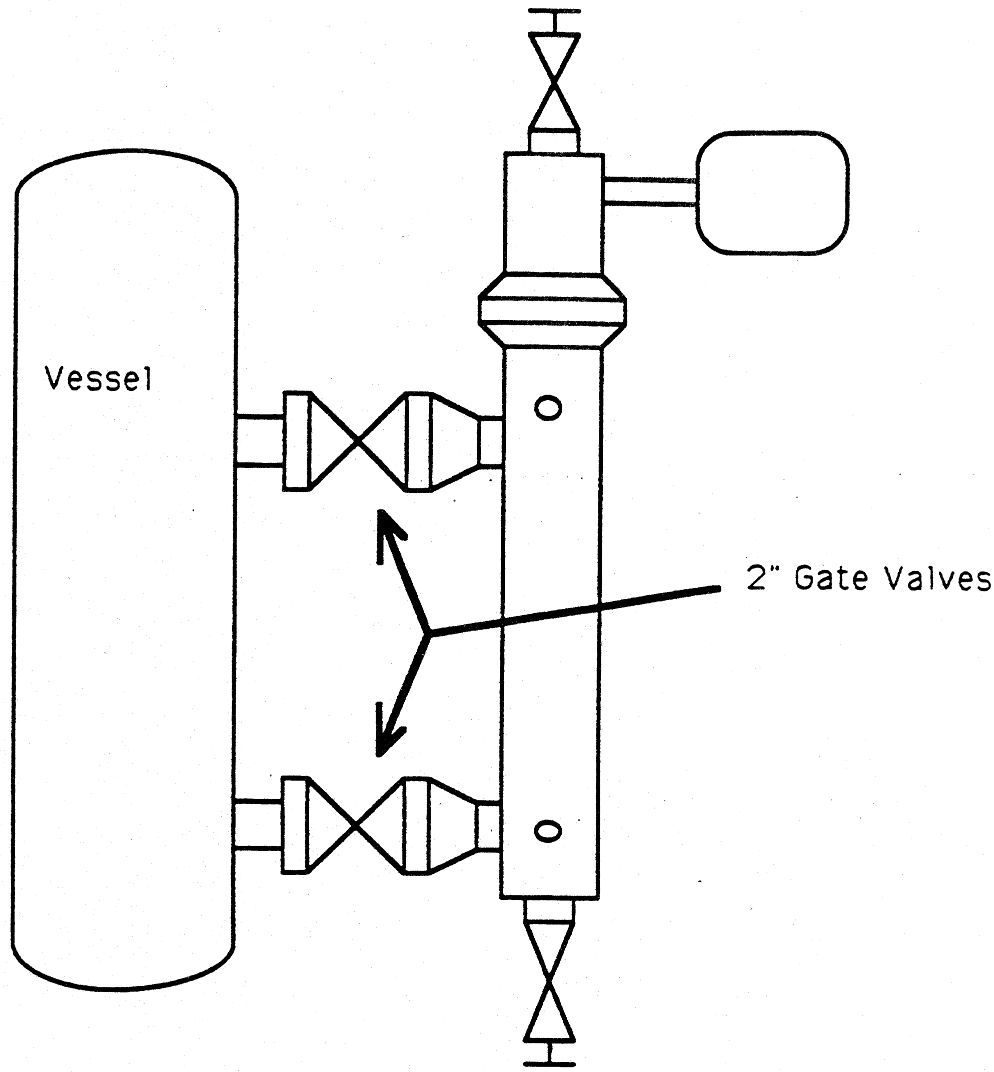


Figure 10-4
Basic Construction Of Displacer

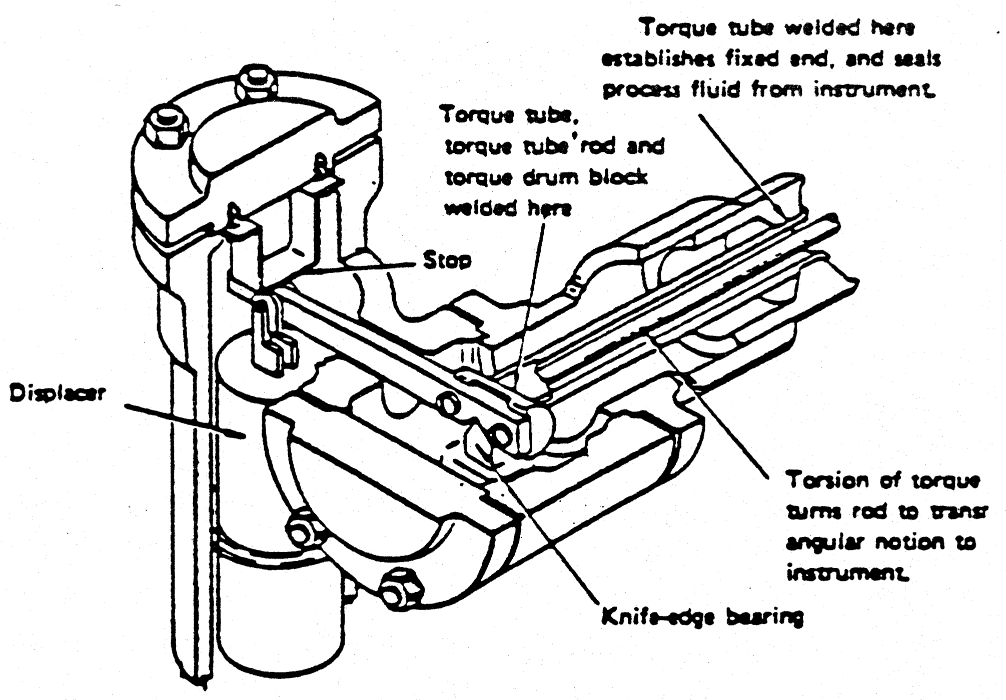


Figure 10-5
Vessel Connection Arrangements

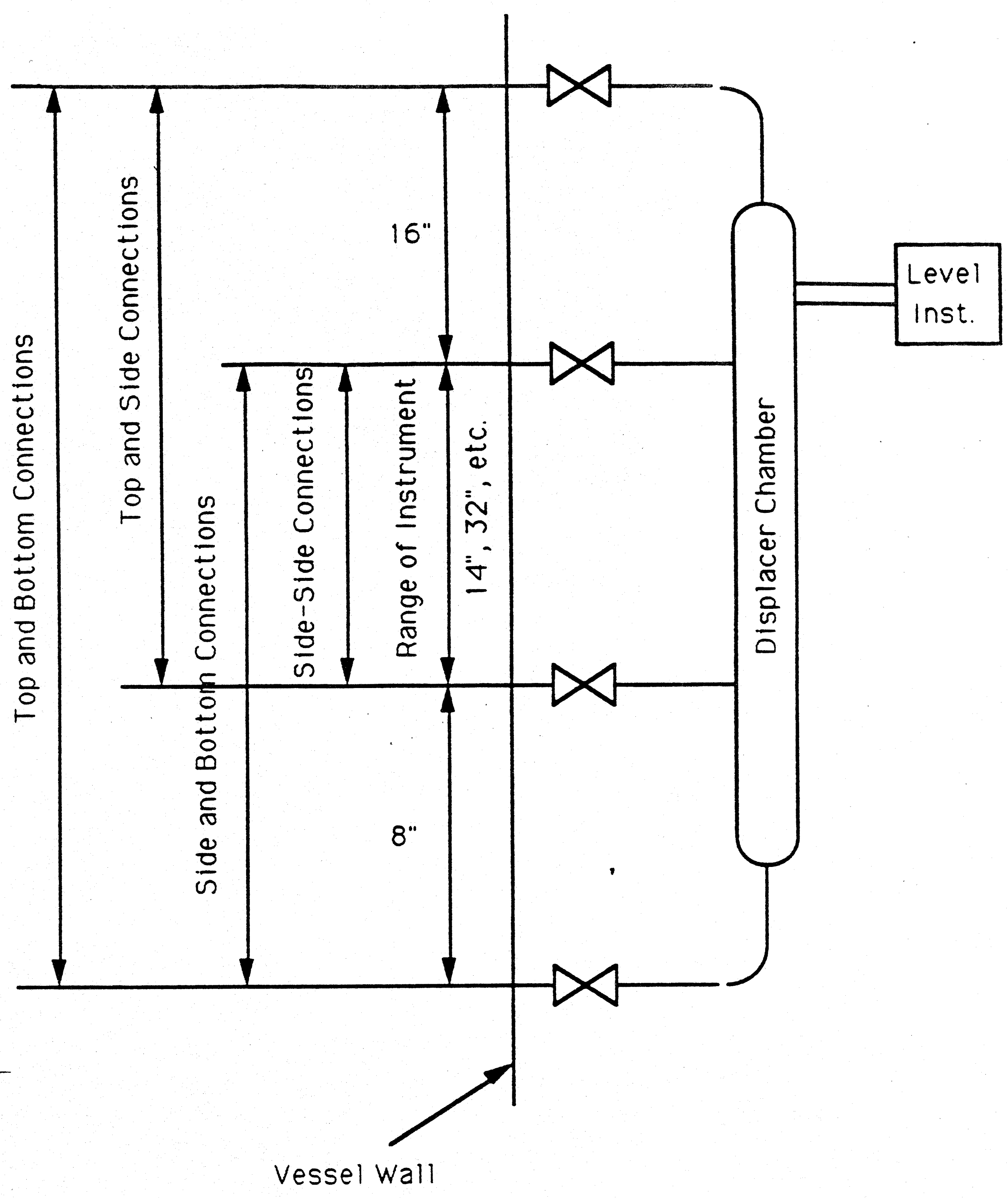


Figure 10-6
Level Errors Due To Specific Gravity Changes

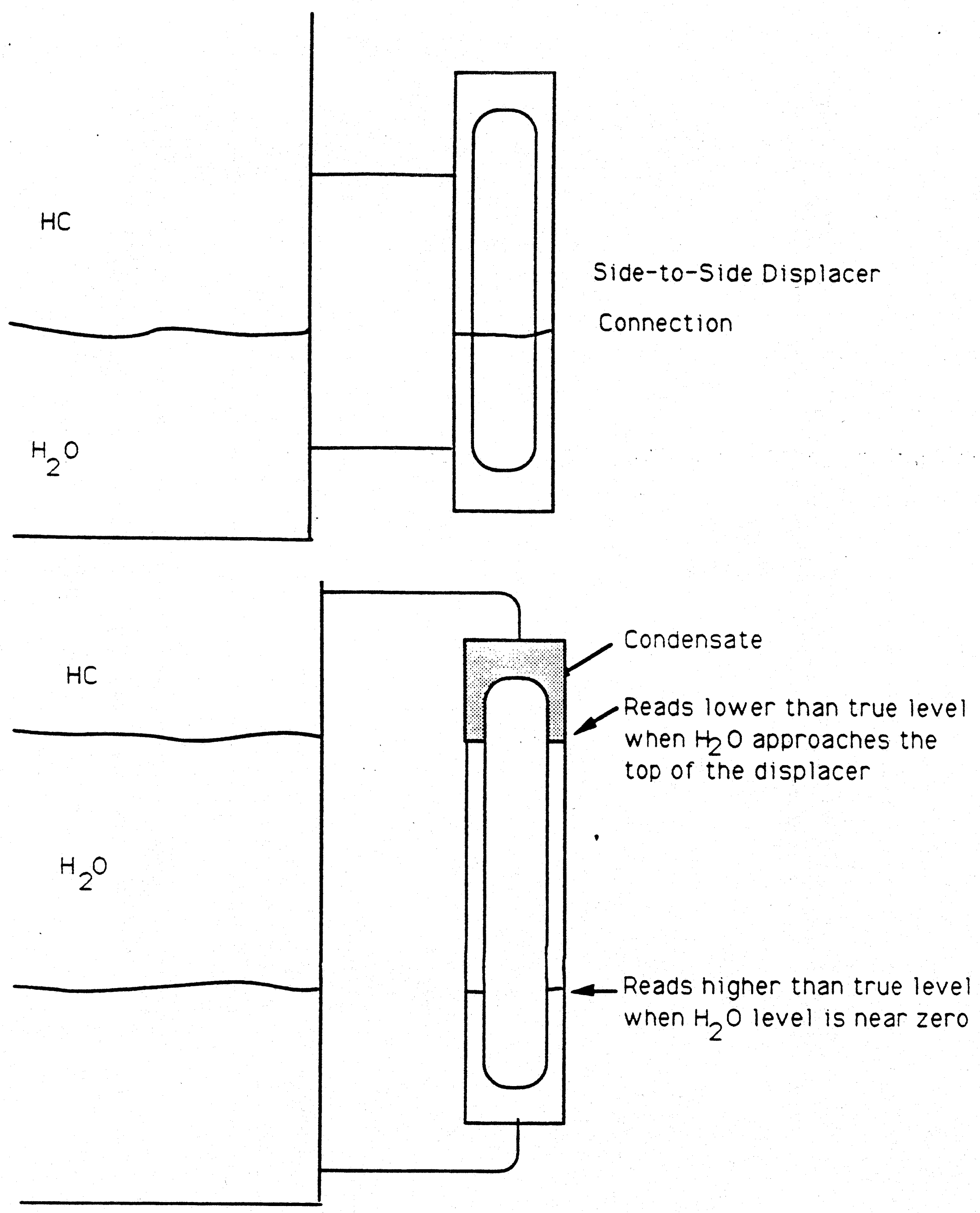


Figure 10-7
Displacer With Local Gauge Glass

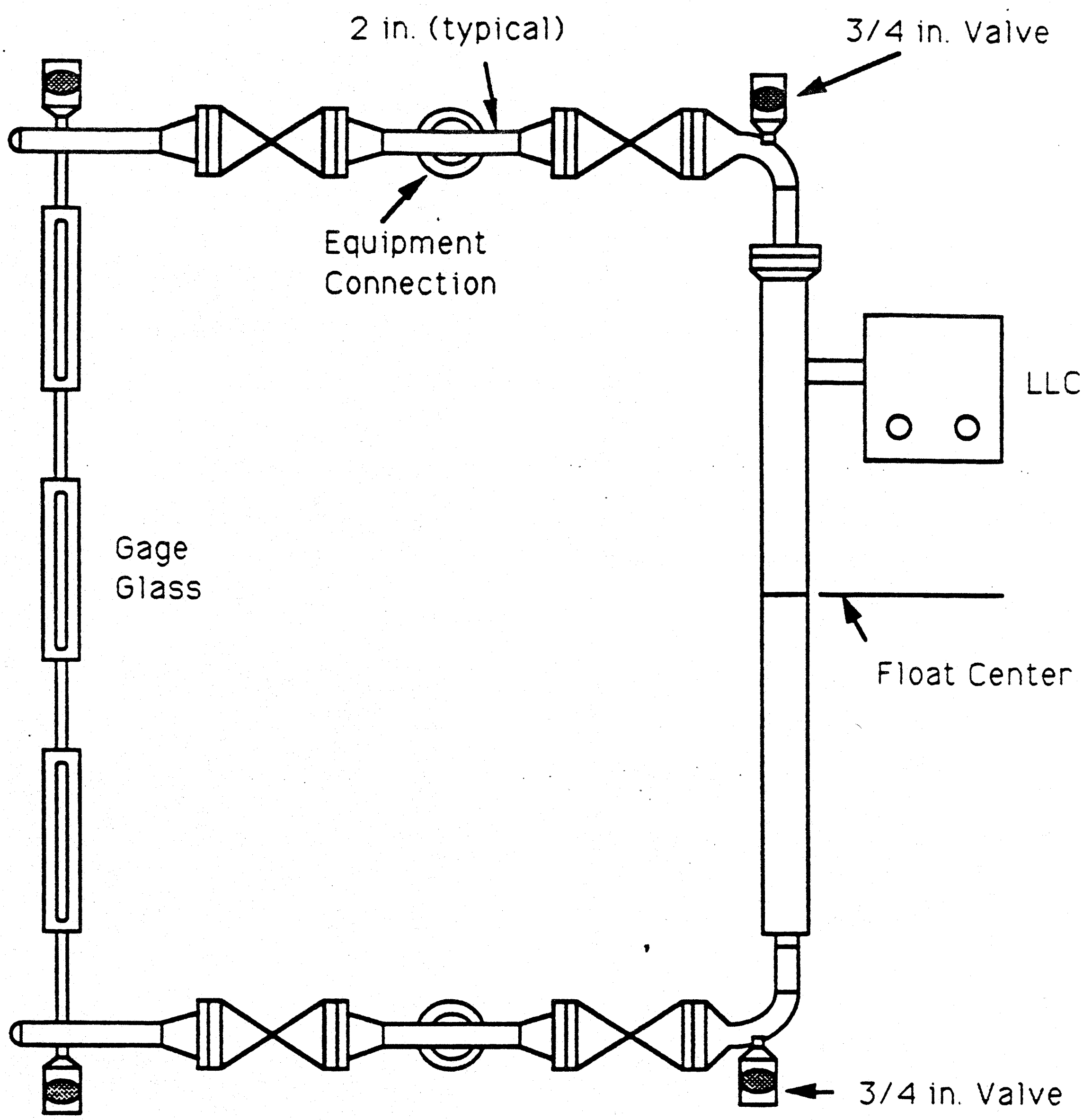


Figure 10-8
Displacer Installation Of Vessel Boot

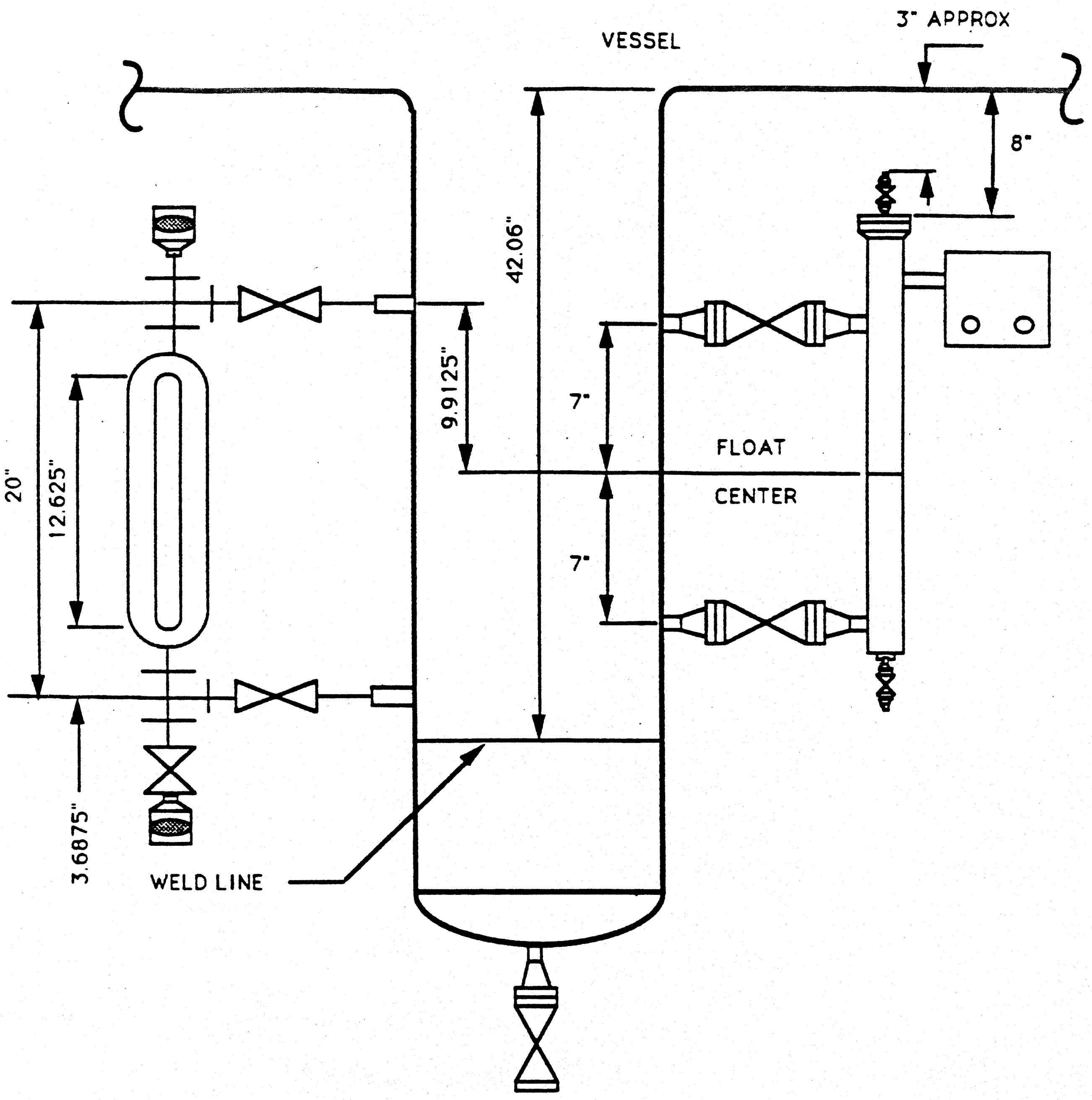


Figure 10-9

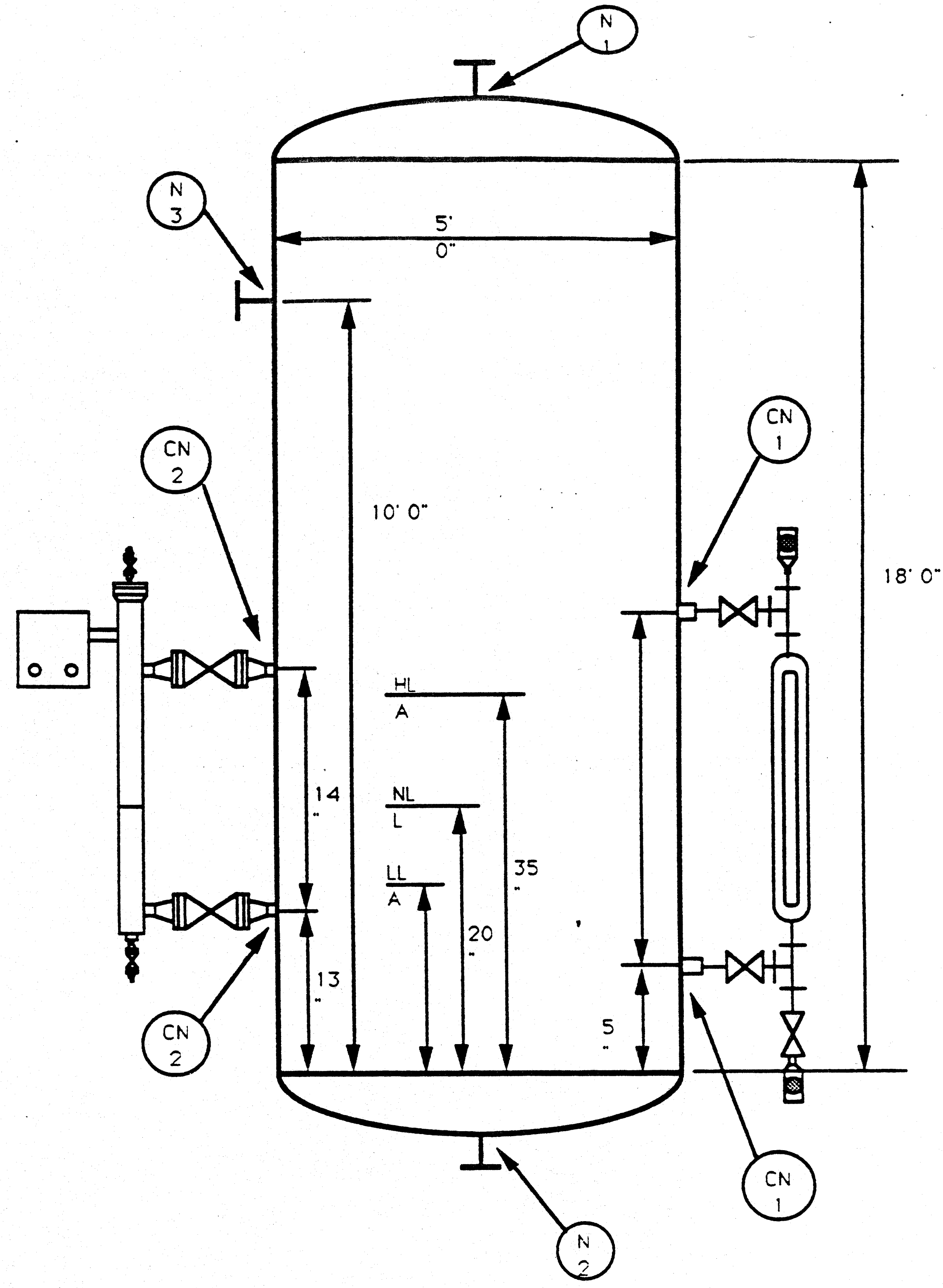


Figure 10-10
Magnetic-Follower Level Gauge

in safety service

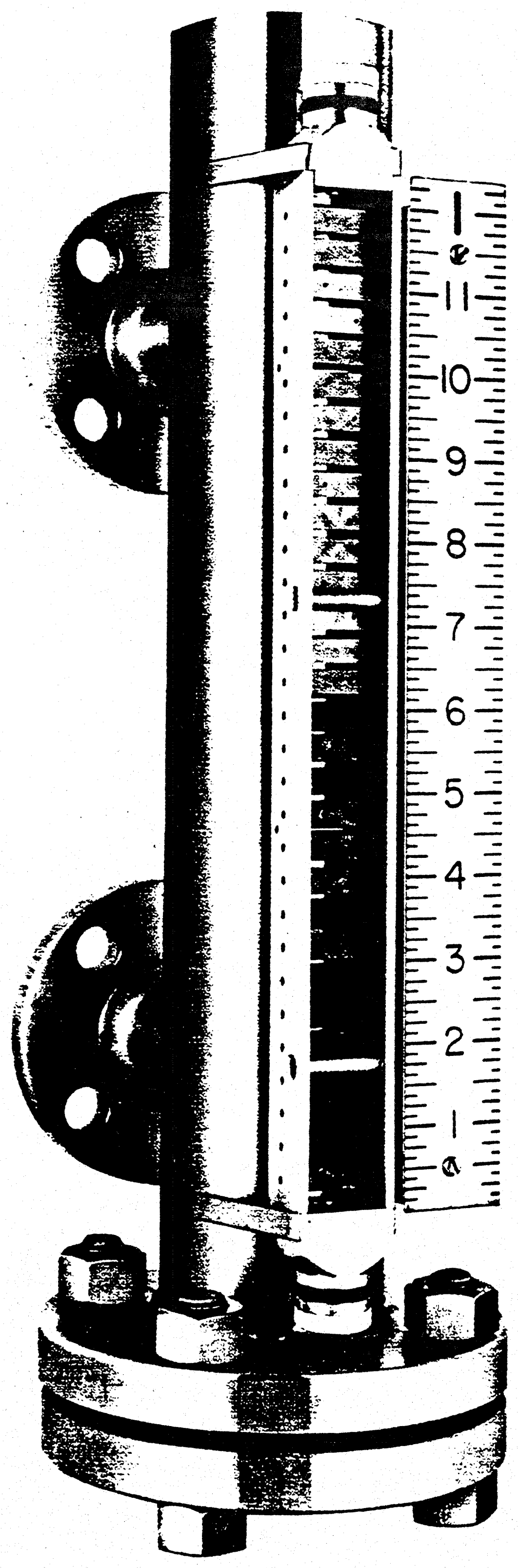
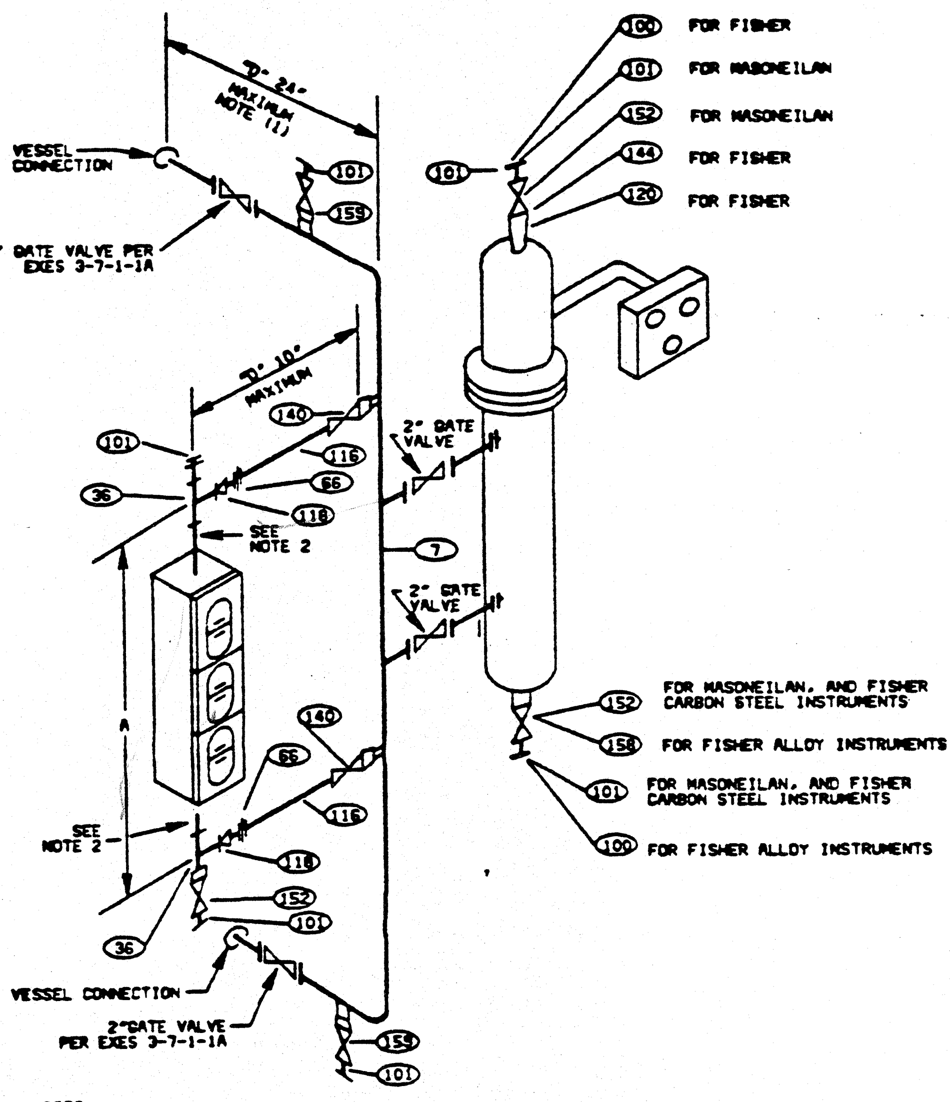


Figure 10-11
Level Gauge Bridle Assembly

EXXON ENGINEERING STANDARDS	LEVEL INSTRUMENT AND GAUGE GLASS PIPING	EXES 3-6-1-6C	
		REV. 4	MAY 1989
		Page 11 of 20	



NOTES:

(1) The above installation requires bracing on the bridle to avoid over-stressing the vessel connections if:

a. Dimension "D" is greater than 24 inches.
b. The external displacer range exceeds 60 inches.
c. More than five gauge glasses are used.
d. Vibration is likely.
e. The external displacer has a flange rating greater than 600 pounds ANSI.

(2) These nipples shall be XX heavy. Do not seal weld to the gauge glass body.

(3) The combination of a level instrument with the gauge glass column on a common bridle should be used only when it is necessary to minimize vessel connections.

II. D/P Cell

Another type of measurement device is the differential level device (D/P cell) shown schematically in Figure 10-12. When the level in a vessel changes more than 48 inches, a D/P cell begins to make more economic sense than a displacer. This device also connects externally to the vessel and is generally used where level variations are greater than can be measured by the displacer float. There are several installation variations of this device as shown in Figure 10-13.

The D/P cell is connected with its high-pressure side to the bottom of the vessel and its low pressure side to the vapor space in the vessel. In such an arrangement, the pressure differential sensed by the device varies with the hydraulic head of the liquid column in the vessel. Any internal vessel pressure is sensed by both the high and low side of this D/P cell and is canceled out. Thus the hydraulic head is a true indication of vessel level provided the fluid density remains constant. The pressure due to the fluid in the wet leg (Specific Gravity SG2) is a constant and is removed from consideration during calibration. This level measurement method is sensitive to composition, operating temperature, or liquid specific gravity changes and if these changes are not accounted for at the time they occur, errors will result.

The following derivation shows how the pressure (P) measured by a D/P cell relates directly to head (h).

$$P = h\,(ft_{liq}) \times \rho\,\frac{lb(m)}{ft3} x \frac{g}{gc} (\frac{lbf}{lbm})$$

$$= h \times \rho \text{ lb f/ft}^2 \text{ when } g = gc$$

to convert Pressure in lb ft/ft2 to psi, recall	1 $ft^{2'}$ = 144 in^2
therefore:	1 psi = 144 lb ft/ft^2
and:	10 psi = 1440 lb ft/ft^2

Transmitters read in Pressure (psi)

To get from PSI to head (in.) you must divide by ρ (assume = $\frac{g}{g_c} = 1\frac{lbf}{lbm}$)

therefore: $P = h \times \rho \Rightarrow h = P/\rho$

if liquid is water, and pressure is 10 psi, then,

$$P/\rho = \frac{10\,psi}{62.4\,lb_m/ft3} = \frac{1440\,lb_f/ft2}{62.4\,lb_m/ft3} = 23\,\frac{ft-lb_f}{lb_m} = 277\,\frac{in-lb_f}{lb_m}$$

now, $\frac{g}{g_c} = \frac{1\,lb_f}{lb_m}$, therefore $h = 277$ in H_2O

Using this relation, you can calibrate a transmitter in head (in. of water) using this relation.

To convert from head (in. of water) to head (in. of another liquid, use the specific gravity (S.G.) relation:

$$h_{liq} \times S.G. = \frac{P}{\rho} \times \frac{\rho}{\rho_{H_2O}} = \frac{P}{\rho_{H_2O}} = h \text{ (in } H_2O)$$

Figure 10-14 shows both wet and dry leg connections. The wet leg is shown in the right figure and is usually insulated, steam traced or sealed from the process fluid via a diaphragm and seal fluid. Dry legs are used when there is a need to sense internal tank pressure and there is no possibility of process fluids condensing in the dry leg (a cause of error that is proportional to the depth of condensate). If the tank is vented, there is no need for either a dry or wet leg. With either approach, it is common to use D/P cells where the level change is as much as 800" of liquid.

Whenever a D/P cell is used, we need to consider biasing the instrument in order to make sure the output (3-15 psi or 4-20 mA) reflects the actual range of operation in the tank/ vessel. This action is called zero suppression or zero elevation (depending on the direction of the bias) and is depicted in Figure 10-15. As one can see from these figures, the D/P cells would read a differential pressure and produce an output different than zero when the tank level was at zero level if no biasing were done.

In the top picture, the real zero (zero differential pressure across the D/P cell) occurs well below the level of the tank. When the tank level is at its zero point, the transmitter would be producing a reading greater than 3 psig (pneumatic) unless something is done. We want it to produce a 3 psig signal at this point so we need to elevate the span to read the real level in the tank accurately. In order to do this, we need to suppress the zero of this instrument. (Thus the instrument would read zero [3 psig] when the level in the tank is zero.) To see how this works, consider:

Full Tank:

High pressure side reads: 100" + x" (amount instrument is below tank bottom)
Low pressure side reads: 0"

Empty Tank:

High pressure side reads: x"
Low pressure side reads: 0"

In both cases, the delta across the D/P cell is greater than zero. For this to translate into the output range of the instrument, the zero needs to be suppressed. Thus the x" becomes the new zero output of the instrument.

In the case of the lower picture, the wet leg changes the situation so that the low pressure side of the cell always sees a higher pressure than the high pressure side. Thus the cell is always seeing negative pressure differences. Thus the range is from one negative number to less negative number. For example, from -200 inches to -100 inches of water. For this situation to translate into the correct 3 to 15 psi signal, the span of the instrument needs to be suppressed to match the negative band observed.

Another way to think about this is that whenever the span of the instrument is elevated, the zero is suppressed and vice versa.

Figure 10-12
Differential Level

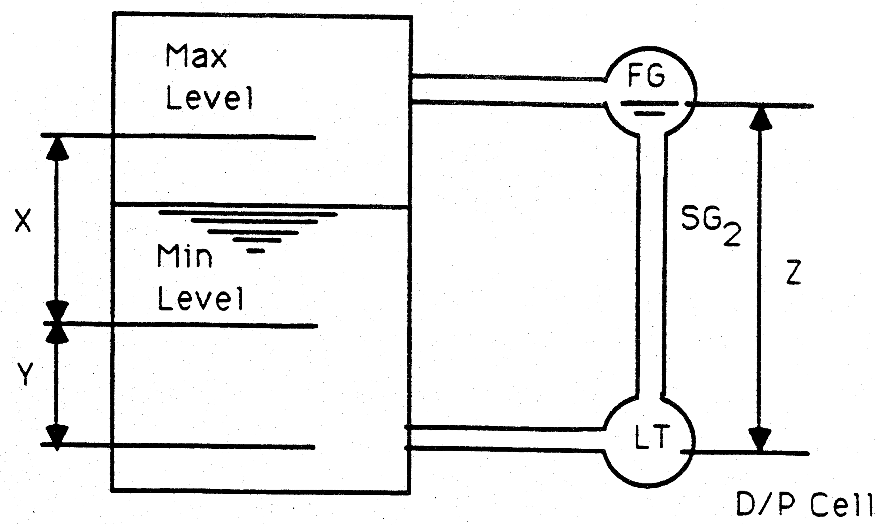


Figure 10-13
Installation Variations In Differential Level

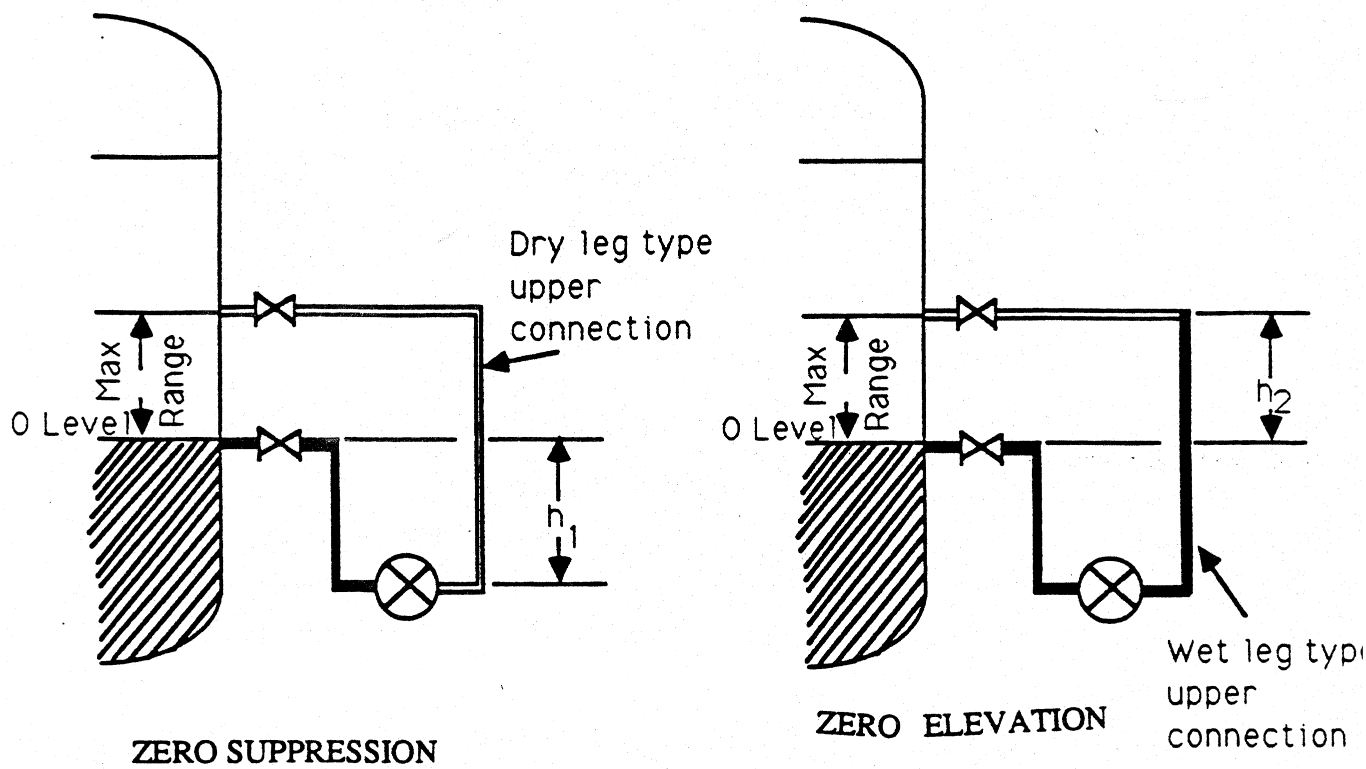


Figure 10-14

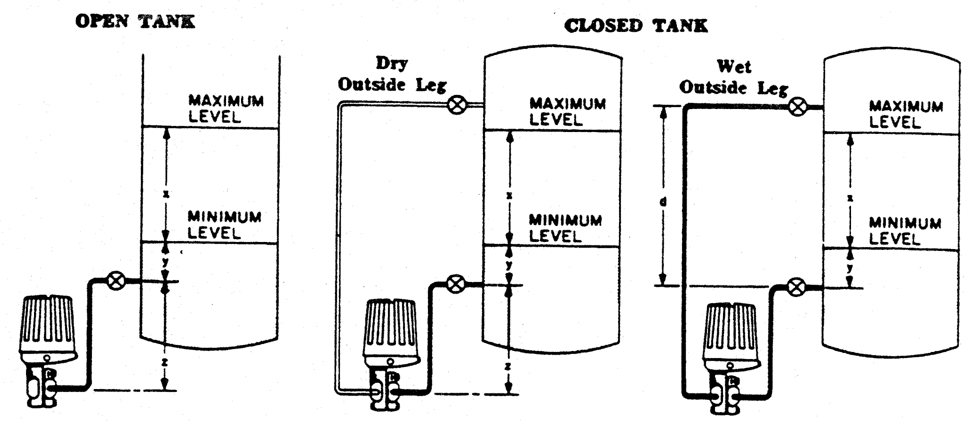


Fig. 3-7.

Span $= xG_L$
Suppression $= yG_L + zG_s$

Span $= xG_L$
Suppression $= yG_L + zG_s$

Span $= xG_L$
Elevation $= dG_s - yG_L$

Where G_L = specific gravity of liquid in tank

G_s = specific gravity of liquid in outside filled line or lines

If transmitter is at level of lower tank tap, or if air purge is used, $z = 0$.

(Note: The density of the gas in the tank has been disregarded in these calculations.)

EXAMPLE: Assume an open tank with $X = 80$ inches, $y = 5$ inches, and $z = 10$ inches. The specific gravity of the tank liquid is 0.8; the specific gravity of the liquid in the connecting leg is 0.9.

Span = 80 (0.8) = 64 inches head of water

Suppression = 5 (0.8) + 10 (0.9)

= 4 + 9 = 13 inches head of water

Range = 13 to 77 inches head of water

EXAMPLE: Assume a closed tank with $X = 70$ inches, $y = 20$ inches, and $d = 100$ inches. The specific gravity of the tank liquid is 0.8; a sealing liquid with a specific gravity of 0.9 is used.

Span = 70 (0.8) = 56 inches head of water

Elevation = 100 (0.9) − 20 (0.8)

= 90 − 16 = 74 inches head of water

Range = −74 to −18 inches head of water

D/P cell technology forms the basis for hydrostatic tank gauging (HTG). In this case, three pressure readings may be taken as shown in Figure 10-16. Recall that the fluid density is given by:

$$\rho = \frac{P_1 - P_2}{H} = \#/in^3$$

the mass of fluid in the tank is:

$$m = V \times \rho \text{ where } V = \text{fluid volume}$$

$$= h \times A \times \rho = h \times \rho \times \left[\begin{array}{c} \text{Look up A vs h in} \\ \text{Strapping Tables} \end{array} \right] = h \times \rho \times [A(h)]$$

and,

$$h = \frac{P_1 - P_3}{\rho}$$

Therefore,

$$m = \frac{P_1 - P_3}{\rho} \times \rho [A(h)]$$

$$= (P_1 - P_3)[A(h)]$$

Thus, the mass of the fluid in the tank is given by the difference in the bottom tank pressure and the top tank pressure times the area as given by the strapping table for the tank. Note that one would have to use the average area over the height of the fluid. While these calculations may be cumbersome by hand, they are automated in the HTG systems. Figure 10-17 shows a schematic of one integrated system where HTG technology exists with older technology in a tank farm setup.

Table 10-1 Wet Leg Seal Fluids

Table 8-1—General Properties of Sealing and Manometer Liquids

	Specific Gravity		Action with Water Vapor	Vapor Pressure (millimeters of mercury)	Viscosity (centipoises)		Freezing Point		Boiling Point		Flash Point	
	60 F/60 F (15.6 C/15.6 C)	68 F/60 F (20.0 C/15.6 C)			60 F (20 C)	68 F (20 C)	F	C	F	C	F	C
Water	1.0000	0.9992	—	17.5	1.1249	1.0050	32	0	212	100	Nonflammable	—
Mercury	13.57	13.56	Negligible	0.0012	1.62	1.6	−38	−38.9	679	359	Nonflammable	—
Kerosine, 41 deg API at 60 F	0.8200	—	Negligible	—	2.2	2.0	−20	−28.9	300+	149+	120	49
Ellison gage oil	0.8340	—	Negligible	—	—	—	—	− 4.46	300+	149+	140	60
Halowax oil	—	1.19 to 1.25	—	0.3[a]	—	—	24 to −42	−41	—	—	203	95
Ethyl alcohol, C_2H_6O	0.7939	0.7907	Absorbs	43.9	1.3	1.2	−179	−117	173	78	55	12.8
36 percent by volume ethyl alcohol in ethylene glycol	—	1.000	Absorbs	—	—	—	−60	−51	173	78	70	21.1
Ethylene glycol, $C_2H_6O_2$	1.117	1.114	Absorbs	0.12	25.66	20.9	9	−12.8	388	198	245	118
50 percent by weight ethylene glycol in water	1.068	1.065	Absorbs	13.3	4.364	3.76	−32	0	225	107	Nonflammable	—
Butyl Cellosolve (ethylene glycol monobutyl ether), $C_6H_{14}O_2$	—	0.9019	Absorbs	0.85	—	3.3	−100	−73	340	171	155	68.5
Carbitol solvent (diethylene glycol monoethyl ether), $C_6H_{14}O_3$	—	1.0273	Absorbs	0.13	—	—	−76	−60	383	195	205	96
Glycerin (glycerol), $C_3H_8O_3$	1.2650	1.2623	Absorbs	9.4	—	1,410.0	64	17.8	554	290	320	160
50 percent by weight glycerin in water	1.1295	1.1274	Absorbs	—	7.5	5.99	−9.4	−23	223	106	—	—
Dibutyl phthalate, $C_{16}H_{22}O_4$	—	1.0484	Negligible	0.01	—	20.3	−31	−35	642	339	340	171
Benzene (benzol), C_6H_6	0.884	0.8794	Negligible	74.7	0.7	0.66	42	5.6	176	80	12	−11
oDibromobenzene, $C_6H_4Br_2$	—	1.959	Negligible	—	—	—	35.2	1.8	430	221	150+	66+
1,1-Dibromoethane, $C_2H_4Br_2$	—	2.093	Negligible	34.7	1.85	1.7	40	4.46	230	110	150+	24+
Acetylene tetrabromide (tetrabromoethane), $C_2H_2Br_4$	—	2.969 slightly	Absorbs	—	—	—	−4	−20	—	—	Nonflammable	—
Fluorolubes FS (trifluorovinyl chloride polymers)	1.868	—	—	0.018[b]	—	—	−75	−59	—	—	—	—
Fluorochemical N-43, $(C_4F_9)_3N$	1.872	—	—	—	—	—	−58	−50	—	—	—	—
Fluorochemical O-75, $C_8F_{16}O$	1.760	—	—	—	—	—	−148	−100	—	—	—	—
Kel-F oil (trifluorochloroethylene polymers)	1.910	—	—	—	—	—	<−35	−37	—	—	—	—

[a] At 122 F (50 C).
[b] At 100 F (37.8 C)

Figure 10-16
Hydrostatic Tank Gauging System

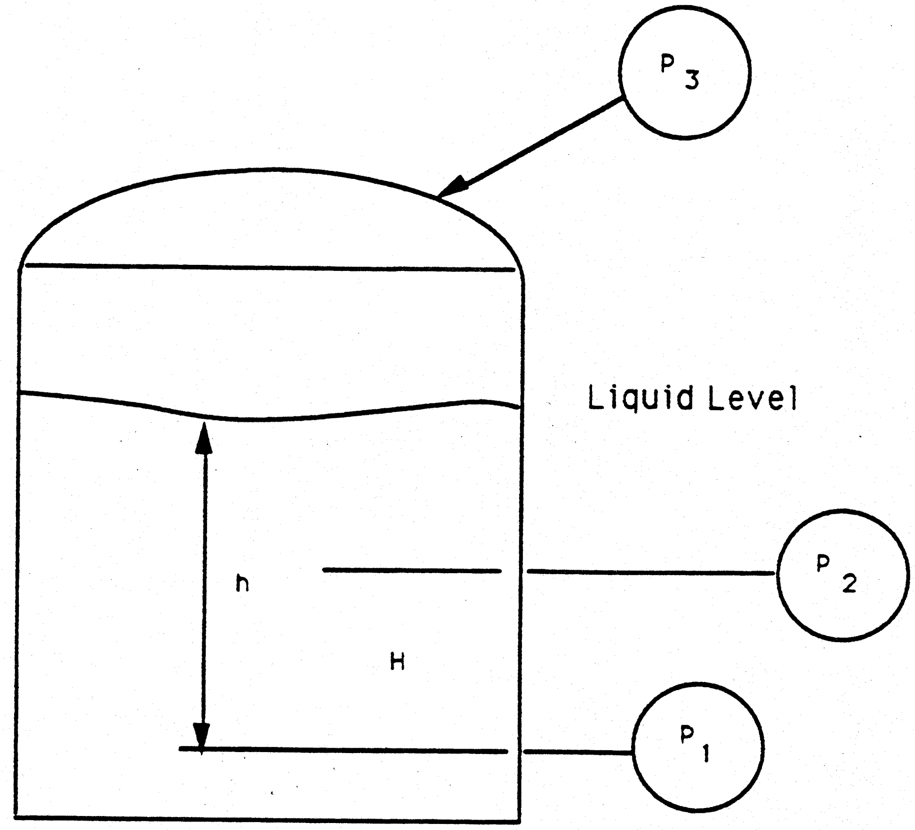
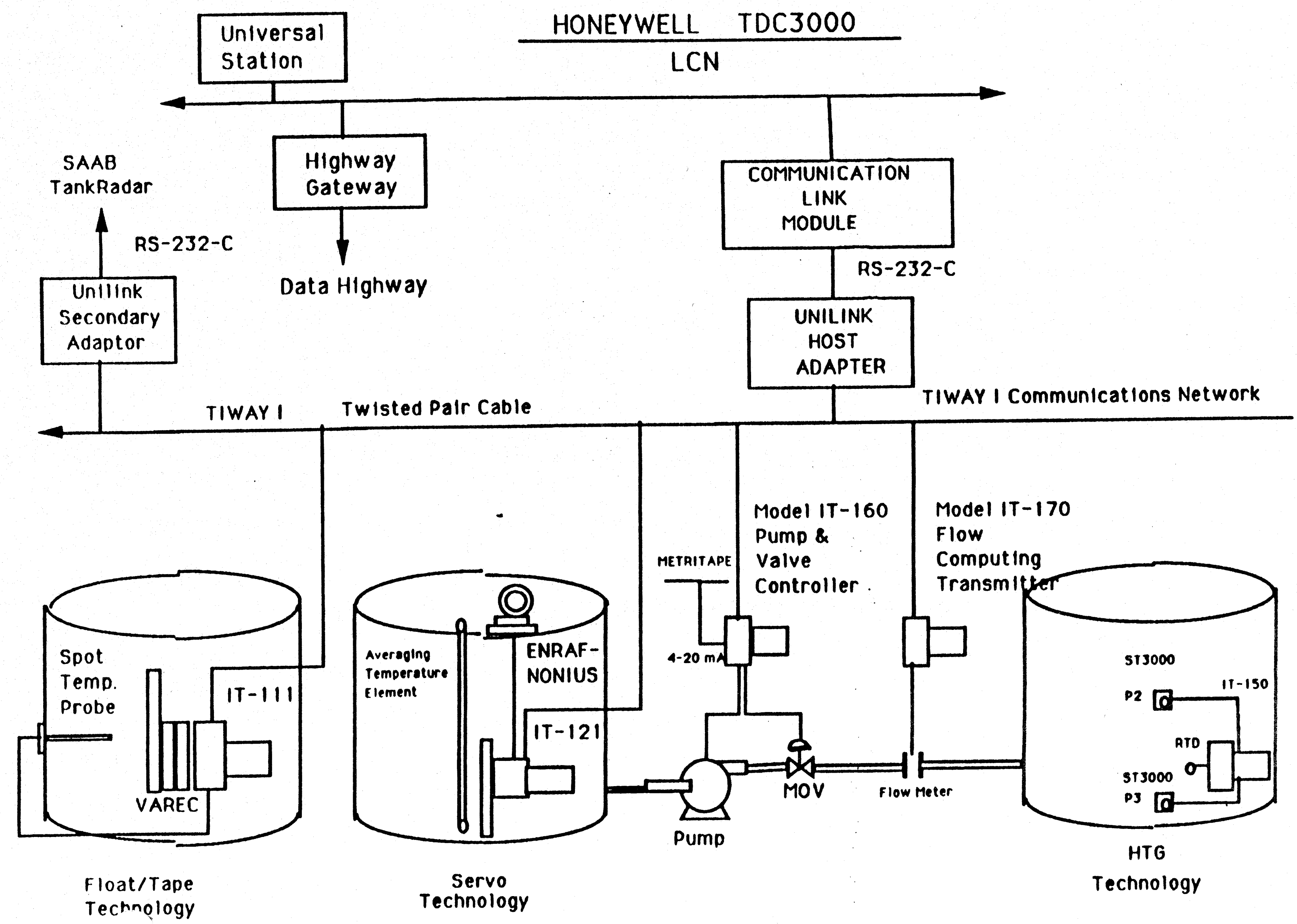


Figure 10-17
Integrated Tank Gauging System

Integrated Honeywell TDC 3000 and TI Tank Farm Automation



III. Bubbler

A bubbler instrument is shown in Figure 10-18. With this instrument, liquid level is determined by measuring the pressure required to force a gas into the liquid at a point beneath the surface.

A source of clean air or gas is connected through a regulator to a bubble tube immersed at a fixed depth in the tank/vessel. The regulator reduces the air flow to a minute amount, which builds up pressure in the bubble tube until it just balances the fluid pressure in the bubble tube. Thereafter, pressure is kept at this value by air bubbles (excess air) escaping through the liquid. Changes in the measured level cause the air pressure in the bubble tube to build up or drop. A pressure instrument is usually connected to the bubbler tube to register the level of liquid in the tank/vessel.

This system is calibrated in inches of H_2O, although other engineering units are possible. The system is very good for measuring the level of dirty and corrosive fluids, but care is needed to prevent plugging. Usually a 2-3 inch space is left between the bottom of the bubbler tube and the tank/vessel bottom.

The major drawback of this system is that it introduces a foreign substance into the process.

IV. Floats

Float level switches and indicators are designed with a float that follows the liquid level or interface level between liquids of differing specific gravities. Figure 10-19 shows an internal type ball float. Although a float installed this way avoids plugging, or boiling problems associated with some other designs, the installation of the float inside the tank makes it unserviceable. In addition, it can only be tested using the level in the vessel. For these reasons, this design cannot be recommended.

Figure 10-20 shows an external arrangement used for alarms and shutdowns. The external cage can be isolated by valves to allow maintenance. Again, the float design must be compatible with the fluid. Attachment to the tank must be at the proper height to allow the primary function (alarm or shutdown) to be achieved.

Figure 10-18

BUBBLER SYSTEM

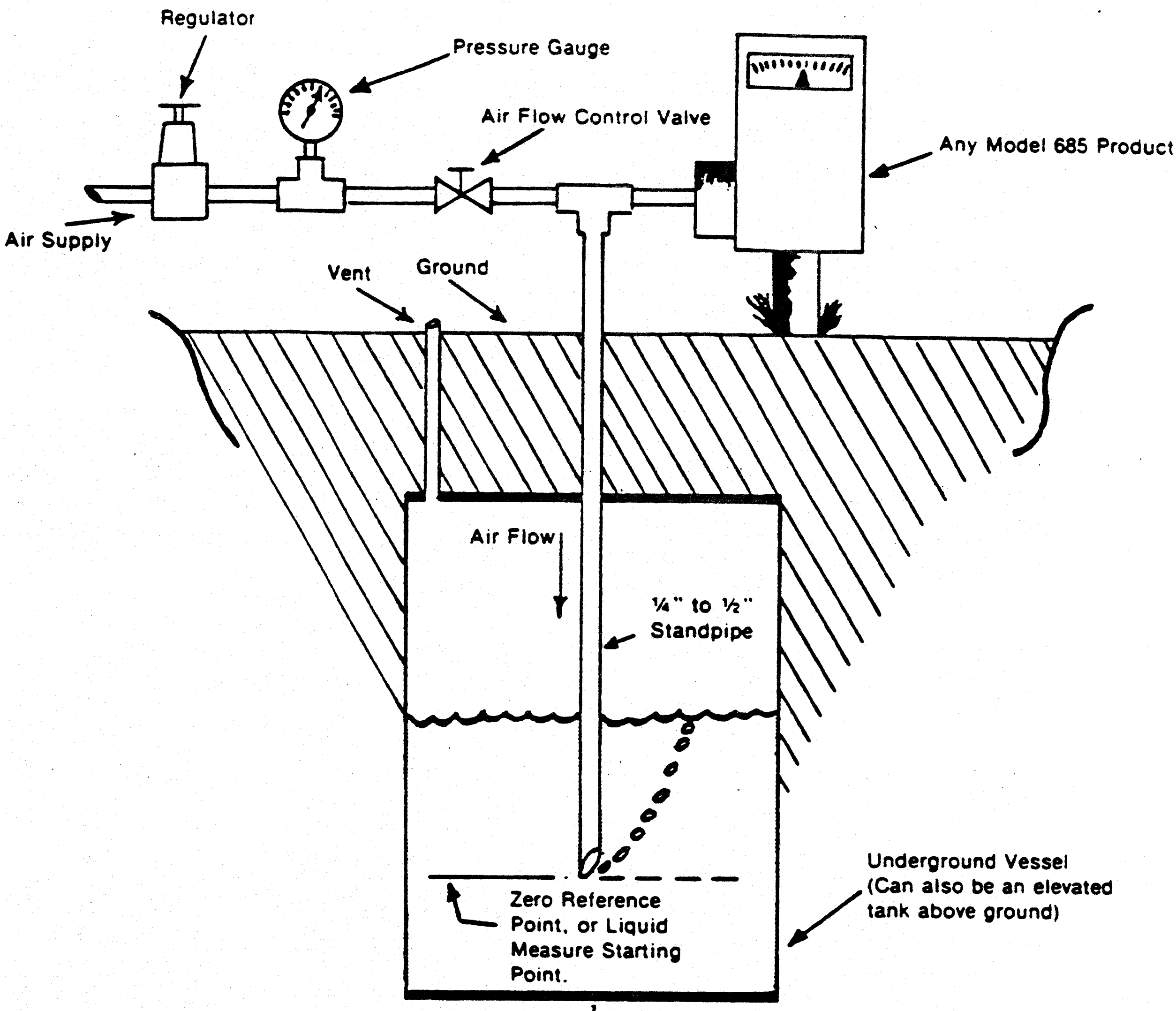


Figure 10-21 shows how the position of the float is detected magnetically for a switch operation. This kind of device can be used to detect high levels in compressor or fuel gas knockout drums and can trigger high or low level alarms.

Figure 10-22 shows the piping arrangement used to attach a level float to vessel. Location 66 on the figure is where unions exist for easy installation/removal of the instrument. Location 102 is for attaching the test equipment.

V. Float and Tape Mechanisms

Figure 10-23 shows the typical installation of a float and tape. This is probably the most direct and simple method of level measurement. In this setup, a tape is connected at one end to a float and to a counterweight on the other to keep the tape under constant tension. Any float motion caused by level changes causes the counter weight to ride up and down a direct reading gauge board, thereby indicating level in the tank to an outside observer. This device can be used without difficulty on any tank left vented to atmosphere. For pressurized tanks, this method requires seals or some indirect (e.g. magnetic coupling) way to transfer the tape motion to an external display. Figure 10-24, 10-25, 10-26.

VI. Ultra-sonic Level Instrument

Figure 10-27 illustrates a typical ultra-sonic level instrument installation. The operating principal of this instrument is as follows:

The sender/receiver sends out a burst of sound waves which are directed at the surface of the material to be measured. These waves travel to the material and are reflected back towards the sender/receiver unit at the same frequency at which they were generated. The time necessary for the sound waves to profligate through the air or gaseous medium to the material and back to the sender/receiver is linearly proportional to the distance separating them. This elapsed time is used to produce an output signal equal to the material level.

Care must be taken when installing/mounted this instrument that its sound beam is free to travel straight to the material surface and back without any obstructions such as pipes, braces, etc. being in its path. Such obstructions can cause premature reflections which led to level measurement errors.

Figure 10-19

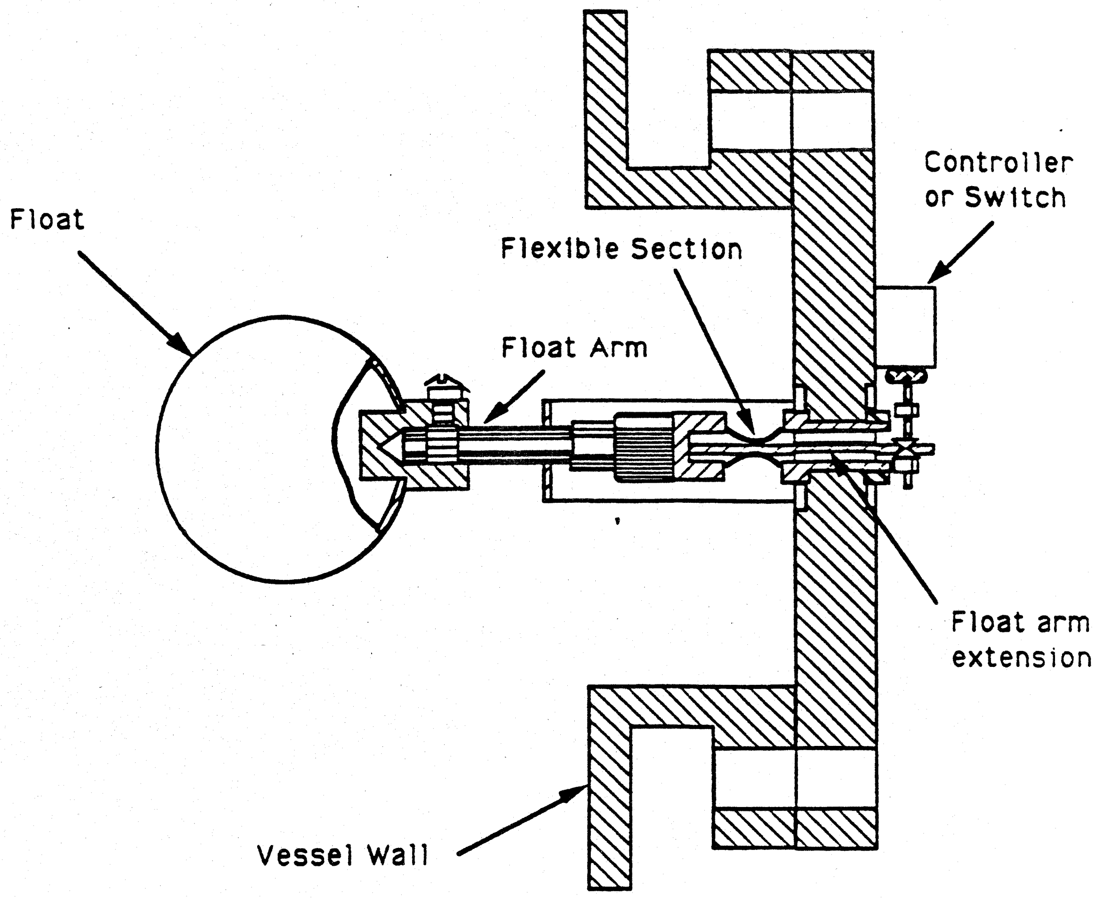
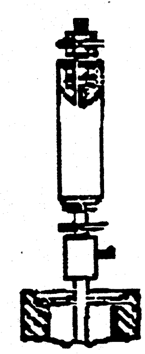
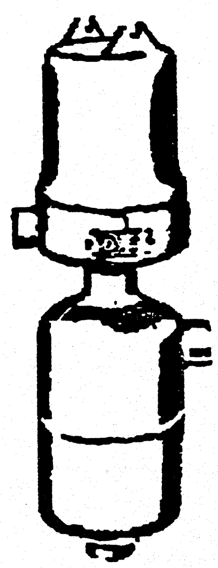

Float
Flexible Section
Float Arm
Controller or Switch
Float arm extension
Vessel Wall

Figure 10-20



SHEATHED TYPE
ATTRACTION SLEEVE



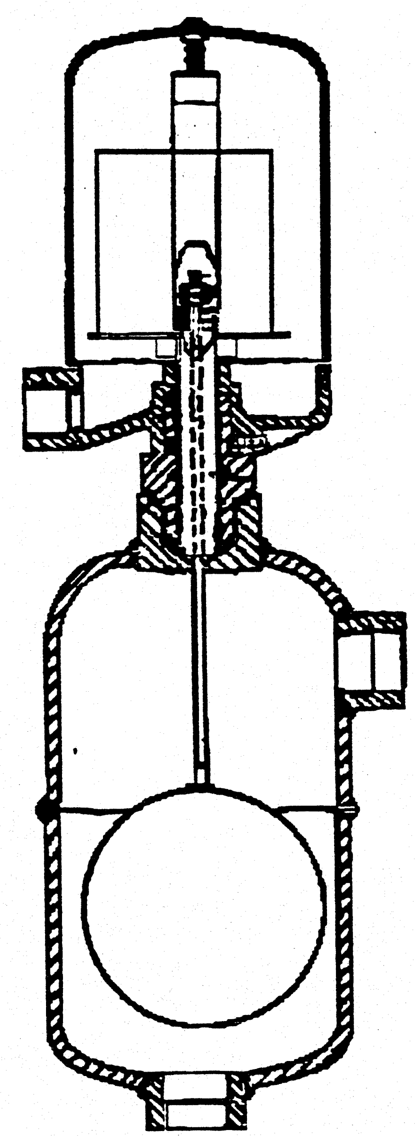
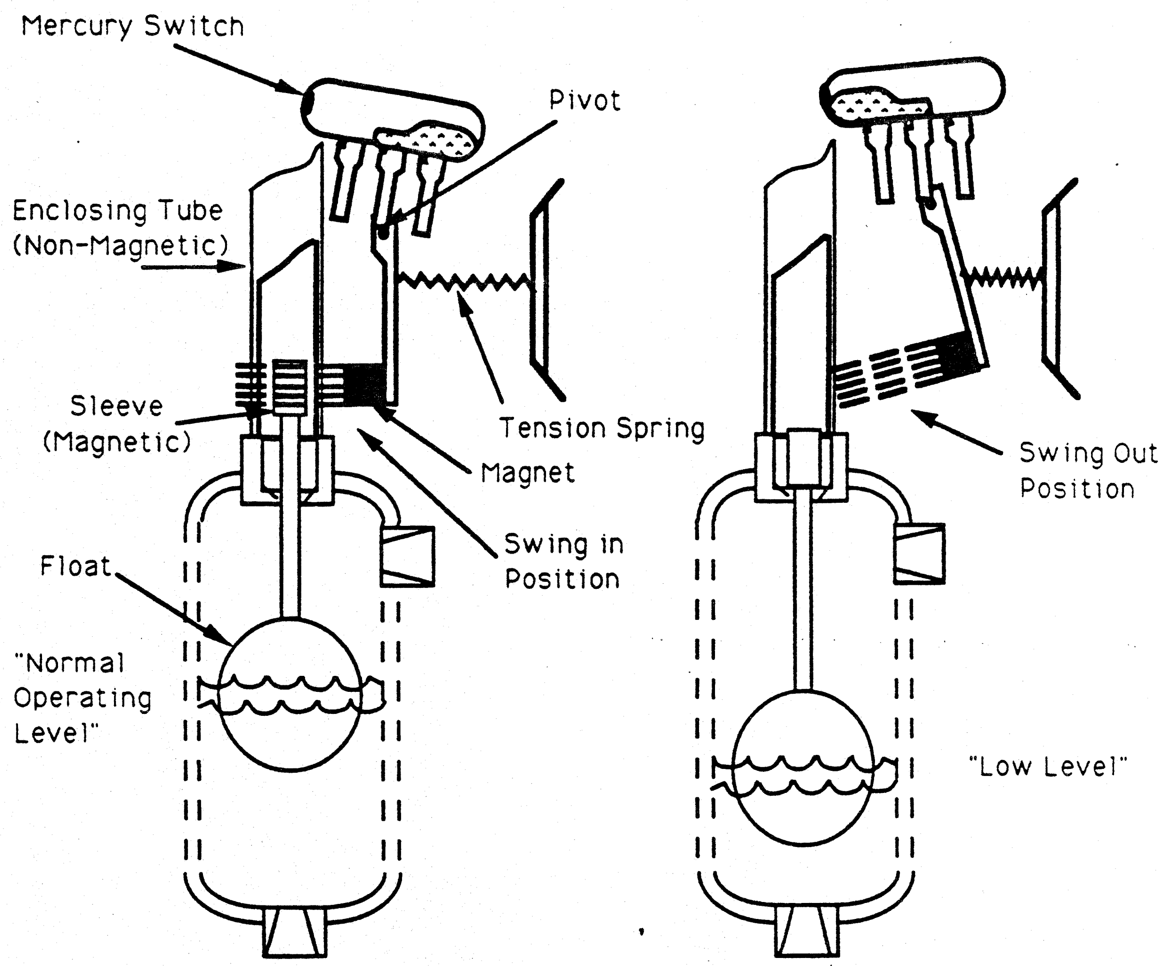
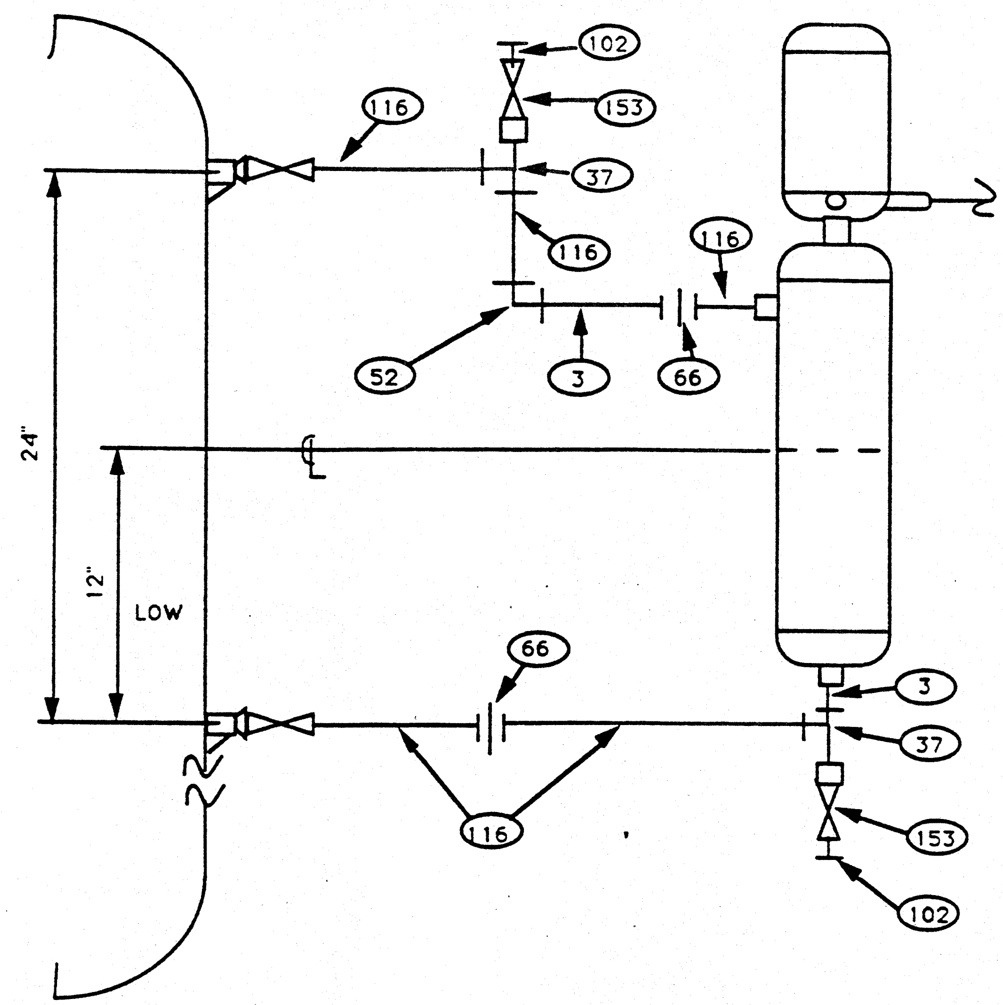


Figure 10-21



Mercury Switch
Pivot
Enclosing Tube
(Non-Magnetic)
Sleeve
(Magnetic)
Tension Spring
Magnet
Swing in
Position
Float
"Normal
Operating
Level"
Swing Out
Position
"Low Level"

Figure 10-22



LIST OF MATERIALS

3	PIPE 1", CS, SEAMLESS, EXTRA STRONG
37	TEE, CS, 1", 3000 LB., THREADED
52	ELBOW, CS, 1", 90 DEGREE, THREADED, 2000 LB.
66	UNION, CS, 1", THREADED, 3000 LB.
102	PLUG, 1" DIAMETER X 2" LONG, THREADED
116	NIPPLE, CS, 1" DIA. X 3" LONG, X-STG SEAMLESS PIPE
153	VALVE, GATE, CS, 1", 600#, EXT BODY, M-THD EXT. F-THD.KLK

Figure 10-23

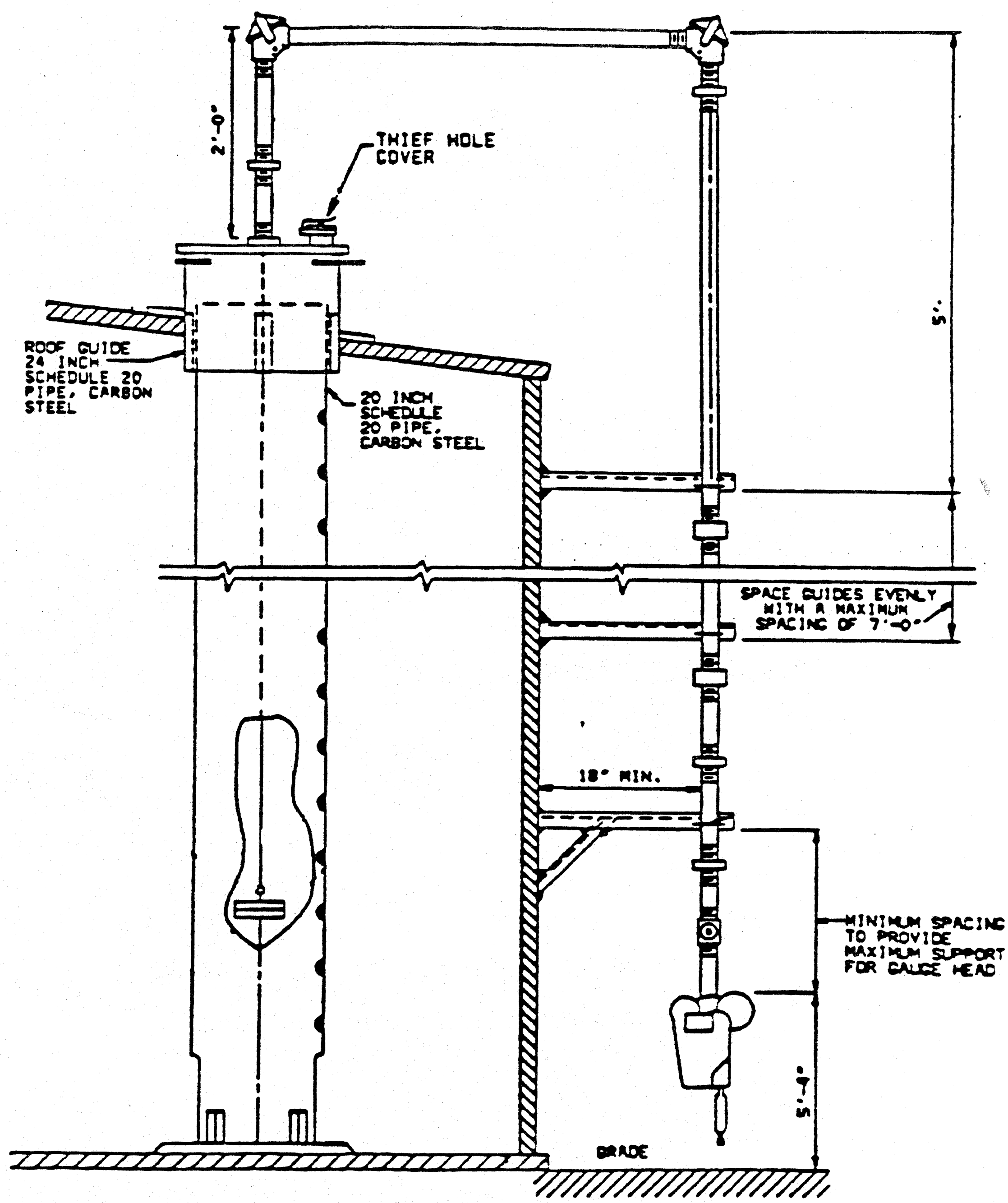

THIEF HOLE COVER
2'-0"
ROOF GUIDE 24 INCH SCHEDULE 20 PIPE, CARBON STEEL
20 INCH SCHEDULE 20 PIPE, CARBON STEEL
5'
SPACE GUIDES EVENLY WITH A MAXIMUM SPACING OF 7'-0"
18" MIN.
MINIMUM SPACING TO PROVIDE MAXIMUM SUPPORT FOR GAUGE HEAD
5'-4"
GRADE

Figure 10-24
Enraf Servo Gauge

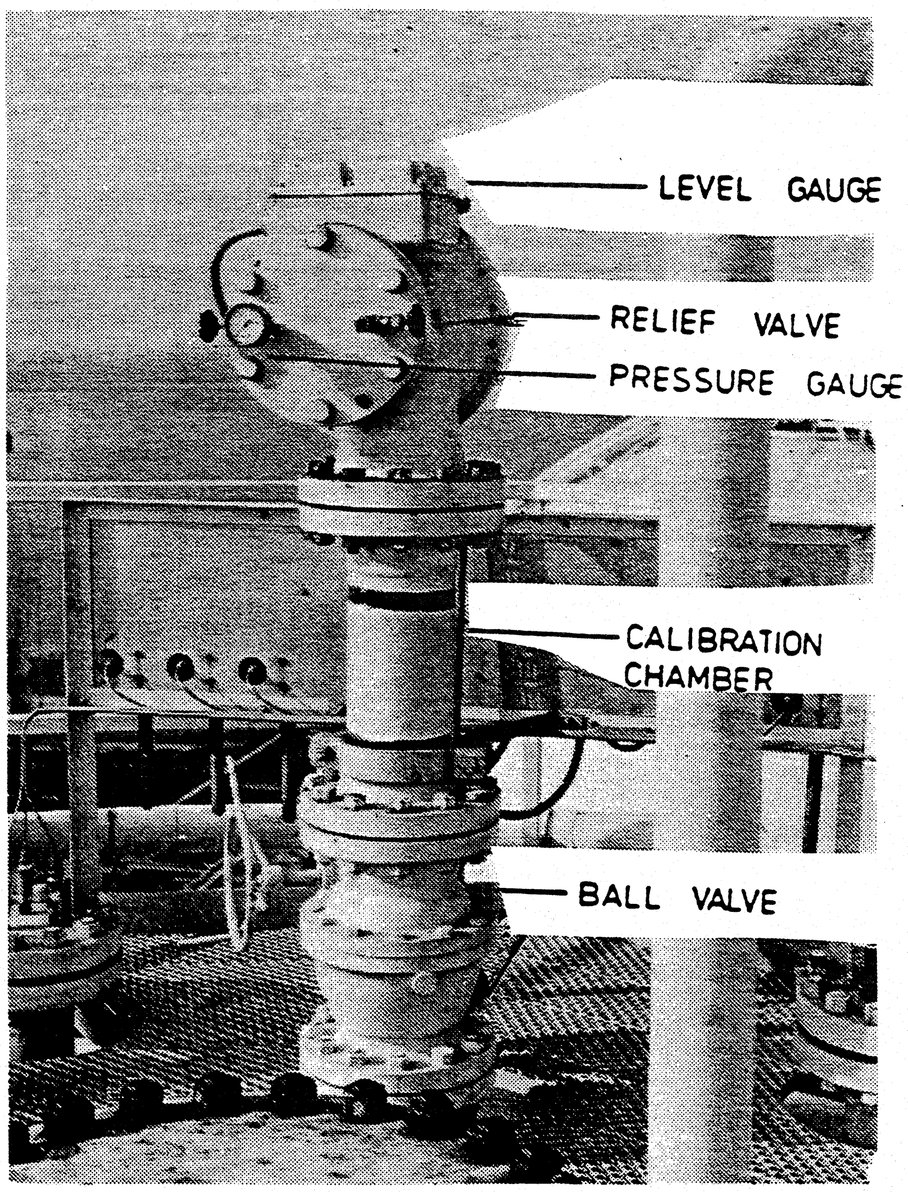


Figure 10-25
Pressurized Vessel With Still Pipe

MOUNTING OF LEVEL GAUGE ON A SPHERICAL TANK WITH STILL WELL

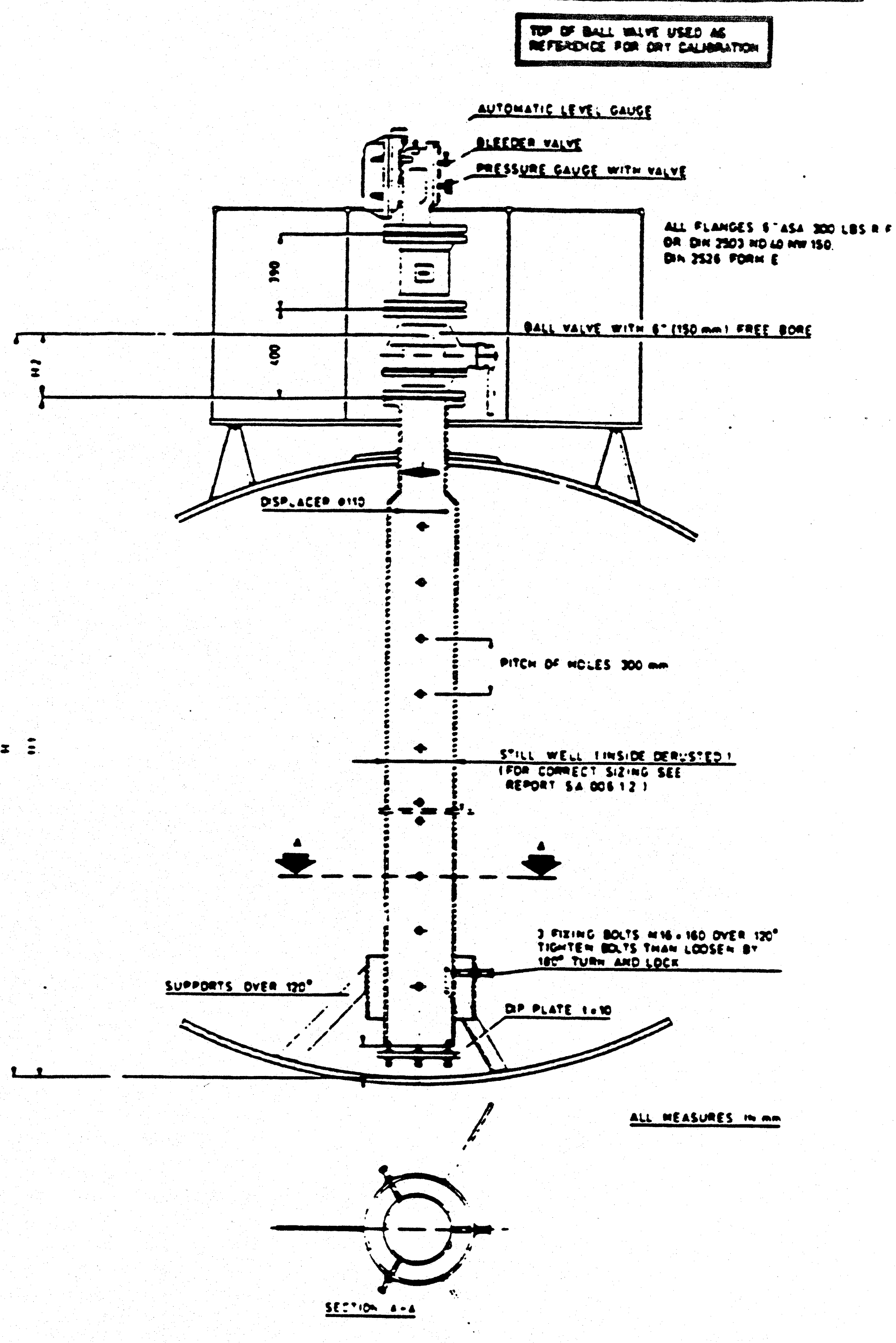
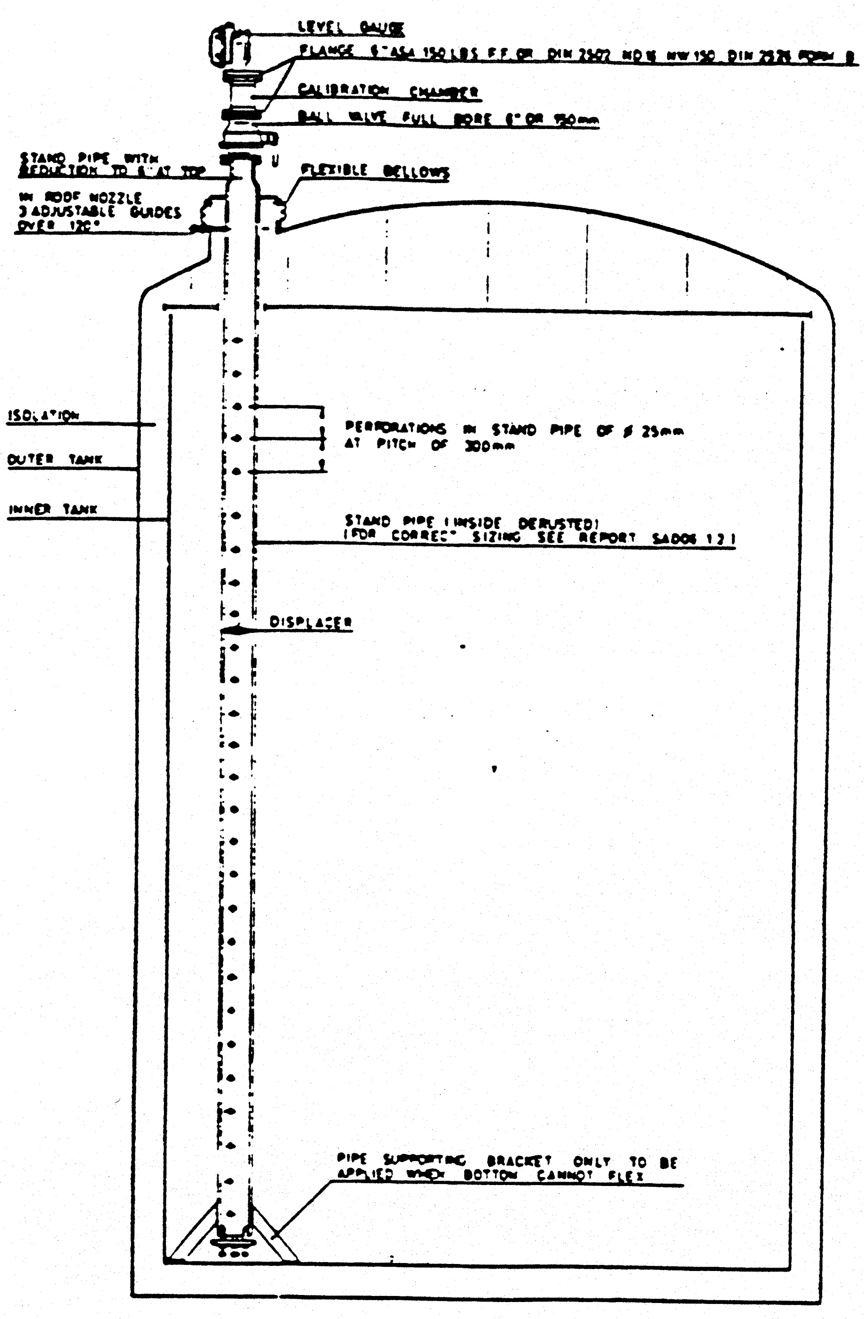


Figure 10-26
Cryogenic Vessel With Still Pipe

MOUNTING OF LEVEL GAUGE ON A DOUBLE WALL CRYOGENIC STORAGE TANK WITH STAND PIPE SUPPORTED BY TANK BOTTOM



The ultra-sonic level instrument can be used to measure the level of liquids, slurries, and solids. Since the measured material is not in contact with the sender/receiver unit, this makes it useful for sticky, gummy, abrasive, or corrosive application. The instrument is not recommended for powered solids, or liquids with thick coverings of heavy foam since these materials are good sound absorbers and only a marginal sound signal is reflected back.

VII. Capacitance Probe

A Capacitance level instrument is shown in Figure 10-28. The probe forms a capacitor together with the wall of the tank/vessel. The probe sets up a high frequency electro magnetic field between itself (as one plate of the capacitor) and the wall of the tank/vessel as the second capacitor plate. The dielectric of this capacitor is the material to be measured in the tank/vessel.

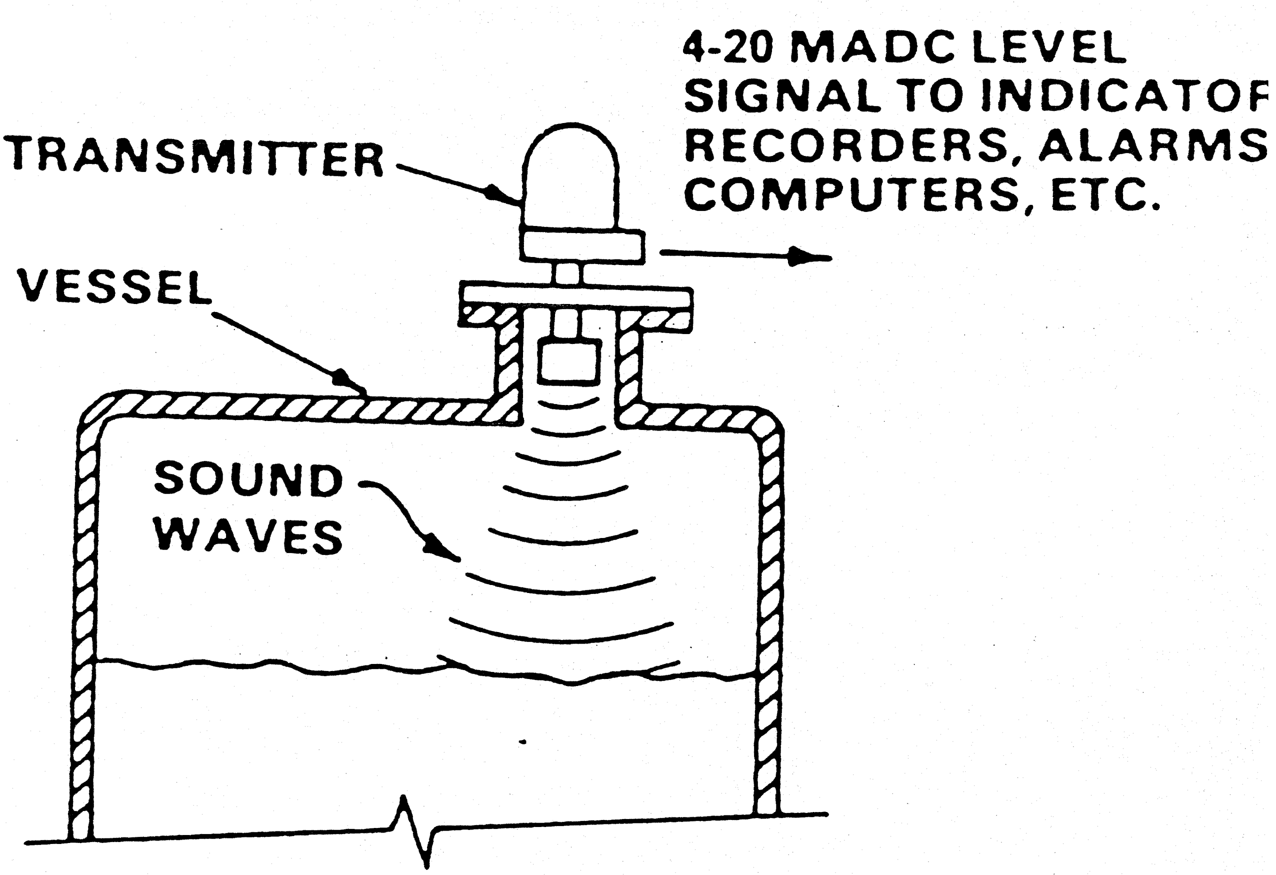
As long as the probe is in air (uncovered) the relative dielectric constant epsilon = 1 between the tank/vessel wall and the probe, and only a weak high frequency current flows through this capacitor into a measuring converter. As the process material rises in the tank/vessel between the two plates, displacing one dielectric material (i.e. air) with a material having a different constant, the capacitance value changes. This change in capacitance value is then translated by a converter into a signal which is proportional to level.

VIII. Radar Level Gauge

Figure 10-29A depicts a Radar level gauge installation. Similar in operating principle to the ultra-sonic level instrument, the Radar device emits microwaves towards the surface of the tank contents. The echo from the surface of the material is picked up by the Radar and reflected signal is directly proportional to the measured distance. This is a non-contact measuring methods. Figure 10-29B.

This is a non-contact measuring method. As such, it can be used on sticky, corrosive, gummy or abrasive materials. Although the Radar gauge has a high degree of level accuracy, its hardware and installation costs are very expensive.

Figure 10-27
Ultra-Sonic Level Gauge

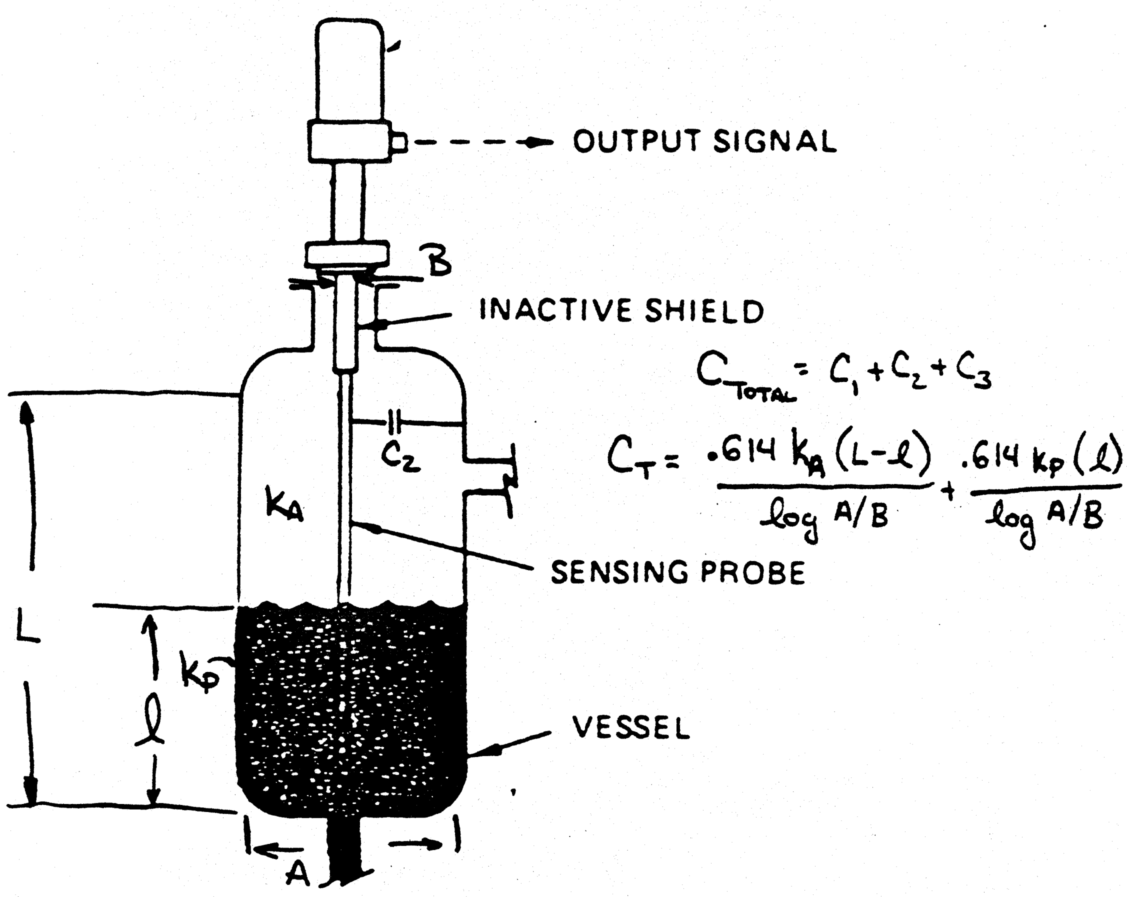


IX. Nuclear Level Gauges

A nuclear level gauge installation is shown in Figure 10-30. In this approach a small gamma radiation source is safely housed in a shielded holder mounted outside the process vessel. When the shutter mechanism is opened, a collimated radiation beam is emitted. This gamma energy penetrates the vessel walls, spans across the entire width of the vessel and is received by a detector-also externally mounted directly opposite the source. As the material level within the vessel rises, it blocks a portion of the radiation beam. The detector senses this radiation change and produces a signal related to level.

Although this approach is non-contact, and has good success in pipestill bottoms level measurement, extreme care must be taken during the installation phase to assure personnel safety.

Figure 10-28
Capacitance Probe



LIQUID LEVEL

TRANSMISSION, ALARM
AND/OR CONTROL

Figure 10-29A
Radar Level Gauge

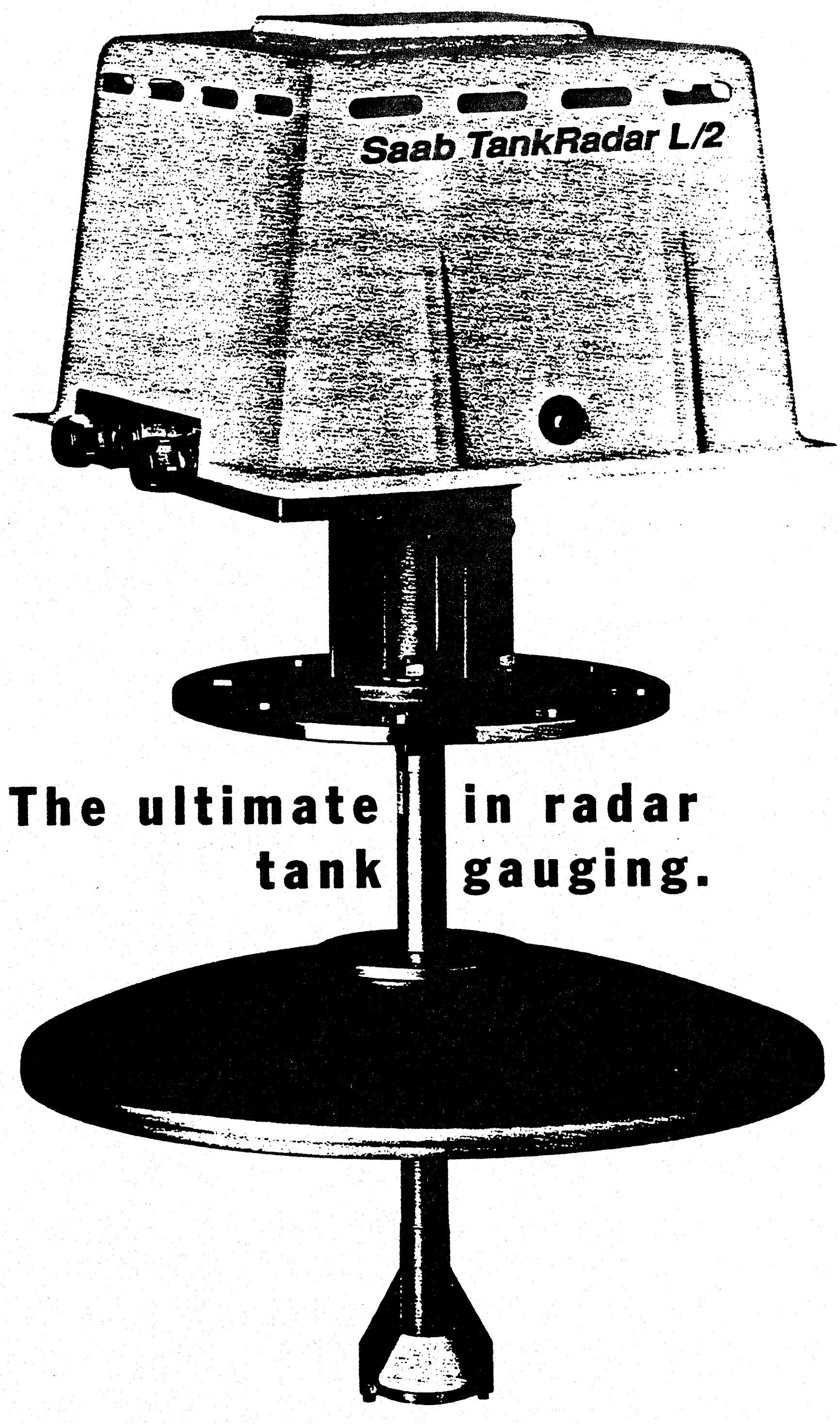


Figure 10-29B
Radar Level Gauge Installation

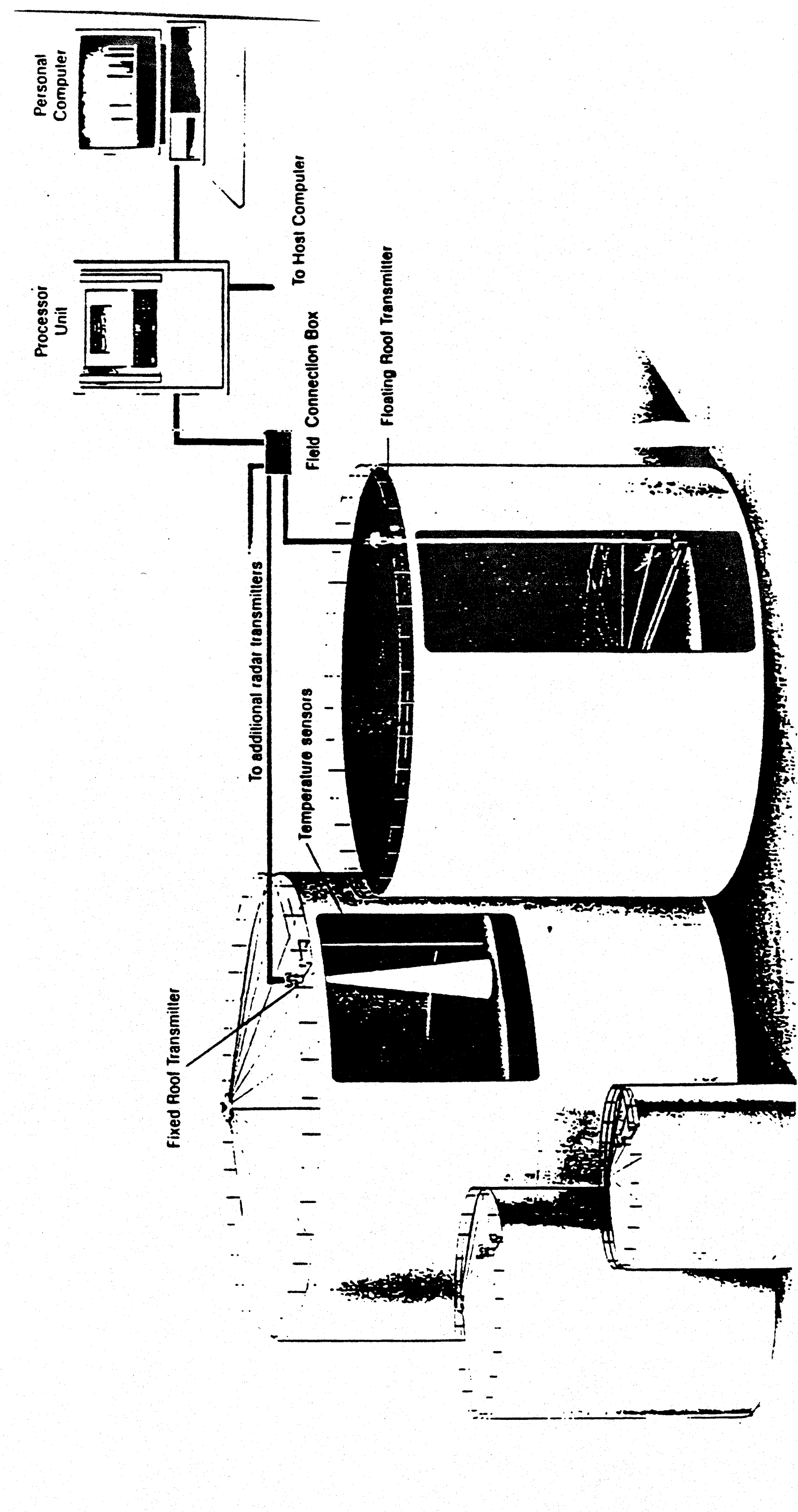


Figure 10-30
Nuclear Level Gauge