Mars Space Construction, LL

Section 3

VESSELS

Refinery or chemical plant vessels come in all shapes and sizes, andare used to contain liquids, gases, and powders. Since these fluids are usually stored under pressure or vacuum, the containers are referred to as pressure ves s el s , The vessels used most commonly in a process unit are the vertical-distillation column and the horizontal drum or sepa a to r ,

3. 1 DISTILLATIO COLUMN

3. 1. 1 Description

A di°stillation column is a cylinderical vertical vessel, which can range in height from 20 to 200 feet. It contains a number of trays spaced vertically at regular intervals. The trays are designed *to* allow a flow of vapor upwards and passage of liquid condensate downwards, and are usually numbered from bottom to top. These numbers appear on the vessel d r a wi ng , and also on the Piping and Instrument Diagram (P&ID) for con-venient identification, Normally, a hot liquid enters the mid-section of the column on a feed tray. By repeated vaporizations and condensations, the components of the feed are separated and drawn from the column at elevations corresponding to their respective boiling points,

The components which boil at lower ranges concentrate in the upper section of the column; those which boil at higher ranges concentrate in the bottom, · Thus , wl1en designing piping, we must consider that th'e bottom of the column is much hotter than the top,

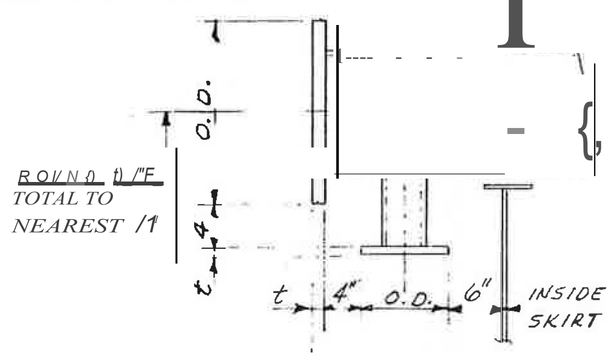
The process department determines column length and diameter, nozzle attachments, and approximate elevation, The vessel department produces the vessel design (see Drawings B-501, B-502, B-503, B-504, SK-50C-l, SK-50C-2, and Figure 3-1).

3. 1, 2 <u>Locating</u>

Normally, a column is located so that its perimeter is 10 to 15 feet from the edge of an overhead pipeway. It is usually surrounded by related equipment: reboilers and heat exchangers on one side, ov rhead condensers on the other. Drawoff and reflux pumps are close to, or under, the pipeway side (Figure 3-2), The most economic relationship is determined by a

NOZ. SIZE	FLANGE RATING 150# O.D.	150# t	300# O.D.	300# t	600# O.D.	600# t*
1½"	5"	11/16"	6⅛"	13/16"	6⅛"	1⅛"
2"	6"	¾"	6½"	⅞"	6½"	1¼"
3"	7½"	15/16"	8¼"	1⅛"	8¼"	1½"
4"	9"	15/16"	10"	1¼"	10¾"	1¾"
6"	11"	1"	12½"	17/16"	14	2⅛"
8"	[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20"	[illegible]
[illegible]	12"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27"	[illegible]
18"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24"	32"	1⅞"	36"	2¾"	37"	4¼"

* INCLUDES ¼" RAISED FACE



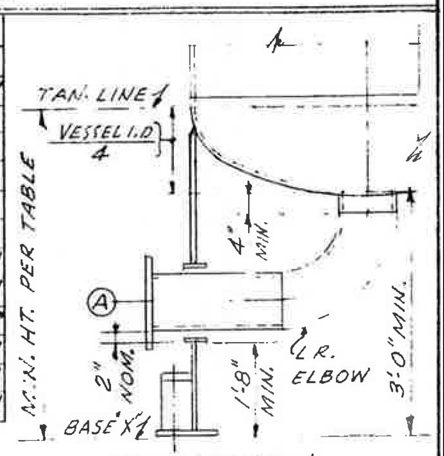
ELEVATION

BOTTOM OUTLET W/ DRAIN CONNECTION

VESSEL DIA. (1)	MINIMUM SKIRT HEIGHT (SEE NOTE (2)) NOZZLE SIZE (A) 4" & LESS	6"	8"	10"	12"	14"	16"	18"	20"	24"
2'-0"	3'-6"	3'-8"	4'-0"	4'-4"	4'-8"	—	—	—	—	—
3'-0"	3'-9"	3'-11"	4'-3"	4'-7"	4'-11"	—	—	—	—	—
4'-0"	4'-0"	4'-2"	4'-6"	4'-10"	5'-2"	5'-6"	5'-10"	6'-2"	—	—
5'-0"	4'-3"	4'-5"	4'-9"	5'-1"	5'-5"	5'-9"	6'-1"	6'-5"	6'-9"	—
6'-0"	4'-6"	4'-8"	5'-0"	5'-4"	5'-8"	6'-0"	6'-4"	6'-8"	7'-0"	—
7'-0"	4'-9"	4'-11"	5'-3"	5'-7"	5'-11"	6'-3"	6'-7"	6'-11"	7'-3"	7'-11"
8'-0"	5'-0"	5'-2"	5'-6"	5'-10"	6'-2"	6'-6"	6'-10"	7'-2"	7'-6"	8'-2"
9'-0"	5'-3"	5'-5"	5'-9"	6'-1"	6'-5"	6'-9"	7'-1"	7'-5"	7'-9"	8'-5"
10'-0"	5'-6"	5'-8"	6'-0"	6'-4"	6'-8"	7'-0"	7'-4"	7'-8"	8'-0"	8'-8"
11'-0"	5'-9"	5'-11"	6'-3"	6'-7"	6'-11"	7'-3"	7'-7"	7'-11"	8'-3"	8'-11"
12'-0"	6'-0"	6'-2"	6'-6"	6'-10"	7'-2"	7'-6"	7'-10"	8'-2"	8'-6"	9'-2"

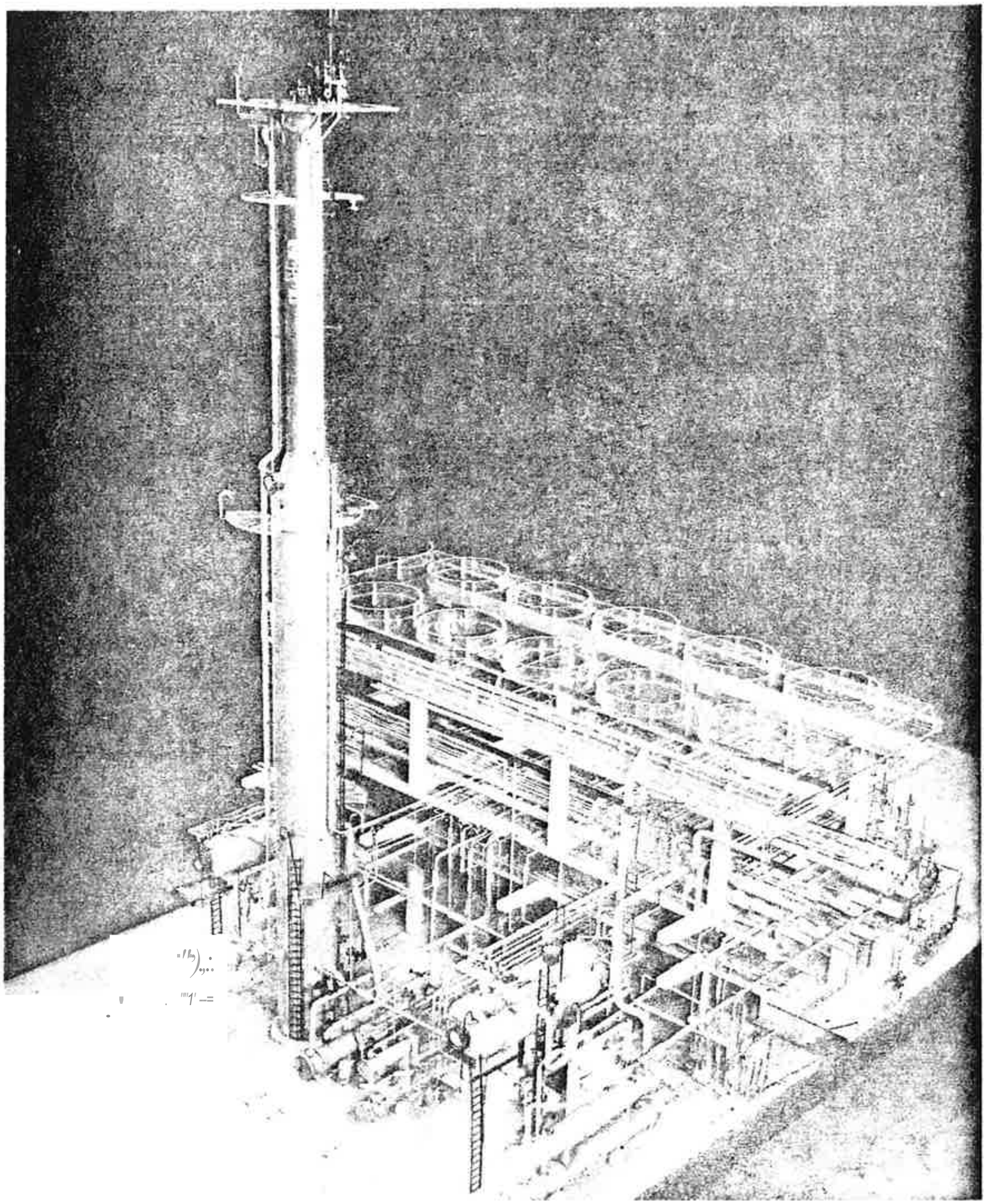
(1) FOR INTERMEDIATE DIAMETERS USE NEXT LARGER LISTING.

(2) FOR VESSELS WITH DRAIN CONNECTION LOCATED IN BOTTOM OUTLET NOZZLE, SKIRT HEIGHT SHALL BE INCREASED OVER LISTED MINIMUM AS REQUIRED TO ACCOMMODATE DRAIN PIPING.



ELEVATION
(BASIS FOR DIMS. SHOWN IN TABLE)

Figure 3-1. Botton, Outlet with Drain Connection Minimun1 Skirt Heights.



simple routing diagram. Usually, the segment of the column farthest from the pipeway which faces an access road is reserved for maintenance. This segment is referred to as the "drop out" area (for removal of trays, valves, etc.).

3.1.3 Piping

General: Having established the plot arrangement of the column and its adjacent equipment, the next step is to develop pip routing in sufficient detail to allow the column appurtenances *to* be oriented. Here the designer should apply the four prime factors of good design:

1, Operability
2. Safety
3. Economy
4. Maintenance

Normally, the layout of nozzles and platforms is made on a copy of the vessel design drawing (Drawing SKL-2-14).

Before developing pipe routing, we should review the job specifications. These describe minimum access, walkways, platform widths, clearances, ladder requirements, etc. Other items that must be checked include: P&ID and Line Designation Tables for temperature and insulation requirements, instrument standards for level gauges, controllers, alarms, and pressure and temperature connections, Bechtel

Specification LSOZ, for example, gives these requirements for column ;,1.nd vessel piping:

- Piping at columns will be located radially about the column on the pipe way side, when possible; manways and platforms on the access side. Overhead vapor lines and similar connections 18 inches and larger may be welded, except where flanges are required for maintenance.

- Valves and flanges will not be located inside vessel skirts.

- Water drawoff boots on elevated horizontal vessels may be extended a reasonable amount, to place the center of gage glass and level controller not over five feet from grade, platform, or ladder access.

- Vents, drains, and utility connections will be arranged to-prevent unintentional or undetected leakage. Gravity drains to underground systems will have open connections terminating two inches above the drain hub, so the discharge is plainly visible.

- Relief valves required for pressure vessels will be shown on the P&:ID. Davits or other suitable means will be provided to lower vessel pressure relief valves larger than two inches inlet size when not within reach of mobile equipment.

<u>Layout:</u> The column can now be piped in a logical fashion, The design may start at the topor bottom of the column, depending upon its complexity. It often helps to use a series of transparent overlays, placing one level over another, to help define the interference fron onelevel *to* another.

Figure 3-3 shows how piping is grouped radially on the pipe-way side of the column. Supports are shown in Figures 3-4 and 3-5.

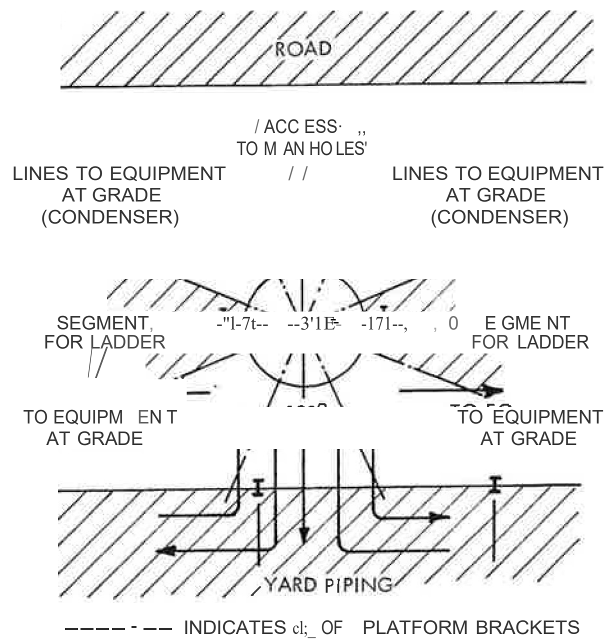
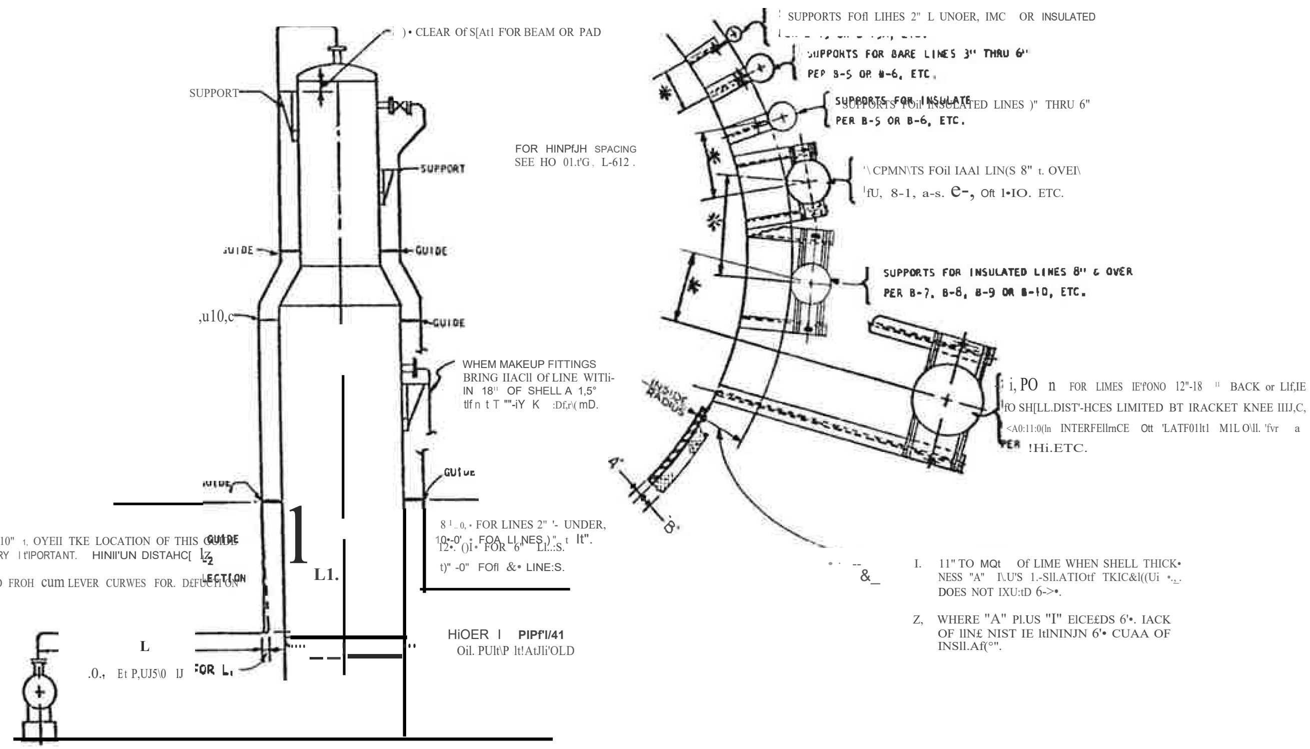


Figure 3-3. Tower Plan Sketch Showing Segments Allotted to Piping Nozzles, Manholes, Platform Brackets, and Ladders.

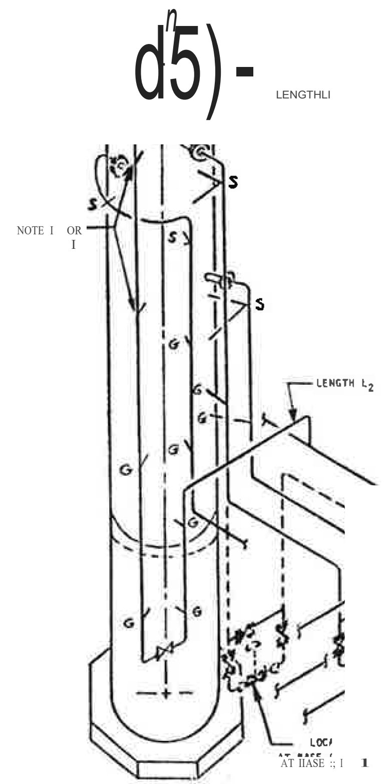
Vapor overhead lines may be connected to a nozzle in the top head or in the side of the column above the last tray, depending upon space and expense limitations (Figure 3-6). For large lines, a side outlet connection can considerably reduce

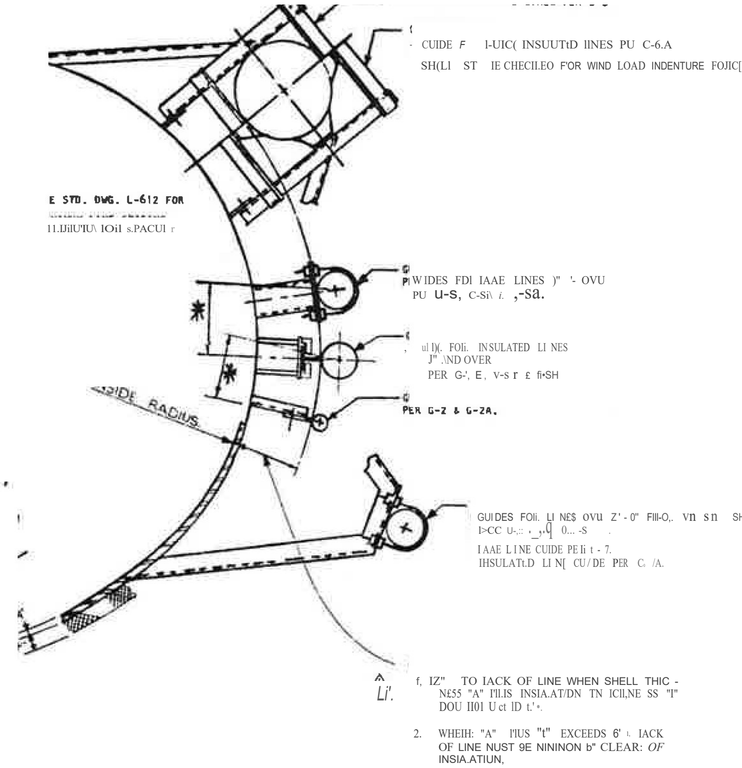


LIN[S LOCATEO CONCEHTf.lCAllY ON VESSEL ARE Pt\EFEfU\(O TO fKOSE SHOWN OH L-601, THEY DO kOT FiEQ.UIRE EXTRA Pfpf AHO flTTlNCS ro PflOYIDE flEXIIILITY ll£TW£[N SUPPORTS AHO NOZZLES AHO uu: STAtlCIMO SUPPO,,l5 OfSIPf'\.[DESIGN. THEY SHOIA.D IE LCICATED, If POSSIBLE, ON PlATFOIU'i FI\EE SEGNEKTS OF THE WESSEL P[fl.lKE.TEA flY LOCATINli LINES CLOSE TD THE ll'ESSEL SHELL, THE RESIl.TINli KOMENTS FOACES ARE A NINIKUH AHO, SMI..L LIMES, COULD PENETRATE fLATFORl'IS WITHOUT BLOCK I HG THEM, THE SUffORTING NOt1ENTS OR INDENTLR[FORCES PIUST BE WITHIN THE KOtlENT AMO I NDE KT JftE TAaLE VALUES. L I MES AMU SUPPORTS SHOWN ON L-f>DI AU NOST COIV40ttl.Y USED ON SW.LL DIMETER VESSELS ONl.Y.

SIWl'OfLTS ON snus IUllEVEO VESSELS

PIPE su,,o,ns FOP. VESSELS STUSS RELIEVED DUE ro SHELL THICKNESS OKI.Y CAN IE FIELD W'f.lDfO WHEN APMOV[O BY THE PflOJECT ENGINEER. VESSlLS STft.ESS flELIEVED FOR PROCESS lt[ASONS HUST HAVE N..L ATTACHMENTS TO THE SHELL PROVIDED IN Pl.ACE 1Y THE VESSEL FABRICATOR 8EFORE STRESS RELIEVING. WHEN APPROVED av THE PROJECT EH<ilNEER CIRCULAR PADS, PMVIDED 8Y THE VESSEL FABRICATOI\, HA'f BE SUBSTITUTED FDft SUPPORT ATTACH,,ENTS AND THC SUPPORTS FIELD WELDED TD THE/1. PADS ARE USED l"fllHARILY ON lARliE DIAHETEfl VES ELS \IHEN PROJECTING ATTACHHEHTS WOUlD OFFER SHIPPING fROBLE,,S. TH£ PIPING, INCLUOIHC UTILITY LINES, „UST BE CDNPLETED AT TliE EARLIEST POSSIl!LE DATE. TO PEIU11T LOCATING AND DESIGNING THE SUPPORT ATTACH"EHTS TO BE PROVIDED l'f THE VESSEL fA IIAICA TOft.





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(I} TH[111.15£111: FROM THE VALVE NE.Ii" G-.ADE IS USUALLY AT At1BIENT ll.HP'EMTIJIU WHICH ANS BELOW Fl\[EZING IN SOHE PLACES IN THE WINTU BECAUSE THE IUi.INC. OPERATION IS NOT FI\EQU(NT.

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CONTROL WAL'I'£ ASSE NIIL Y LOCATIONS

LOCATIOH " *N'* IS PIIIHIP.AIU BECAUSE TKf. HORI l ONTAL Jl INE IIIUN FRc»I COLUl'tt TO TH£ VAL E ASS[peLY 15 USUALLY LONG ENOUGH TO PW((S ING SUPPORTS UNNECE SSARY, IN POSITION "!!l" J OOUIILE SPRING SUPPOAT IS USUALU REQ.UIREO WHEN TlfE VESSEL IS HOT AND THE LINE AT Tte: LOW TENPERATUIIIES C011NON TO REFLUX LIHE".. rloft: DOUBLE S" IMG kEQ.UIIIES A HEIGHT MOVE liRADr TO CENTER OF CONTIOL VALVE or A!IOUT) ' - 0" .

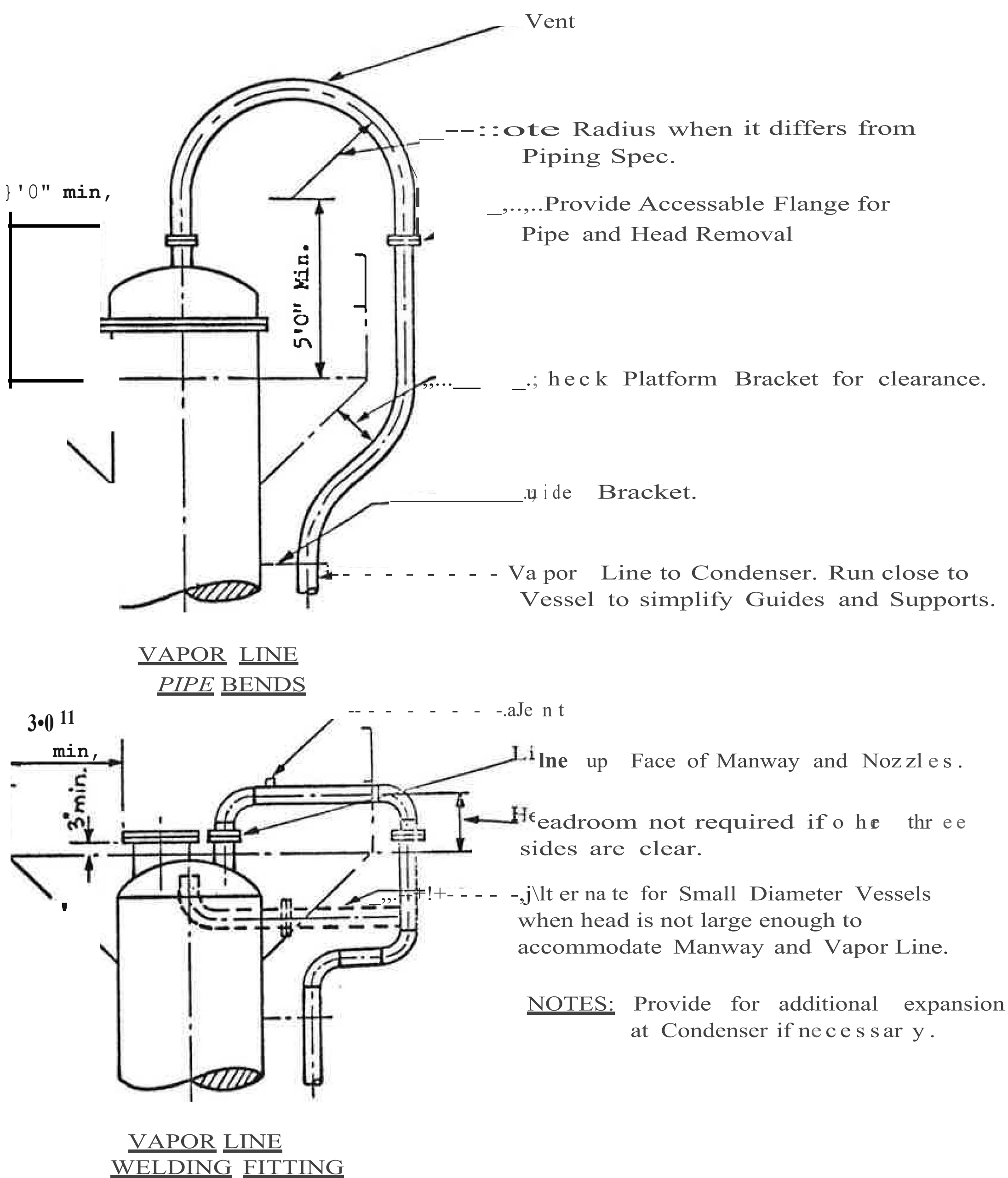


Figure 3-6. Typical Vapor Line Piping at Towers.

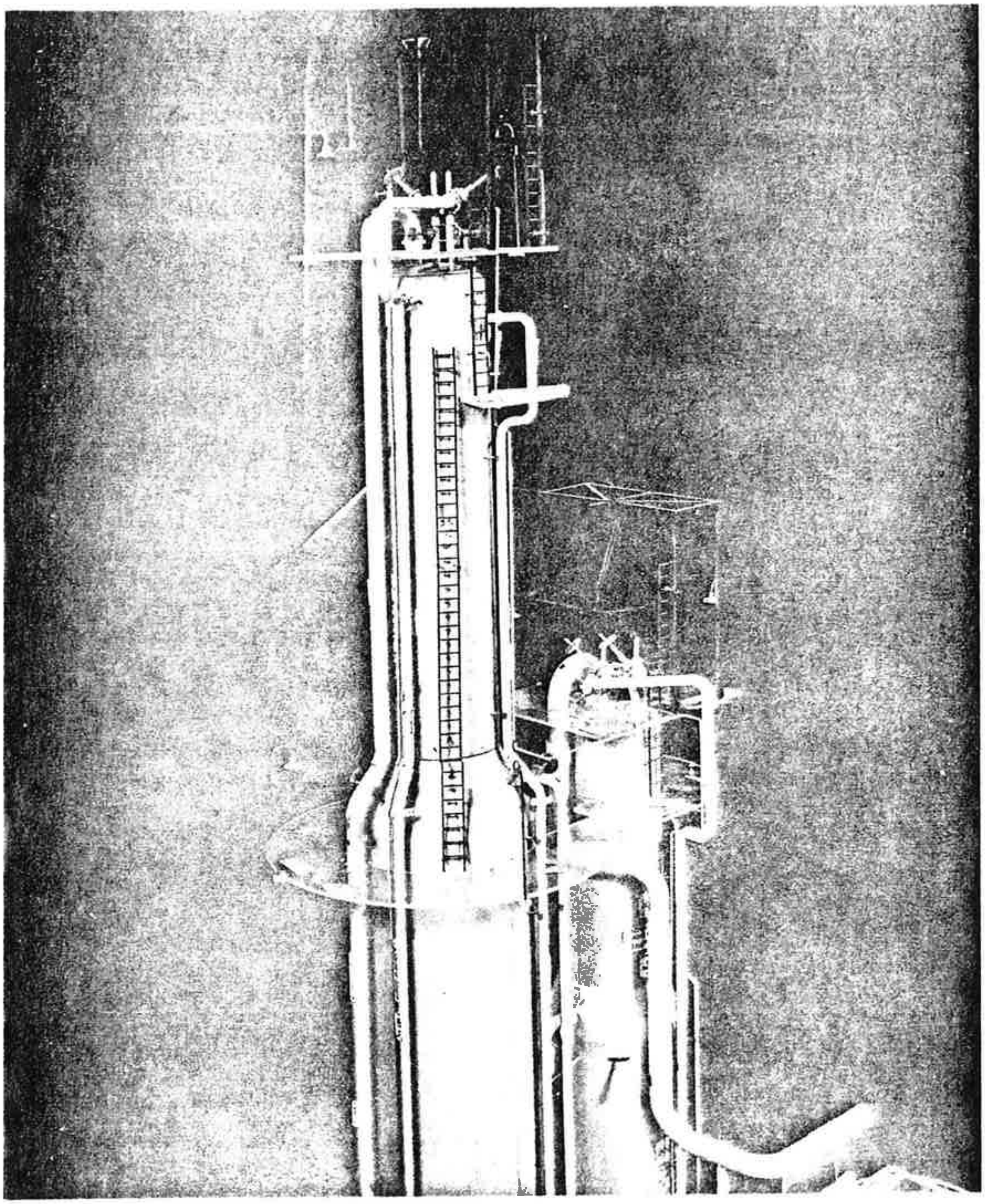
expense. Figures 3-7 and 3-8 show typical piping in the upper column.

Internal piping can often be provided on reflux and feed lines to facilitate the piping (Figures 3-9 and 3-10).

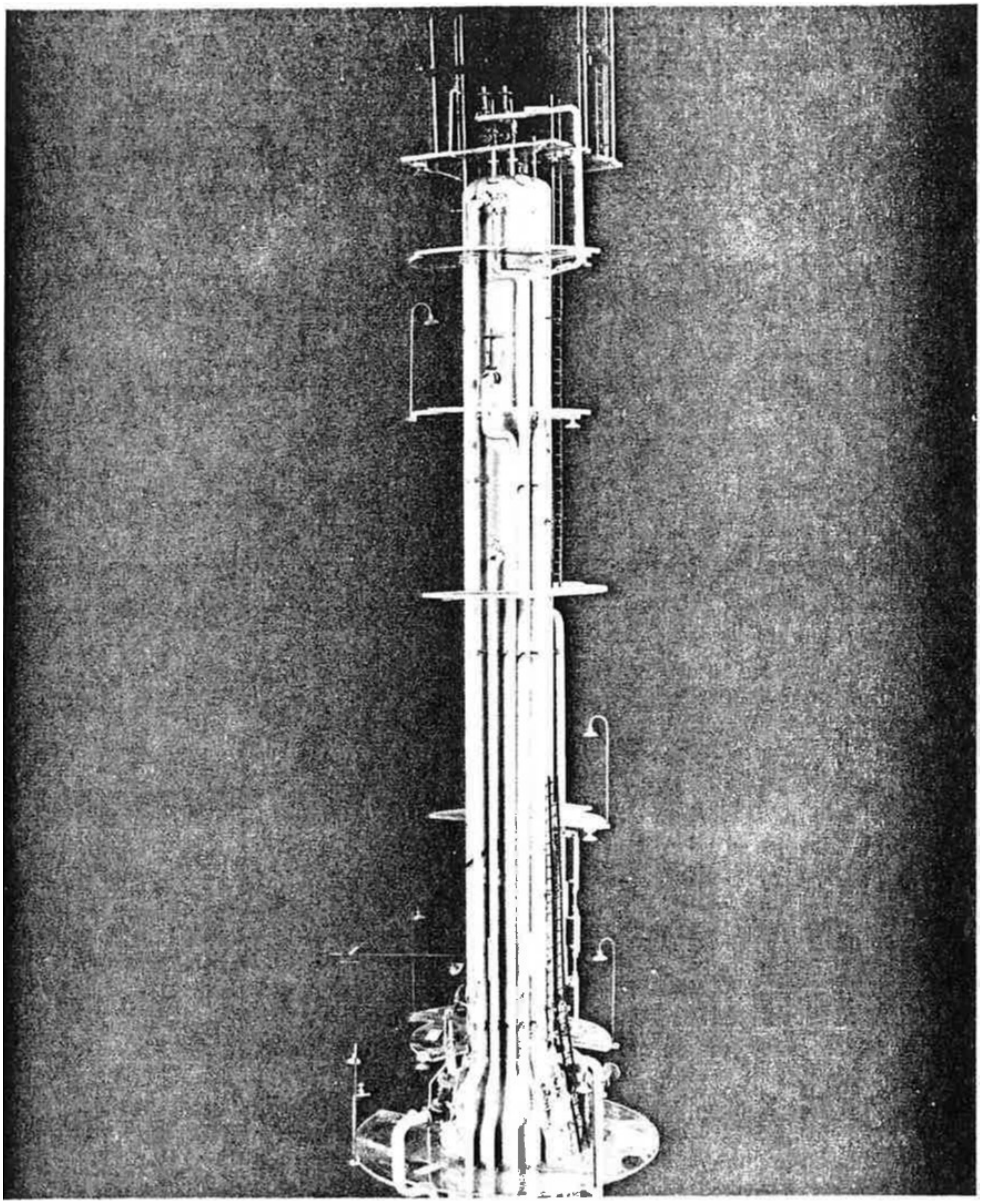
Relief valves .may also be piped from a nozzle in the column head, or from a side nozzle (Figure 3-9). Davits must be situated :for the top platform so that it can handle internals from side 1nanways, relief valves, etc. completely *to* grade. Sometimes, additional davits at intermediate levels must be provided. Orientation of the remaining equipment is determined by solutions of problems arising at the top and bottom of the colunm, since problems n1ost often arise at these areas.

Observe the following rules:

- Align manholes vetically, facing a drop out area.
- Provide good working areas on manhole platforms, and allow space for a service hose.
- Donot obstruct platform passageway at ladder entrance or exit. Allow clearance for manhole cover swing.
- Drop side-srteam d_raw-off lines immediately at draw-off nozzle. Locate valve on the nozzle if possible.



Piping and Platforms [illegible]



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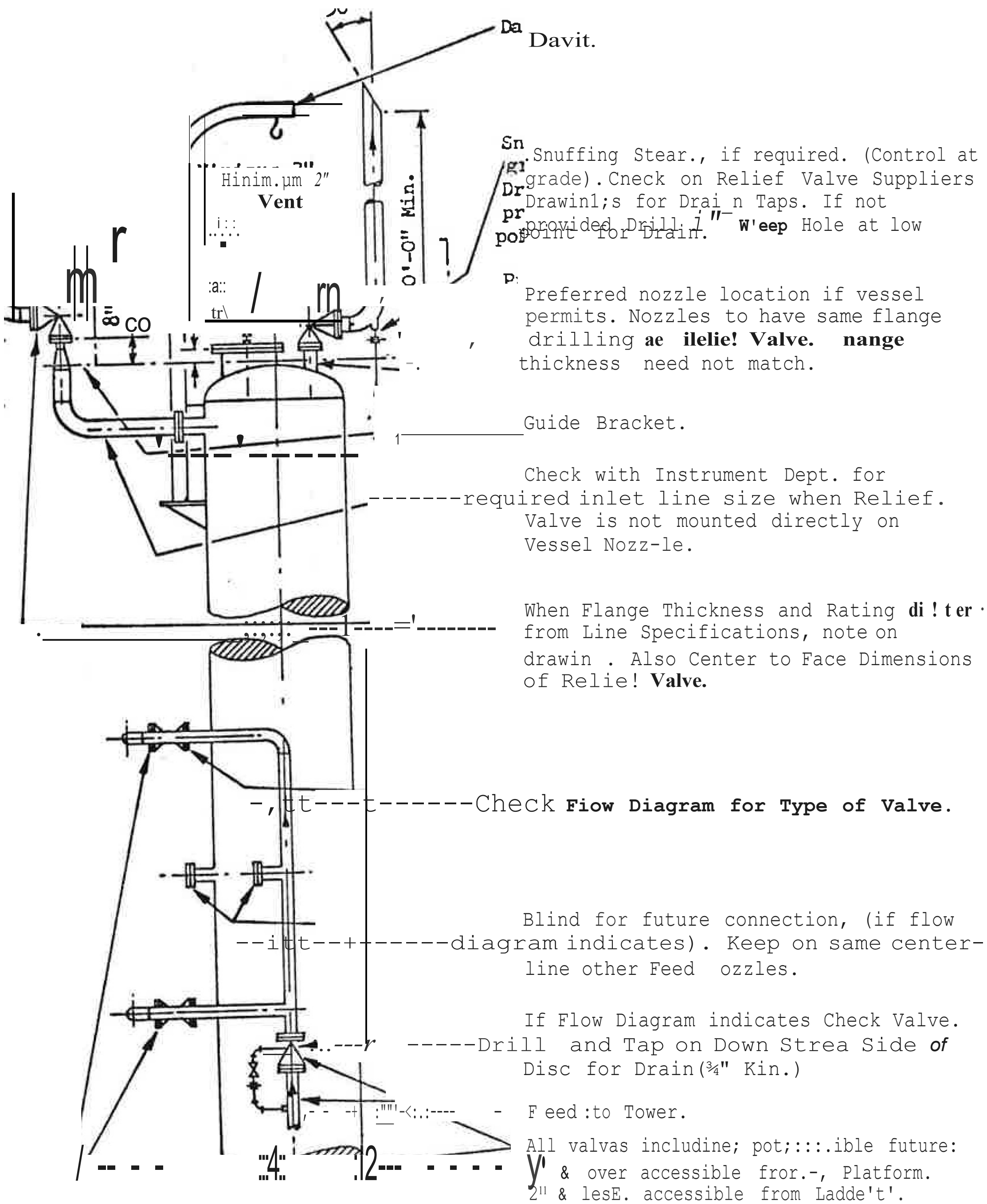


Figure 3-9. Typical Relief Valve and Feed Piping at Towers.

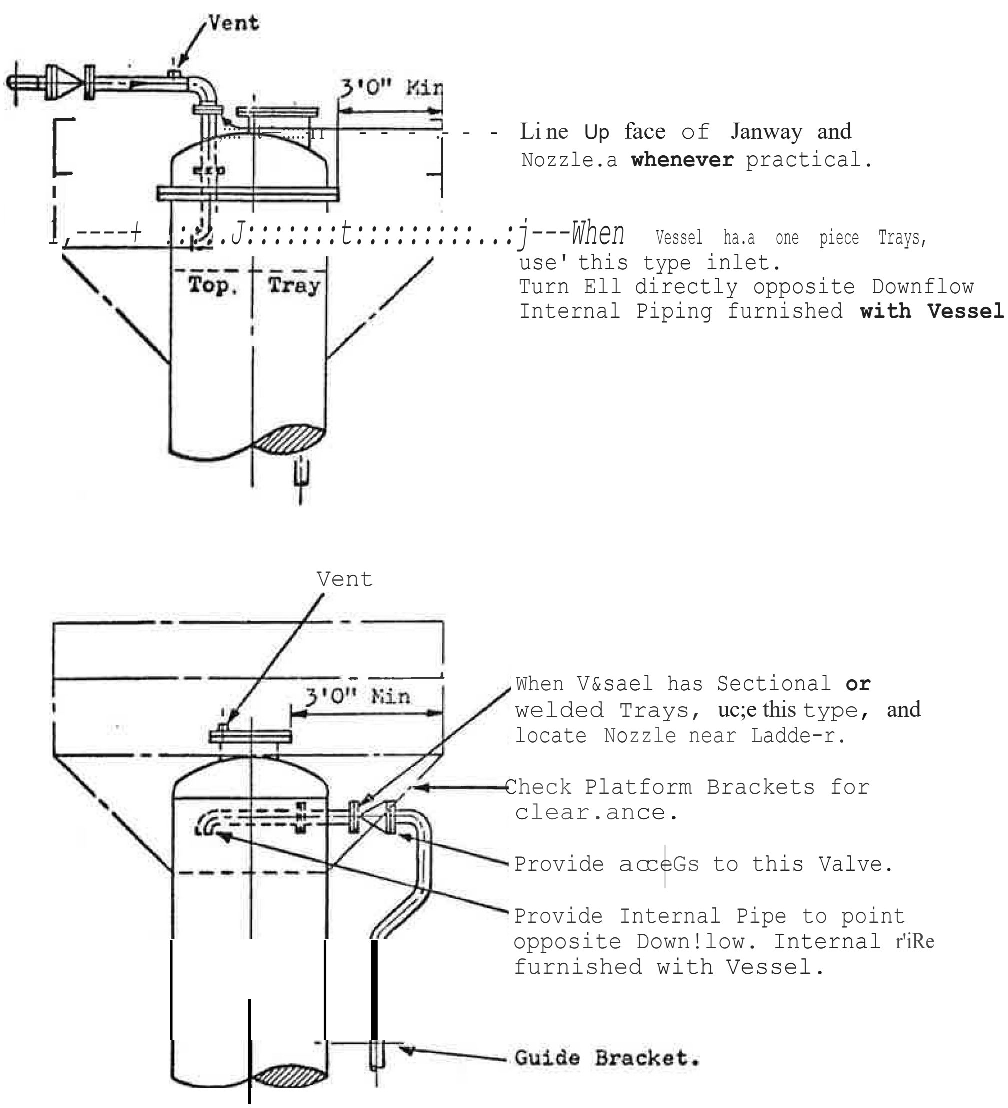


Figure 3-10. Typical Reflux Piping at Towers.

- Locate control valve manifolds at grade whenever possible. Care must be taken when flashing conditions occur downstream of a control valve. In these cases, it may be necessary to elevate the valve close to the column nozzle to minimize slugging.

- Align support brackets for platforms vertically to minimize interferences.

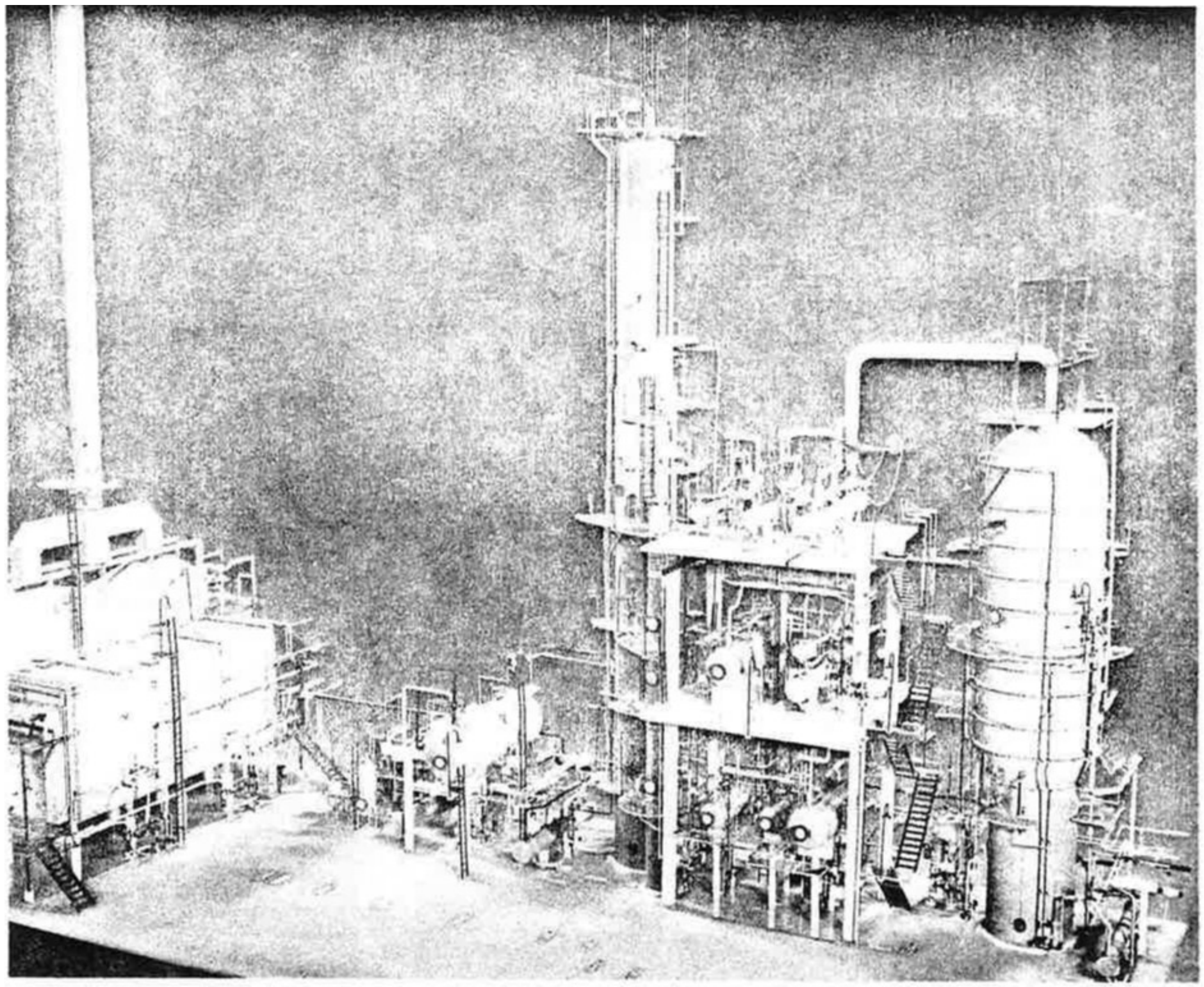
- Place valves directly against nozzles to provide self uraining on both sides of valve.

- Orient gage glasses so that they are visible from the control station with which they are associated.

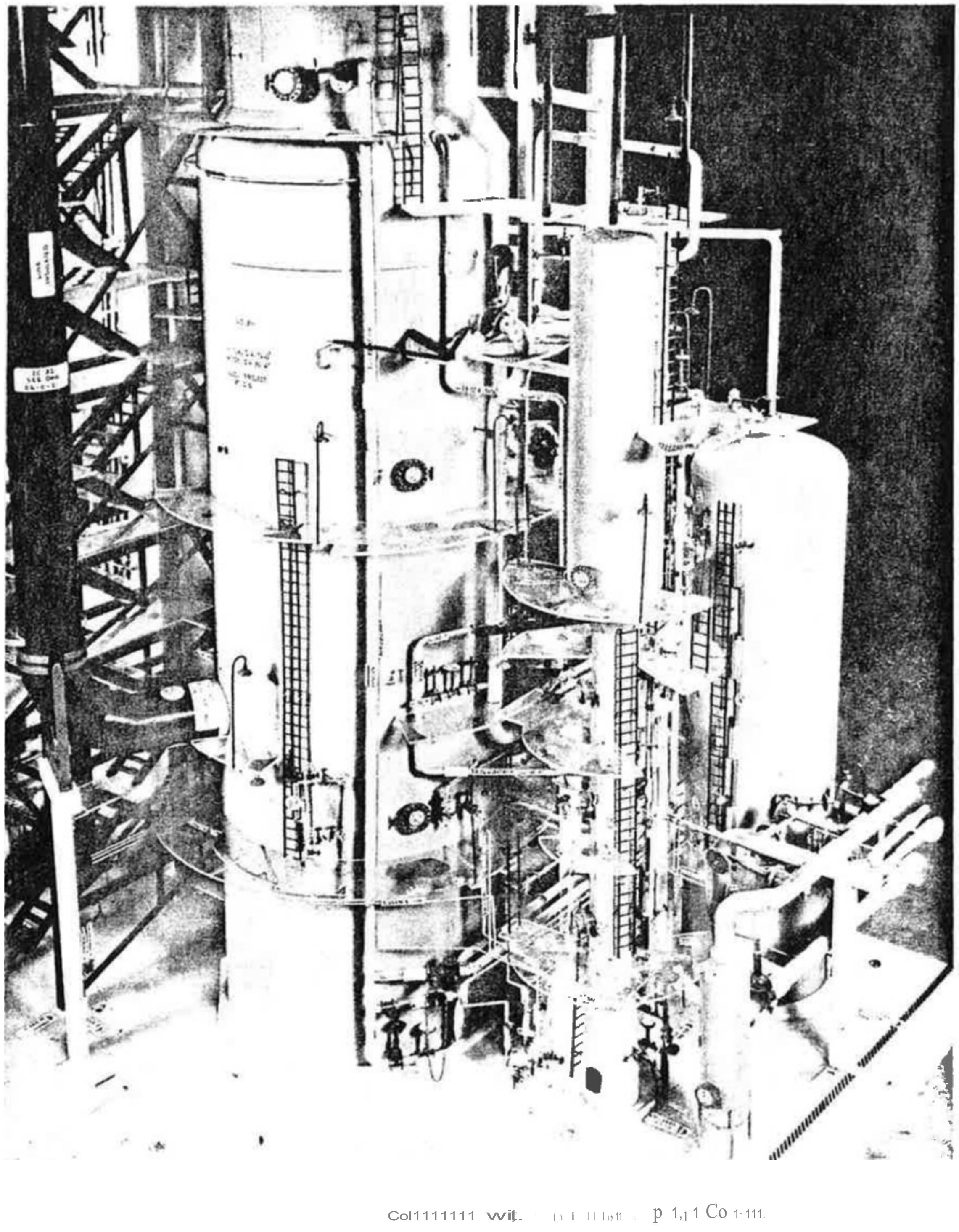
- Watch for steamout temperatures as opposed to operating ten,peratures. Expansion of hot lines should not be overlooked. This can add a loop or leg in n,ost inconvenient places.

- Symmetrical piping arrangements are preferred on reboiler circuits in order to obtain equal flow.

- Some vessels are required to be stress relieved. Therefore, consider the effect on stress of welded brackets, clips, etc. when the nozzles are positioned.



Piping-Fractionating Column, Vacuum Column Related Structure.



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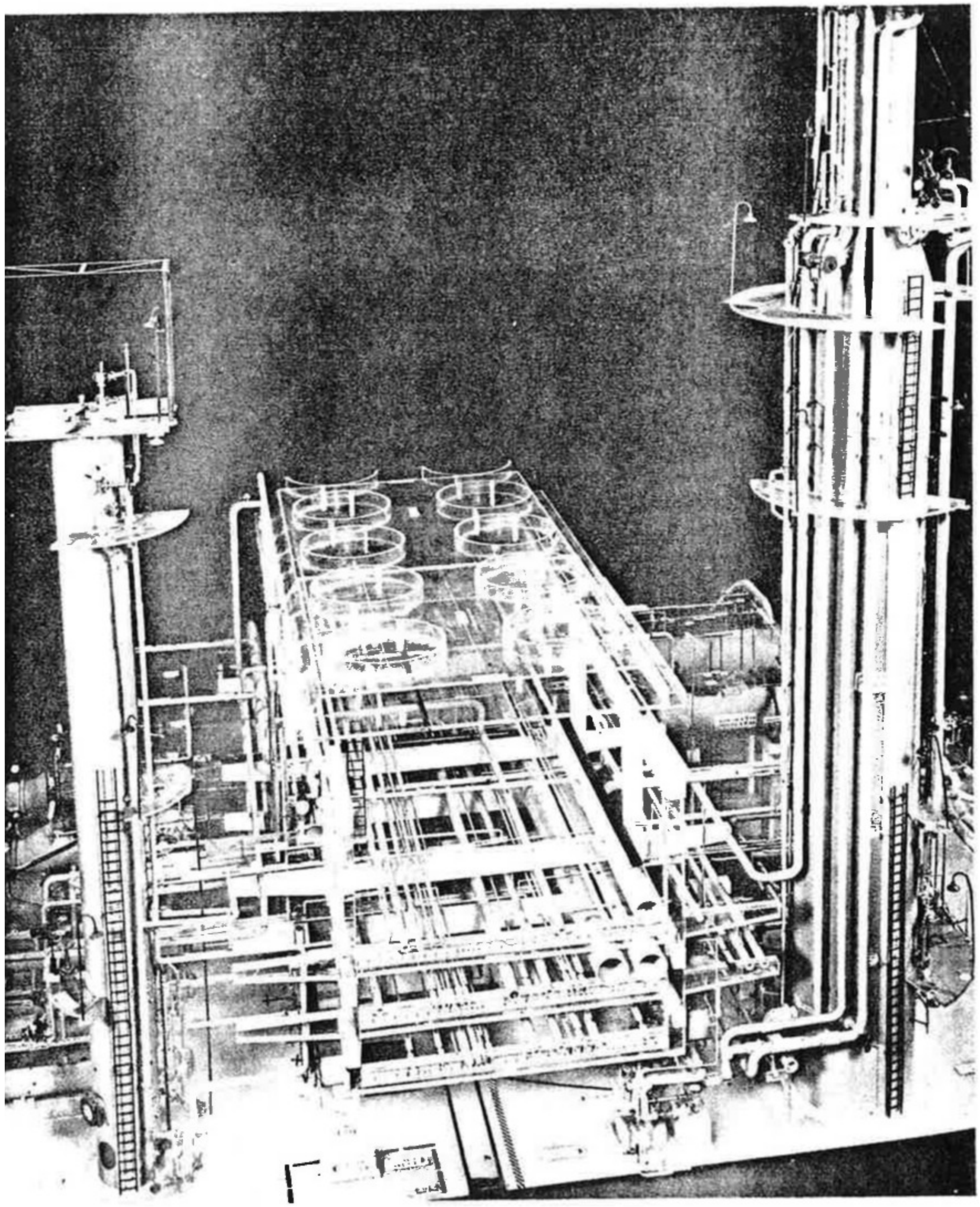


[illegible] oss-section through [illegible] Columns.

[illegible]

Guidelines for orienting Level Instruments are shown on Drawings SK-50C-l and SK-SOC-2.

Figures 3-11, 3-12, and 3-13 are photographs of models which show typical piping around cohunns and related equipment. Drawing No. 1 shows how manways are positioned in pressure vessels.

Some examples of layout problems and solutions follow. Figure 3-14 provides the same approximate information the layout draftsman receives from the initial plot plan.

Figure 3-14.

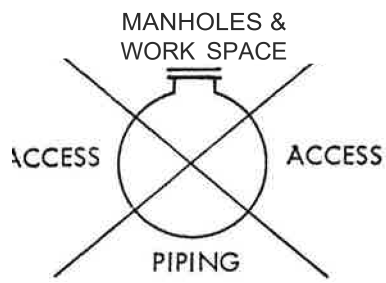


Figure 3-15.

How do we start with the column itself? We find that our column divides itself into zones (Figure 3-15).

Consider a typical platform. At this level we have a manhole and a feed connection. For the moment, ignoring all other practical considerations, we have placed these features in ideal locations (Figure 3-16).

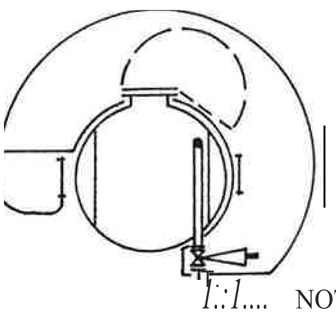


Figure 3-16.

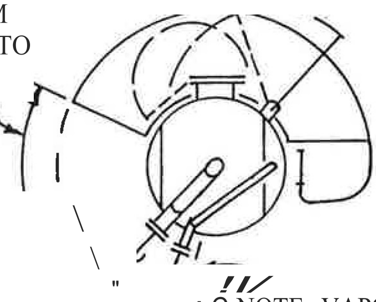


Figure 3-17.

Consider a top platform. Here we have a manhole, vapor connection, reflux connection, and a davit. Again ignoring our worries about practical matters, we arrange these features in ideal locations Figure 3-17.

Consider the piping arrangement now. We may choose a bent guide bracket (Figure 3-1*BA),* or straight bracket (Figure 3-1SB), but note carefully that the lines have a logical sequence.

This is done so that access *to* nozzles (and valves, if present) will not be obstructed by lines continuing *to* a higher level

It looks as though the column has designed itself. It hasn't. Wemust still put together a workable arrangement combining these features and, in cases, compromising between them. Our chosen downcomer arrangement will affect every level

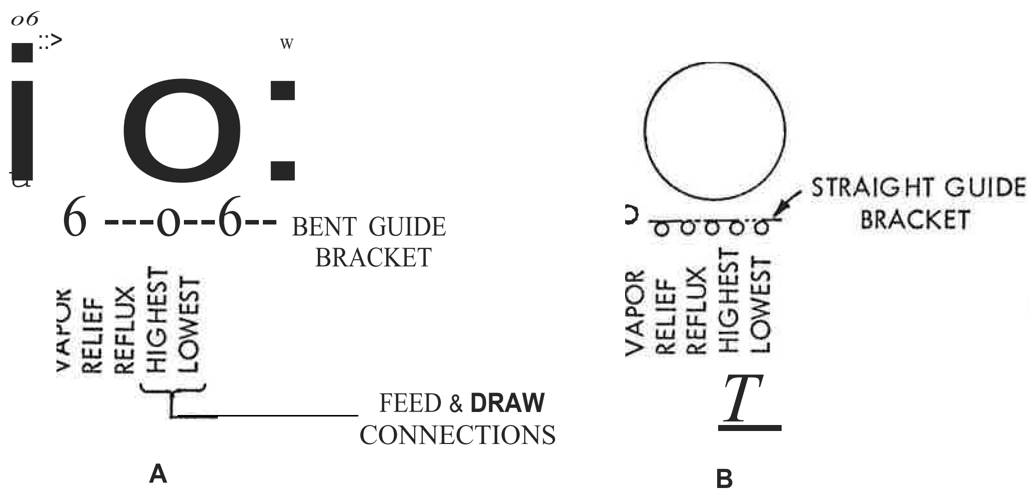


Figure 3-18.

at which we have inlets, draws, or instrumentation. Our ladders can span only thirty feet. We must have headroom between platforms, Multiple feed connections to full cross - flow trays are changed to even and odd trays. Temperature points persist in being just beyond reach of the platform level fixed by a manway. The ganie has only started, butif we remembei- the basic principles, we have a greater chance of success in a shorter time,

The lower section of a column may be equipped with any or all of the following:

Reboile.r (or two)
Manhole
Level Controller
Level gage (or gages)
Level alarm
Permanently piped steam-out

All of these items must be accessible and all of them must occur at about the same general level. This results in two platforms, one serving the reboilers placed high enough to provide access to channel and cover, and one several feet lower serving the other facilities. On a large column, this may not be much of a problem, because the size of the column permits spreading the equipment and building a platform big enough to serve it. A small-diameter column, however, presents a more difficult situation.

First attempts to find a solution usually look like Figure 3-19, and many hours can be wasted struggling *to* improve such a layout.

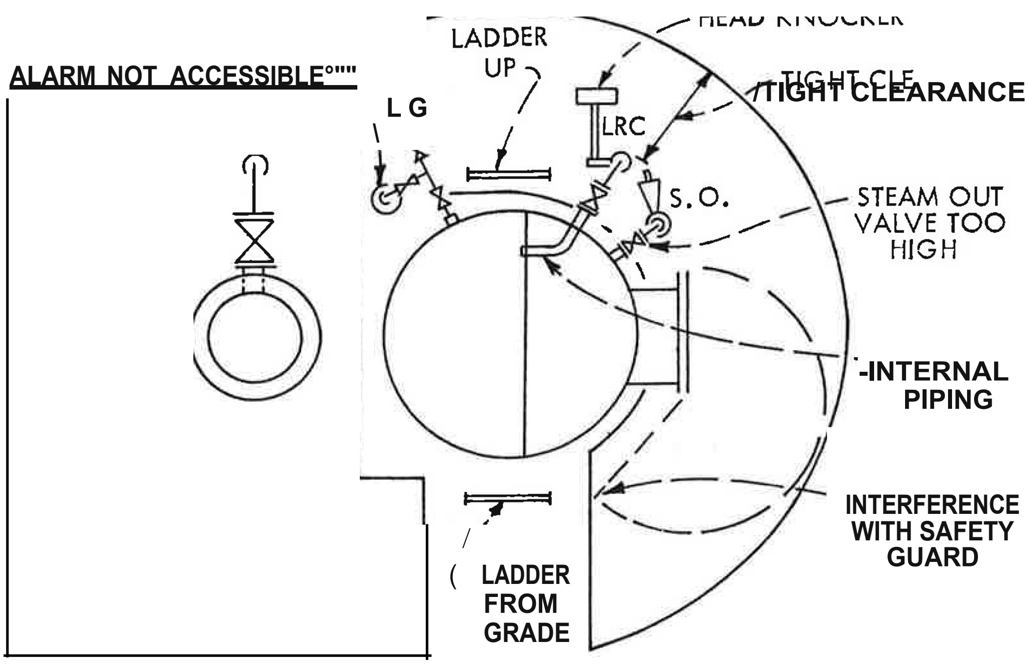


Figure 3-19.

The situation may be improved by applying the following hints:

- Place the manhole slightly off column cente rl ine.

  (Keep it radial to avoid ext-r a fabrication expense.)

  This may provide space for manhole cover clearance.

- Mount the level controller at the end of the platform, so that the platform width will not have to be excessive.

- Consider non-radial connections for level instruments.

- See ii the alarm can be mounted in one plane with level gage, or if this assemblage can be folded back on itself.

- Put the steamoL1t connection at reboiler platform level.

- Do not start a ladder at lower platform level. Run ladders from grade past lower and reboiler platiorm levels to a postage stamp transition platfor m within thirty feet of grade.

- On columns larger than thirty-inch diameter, consider putting this ladder off the centerline of the column.

When these id as are applied to our problem layout, the improvements are obvious (F igure 3-20}. We have now gained proper platform access to valves, instruments, and manholes, have eliminated hazards, and have provided a logical a rrange- ment from operating and maintenance stand points.

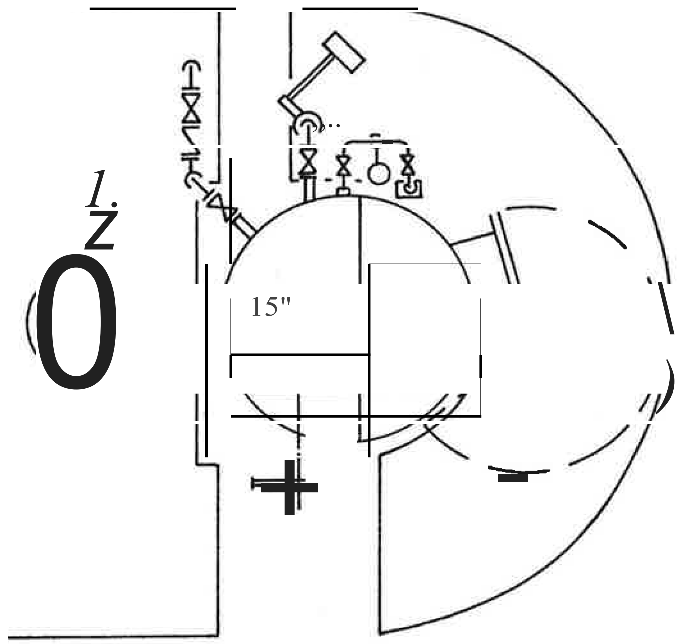


Figure 3-20.

We have achieved a workable arrangement, but we also have created a new problem. We must not forget that our ladder can only span 30 feet, and will require a small stepover platform before the next major platform (Figure 3-21). If a temperature indicator is needed in a downcomer in this vicinity, set this platform elevation to accommodate it.

The solution we have just reviewed is very neat, but what if the range of the level instruments is so great that the bottom connections, top connections, and the level control transmitter cannot be reached from the same platform?

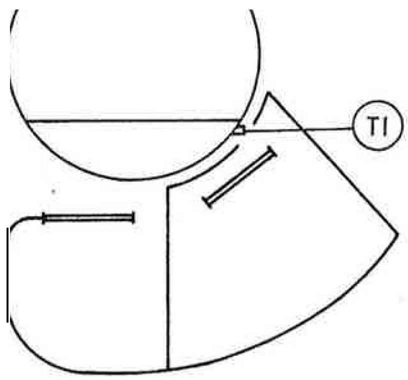


Figure 3-21.

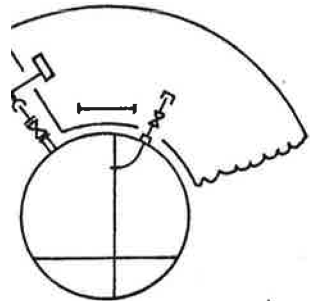


Figure 3-22.

Several possible solutions follow:

- Simplest, but requiring operator agreement: Place level gage and level control adjacent to ladder and reach top connections and controller from ladder (Figure 3-22). Unfortunately, we are tending to recreate the same arrangement we were criticizing in Figure 3-19 and, in the case of a small-diameter column, we know this will not be satisfactory.

- Reach the top level instrument connections from the reboiler platform (Figure 3-23). This arrangement is not very convenient from the operating standpoint and should have the agreement of the operator.

- On columns of sufficient diaJneter, a reasonable alternative exists (Figure 3-24). Here, we must have headroom clearance between platforms, and of course must avoid interference with the reboiler support brackets.

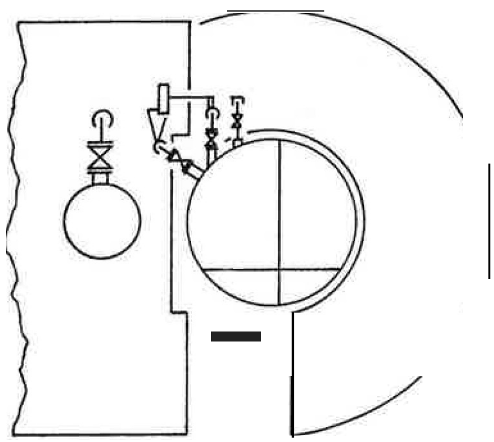


Figure 3-23.

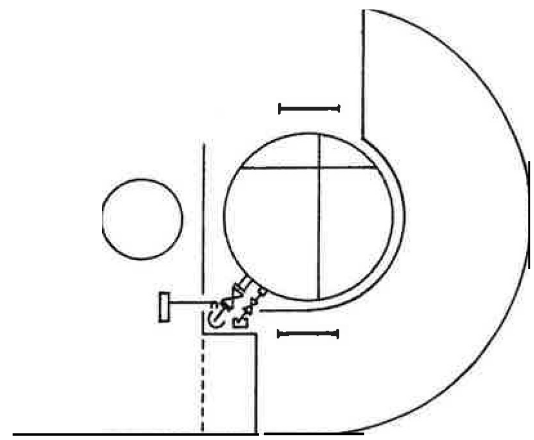


Figure 3-24.

If anything, we have oversimplified colum problems. Actual problems will vary from these very basic ones, but this sort of logical procedure can and should be used, rather than a random trial anderror approach.

Elevation: Net Positive Suction Head (NPSH) of pumps, or thermosiphon reboiler data determines the tangent line elevation of the column above grade. The unit engineer usually makes this decision. Petroleum Refiner, vol. 37, no. 3, March, 1958, pp. 138-140, gives a detailed discussion of the engineering problems found in column elevation. The following paragraphs briefly describe fiver easons why columns are elevated:

1. If the line from the bottom of the column goes to a pump, then the Net Positive Suction He ad (NPSH) requirements of this pump can elevate the column bottom.

2. Ther mosiphon reboiler circuits can elevate a column, since the circulating flow depends on liquid head.

3. Gravity flow from the bottom of the column to other equipment may require liqui d head as provided by elevation.

4. When the liquid leaving the bottom of a column is near the boiling point, it may be desirable to provide enough liquid head by elevation to prevent Hashing.

5. Finally, the column can be at minimum ele - vation if flow conditions permit it. Practical skir.t heights vary from three to six feet for columns two to fift een feet diameter , with bottom temperature 100 to 400F. Higher temperatures can add one or two feet to these

heights, to prevent the transmission of unduly high temperatures to the concrete column foundation or supporting steel structure, Column temperatures below freezing point also warrant investigation and will elevate the column higher than the practical minimum.

These five points affect tower heights, and thus affect costs caused by elevating the tcwer. To support the tower at the chosen elevation, a steel skirt to grade, or a combination of a short steel skirt anda concrete plinth, will be required. It is difficult to decide between steel skirt andconcrete plinth. The cost is affected by local conditions, type of soil, and foundation. Long skirts can affect skirt andshell thicknesses of a tower, wind load moments, and skirt interior access. Slender towers often have flared skirts, etc. Cost comparison between alternatives, if possible, and if data is available, decides the most economical solution.

Figure 3-1 is a Bechtel drawing which shows minimum skirt heights.

3.2 HORIZONTAL DRUM

3.2.1 Description

This is also a cylindrical vessel, with closed ellipsoidal or elliptical ends. Internals are not as complicated as the column, and are usually limited to agitators, or simple baffles and demister pads, which aid phase-separation. Nozzles are normally located along the top or bottom centerline. Some drums have a "boot" which is a well attached to the underside. Once again, the parameters of the drum are normally determined by the process department.

3.2.2 Locating

Once again, a routing diagram is made to establish the relationship between the drum and associated equipment. Drums are normally located alongside an overhead pipeway, with the longitudinal axis perpendicular to it.

All dimensions are to the tangent line on the head. A platform is usually required adjacent to the nozzles on top and, depending upon the height, a platform is sometimes needed underneath, especially if there is a "boot" attachment.

Drums should be grouped, where possible, in order to provide common platform and pipe supports.

3.2.3 Piping

The problems here are not as complex as with a column, although generally most of the same rules and requirments apply.

The elevation of the drum must first be established, and is determined by any one of the following:

- NPSH (determined by unit engineering)
- Minimum head room under suction lines
- Water boots
- Common platforming or supports with adjoining vessels

The number and size of nozzles is determined by the process department. Unless there are internals to consider, these nozzles are arranged by the piping designer to suit his layout. Figure 3-25 shows typical nozzle placement for a drum. Drawings SKL-1-41 and SKL-6-1 S show both nozzle and platform position.

The following points should be remembered:

- Relief valves, which are usually mounted on top of the drum, should be self-draining

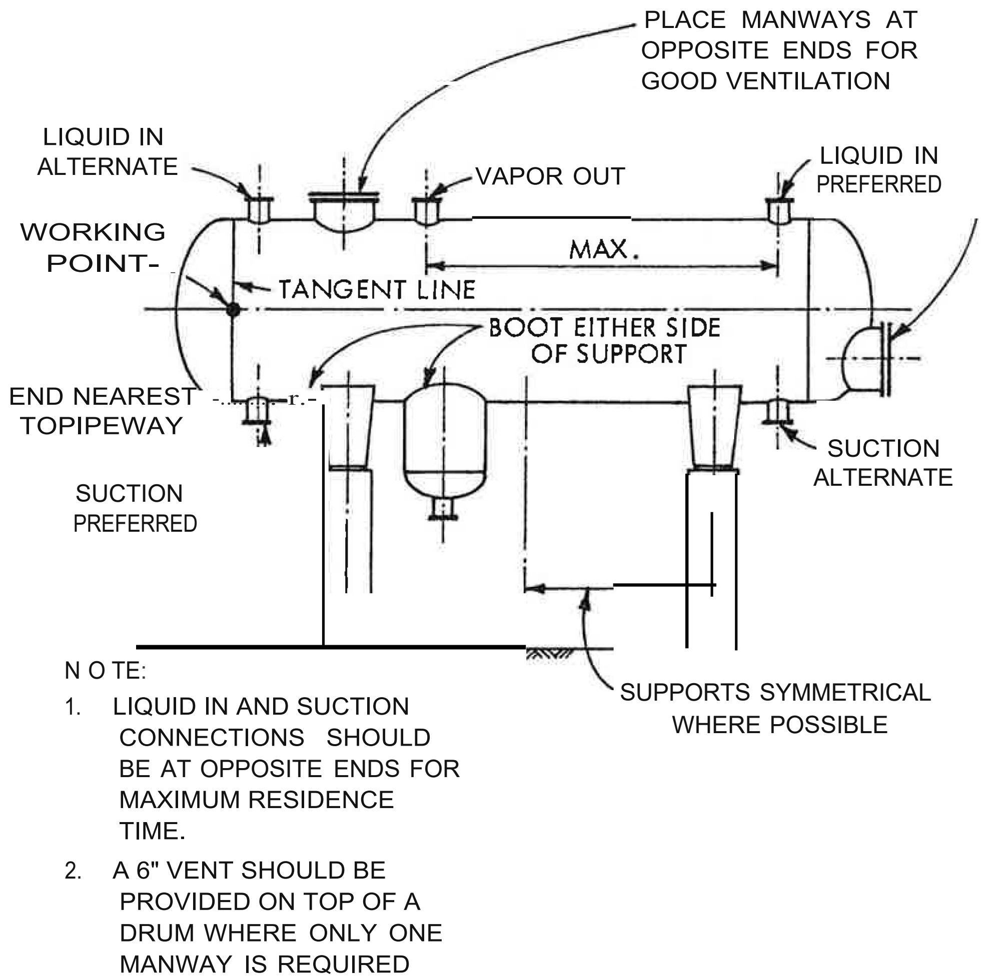


Figure 3-25. Typical Nozzle Placement - Drum.

- Liquid level indicators or controllers should be located at a point remote from any turbulence

- Location of support clips should be included with orientations on stress relieved vessels

Liquid level instruments require special consideration. Connections should be placed to provide vents and drainage. In cases where the drum contains a vapor space, the top connections can be on or near the top centerline of the drum (Figure 3-26A). If the drum will operate filled with liquid, and the instruments are intended to locate or control an interface, the top connection should enter the upper quadrant of the drum horizontally. This will prevent vapor from collecting in the loop formed by the upper portion of the instrument piping (Figure 3-26B).

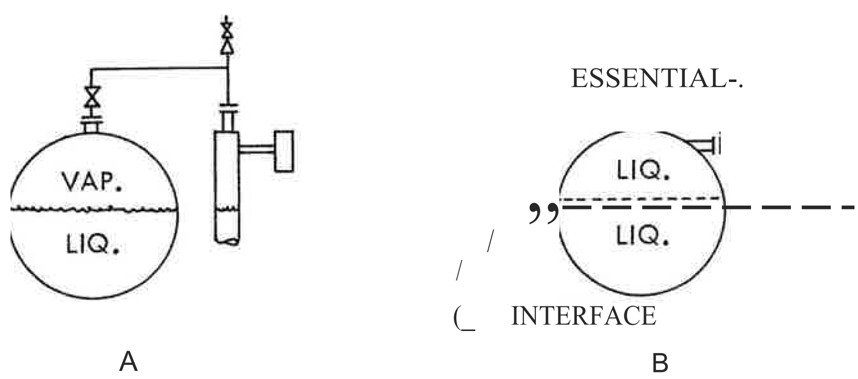
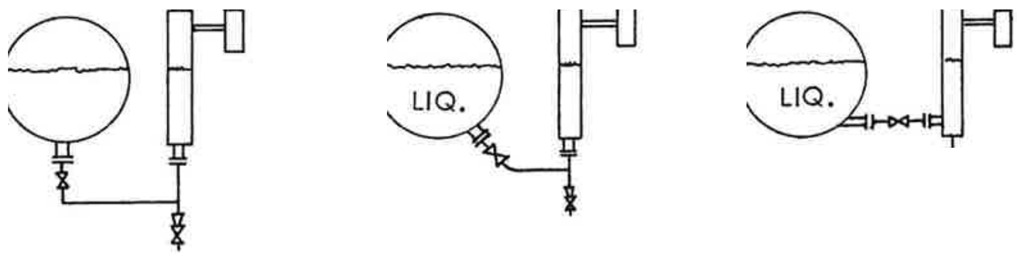


Figure 3-26.

The bottom connections should. unless very low ranges must be reached, enter the lower quadrant of the drum horizontally. This will prevent the bottom connection from "crudding up" with solids from the bottom of the drum (Figure 3-27 A, B. C).



A POOR B BETTER C BEST

Figure 3-27.

When the drum diameter exceeds six feet, the use of a strongback should be adopted, to support instruments (Figure 3-28). The same considerations which apply to venting and draining of single instruments must also apply to the design of the strongback.

A single manway should be placed in the end of the drum away from the pipeway, unless plant requirements call for a platform to serve the level instruments. If such a platform will exist at the pipeway end, take advantage of it and place the manway there.

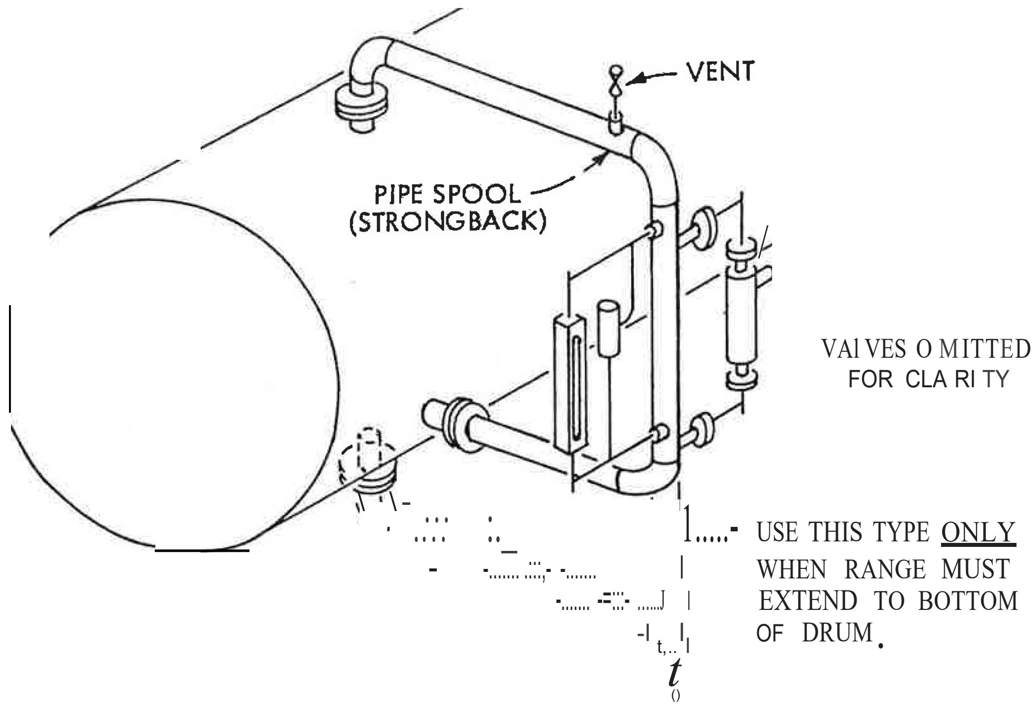


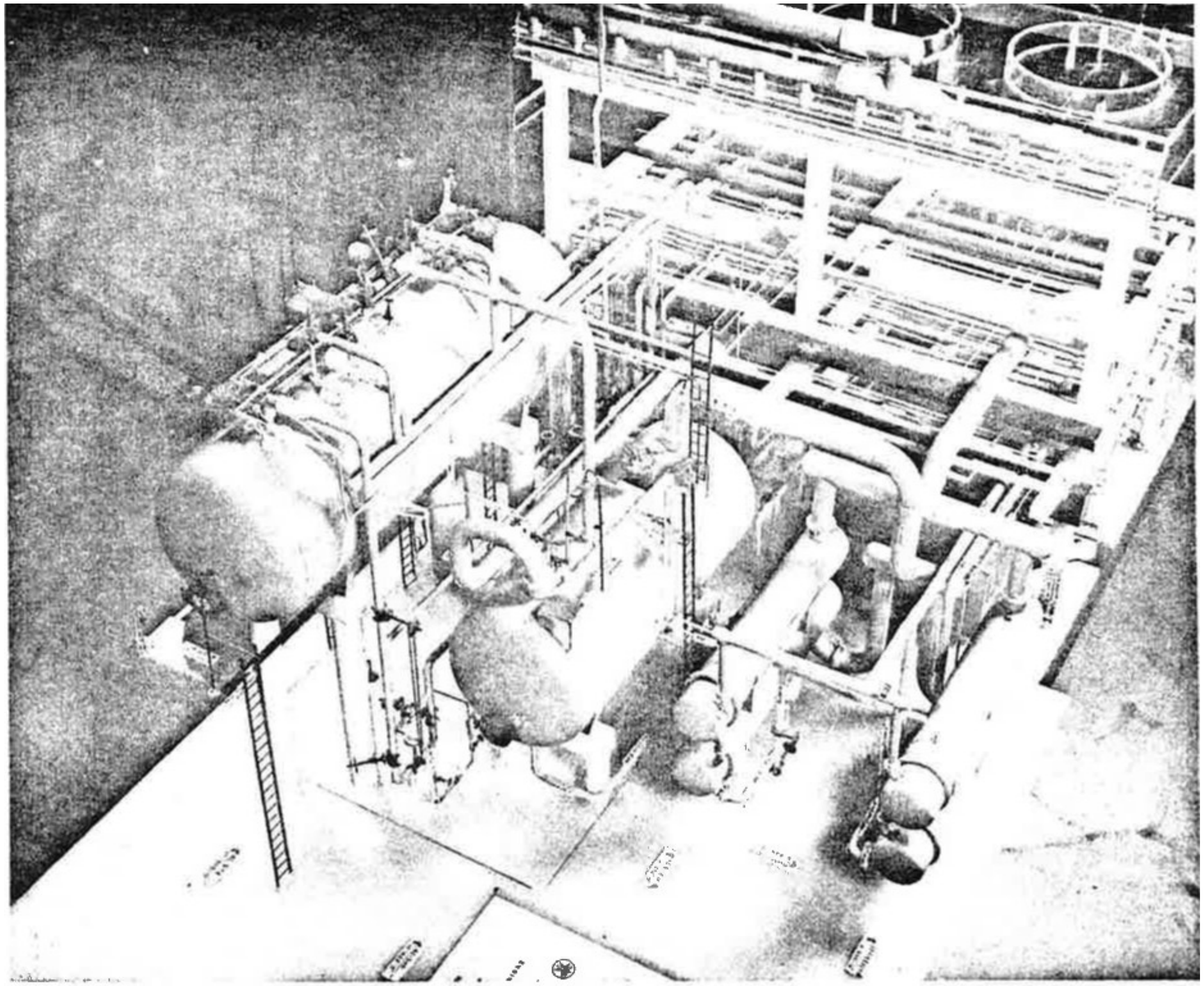
Figure 3-28.

Any vessel provided with manway access should have a ventilation opening at the opposite end. This can be a piping connection which has a .removable spool or a separate vent opening.

Figures 3-29 and 3-30 sho typical piping of horizontal drums.

Figure 3-31 shows the problems of piping an odd shape vessel.

Figures 3-32, 3-33, and 3-34 are plant photos showing columns, drums and conne ting piping.



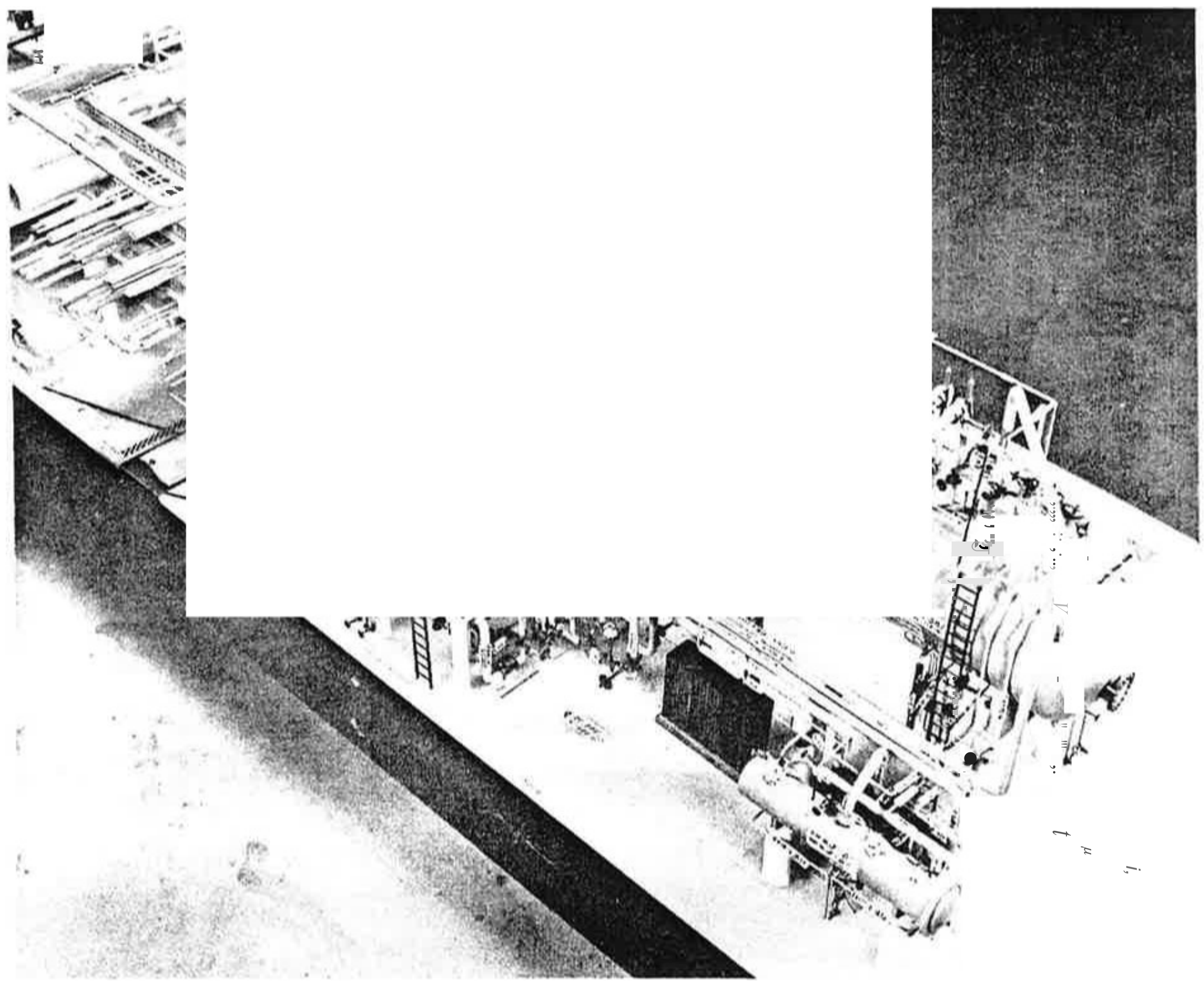
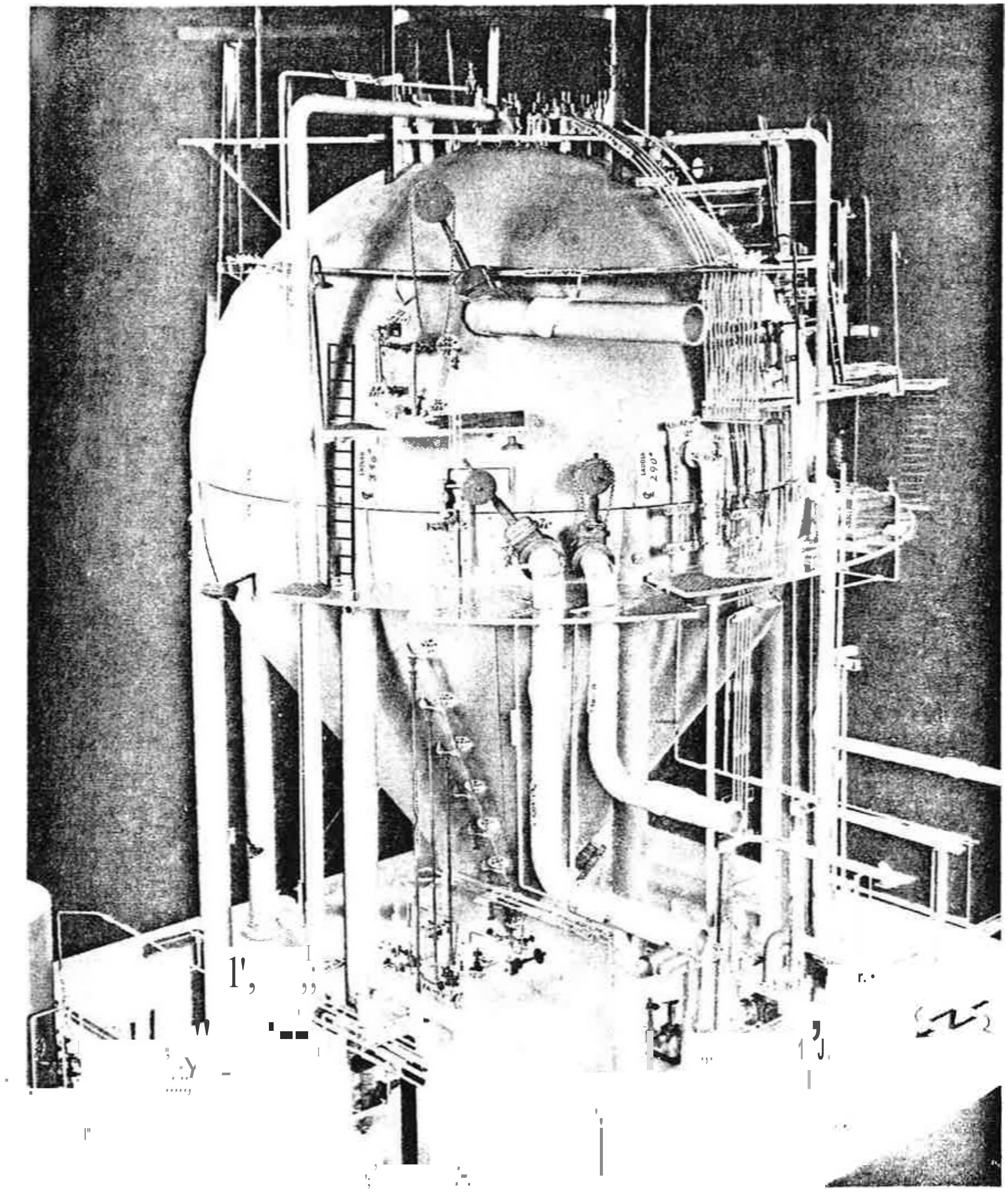


Figure [illegible] Typical Piping Horizontal Drums



...gure 3-31. Piping - Odd-Shaped Vessels

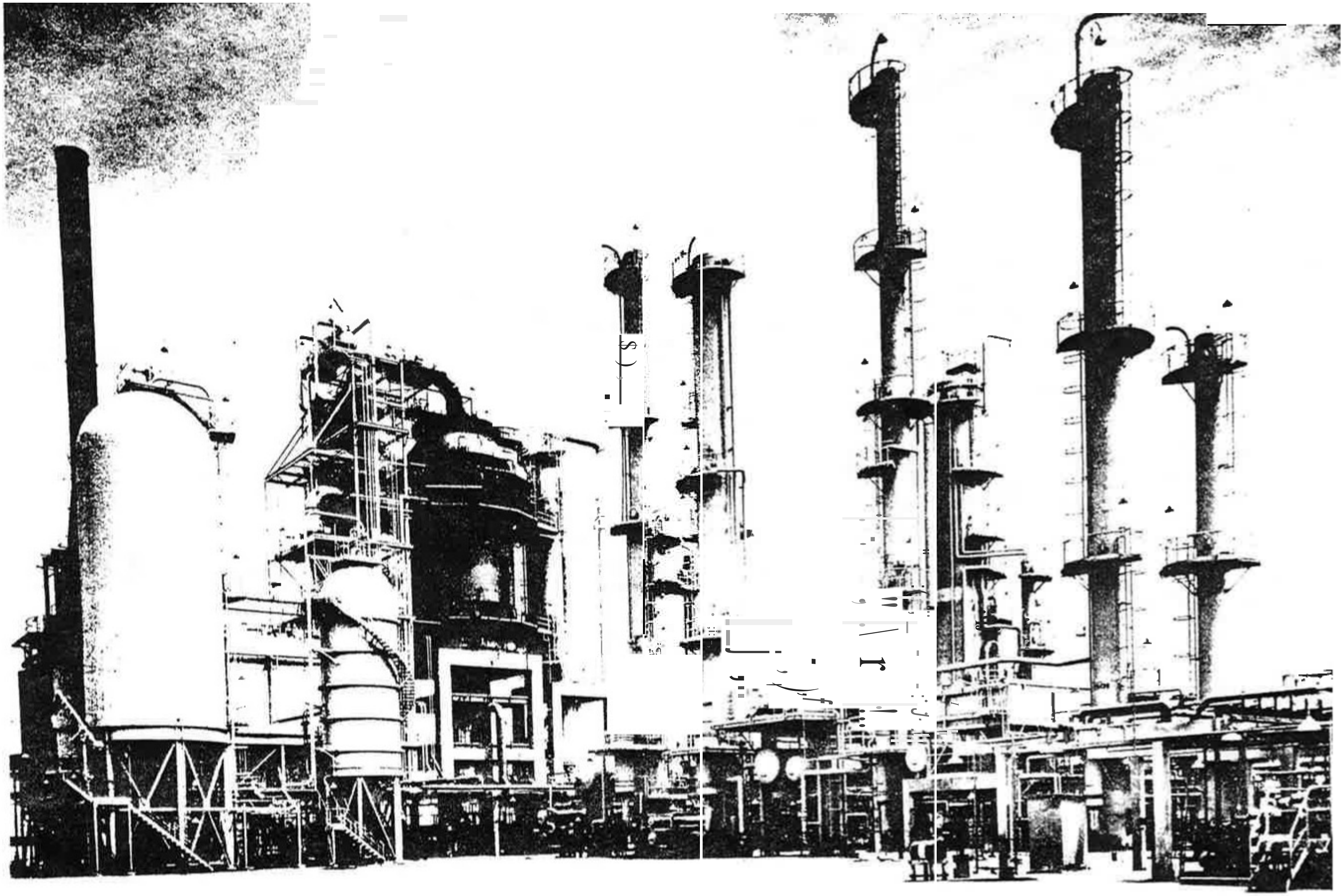


Figure 3-3