

Reference Information

For

# **Heat Exchanger Applications**

PDH Course

a reprint from

*Chemical  
Engineering*

# Shortcut to Heat Exchanger Design <sup>#52</sup>

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COMPUTATIONS FOR HEAT EXCHANGERS  
FOR VERTICAL VAPOR-IN-TUBE CONDENSERS CONTAINING NON-CONDENSABLE FLUIDS, CROSS FLOW IN SHELL

HEAT TRANSFER CALCULATIONS:

		Tube Side			Shell Side	Tube Wall	Fouling
Material	Gas Cooling Precondensing	Gas Cooling Post Condensing	Condensing	Gas Liquid	Copper Brass Stainless Steel	Scale Tar Polymer	
Numerical Factor $F_n$	248	248	8.55	Spacing Tri: 0.475 Sa: 0.270	0.604 0.342	159	3820
Liquid Physical Property Factor $F_p$	X	X	$C_o$ 1.00 $C_i$ 0.99 $Z_i$ 0.22 $M_i$ 18 $S_i$ 0.99 $F_{p1}$ 1.63	$C_o$ 1.0 $Z_o$ 0.72 $M_o$ 18 $S_o$ 1.0 $F_{p0}$ 1.8	$C_o$ 1.0 $C_o$ 10 $C_o$ 0.1 $C_o$ K	$C_o$ 1 $C_o$ 182 $C_o$ 0.0055 $C_o$ K	
Work Factor $F_w$	$6.044$ $33$ $127$	$W_i$ $W_H$ 1569 $W_H - T_L$ 114 $\Delta T_M$ 127	$(a)$ 1.64 $137$ $35$ $127$ $(b)$ 37.7 $W_o$ 137 $T_H - T_L$ 35 $\Delta T_M$ 127 $(a) \times (b)$ 62	$W_o$ 137 $T_H - T_L$ 35 $\Delta T_M$ 127	$137$ $35$ $127$ $37.7$	$137$ $35$ $127$ $37.7$	
Mechanical Design Factor $F_m$	$224$ $0.62$ $12$	$n$ $d_i$ $L$	$n$ 224 $d_i$ 0.62 $L$ 12	$n$ 224 $d_i$ 0.62 $L$ 12	$224$ $12$ $9.5$	$0.75$ $0.62$ $0.13$	$n$ 224 $d_o$ 0.75 $L$ 12
Product $F_n \times F_p \times F_w \times F_m$	0.071	0.186	0.099	0.128	0.039	0.392	

PRESSURE DROP CALCULATIONS:

		Tube Side	Shell Side	Products tube	A	B	C
Physical Property Factor $f_p$	$Z_v$ 0.015 $S_v$ 0.00194 $t_p$ 222		$f_{p0} = \frac{0.326}{S_o}$ 0.326		0.071	0.186	0.099
Work Factor $f_w$	$f_{w1} = (\frac{W_i}{n})^{1.8}$ 0.00147		$f_{w0} = W_o^2$ 19800				
Mechanical Design Factor $f_m$	$L_o/d_i$ 19.3 Plus 25 25.0 $f_{d1}$ 44.3 $f_{m1}$ 0.45 $f_{m2} = 0.7$		$f_{m0} = \frac{L}{p^{3.0}}$ 857 x 19.25				
$f_p \times f_w \times f_m$	0.103	$\Delta P$ total	4.45	Product shell			
				Product wall			
				Product fouling			
				Sum products			
				This sum must be equal to, or less than 1			
				Item No.	Example 13.5, p. 346, Kern		
				Surface area	528 sq.ft.		

MEAN TEMP. DIFFERENCE AND TEMP. CHANGE

$\Delta T_M$ 127 **	$t_H$ 267 $t_u$ 234 ** $t_L$ 120 $t_H - t_M$ 33 $t_M - t_L$ 114	$115$ $80$ $35$	$T_H$ $T_L$ $T_H - T_L$	Size: 19-144
				Number of tubes: 224
				Outside diameter of tubes: 3/4"
				Length of shell or length of single tube pass: 144"
				Inside diameter of shell: 19 1/4"

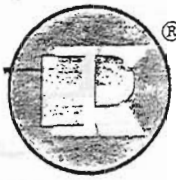
\* For Gases Omit This Factor  
 \*\* Obtain From Plot of Temperatures vs % Total Heat Load

## HEAT EXCHANGER COMPUTATION SHEET

For conditions of no phase change, forced convection, turbulent flow, parallel flow in shell

HEAT TRANSFER CALCULATIONS						
	Tube side		Shell side		Tube wall	Fouling
Numerical factor $F_n$	Gas	2.48	Tri.	Square	<b>STEEL</b>	3820
	Liquid	2.62	5.45	6.75		
			5.75	7.13	159	
Liquid physical property factor $F_p$	GAS		GAS			
	$z_1$	0.025	$z_0$	0.021	$c_1$	0.25
	$M_1$	29	$M_0$	29	$k$	26
	$s_1$	0.0084	$s_0$	0.0101	$c_1/h_s$	0.0033
	$F_{p1}$	—	$F_{p0}$	—	$c_1/k$	0.0096
For gases →	Omit this factor		Omit this factor			
Work factor $F_w$	$W_1$	123	$W_0$	123	$W_1$	123
	$t_H - t_L$	158	$t_H - t_L$	158	$t_H - t_L$	158
	$\Delta T_M$	82	$\Delta T_M$	82	$\Delta T_M$	82
	$F_{w1}$	18.8	$F_{w0}$	18.8	$W_1(t_H - t_L)$	238
					$\Delta T_M$	$\Delta T_M$
Mechanical design factor (see footnote) $F_m$	$n$	397	$n$	397	$d_o$	1.00
	$d_i$	0.87	$d_o$	1.0	$d_i$	0.87
	$L$	36	$L$	36	$d_o - d_i$	0.13
			$N_{PT}$	1		
	$F_{m1}$	0.0072	$F_{m0}$	0.0085	$d_o - d_i$	0.13
			$F_{m02}$	0.5	$n d_o L$	14300
Product $F_n \times F_p \times F_w \times F_m$		0.336		0.435		0.0033
						0.210
PRESSURE DROP CALCULATIONS						
	Tube side		Shell side		Product tube	0.336
Physical property factor $f_p$	$f_{p1}$	57	$f_{p0}$	45.5	Product shell	0.435
Work factor $f_w$	$f_{w1}$	0.123	$f_{w0}$	0.123	Product wall	0.003
Mechanical design factor $f_m$	$L_o/d_i$	20.7	$L_o$	18	Product fouling	0.210
	U-bend +16	45.7	$f_{m01}$	0.005	Sum of products	0.984
	Straight +25	45.7	$f_{m02}$	0.0022		
	Times $N_{PT}$	1	$f_{B1}$	15	This sum must be equal to or less than 1.	
	$f_{d1}$	45.7	$f_{B2}$	5.7		
	$f_{m1}$	0.12	$f_{m0}$	0.278		
$f_p \times f_w \times f_m = \Delta P$		0.84	$\Delta P$ per shell	1.56	For square pitch multiply by 0.75	
$\Delta P \times$ No. of shells		1.68	$\Delta P$ total	3.12	Item No. <b>GAS-GAS HEAT EXCHANGER</b>	
MEAN TEMPERATURE DIFFERENCE (CORRECTED) - $\Delta T_M$						
	Heating and cooling temperature ranges and abscissa and parameter of $\Delta T$ correction factor charts.					
$\Delta T_H$	$t_H$	280	High	198	$T_H$	
	$t_L$	122	Low	40	$T_L$	
$\Delta T_L$	$t_H - t_L$	158	0.659K	1.0	158	
Differ.	$t_H - t_L$	240	1-2	imp.	158	
Ratio	$t_H + t_L$	402	2-4	0.82	$t_H - t_L$	
$\Delta T_{LM}$	$t_{AVE}$	201	3-6	0.93	$t_H + t_L$	
$F_{MTD}$			4-8	0.96	119	
$\Delta T_M$	*Or $t_H - t_L$ whichever is larger positive value		Passes		$F_{MTD}$	

As a first approximation, a value of  $n$  may be obtained from:  $n = W_1 / 2 d_i z_1$

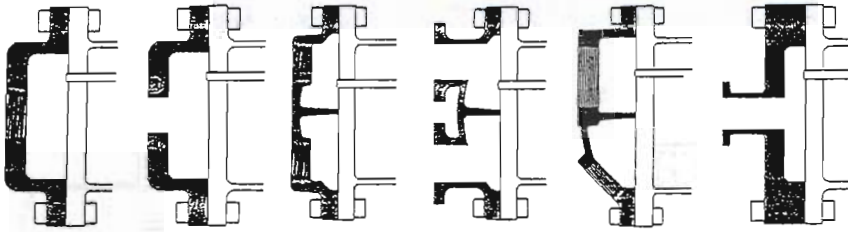


# master shell and head coding index

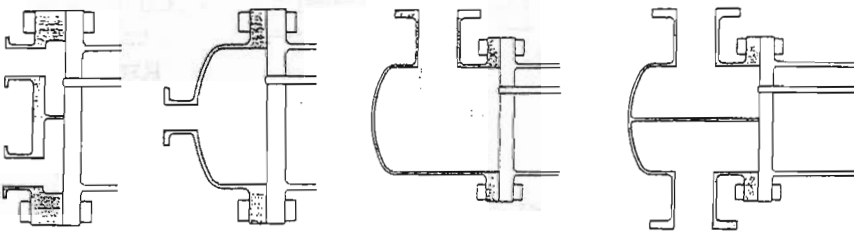
On these two pages, you will find the most popular P-K designs for heat exchanger front heads, shell sections and rear heads grouped together and identified by individual code designations. This master coding index is designed to enable you to survey and specify rapidly the *standard* types of components that are available from P-K for your process requirements.

Complete descriptions of each design, along with further information on front heads, shell sections, and rear heads, are provided on the following pages.

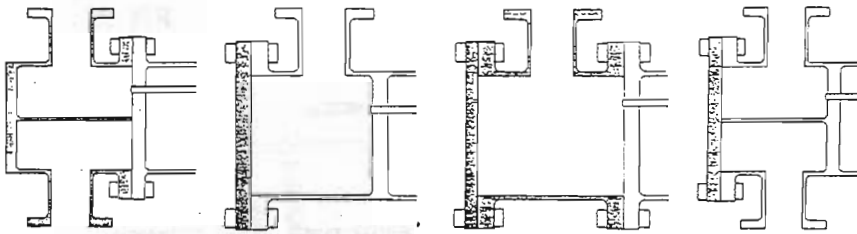
## P-K standard front head (FH) designs



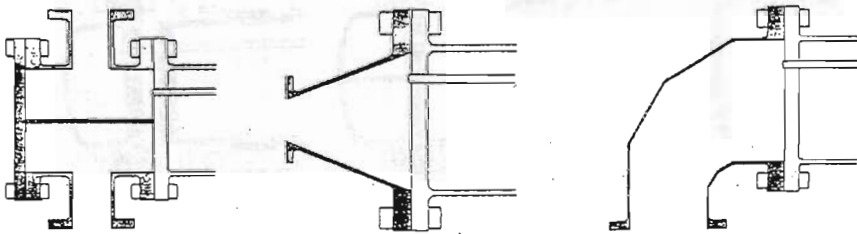
FH-1 FH-2 FH-3 FH-4 FH-5 FH-6



FH-7 FH-8 FH-9 FH-10



FH-11 FH-12 FH-13 FH-14



FH-15 FH-16 FH-17

front heads

FH-  
red

shell sections

SS-  
gray

rear heads

RH-  
blue

## P-K standard shell section (SS) designs



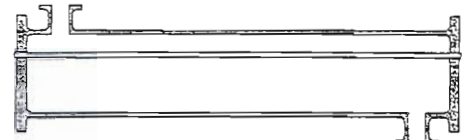
SS-1



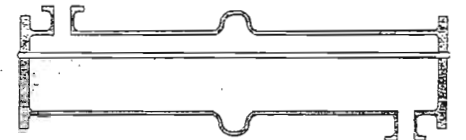
SS-2



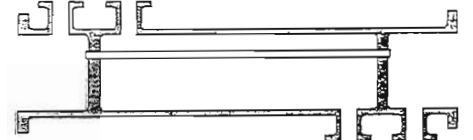
SS-3



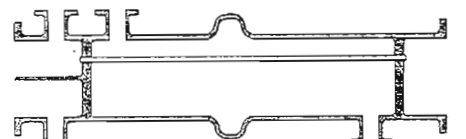
SS-4



SS-5



SS-6

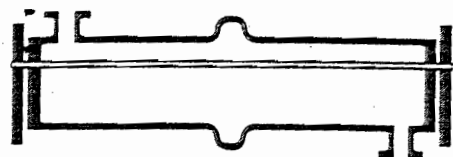


SS-7



SS-8

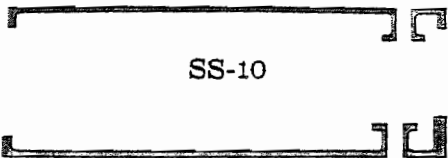
P-K standard shell section (SS) designs



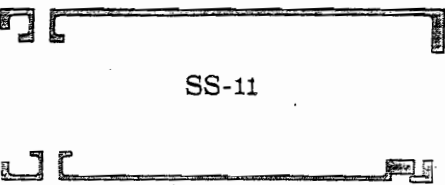
SS-9



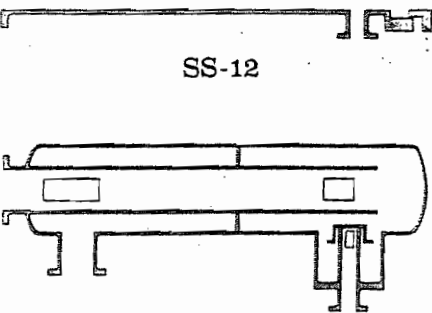
SS-10



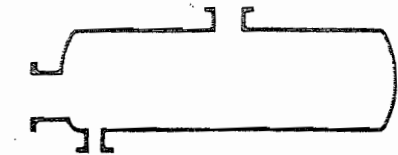
SS-11



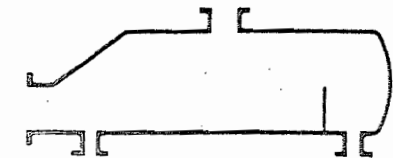
SS-12



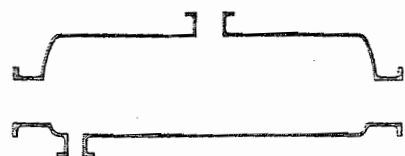
SS-13



SS-14

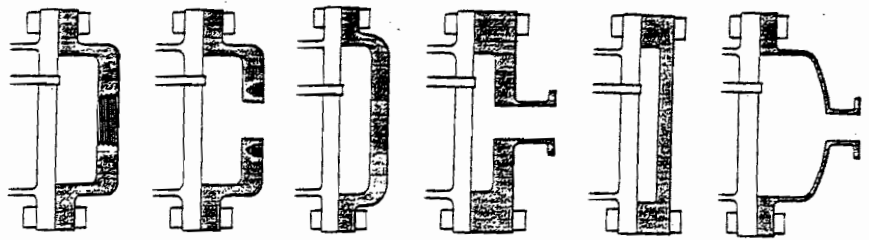


SS-15



SS-16

P-K standard rear head (RH) designs



RH-1

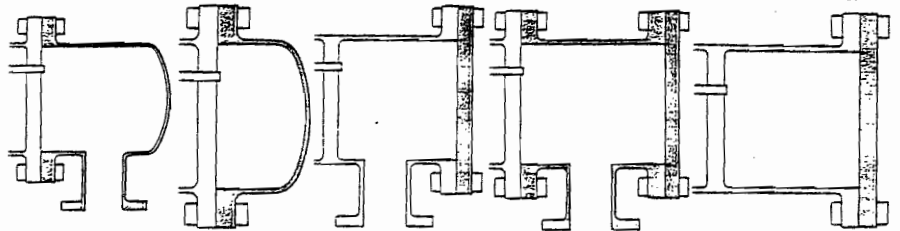
RH-2

RH-3

RH-4

RH-5

RH-6



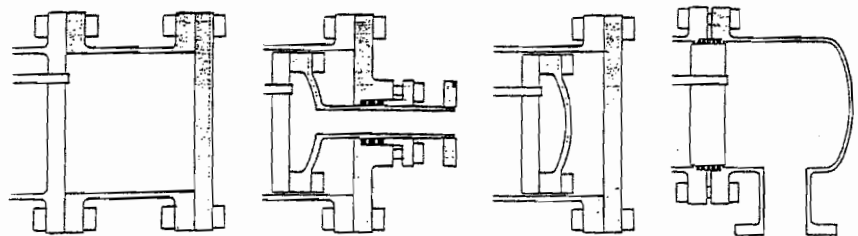
RH-7

RH-8

RH-9

RH-10

RH-11

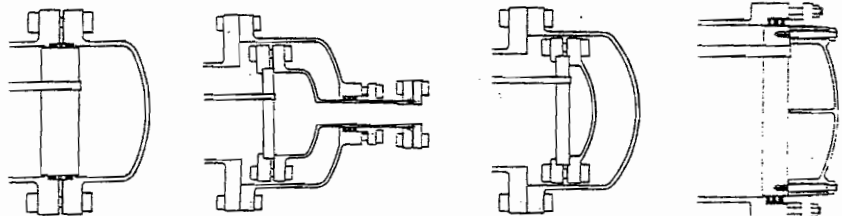


RH-12

RH-13

RH-14

RH-15

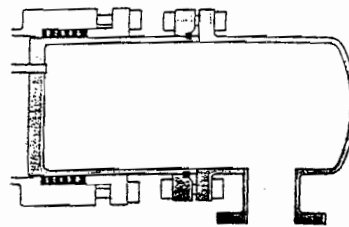


RH-16

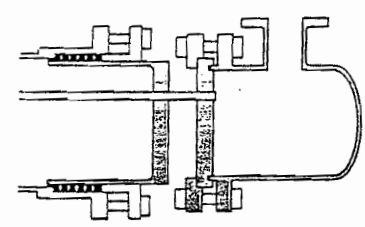
RH-17

RH-18

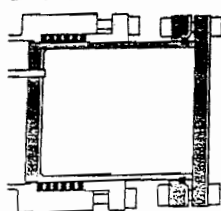
RH-19



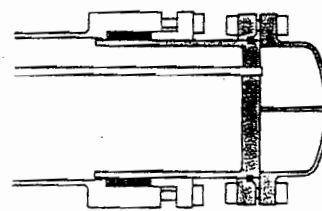
RH-20



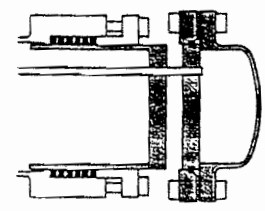
RH-21



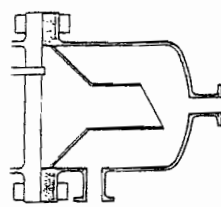
RH-22



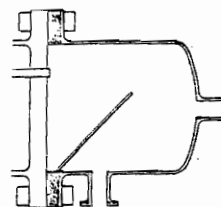
RH-23



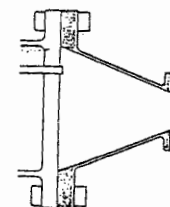
RH-24



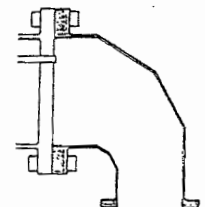
RH-25



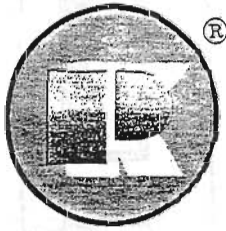
RH-26



RH-27



RH-28



## standard front head (FH) designs

A few of the most popular standard front head (FH) designs available from P-K are illustrated in the accompanying drawings.

Cast bonnets such as FH-1, FH-2 and FH-3 are usually the least expensive and offer a number of alternate openings where threaded or studded and flanged connections are suitable. Where bolted flanged connections are needed in a multi-pass design, a relatively inexpensive choice is a bonnet such as FH-4, which can be either cast or fabricated.

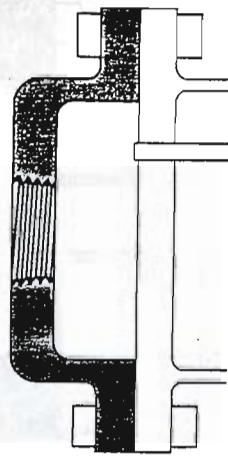
FH-6 and FH-7 are fabricated billet designs. Where a deeper head is required, comparable strength can be obtained in a fabricated dished head design such as FH-8.

Designs such as FH-9, FH-10 and FH-11 provide many possible piping arrangements and greater accessibility for maintenance. The radial flanged connections permit easy removal of the head with minimum disturbance to the piping of the whole installation. Inlets in the upper part of the head and outlets in the bottom make for easier drainage in multi-pass designs.

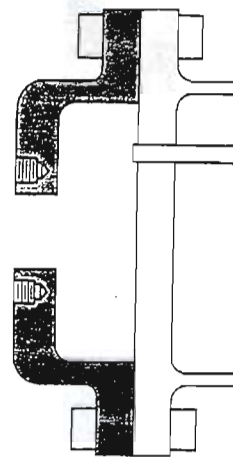
If the application entails frequent inspection and cleaning of tubes, channel construction such as FH-12, FH-13, FH-14 and FH-15 may be the best choice. Channel designs are available for single pass or multi-pass units. Piping doesn't need to be disturbed at all for access to tubes; it is only necessary to unbolt and remove the cover plate. Where the channel is not integral with the shell, the entire channel may be removed when necessary.

FH-16 and FH-17 are two of the special front head designs that can be made to accommodate special conditions.

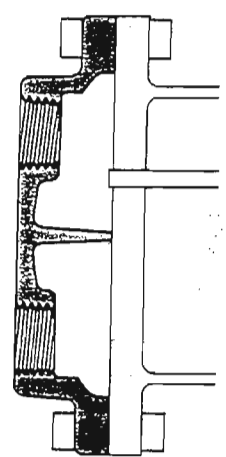
Each cast head design is available with only the type of connection shown. However, fabricated head designs can be supplied with threaded, flanged, wrought or other type connections.



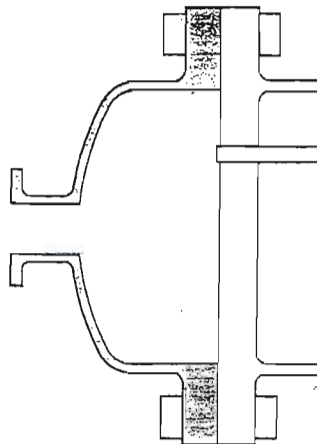
**FH-1**  
cast bonnet — single  
pass — FPT connection



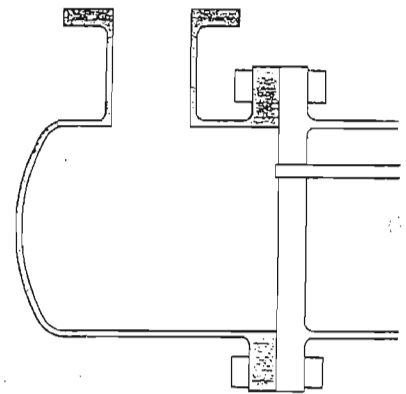
**FH-2**  
cast bonnet—single pass—  
studded flanged connection



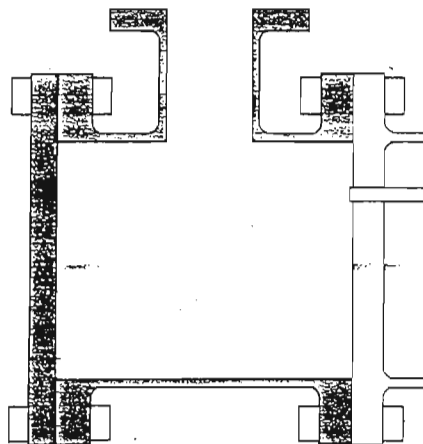
**FH-3**  
cast bonnet — multi-  
pass — FPT connections



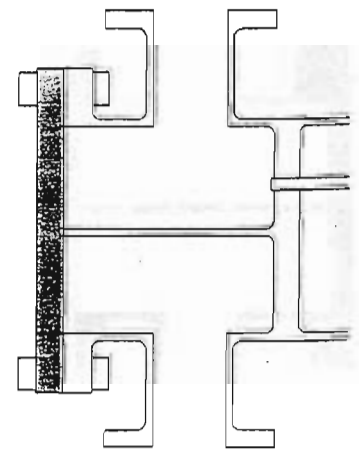
**FH-8**  
bonnet — single pass  
— flanged connection



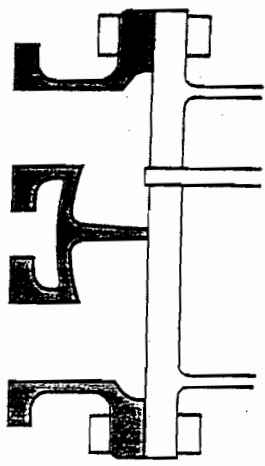
**FH-9**  
bonnet — single pass —  
radial flanged connection



**FH-13**  
channel with removable cover plate —  
single pass — radial flanged connection

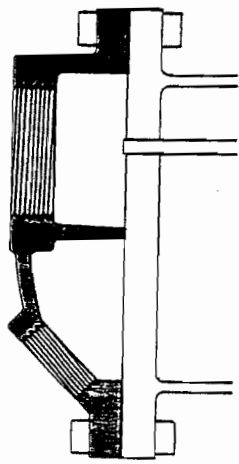


**FH-14**  
channel with removable cover plate  
— multi-pass — channel integral with  
shell — radial flanged connections



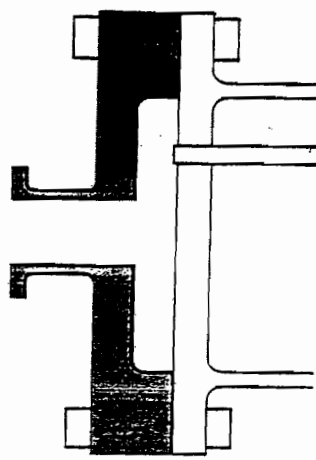
**FH-4**

cast or fabricated bonnet —  
multi-pass — flanged connections



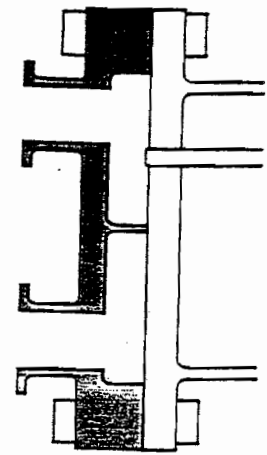
**FH-5**

cast vapor bonnet — two  
pass — FPT connections



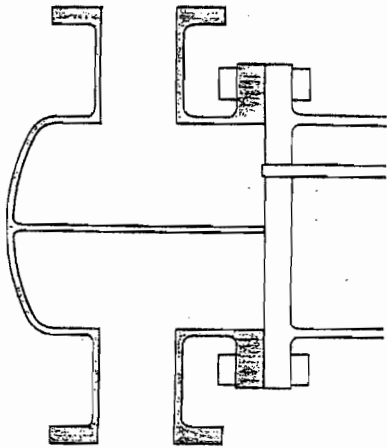
**FH-6**

billet — single pass  
— flanged connection



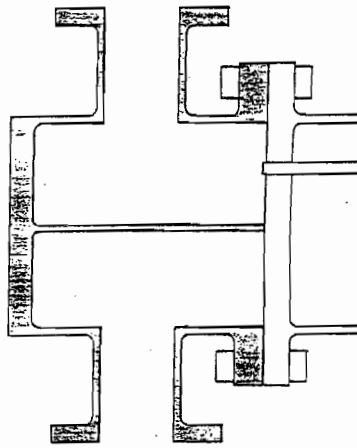
**FH-7**

billet — multi-pass —  
flanged connections



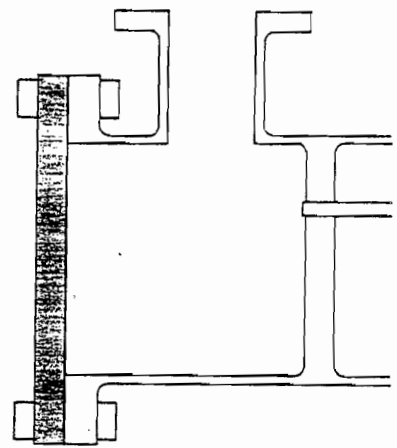
**FH-10**

bonnet — multi-pass — radial flanged connections



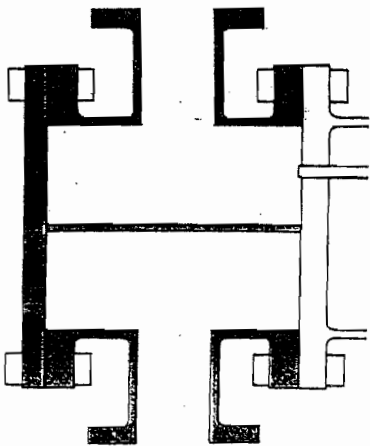
**FH-11**

bonnet — multi-pass — radial flanged connections



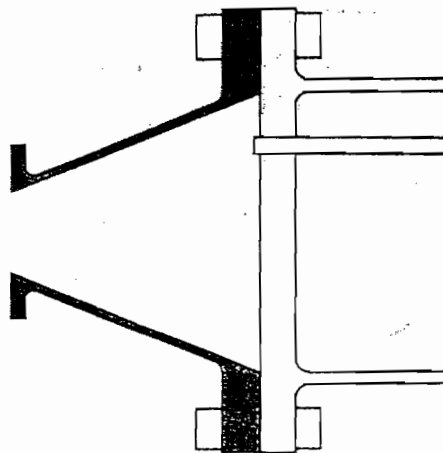
**FH-12**

channel with removable cover plate  
— single pass — channel integral with  
shell — radial flanged connection



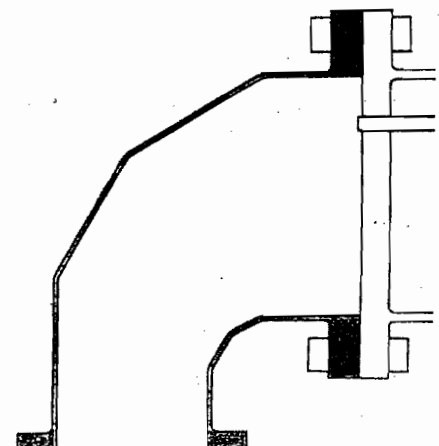
**FH-15**

channel with removable cover plate —  
multi-pass — radial flanged connections



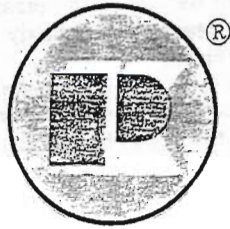
**FH-16**

cone — single pass — flanged connection



**FH-17**

mitered conical elbow — flanged connection



## standard shell section (SS) designs

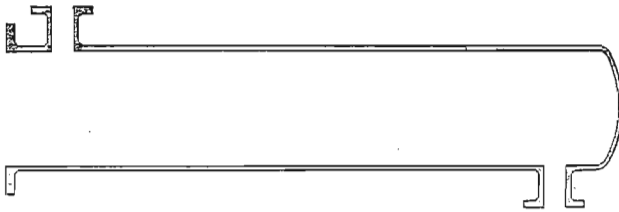
Sixteen standard P-K shell section (SS) designs are shown on the following pages.

Three variations of shells to accommodate removable "U" tube bundles are shown. These are SS-1, SS-2 and SS-3. SS-3 is designed with double tubesheet construction.

The fixed tubesheet, non-removable bundle types provide a number of choices in such features as tubesheet construction, expansion joints, and type of connections.

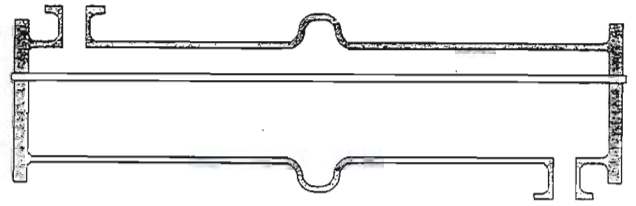
Such fixed tubesheet designs as SS-4, SS-6 and SS-8 have no expansion joint. They are suitable where the temperature difference between shell side and tube side fluids is such that the resultant differential thermal expansion does not exceed the conservative stress limits of tube and shell materials. Where the temperature difference and resultant differential thermal expansion exceeds the stress limits of the materials, a shell section with an expansion joint is required. SS-5, SS-7 and SS-9 are of this type.

Where the possibility of leakage from one fluid into the other cannot be tolerated, a double tubesheet shell section



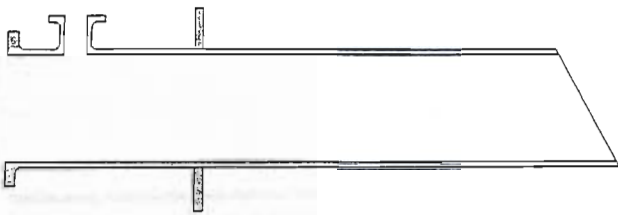
**SS-1**

"U" tube removable bundle construction



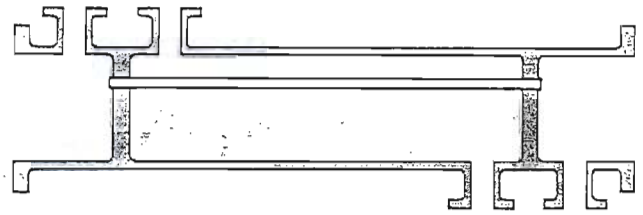
**SS-5**

straight tube — fixed tubesheet — non-removable bundle with expansion joint



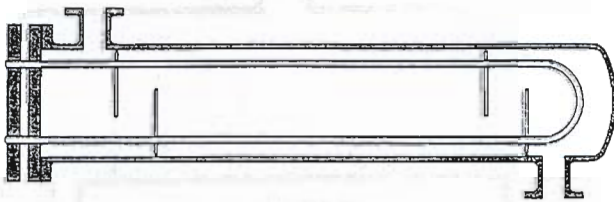
**SS-2**

"U" tube removable bundle — suction heating construction



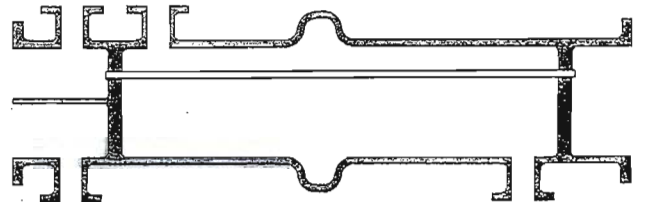
**SS-6**

straight tube — fixed tubesheet — non-removable bundle — single pass — channels integral with shell



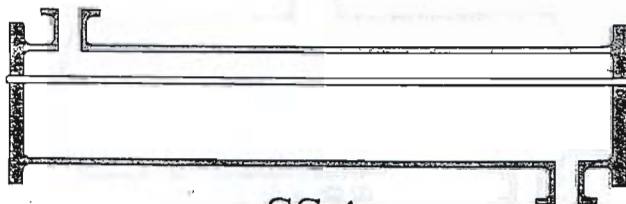
**SS-3**

"U" tube — double tubesheet — removable bundle construction



**SS-7**

straight tube — fixed tubesheet — non-removable bundle — multi-pass channels integral with shell — expansion joint



**SS-4**

straight tube — fixed tubesheet — non-removable bundle



**SS-8**

straight tube — fixed double tubesheet — non-removable bundle

such as SS-8 or SS-9 should be specified. Single tubesheet construction used in SS-4, SS-5, SS-6 and SS-7 is satisfactory for the majority of applications.

SS-6 and SS-7 are designs which have channels integral with the shell. Hence, for a complete combination of front head, shell section and rear head, only channel covers are required.

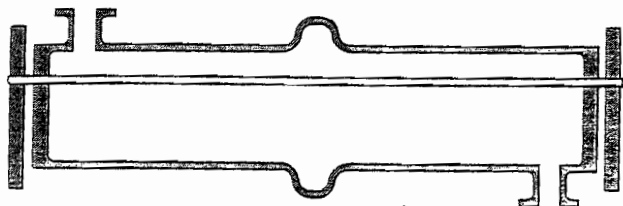
Such designs as SS-10 to SS-12, are for use with floating tubesheet type construction. SS-10 can be used with either the pull-through bundle type in which the floating tubesheet has a separate cover within the shell, or the outside packed lantern-ring construction. SS-11 is designed to accommodate a floating head cover that is fastened to the tubesheet with a split backing ring. In SS-12, an outside packed gland seals the shell side fluid from the atmosphere. In such a design, the outer skirt of the floating tubesheet is part of the floating head; and the cover is fastened with a split key ring.

In applications where separating liquid from the vapor in the shell side fluid is a problem, a design such as SS-13

embodying a surge drum and vapor liquid separator may be necessary. For details of the separator design, see section C, page 11. This design is commonly used for mounting directly over a compressor.

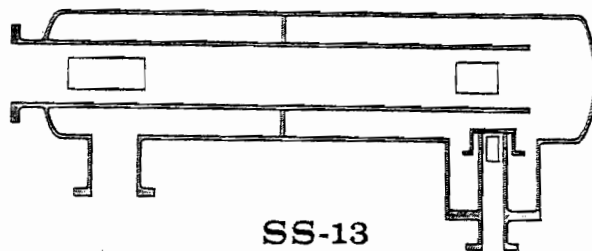
Where vapor is generated, shell designs SS-14 to SS-16, should provide a large open volume over the boiling liquid. This permits the vapor to travel at a sufficiently low velocity toward the outlet so that entrained liquid settles out before it leaves the shell. Shell outlet connections are located above the center of the tube bundle length. This allows a maximum volume of vapor to leave the shell for a given vapor velocity since no vapor has to traverse more than half the dome area to exit.

All can be used with either "U" tube or straight tube, pull-through bundle type construction. SS-15, a kettle-type reboiler, has an overflow weir with bottom drain to keep the liquid at the optimum level. SS-16 permits the installation of two bundles within one shell. SS-14 and SS-16 may also be used for heating and cooling service.



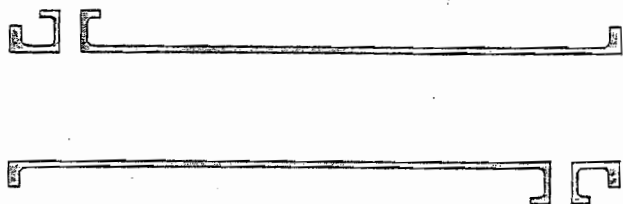
**SS-9**

straight tube—fixed double tubesheet—  
non-removable bundle — expansion joint



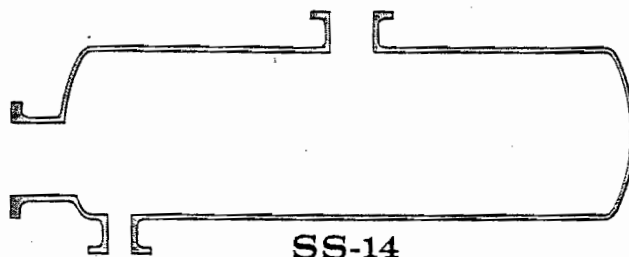
**SS-13**

"U" tube or straight tube floating head—pull through removable bundle with surge drum and integral vapor liquid separator (see section c, page 11 for details on separator)



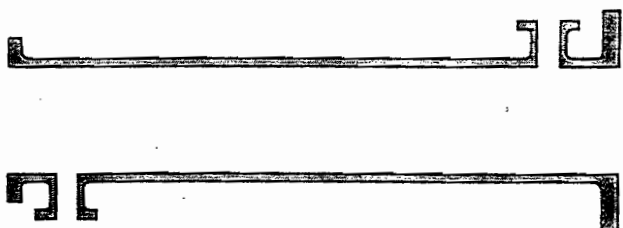
**SS-10**

straight tube floating head—pull-through removable bundle or outside packed lantern-ring construction



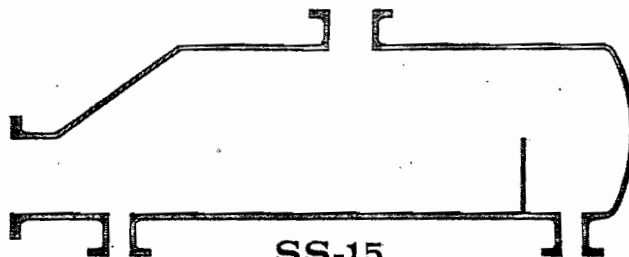
**SS-14**

multi-purpose vessel—"U" tube or straight tube — pull-through removable bundle construction



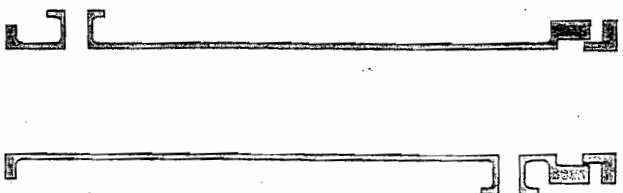
**SS-11**

straight tube — removable bundle — split backing ring construction



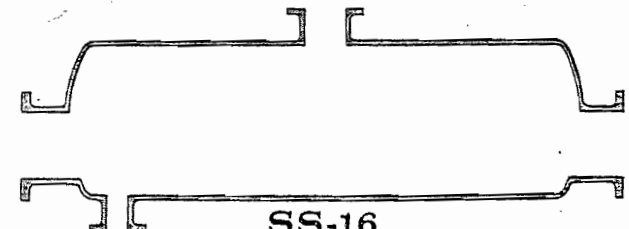
**SS-15**

kettle type reboiler with overflow weir for "U" tube or straight tube pull-through bundle construction for vapor generation



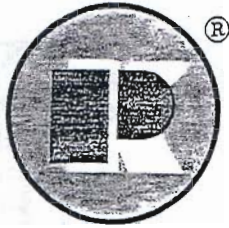
**SS-12**

straight tube — removable bundle — outside packed stuffing box and split key ring construction



**SS-16**

multi-purpose vessel — dual "U" tube or dual straight tube pull-through removable bundle construction



## standard rear head (RH) designs

These diagrams illustrate 28 standard rear head (RH) designs. These are similar to front head designs in that they offer varying degrees of piping convenience and tube accessibility. But there are more RH designs because, unlike front heads, they are used with the floating tubesheets as well as fixed tubesheets.

As with front heads, the least expensive design is a cast bonnet, RH-1 to RH-3. These offer a variety of connections in single pass. For multi-pass, the bonnet type gives slightly more depth than billet construction, as shown in RH-4 and RH-5.

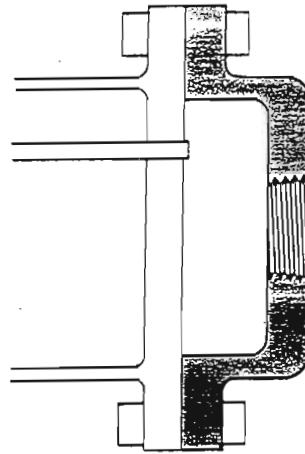
RH-1 to RH-12 designs are for use with fixed or stationary tubesheets. More elaborate designs are required where a floating head is provided, such as RH-13 to RH-24 designs.

Where the floating head has an internal gasketed cover, as in the pull-through bundle type (RH-14) and split backing ring type (RH-18) only a multi-pass heat exchanger is possible unless a packed joint is installed in the floating head. RH-13 and RH-17 are such designs. The packing gland seals the shell side fluid from the atmosphere at the opening through the rear cover. The tube bundle of RH-17 and RH-18 can be removed after the shell cover and the floating head cover are removed.

In RH-15 and RH-16, an outside packed lantern-ring provides the seal between shell side and tube side fluids as the tubesheet moves back and forth with expansion and contraction of tubes. Weep holes in the ring vent any seepage to the atmosphere. Unlike floating heads with internal covers, this design is readily adaptable to single pass operation.

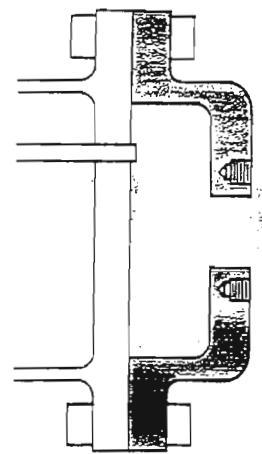
A number of rear head designs such as RH-19 to RH-24 employ an outside packed stuffing box to seal the shell side fluid from the atmosphere. The outer skirt of the floating tubesheet forms part of the head in single tubesheet construction as in RH-20, RH-22, and RH-23. Where double tubesheet construction is used, a separate head is fastened to the outer tubesheet with a split key ring as in RH-21 and RH-24. The heads of the single tubesheets are similarly fastened. This type of design is adaptable to either single or multi-pass operations. With a double tubesheet design, there is no possibility of tube side and shell side fluid leaking into each other.

The remaining designs are single pass rear heads. RH-25 and RH-26 have entrainment separators and bottom drains for separating liquid from vapor as it leaves the exchanger. RH-27 and RH-28 are two of the special rear head designs that can be made to accommodate special conditions.



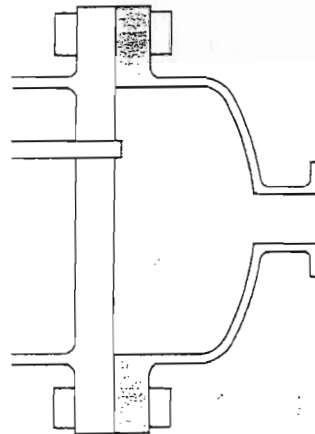
**RH-1**

cast bonnet — single pass — FPT connection



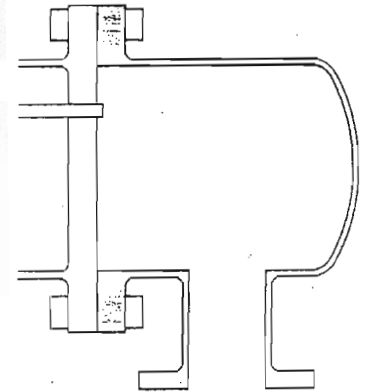
**RH-2**

cast bonnet—single pass—studded flanged connection



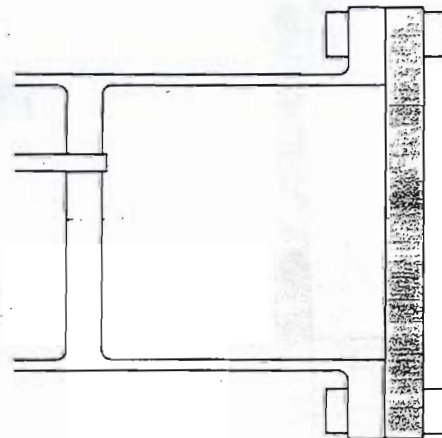
**RH-6**

bonnet — single pass — flanged connection



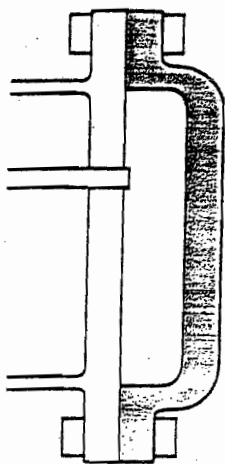
**RH-7**

bonnet — single pass radial flanged connection



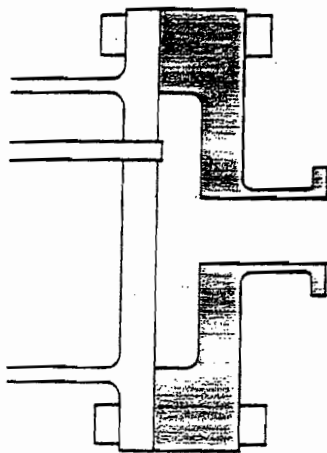
**RH-11**

channel with removable cover plate — multi-pass — channel integral with shell



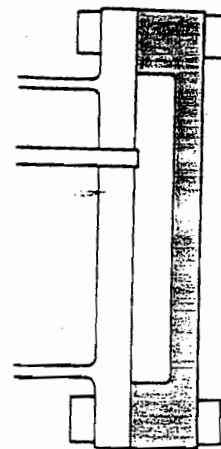
**RH-3**

cast bonnet — multi-pass



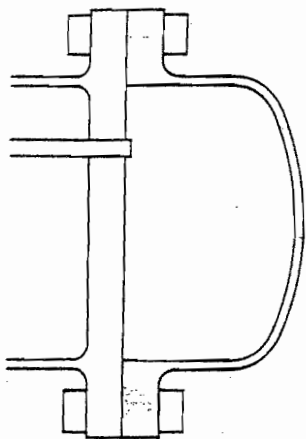
**RH-4**

billet — single pass — flanged connection



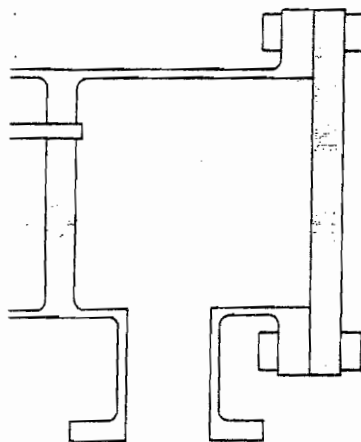
**RH-5**

billet — multi-pass



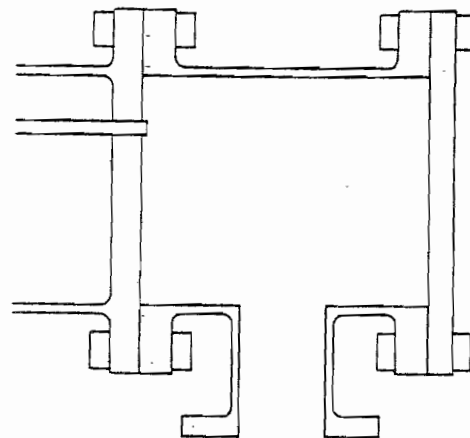
**RH-8**

bonnet — multi-pass



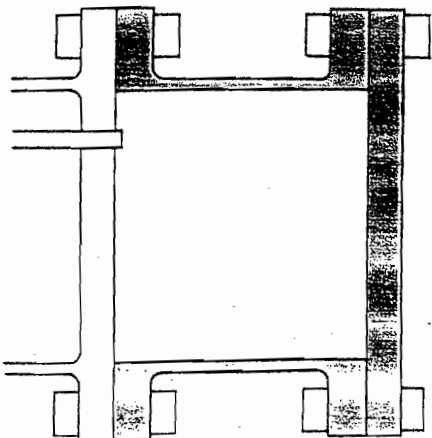
**RH-9**

channel with removable cover plate  
— single pass — radial flanged connection — channel integral with shell



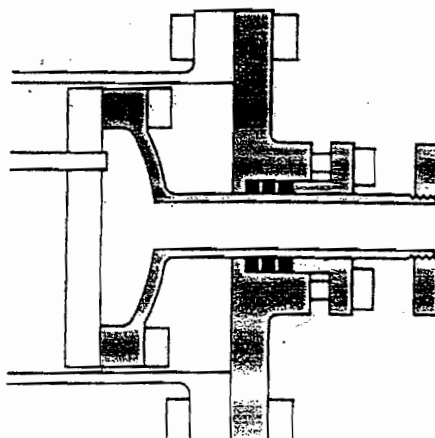
**RH-10**

channel with removable cover plate — single pass — radial flanged connection



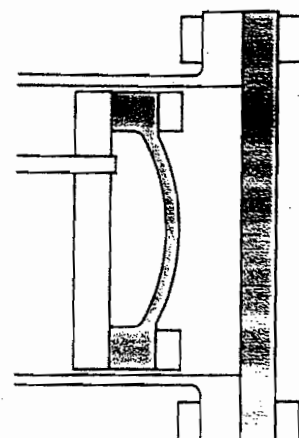
**RH-12**

channel with removable cover plate — multi-pass



**RH-13**

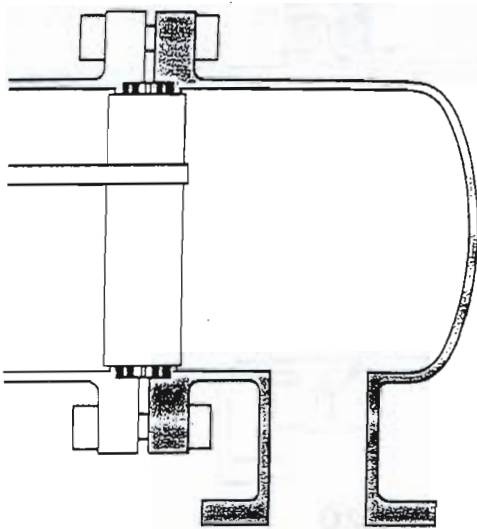
straight tube floating head — pull-through removable bundle — single pass — flanged connection with packed joint



**RH-14**

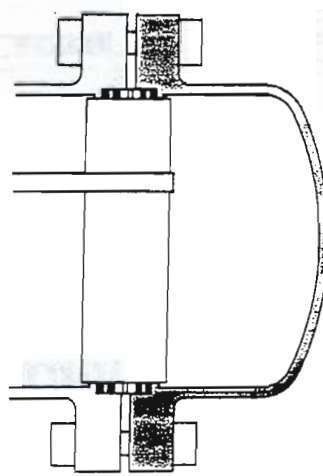
straight tube floating head — pull-through removable bundle and shell cover plate — multi-pass

# p-k standard rear head (RH) designs (cont.)



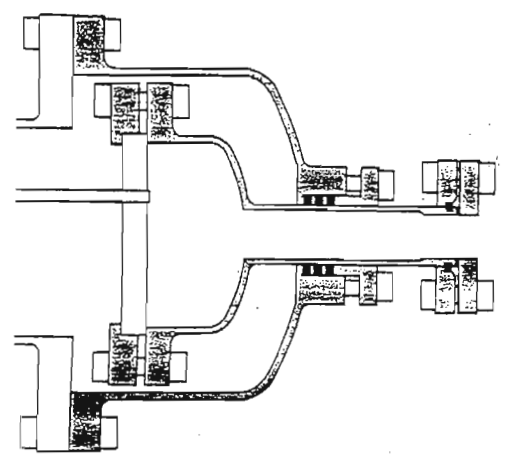
**RH-15**

straight tube floating head — removable tube bundle — outside packed lantern-ring construction — single pass — radial flanged connection



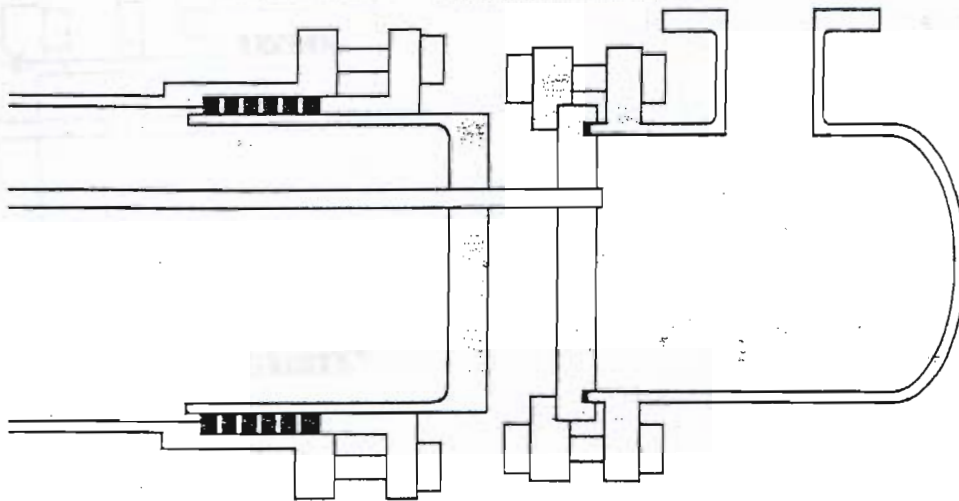
**RH-16**

straight tube floating head — removable tube bundle — outside packed lantern-ring construction — two pass



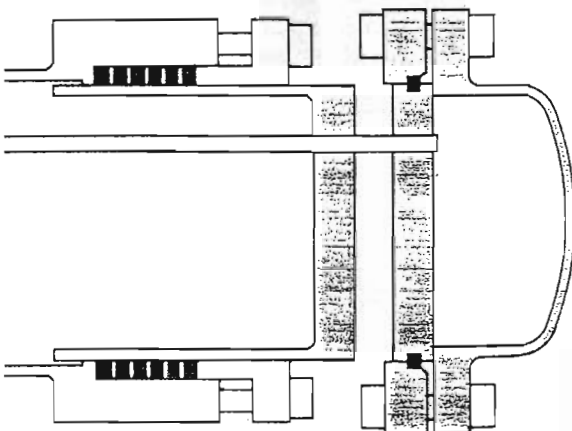
**RH-17**

straight tube floating head removable bundle — split backing ring construction with shell cover — single pass — flanged connection with packed joint



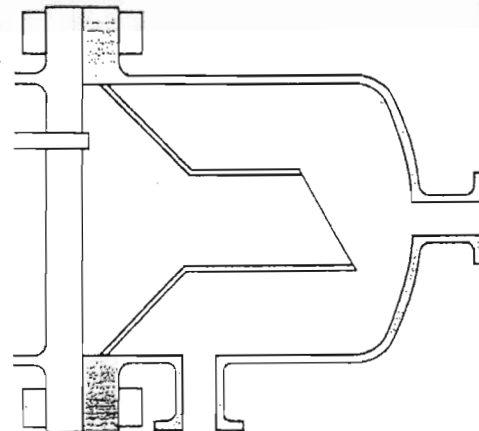
**RH-21**

straight tube floating head — double tubesheet — removable tube bundle — outside packed stuffing box and split backing ring construction — single pass — radial flanged connection



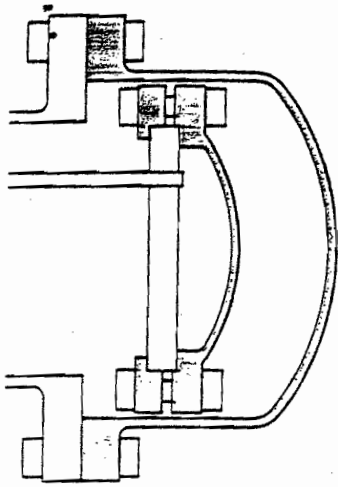
**RH-24**

straight tube floating head — removable tube bundle — double tubesheet — outside packed stuffing box and split key ring construction — multi-pass



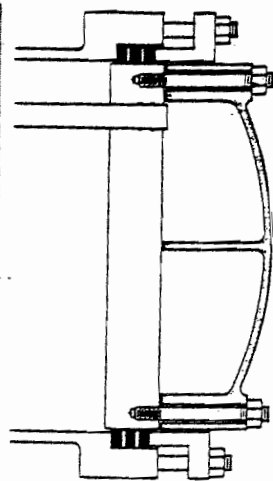
**RH-25**

bonnet — single pass with entrainment separator — flanged connection



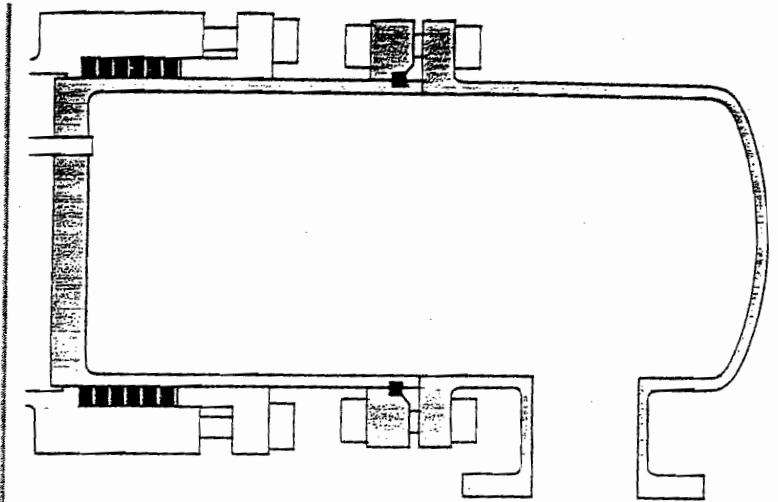
**RH-18**

straight tube floating head — removable tube bundle—split backing ring construction with shell cover — multi-pass



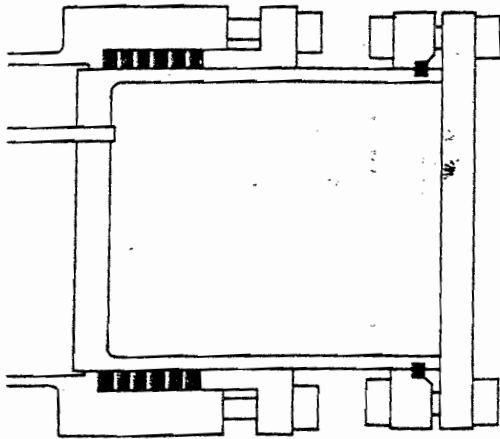
**RH-19**

straight tube floating head — pull-through removable bundle — outside packed stuffing box — multi-pass



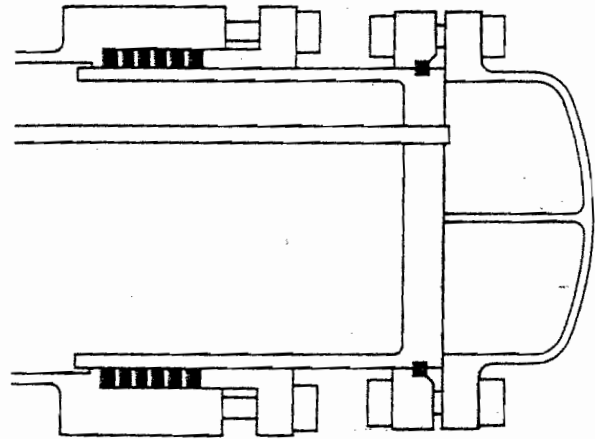
**RH-20**

straight tube floating head — removable tube bundle — outside packed stuffing box — single pass



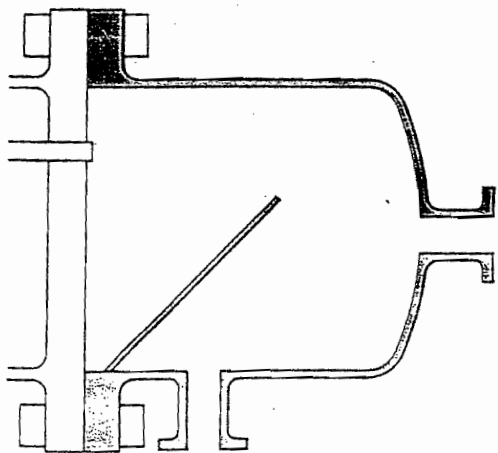
**RH-22**

straight tube floating head — removable tube bundle — outside packed stuffing box and split key ring construction — multi-pass



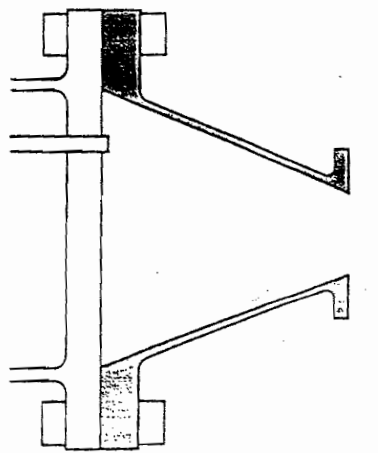
**RH-23**

straight tube floating head — removable tube bundle — outside packed stuffing box and split key ring construction — multi-pass



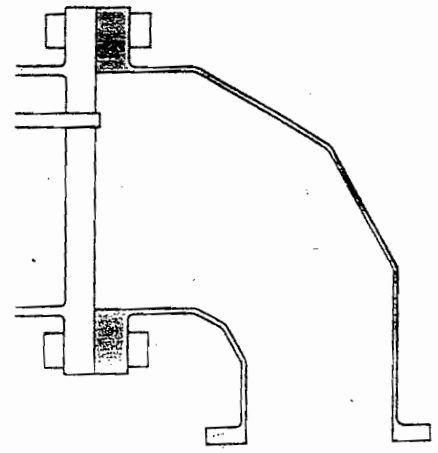
**RH-26**

bonnet — single pass with entrainment separator—flanged connection



**RH-27**

cone — single pass — flanged connection



**RH-28**

mitered conical elbow — flanged connection

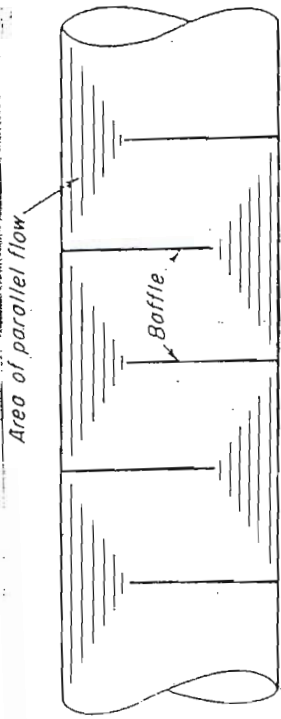


Fig. 11-7. Areas of parallel flow in a heat exchanger with segmental baffles.

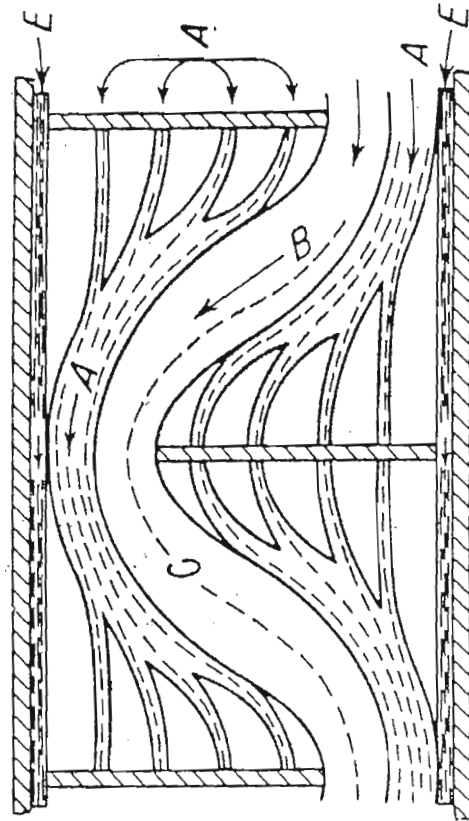
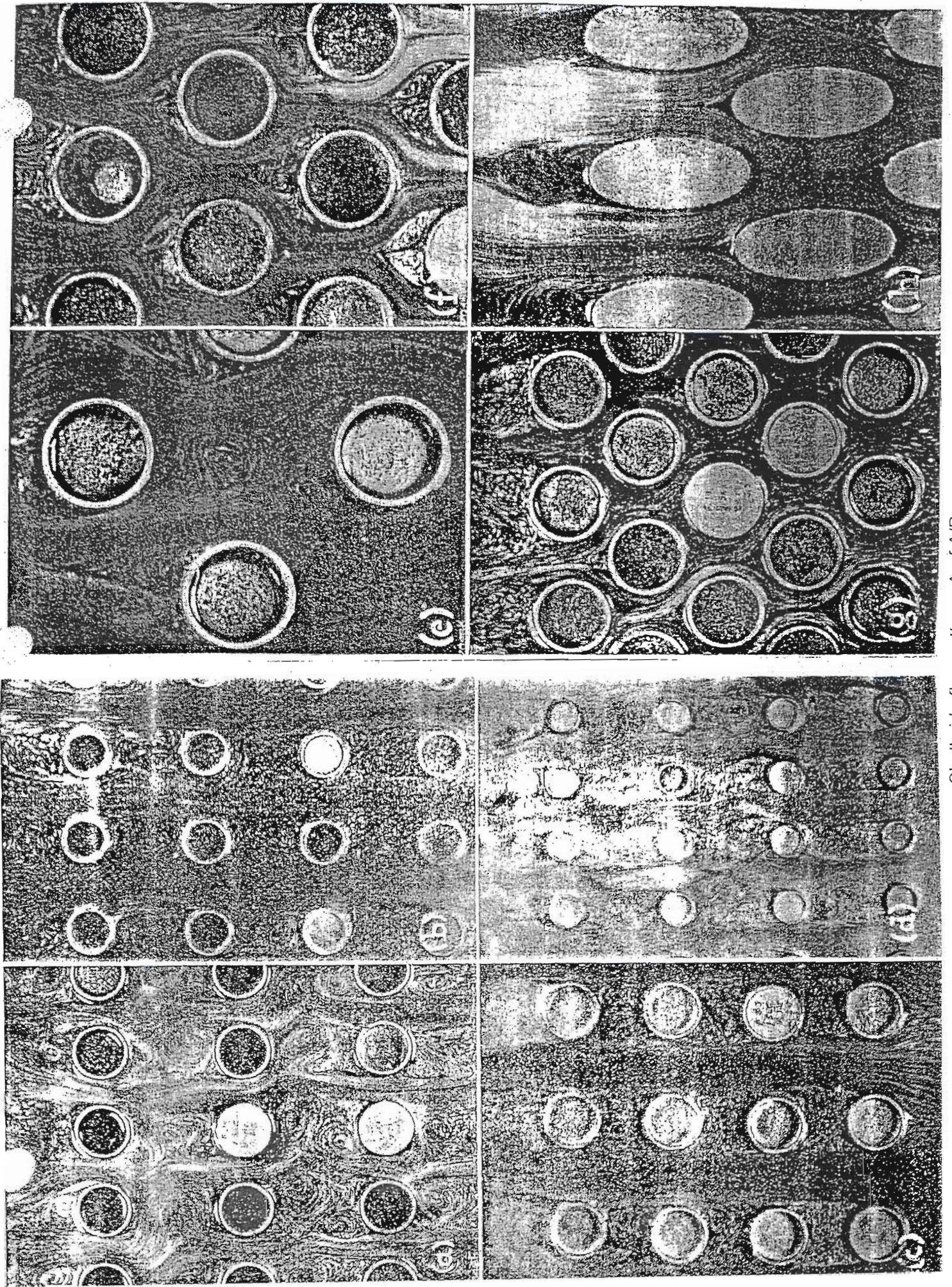
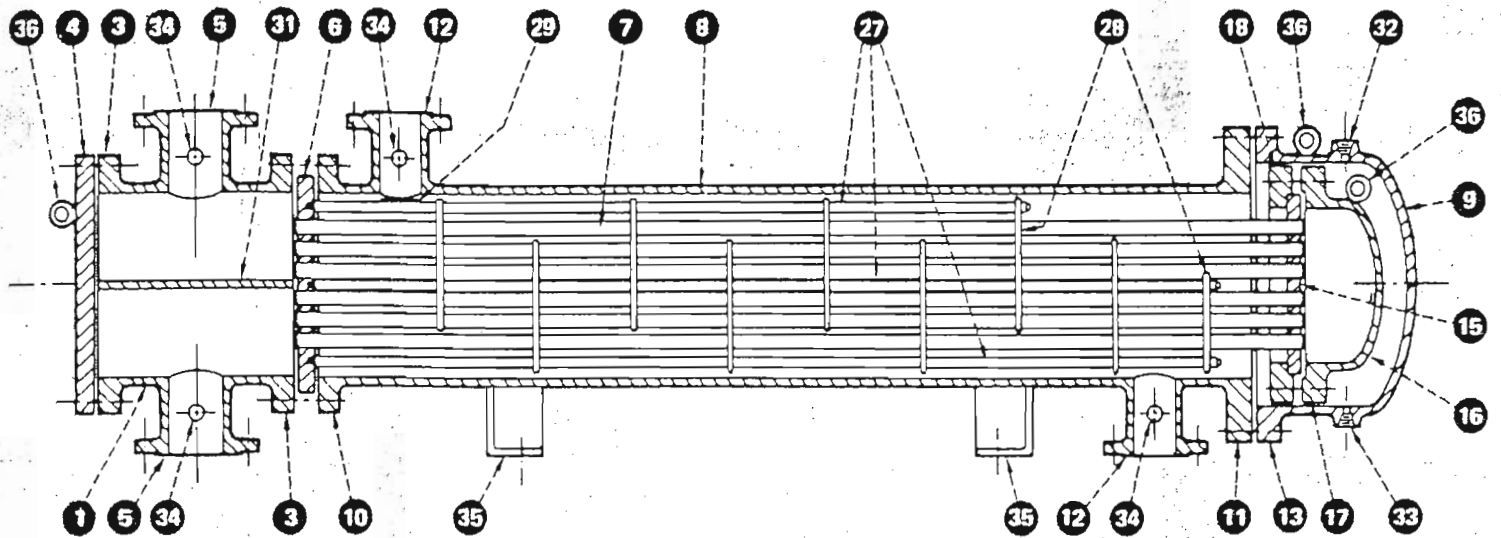


FIG. 11-9. Fluid streams through heat exchanger shell. (From T. Tinker, "Proceedings of the General Discussion on Heat Transfer," Institution of Mechanical Engineers, London, and American Society of Mechanical Engineers, New York, 1951 p. 89.)





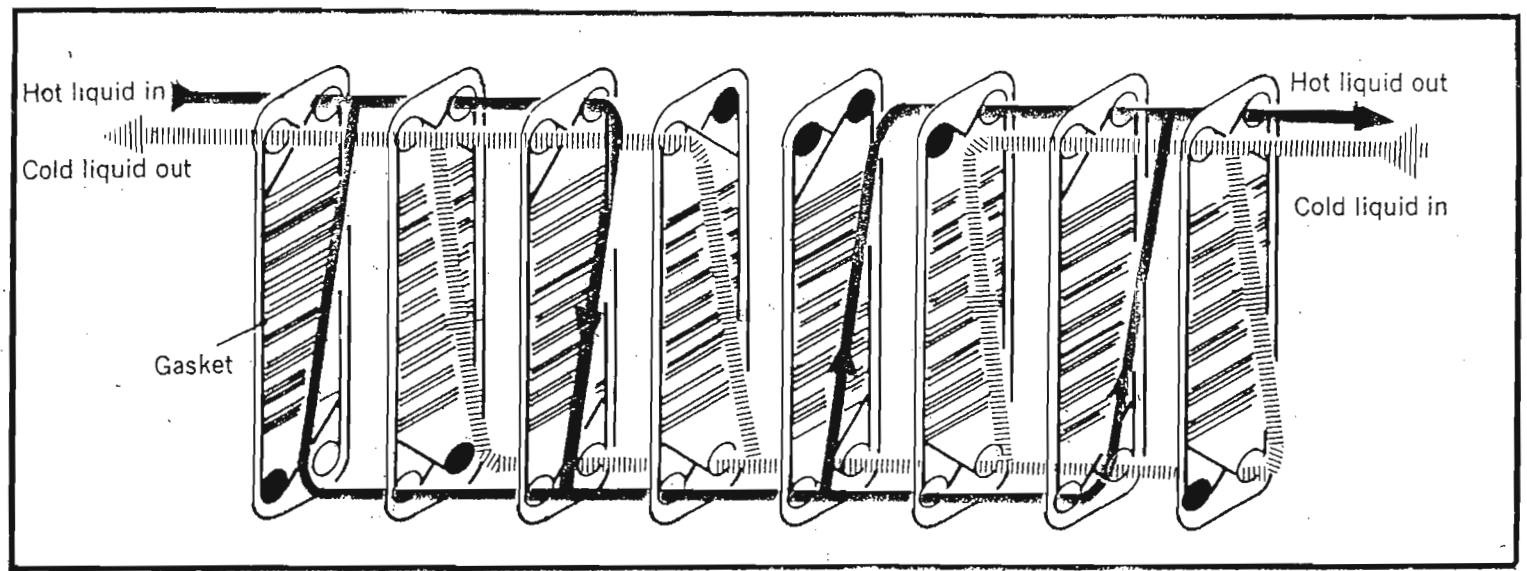
Shell side flow patterns A of A/B  
 "Fluid Dynamics & Heat Transfer", Knudsen & Katz. McGraw-Hill 1958 New York NY



- |   |                                  |  |
|---|----------------------------------|--|
| 1. Stationary head—channel                  | 14. Expansion joint              | 27. Tierods and spacers                  |
| 2. Stationary head—bonnet                   | 15. Floating tubesheet           | 28. Transverse baffles or support plates |
| 3. Stationary head flange—channel or bonnet | 16. Floating head cover          | 29. Impingement plate                    |
| 4. Channel cover                            | 17. Floating head flange         | 30. Longitudinal baffle                  |
| 5. Stationary head nozzle                   | 18. Floating head backing device | 31. Pass partition                       |
| 6. Stationary tubesheet                     | 19. Split shear ring             | 32. Vent connection                      |
| 7. Tubes                                    | 20. Slip-on backing flange       | 33. Drain connection                     |
| 8. Shell                                    | 21. Floating head cover—external | 34. Instrument connection                |
| 9. Shell cover                              | 22. Floating tubesheet skirt     | 35. Support saddle                       |
| 10. Shell flange—stationary head end        | 23. Packing box                  | 36. Lifting lug                          |
| 11. Shell flange—rear head end              | 24. Packing                      | 37. Support bracket                      |
| 12. Shell nozzle                            | 25. Packing gland                | 38. Weir                                 |
| 13. Shell cover flange                      | 26. Lantern ring                 | 39. Liquid-level connection              |

The nomenclature of shell-and-tube heat exchangers

Fig. 1



C. GASKETED PLATES can be assembled as shown, or rearranged to optimize heat transfer—Fig. 1