

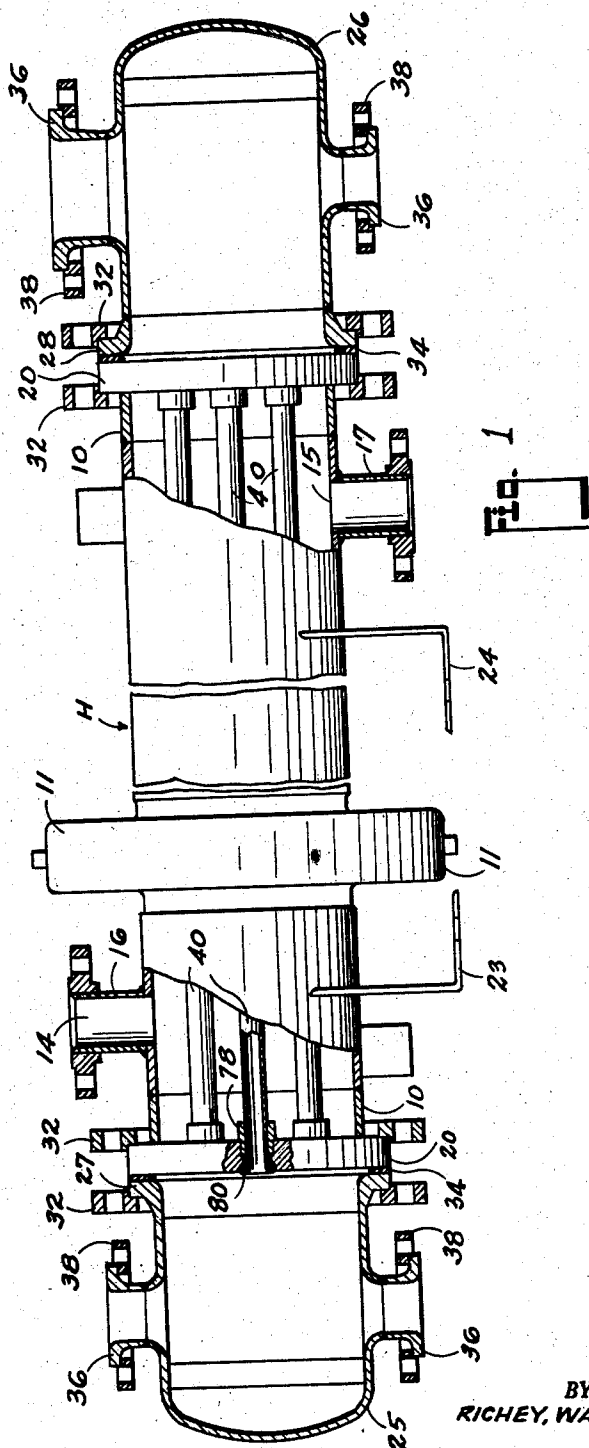
March 31, 1959

M. B. ROBINSON ET AL
GLASSED TUBE SHEET SEAL

2,880,018

Filed June 15, 1955

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

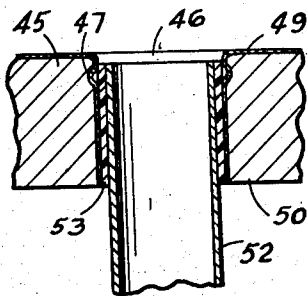


Fig. 2

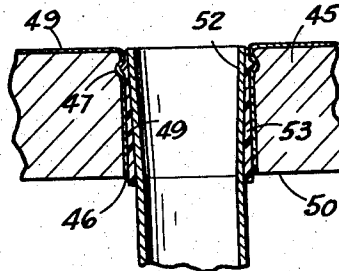


Fig. 3

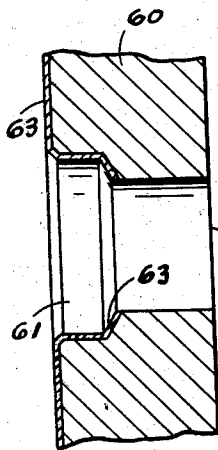


Fig. 4

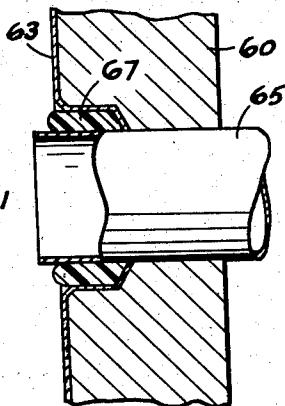


Fig. 5

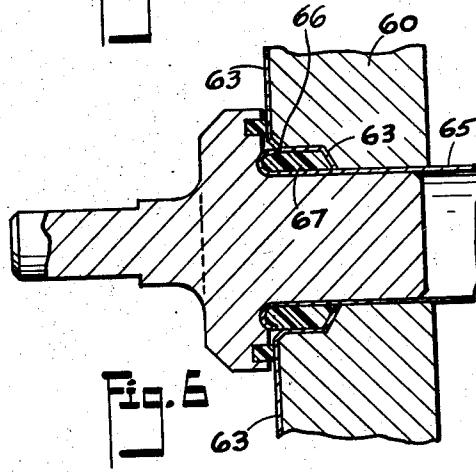


Fig. 6

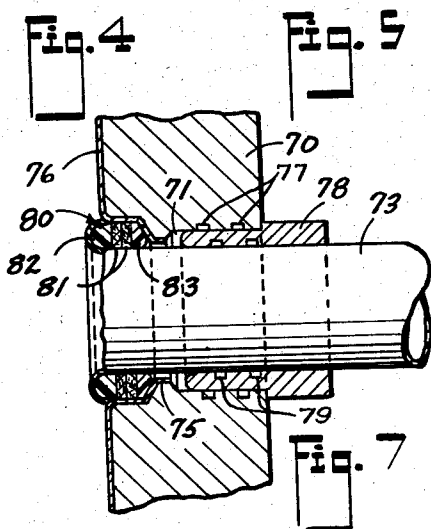


Fig. 7

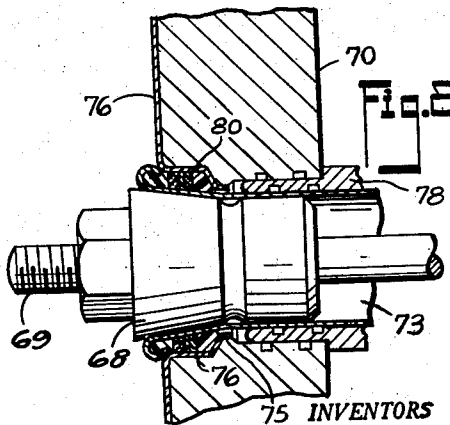


Fig. 8

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2,880,018

GLASSED TUBE SHEET SEAL

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5 Claims. (Cl. 285—55)

The present invention relates generally to the heat ex-
changing art and is more particularly concerned with a
novel tube sheet and tube assembly for use in heat ex-
changers for corrosive fluids and with a novel method
of making these assemblies.

In the manufacture of heat exchangers where corro-
sion resistance is a serious problem, glass and special
corrosion-resistant metals and alloys have been used to
make the tube sheets and tubes of these devices. How-
ever, glass falls far short of being an ideal material
for this purpose because of its relatively inferior heat
transfer and pressure-resistance characteristics. Tanta-
lum, being far superior to glass in both these respects
and having superior corrosion resistance, has come into
relatively large scale use for this purpose despite its
excessive cost and the consequent pressure upon those
skilled in the art to develop some method or means by
which tantalum might be replaced at least in substantial
part in heat exchangers of this type.

To the best of our knowledge, prior to the present
invention there has not been known to anyone a solution
to this problem. No relatively inexpensive alloy which
could be used to advantage in place of tantalum in this
service has been developed or discovered. Likewise, no
satisfactory means has been developed or discovered
which would overcome the serious drawbacks of glass
as a material of construction for this purpose.

In accordance with the present invention, it is now,
for the first time to our knowledge, possible to dispose
of this problem in a manner which is completely satis-
factory in all respects. In particular, material costs are
drastically reduced by eliminating the bulk of tantalum
and the like from these assemblies without adverse effect
upon the efficiency or the effectiveness of these assemblies
or upon the length of their service lives. Furthermore,
compared to the heretofore known tube and tube sheet
assemblies, the assemblies of our invention involve rel-
atively few manufacturing operations, all of which are
easily and quickly carried out. Still further, the tools
required in accordance with a preferred embodiment of
the present invention, while special in nature, are com-
paratively uncomplicated in form and design and are easy
to manufacture.

As a further advantage of the present invention, it
affords a variety of alternatives in respect to the forms
of the apparatus to be produced and the methods which
may be carried out in their production. In other words,
this invention provides an unusual latitude and flexibility
of choice as to the apparatus, elements, tools and methods
for the individual operator to select for his own special
purposes and conditions.

This invention is, to a substantial degree, predicated
upon our surprising discovery that a tube of tantalum
or similar metal may be fluid-tightly secured substan-
tially, permanently, but removably, to a glassed surface
portion of a metal tube sheet. This invention is based,
in addition, upon our discovery that a fluid-tight seal
can be established and maintained between a metal tube

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and a glass-coated tube sheet by means of a gasket of
deformable material which is deformed in any suitable
manner as by rolling the tube in the sheet until the
gasket is wedged or pressed firmly against an annular
portion of the tube and an opposing annular portion
of the glassed wall within the tube sheet opening.

Accordingly, the novel method of this invention gen-
erally comprises the steps of providing an opening in a
corrosion-resistant tube sheet, disposing a tube in said
opening and thus providing an annular space within the
tube sheet, introducing a gasket of deformable material
into the said annular space, and finally deforming the
gasket between the tube and sheet to produce fluid-tight
engagement of the gasket with both the tube and the tube
sheet.

It will also be understood, in view of the foregoing,
that in a preferred embodiment, the method of this in-
vention includes the step of applying a coating of corro-
sion-resistant material on the tube sheet and on the tube
sheet inner walls defining a tube opening therein, and
the further step of disposing the gasket in the tube sheet
opening in order that the gasket, on deformation, fluid-
tightly engages the tube and an opposed coated surface
portion of the tube sheet. Still further, the method prefer-
ably includes the step of deforming an outer end por-
tion of the tube and thereby forcing the gasket into fluid-
tight engagement with both the tube and the tube sheet.

Those skilled in the art will gain a further and better
understanding of the present invention in both its method
and its apparatus aspects and the advantages thereof on
consideration of the detailed description set forth below,
reference being had to the drawings accompanying and
forming a part of this specification in which:

Fig. 1 is a longitudinal, sectional view of a heat ex-
changer embodying the present invention apparatus in a
preferred form;

Fig. 2 is a fragmentary, sectional view taken axially of
a tube sheet and tube assembly of this invention, illus-
trating the disposition of the several elements at an in-
termediate stage of manufacture of this apparatus;

Fig. 3 is a view like Fig. 2, showing the Fig. 2 assembly
after the tube has been rolled into the tube sheet and
thereby secured in fixed fluid-tight relation to the sheet;

Fig. 4 is a fragmentary, sectional view taken axially
of a tube sheet through a tube opening therein, showing
the glassed portions of the tube sheet;

Fig. 5 is a view similar to Fig. 4 of an assembly in-
cluding the Fig. 4 tube sheet and the relationship between
the tube and its seal elements at an intermediate stage of
manufacture;

Fig. 6 is a view similar to Fig. 5, showing the Fig. 5
assembly at a later stage of manufacture and a processing
tool used therein;

Fig. 7 is a fragmentary, sectional view of an apparatus
of this invention taken axially of a tube sheet and
embodying the invention in a preferred form; and

Fig. 8 is another view of the Fig. 7 assembly, illus-
trating the final stage in securing the parts together fluid-
tightly and showing the tool used for this purpose.

In general, a tube and tube sheet assembly of this
invention comprises a metal tube sheet having a tube-
receiving opening and a coating of corrosion-resistant ma-
terial covering parts of the surface of the tube sheet
subject to contact with fluids corrosive to the tube sheet
metal. It also includes a corrosion-resistant metal tube
having a portion disposed in the tube-receiving opening
in the tube sheet and defining with the tube sheet an
annular space within the said tube sheet. Still further,
this assembly has a body of inert or corrosion-resistant
deformable material, such as Teflon or Kel-F, in the
said annular space and fluid-tightly engaging the tube
sheet and tube. In accordance with our preference,

the body of deformable material is pressed fluid-tightly against an annular portion of the fragile corrosion-resistant material coating the tube sheet metal in order to prevent passage of corrosive fluid into or through the tube sheet for contact with and attack upon unprotected portions of the tube sheet metal. Preliminary to assembling these parts, a suitable corrosion-resistant cement, such as Penchlor, may be applied by brush as a heavy film on the glass surface of the tube sheet. This cement will serve to fill the voids and seal off the Teflon and will bond well to the tube sheet because of its affinity for glass.

In a typical installation in the apparatus of this invention, as illustrated in Fig. 1, the tube sheet and tube assemblies embodying this invention are incorporated in a heat exchanger H specially built for the purpose of handling fluids which are corrosive to metals ordinarily used in heat exchanger construction, such as ferrous metal alloys, brasses and bronzes and the like. Exchanger H comprises a fabricated, generally cylindrical hollow body or shell 10 having open ends and an annular diaphragm portion 11 projecting radially from the body near one end. Shell 10 has an inlet port 14 adjacent to one end and an outlet port 15 adjacent to the other end and flanged tubes 16 and 17 welded to the outside of the shell around these ports to facilitate attachment of lines (not shown) for delivering heat exchange fluid into the shell and removing it therefrom. The ends of shell 10 are closed fluid-tightly by tube sheets 20 which are of substantially greater diameter than the shell and which are suitably welded in place against the ends of the shell. A pair of supporting brackets 23 and 24 are welded to the outer side of the shell for mounting of the heat exchanger upon or against a suitable supporting structure (not shown).

A header 25 is provided at one end of the shell assembly and secured fluid-tightly thereto by means subsequently to be described and a header 26 is similarly secured to the other end of the assembly. Headers 25 and 26 are of essentially the same general design and function with the exception that header 25 serves as an inlet means while the other serves as an outlet means for corrosive fluids to be heated or cooled in this apparatus. Thus, each of the headers 25 and 26 has an annular flange portion 27 and 28, respectively, and an opening therethrough of enlarged diameter for communication with each other through the tubes of the tube sheet assembly extending through shell 10. The headers are secured fluid-tightly in place at the ends of exchanger H by means of two pair of clamping rings 32 which are fitted against the flanges of the headers and the adjacent outer peripheral portion of tube sheet 20 in each instance, and two corrosion-resistant gaskets 34 disposed in the annular space between each flange 27 and the adjacent tube sheet 20. The clamping rings are fitted with any desired type of bolt means (not shown) for drawing the headers up fluid-tightly against gaskets 34 and tube sheets 20.

Each of the headers is provided in addition with two diametrically-opposed flanged projections 36 having openings therethrough whereby the headers may be connected to sources of corrosive fluid to be heated or cooled in exchanger H or to systems in which corrosive fluids treated in this apparatus are to be used. Clamping rings 38 are fitted on the flange portions of projections 36 to facilitate the fluid-tight connection of the headers to lines (not shown) serving this apparatus.

As illustrated in Fig. 1, three metal tubes 40, suitably of a corrosion-resistant metal, such as tantalum, and also preferably of a seamless construction, are assembled in accordance with this invention with tube sheets 20 which have glassed surface portions for protection against corrosive attack. Tubes 40 and tube sheets 20 are secured fluid-tightly together in accordance with

one or another of the several forms of this invention subsequently to be described.

The inside walls of the headers which are subject to contact with corrosive fluids treated in this apparatus are glass-lined throughout so that corrosive fluids processed in exchanger H never come into direct contact with metals which are not substantially impervious to chemical attack by these fluids.

The apparatus illustrated in Figs. 2 and 3 comprises a tube sheet 45 of a ferrous metal alloy conventionally used in the manufacture of heat exchanger tube sheets. Tube sheet 45 has a tube-receiving opening 46 of a diameter substantially greater than the diameter of a tube to be assembled with the tube sheet, and has an annular groove 47 in the wall defining tube-receiving opening 46 near the outer end thereof. A glass coating 49 is provided on the outer side of tube sheet 45 and within opening 46, covering entirely the walls defining that opening and extending to the inner side 50 of the tube sheet.

A seamless tantalum tube 52 is disposed within opening 46 and a sleeve 53 of deformable, corrosion-resistant material, such as Teflon of either the waxy or the leathery type, is fitted in the annular space defined between tube 52 and the inner walls of sheet 45, defining opening 46. As illustrated in Fig. 3, tube 52 is rolled into the tube sheet and sleeve 53 and the outer end of the tube is thereby flared, locking sleeve 53 in place between the tube 52 and tube sheet 45 and fluid-tightly sealing opening 46 around the tube against leakage of corrosive fluid into the inner chamber of the heat exchanger shell and into contact with surface 50 of tube sheet 45. Actually, the rolling operation results in deformation of the outer end of sleeve 53 to seal groove 47 and produce a locking effect, preventing relative motion of the tube sheet, tube and sleeve.

Tube sheet 60 of Fig. 4 has a tube-receiving opening 61 which is enlarged toward the outer side of tube sheet 60 and has a glass coating 63 on the outer side thereof which is continued into opening 61 only to the depth of the enlarged diameter portion of that opening. Accordingly in assembling a seamless tantalum tube 65 with the tube sheet of Fig. 4, tube 65 is rolled into the reduced diameter portion of opening 61 and outer end 66 of the tube is disposed beyond the outer side of the tube sheet. An annular body 67 of Teflon is disposed in the enlarged diameter portion of the tube sheet opening in engagement with the outer portion of the tube with the outer edge of the ring projecting slightly outwardly of the tube sheet.

In the operation illustrated in Fig. 6, end portion 66 of tube 65 is upset so that it grips and substantially encloses ring 67 in cooperation with tube sheet 60 and portions of the tube within opening 61. Consequently, when the finished assembly of this invention is viewed from the outer face of tube sheet 60, body 67 is not visible and it appears that the assembly consists only of the glassed tube sheet and tubes 65, the end portions of these tubes showing on the glassed side of the sheet providing a neat, uniform, annular bead appearance and seemingly making fluid-tight contact with the glassed surface portions of the tube sheet surrounding them.

In the preferred embodiment of this invention shown in Fig. 7, tube sheet 70 of ferrous metal has a tube-receiving opening 71 which throughout is of greater diameter than tantalum tube 73 disposed therein. Near the central portion of opening 71, the wall defining that opening is of reduced diameter defining a throat 75. A glass coat 76 covers the outer surface of tube sheet 70 and the inner walls of the tube sheet defining throat position 75 and the outer end of opening 71. In the inner end of opening 71 and on the inner side of tube sheet 70 no glass or other protective coating is provided or necessary because of the protection against contact of corrosive fluid therewith by means of the seal effected between tube 73 and tube sheet 70 through the use of deformable ma-

terial as will be described in detail below. However, a pair of annular grooves 77 are provided within this portion of the tube sheet. A tube sleeve 78 of bronze, or other similar suitable metal or alloy, is disposed partially within the annular space defined in the inner end of opening 71 by tube 73 and the inner walls of tube sheet 70. Sleeve 78 has a pair of annular grooves 79 adjacent to its inner end and facing tube 73, but offset from grooves 77, to facilitate gripping of the tube and holding of the sleeve and tube in place relative to tube sheet 70.

An annular composite body 80 of Teflon or similar inert corrosion-resistant, deformable material is disposed in the enlarged outer end of opening 71 between the tube and the inner walls of tube sheet 70, defining said opening. Body 80 is firmly and fluid-tightly pressed against the glassed inner walls of tube sheet 70 by the flared and upset outer end portion of tube 73 and is substantially enclosed in opening 71 and the outer end of the said tube. This body is composed of three rings 81 of leathery Teflon and an outer ring 82 and an inner ring 83, both of waxy Teflon. We have found that a composite body of this type has especially good sealing properties when applied to glassed metal bodies in accordance with this invention, being capable of readily adapting to the irregularities of the glass surfaces and combining the best sealing characteristics of both the waxy and the leathery forms of Teflon.

In assembling the Fig. 7 elements, tube sleeve 78 is first rolled into tube sheet 70 and then tube 73 is rolled into the tube sleeve 78. Composite body 80 is introduced into the outer end of opening 71 and the outer end of tube 73 is upset suitably by means of the tool illustrated in Fig. 6. In the finishing operation shown in Fig. 8, composite body 80, as well as the outer part of tube 73 within the enlarged outer end of opening 71, is deformed to produce fluid-tight engagement of body 80 with opposing annular portions of the glassed tube sheet and tube 73. The transition from the Fig. 7 to the Fig. 8 condition is accomplished preferably by the constant application of pressure rather than by impact, a forming tool or mandrel 68 being drawn into the outer end of tube 73 by bolt means including a bolt 69 extending through a central bore in tool 68 and through tube 73.

Having thus described the present invention so that those skilled in the art may be able to understand and practice the same, we state that what we desire to secure by Letters Patent is defined in what is claimed.

What is claimed is:

1. A tube and tube-sheet assembly for use in a heat exchanger for fluids corrosive to iron and similar metals and alloys which comprises a metal tube sheet having

an opening to receive a tube and a glass coating covering the outer surface of the sheet and walls defining the outer portion of said opening, a corrosion-resistant metal tube extending through the tube sheet and having an annular surface portion disposed in said opening and cooperating with said tube sheet to define annular spaces within said tube sheet adjacent to the inner and outer sides of the tube sheet, a metal sleeve disposed in the annular space adjacent to the inner side of the tube sheet in firm gripping engagement with opposing annular surface portions of the tube and tube sheet, the tube and sleeve having interengaging contact with one another and a body of inert deformable material in the other annular space and fluid-tightly engaging opposing annular surface portions of the tube and the glassed internal wall of the tube sheet.

2. The combination of elements set forth in claim 1 in which the said sleeve is provided with at least one annular groove and the tube is adapted to be projected into said groove.

3. The combination of elements set forth in claim 1 in which the tube sheet is provided with at least one annular groove and the said sleeve is adapted to be projected into said groove.

4. The combination of elements set forth in claim 1 in which the said surface is provided with an annular groove on its inner surface in to which the said tube is adapted to be projected and the tube sheet is provided with an annular groove into which the sleeve is adapted to be projected.

5. The combination of elements set forth in claim 1 in which the tube sheet is composed of ferrous metal and the tube is composed of tantalum.

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