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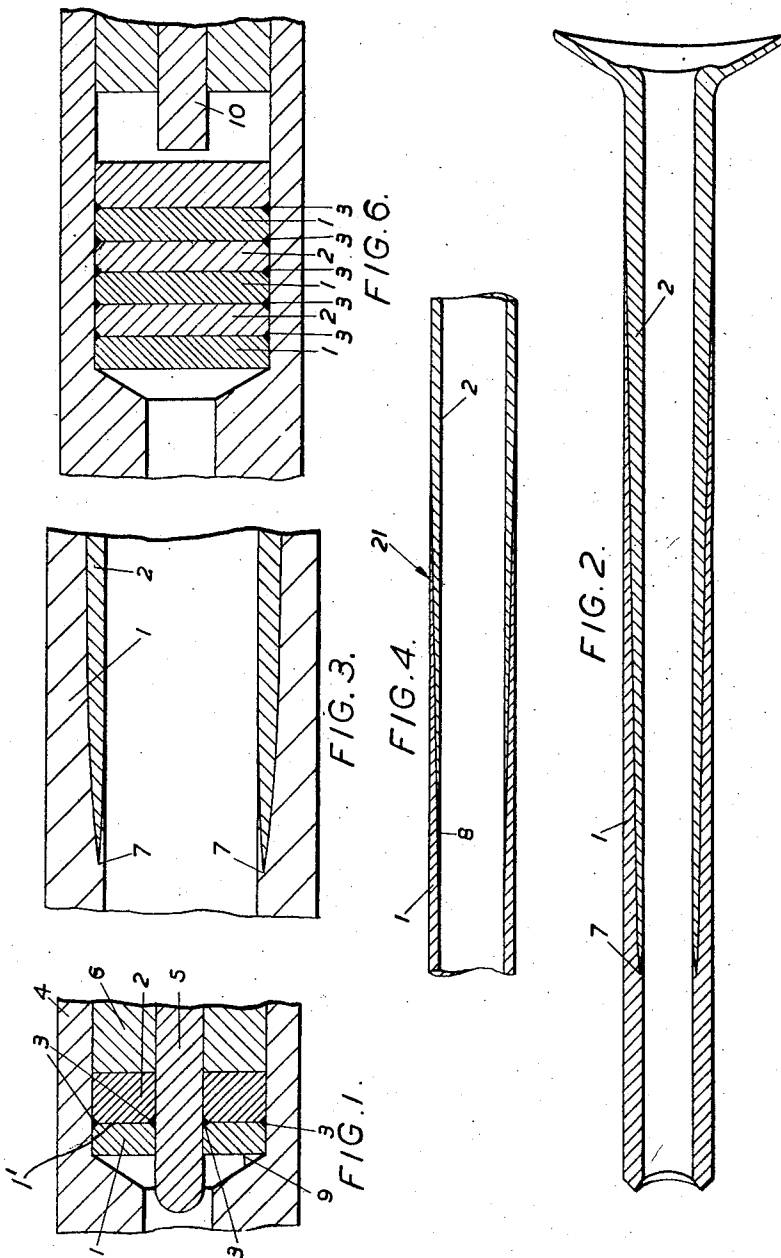
W. E. BARDGETT

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METAL JUNCTION PIECE AND THE PRODUCTION THEREOF

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2 Sheets-Sheet 1



Inventor:  
WILLIAM EDWARD BARDGETT

By  
Bailey, Stephens & Huetting  
Attorneys

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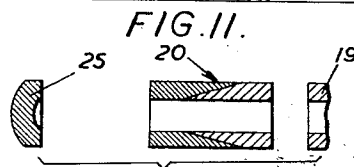
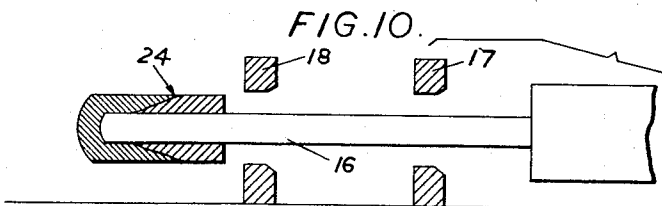
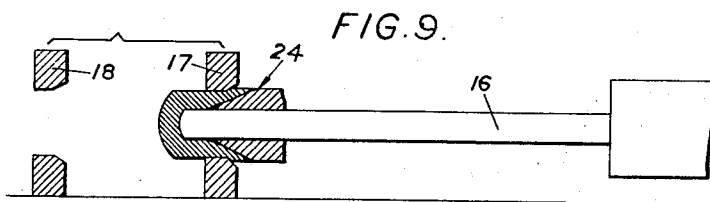
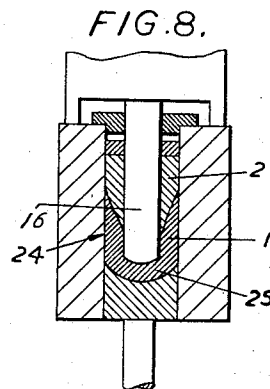
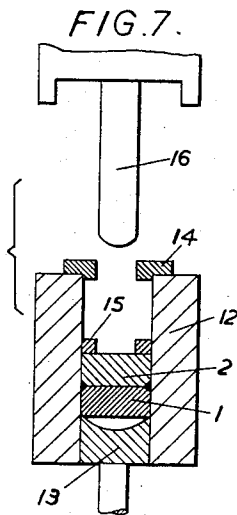
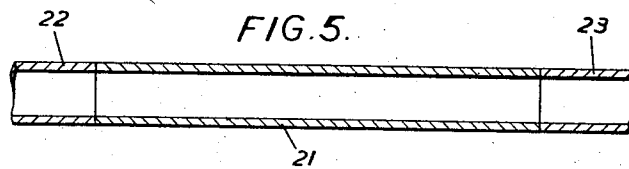
W. E. BARDGETT

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METAL JUNCTION PIECE AND THE PRODUCTION THEREOF

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2 Sheets-Sheet 2



Inventor,  
WILLIAM EDWARD BARDGETT

By  
Bailey, Stephens & Huntley  
Attorneys

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2,986,273

## METAL JUNCTION PIECE AND THE PRODUCTION THEREOF

William E. Bardgett, Rotherham, England, assignor, by mesne assignments, of one-half to The United Steel Companies Limited, Sheffield, England, and one-half to The Chesterfield Tube Company Limited, Chesterfield, England, a company of Great Britain

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4 Claims. (Cl. 207—10)

This invention relates to metal junction pieces and methods for the production thereof.

Joints between two metals with substantially different co-efficients of thermal expansion, e.g. austenitic and ferritic steels, are subjected to sever stresses if they are heated in service, particularly if they have to undergo cyclical changes between high and low temperatures and high and low pressures. Joints which have to undergo such changes are required in heat exchangers of various types, in oil refineries and in steam-generating plants. The temperatures and stresses, and the frequency and rapidity with which they change, vary considerably, but probably the most severe conditions are encountered in some steam power plants due to the use of both high temperatures and pressures which vary cyclically.

Until recent times the temperatures reached by the metals used in steam power plants have been such that the use of ferritic steels has been satisfactory. Examples of such ferritic steels are those (a) containing 0.5% molybdenum, and (b) 1% chromium and 0.5% molybdenum, and recently steels containing (c) 2.25% chromium and 1% molybdenum, and (d) 3% chromium, 0.5% molybdenum, 0.75% vanadium and 0.5% tungsten have been used. There are two limiting factors to be considered in the selection of materials for service at high pressures and temperatures, namely strength and resistance to scaling or corrosion. Scaling of the usual ferritic steels limits them to service temperatures not much in excess of 950° F. With the demand for steels to operate at 1150° F. metal temperature, steels of higher resistance to scaling are called for. An example of such a steel is one which contains 18% Cr, 12% Ni and 1% Nb and which is austenitic. Because of its cost such a steel, however, is used only where the temperatures are high, and at some point it is usually joined to a ferritic steel used where the temperature is lower.

If the joint between two tubular members of such different steels is made by butt-welding, stresses are set up in a plane approximately at right angles to the axis of the tube or pipe on heating and cooling, owing to the difference in the co-efficients of thermal expansion of the two metals. Further, any structural changes, such as carbon migration from the ferritic to the austenitic steel, take place in a similar plane and give rise to weakness.

It is an object of the invention to provide a novel method of making a junction piece between metals of different co-efficients of thermal expansion.

Another object is to produce a tubular metal junction piece from two different metals by an extrusion process.

In my invention, a junction piece for use between metal members having different co-efficients of thermal expansion is made by using a pair of slugs or like pieces of metals which also have different co-efficients of thermal expansion and are pressure-weldable together at high temperature. While these slugs are hot and assembled

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face to face in a die or container, pressure is applied to one of them to extrude the assembly into a space of smaller cross-section than that of the slugs or the like, and in so doing to force the trailing slug or the like into the leading slug or the like. In this way I produce a joint in which a tapering length of one metal surrounds a complementary tapering length of another. In the process the two slugs or the like are welded together. The slugs or the like when put into the die or container may be separate from one another or united into a block.

My invention will be most clearly understood with reference to the accompanying diagrammatic drawings, which illustrate some processes for making junction pieces and in which:

15 Figure 1 shows a stage in one process;

Figure 2 is a longitudinal section through the product of this stage of the process;

Figure 3 shows part of Figure 2 on a larger scale;

Figure 4 shows the finished junction piece;

20 Figure 5 illustrates the use of this junction piece in connecting two tubes;

Figure 6 is a view similar to Figure 1 illustrating a modification of the process; and

Figures 7 to 11 illustrate five stages in another process.

25 In the process illustrated by Figures 1 to 4, the first step is to make two annular slugs 1 and 2. The slug 1 consists of austenitic steel of the nominal composition 18% chromium, 12% nickel, 1% niobium and 0.1% carbon, the balance being essentially all iron. The slug 2 consists of ferritic steel of the nominal composition 2.25% chromium, 1% molybdenum and 0.1% carbon, the balance being essentially all iron. Both slugs are annular, and they are made into a composite block. For this purpose they are machined on the mating faces and welded at the inner and outer edges of these faces as indicated at 3 in order to prevent any oxidation during the heating before the extrusion. The welds are machined flush with the surface so that the resultant block will fit closely within a conventional die 4 of an extrusion press, the die having a tapering part 9 leading to a cylindrical outlet.

Next the block is heated to the extrusion temperature, say 2156° F., and put in the die 4. A mandrel 5 is then introduced into the block, as shown in Figure 1, and pressure is applied to the trailing slug 2 by a plunger 6 which fits the die closely, so that the block is extruded as a tube. During this process the leading end of the trailing slug 2 is forced forwards along the surface of the mandrel 5 into the trailing end of the leading slug 1. As shown in Figure 3, the tip 7 of the slug 2 is just embedded within the tubular wall of the leading slug 1, but very close behind this tip the inner wall surface of the tube is constituted by the metal of the slug 2. Over a substantial length of the tube, the wall is composed of complementary tapering lengths of the two metals, with that of the leading slug 1 on the outside. The angle of the taper is determined by the ratio of the cross-sectional area of the slugs to that of the extruded tubular junction piece shown in Figure 2 and also by the conical angle of the part 9 of the die 4.

30 The extruded tube is next cut to the desired length, the cuts being made so that each end of the finished junction piece consists of a single metal only. Then the tube is machined both inside and outside to the desired diameters, the final product being shown at 21 in Figure 4, and in the course of the internal machining the tip of the inner slug 2 is reduced to a fine edge as shown at 8. Finally the junction piece 21 so produced is butt-welded in position between an austenitic steel tube 22 and a ferritic steel tube 23, as diagrammatically shown in Figure 5.

Although oxidation of the surfaces which are to be welded together by the extrusion may most conveniently be prevented by welding the slugs or the like around the edges of their mating faces, any other method may be used if desired. To avoid the need to weld the inner edges of the mating surfaces, solid slugs may be used and welded at the outer edges only, a central hole being punched in the block immediately before the extrusion.

A tubular junction piece extruded according to the invention must normally be machined to the dimensions required, and it should in general be extruded to a wall thickness greater than that of the tubes which it is to connect, being machined to the wall thickness of these tubes before being welded to them.

If desired, the extruded tube may be drawn down to a smaller wall thickness before being machined. The taper of the overlapping parts will be increased at the same time.

Naturally the metals of the two slugs or the like are preferably the same as those of the tubular members, but provided that they respectively have substantially the same co-efficients of thermal expansion as those members and can be satisfactorily welded to them they may be different in composition.

On cooling from the extrusion temperature, the austenitic metal 1, having the higher co-efficient of expansion, contracts more than the ferritic metal 2, so that tensile stresses are developed in the former and compressive stresses in the latter. On heating again from room temperature to a high temperature at which the metals lose strength, the stresses developed on cooling are reduced.

As shown the austenitic metal is on the outside of the joint, but this arrangement can be reversed if the use to which the final product is to be put so requires. In any process carried out as shown in Figure 1 the leading slug will form the outside of the joint.

In order to prevent migration of carbon from the ferritic into the austenitic steel at elevated temperature, the mating faces of the two slugs 1 and 2 may be separated by a barrier layer of a metal such as nickel, as at 1' which may be applied as an electrolytic coating to one or other slug or as a thin sheet between the slugs before they are welded together.

While a small portion of this layer will be destroyed where the welds take place, permitting a small amount of migration, this portion will be substantially eliminated in the final machining of the joint.

Instead of extruding annular slugs over a mandrel, the slugs or the like may be solid cylinders. Then they may be extruded through a die as shown in Figure 1 to form a bar which is subsequently drilled to provide a tubular junction piece.

A number of junction pieces may be extruded in one operation by putting a corresponding number of composite blocks or pairs of slugs in the die, the resultant extruded tube then being cut to provide individual junction pieces. This is illustrated in Figure 6, which shows three pairs of slugs 1 and 2, all the slugs being welded into a single block by welds 3. These slugs are solid, and a central hole in all of them is pierced by a punch 10. Instead of welding all the slugs into one block, they may be welded together in pairs to form three blocks.

The junction piece can also be made by rearward extrusion with subsequent drawing of the extruded piece. This is illustrated by Figures 7 to 11. As shown in Figure 7, a block composed of two solid slugs 1 and 2 welded together is inserted in a hollow container 12 closed at one end by a movable bottom 13 which serves as an ejector, and having two guides 14 and 15 for a punch 16. During the extrusion the guide 14 is fixed and the guide 15 moves with the slugs. When the punch 16 is forced into the slugs, as shown in Figure 8, they are formed into a hollow cylinder 24 with a closed end

25, the leading end of the slug 2 around the punch being forced into the slug 1. This cylinder is then drawn down by a punch 16 through a pair of dies 17 and 18, as shown in Figure 9, to acquire the shape shown in Figure 10. Finally the closed end 25, and a short length 19 of the open end, are removed, as shown in Figure 11, to leave the final junction piece 20 which may of course be machined as required. The angle of taper between the two steels can be varied by drawing the cylinder 24 down to a greater or less extent.

I claim:

1. A method of forming a joint between members formed of metals having different coefficients of thermal expansion which comprises locating two slugs of such metals with surfaces in juxtaposition to one another, said slugs being of rectangular outline in cross-section in a plane perpendicular to their adjacent surfaces and of circular cross-section in planes parallel to such surfaces, welding the adjacent surfaces of such slugs together along the exposed edges only of such surfaces, heating the slugs to extrusion temperature and extruding the slugs in a direction perpendicular to their adjacent surfaces around a mandrel while reducing the cross-sectional area of the slugs, and during such extruding forcing one slug into the other so as to produce a joint between two hollow parts in which a tapering length of one metal forming the outer surface of the joint surrounds a complementary tapering length of the other metal which forms the inner surface of the joint.

2. A method of forming a joint between members formed of metals having different coefficients of thermal expansion which comprises locating two solid slugs of such metals with surfaces in juxtaposition to one another, said slugs being of rectangular outline in cross-section in a plane perpendicular to their adjacent surfaces and of circular cross-section in planes parallel to such surfaces, welding the adjacent surfaces of such slugs together along the exposed edges only of such surfaces, heating the slugs to extrusion temperature and immediately thereafter punching a hole through the slugs and extruding the slugs in a direction perpendicular to the plane of their adjacent surfaces around a mandrel while reducing the cross-sectional area of the slugs, and during such extruding forcing one slug into the other so as to produce a joint between two hollow parts in which a tapering length of one metal forming the outer surface of the joint surrounds a complementary tapering length of the other metal which forms the inner surface of the joint.

3. A method of forming a joint between members formed of metals having different coefficients of thermal expansion which comprises locating two slugs of such metals with surfaces in juxtaposition to one another, said slugs being of rectangular outline in cross-section in a plane perpendicular to their adjacent surfaces and of circular cross-section in planes parallel to such surfaces, said slugs having aligned holes therethrough, welding the adjacent surfaces of such slugs together along the exposed edges only of such surfaces, heating the slugs to extrusion temperature and extruding the slugs in direction perpendicular to the plane of their adjacent surfaces around a mandrel while reducing the cross-sectional area of the slugs, and during such extruding forcing one slug into the other so as to produce a joint between two hollow parts in which a tapering length of one metal forming the outer surface of the joint surrounds a complementary tapering length of the other metal which forms the inner surface of the joint.

4. A method of forming a joint between members formed of metals having different coefficients of thermal expansion and at least one of which contains carbon which tends to migrate into the other, which comprises locating two slugs of such metals with surfaces in juxtaposition to one another with a thin metal barrier layer therebetween, said slugs being of rectangular outline in cross-section in a plane perpendicular to their adjacent surfaces and of

circular cross-section in planes parallel to such surfaces, welding the adjacent surfaces of the slugs together along the exposed edges only of such surfaces, heating the slugs to extrusion temperature and extruding the slugs in a direction perpendicular to the plane of their adjacent surfaces around a mandrel while reducing the cross-sectional area of the slugs, and during such extruding forcing one slug into the other so as to produce a joint between two hollow parts in which a tapering length of one metal forming the outer surface of the joint surrounds a complementary tapering length of the other metal which forms the inner surface of the joint.

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