July 20, 1937. J. P. IRWIN 2,087,628

HEAT EXCHANGER

Filed Dec. 1, 1936 3 Sheets-Sheet 1

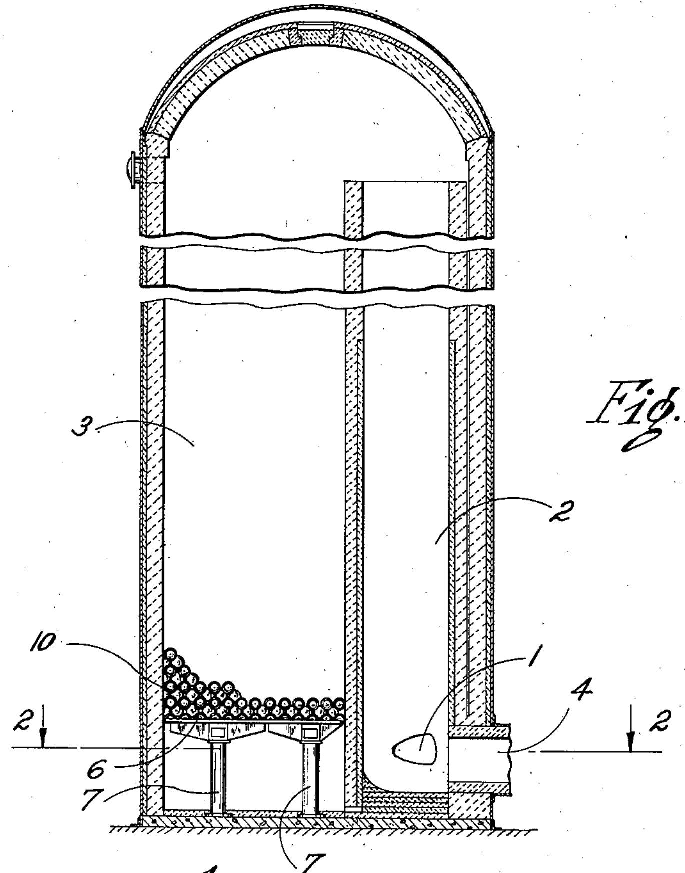

Fig. 1

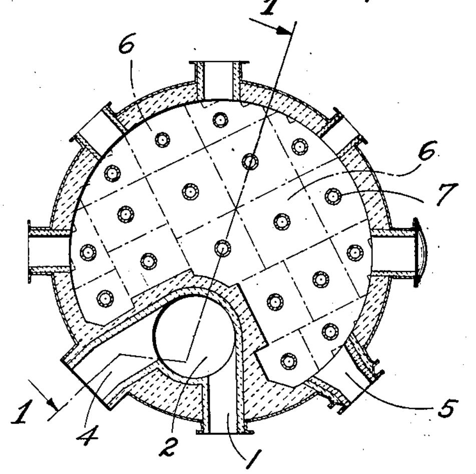

Fig. 2

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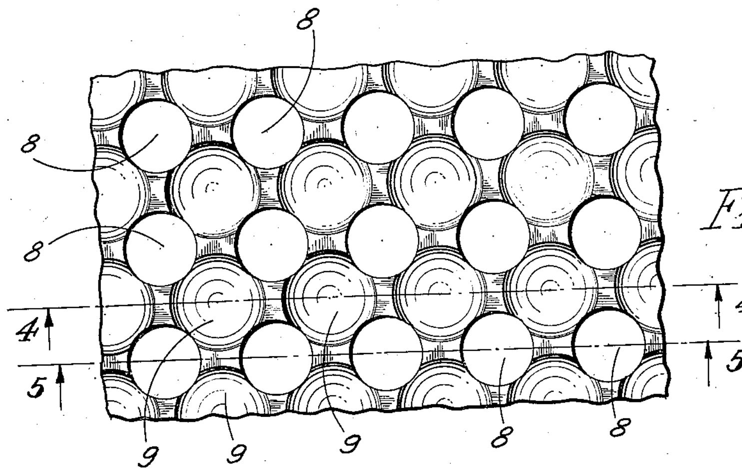

Fig. 3

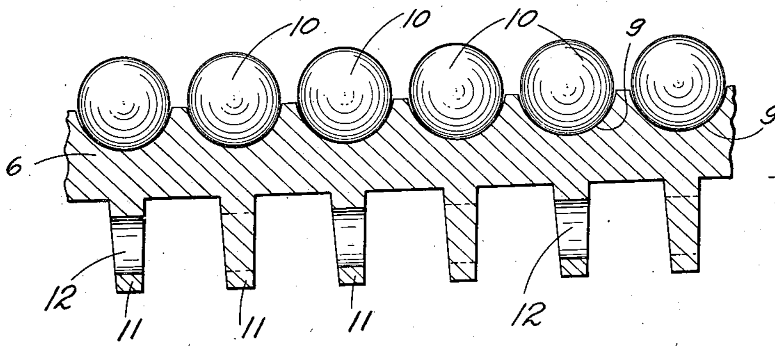

Fig. 4

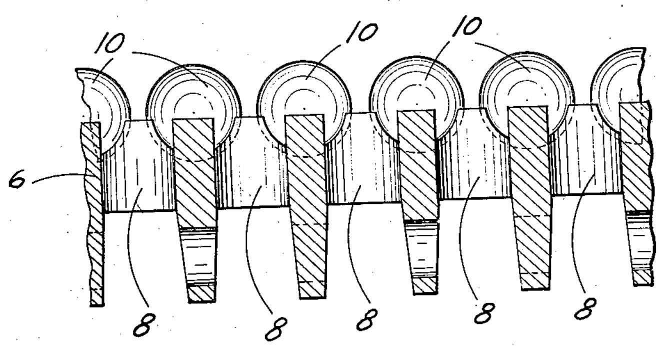

Fig. 5

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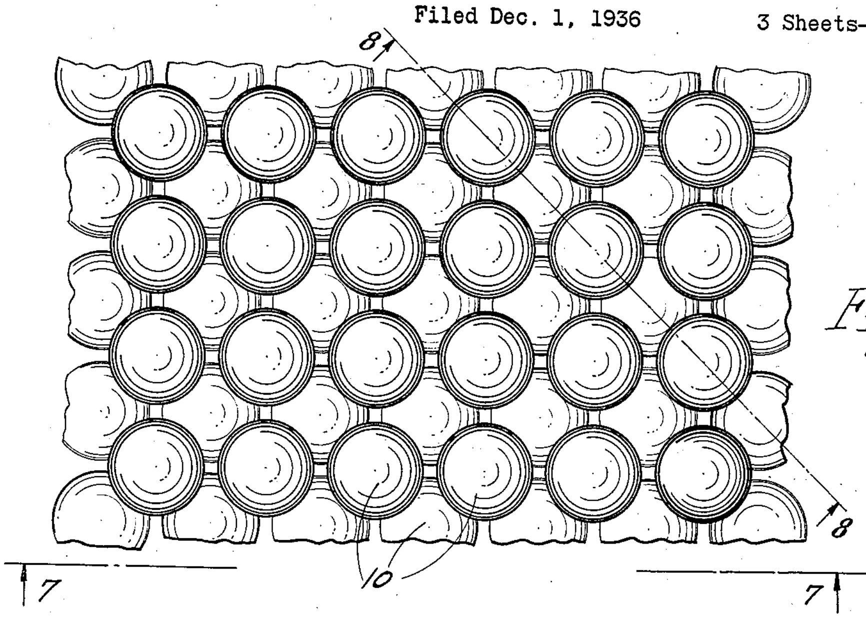

Fig. 6

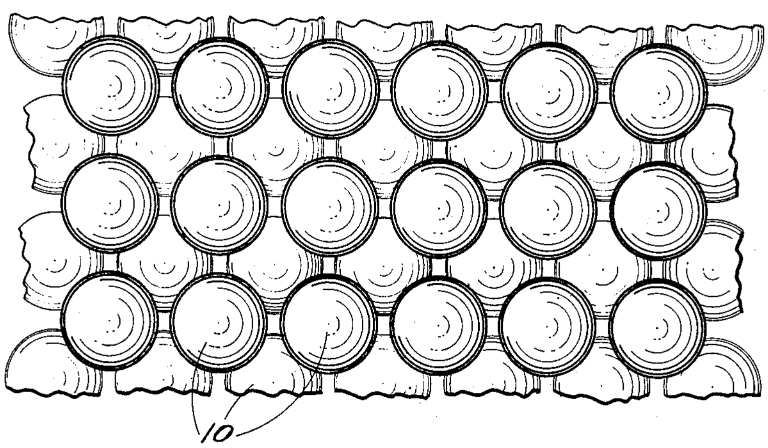

Fig. 7

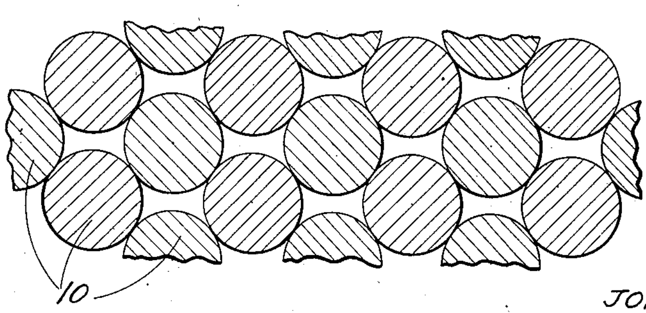

Fig. 8

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2,087,628

HEAT EXCHANGER

John P. Irwin, Cleveland, Ohio

Application December 1, 1936, Serial No. 113,643

5 Claims. (Cl. 263—19)

This invention relates to heat exchangers and more particularly to an improved refractory filler for hot blast stoves and the like.

In the operation of blast furnaces, and in numerous other industrial operations, it is common practice to use regenerative heat exchangers in which hot gases are passed through a chamber containing refractory bodies for a certain period of time and then air or gas to be used for combustion purposes passed through these same chambers, absorbing the heat given off to the refractory bodies by the hot gases previously passed through the chamber.

Many forms of refractory bodies have been employed as fillers for such heat exchangers. In some instances specially formed refractory brick or tile have been used. In other instances common rectangular brick has been laid up in checker form and in still other cases pieces of refractory material of various shapes have been casually or promiscuously deposited in the chamber.

As is well understood, in order to obtain the most efficient operation in this type of apparatus, it is important to provide a relatively unrestricted free passage for gas through the refractory material and at the same time to provide a maximum surface area of the refractory and a maximum refractory volume.

Casual or promiscuous arrangements of brick bats or odd shaped pieces of refractory have not been particularly successful in the past and have not been adopted because of the difficulty in providing the proper cross sectional flue area through the mass of refractory pieces. With the casual arrangement some of the passages through the mass of material are very small and soon become clogged with foreign material such as dust and the like carried by the gases passing through the heat exchanger.

In addition to the miscellaneous odd shaped refractory bodies which have been casually deposited in a heat exchanger or hot blast stove it has been proposed to use spherical refractory bodies. In such proposed arrangements the refractory spheres or balls have been merely dumped in the heat exchanging chamber and are allowed to remain in the positions they assume when deposited in the chamber. I have found that such casual or promiscuous arrangements of refractory spheres or balls results in passages or interstices which are too small to permit operation of a hot blast stove or the like within the efficiency range required for commercial use.

However, spherical bodies of refractory material present certain distinct advantages for use as fillers for hot blast stoves inasmuch as they have great strength and are not subject to cracking or chipping, and may be economically manufactured and installed. It is among the objects of my invention, therefore, to provide an improved arrangement of spherical refractory bodies in the heat exchanging chamber of a hot blast stove or the like whereby the advantages of such spherical bodies may be secured and the necessary minimum cross sectional area of the flues or passages through the checker work provided.

Another object of my invention is the provision of an improved filler for heat exchangers of the type described which may be easily installed with a minimum of skilled labor and which, when once installed, will retain its original arrangement and permit of relatively free passage of gas through the mass of refractory bodies.

The above and other objects of my invention will appear from a preferred embodiment thereof, reference being had to the accompanying drawings in which—

Figure 1 is a vertical cross section through a typical hot blast stove showing a heat exchange checker work structure employing my arrangement of spherical bodies.

Figure 2 is a horizontal cross section taken substantially on line 2—2 of Figure 1.

Figure 3 is an enlarged fragmentary plan view of the supporting and sphere registering base of my improved heat exchanger.

Figure 4 is a vertical cross section taken on line 4—4 of Figure 3, and showing how the refractory balls are supported by the ball registering or locating base.

Figure 5 is a view generally similar to Figure 4 but taken on the line 5—5 of Figure 3.

Figure 6 is a fragmentary plan view of the spherical refractory filler members as disposed in the stove in accordance with my preferred arrangement.

Figure 7 is a fragmentary view generally similar to Figure 6 but illustrating in elevational view my preferred arrangement of the refractory bodies.

Figure 8 is a vertical section taken through the ball filler bodies on the oblique line 8—8 of Figure 6 and illustrating the minimum flue passage area between adjacent spheres.

Referring to Figures 1 and 2, the hot blast stove illustrated includes the gas inlet passage 1, combustion chamber 2, the main heat exchanging chamber 3 and the hot blast outlet passage 4. It is to be understood that the heat exchanger illustrated is of a type commonly used in blast furnace practice and is merely illustrative of the general type of heat exchanging apparatus in which my improved refractory filler arrangement may be advantageously used.

In operation of this type of apparatus, gas from the top of a blast furnace may be burned in the stove and blown through the heat exchanger **3**, and out through the passage **5**. After such gases have passed through the heat exchanging chamber **3** for a predetermined time the flow of hot gases may be shut off and cold air blown through the stove in the opposite direction from the hot gases. This cold air is heated by the refractory bodies in the heat exchanging chamber **3** and thus is supplied to the blast furnace at the desired relatively high temperature.

In Figure 1 it is to be understood that the entire chamber **3** would be filled with refractory balls **10** in the same arrangement as illustrated at the bottom of the chamber. The supporting base for the filler members is illustrated at **6** and this may be conveniently made in sections as shown in Figure 2 which are supported by suitable columns **7**.

As the gases which pass through the chamber **3** must have a free passage through the base **6**, I have provided the metallic supporting member shown in Figures 3, 4 and 5. This may be made of cast iron or steel or other suitable material and will, of course, be properly proportioned to support the weight of the refractory balls carried thereby. Referring to Figures 3, 4 and 5 it will be seen that the base includes a plurality of regularly arranged cylindrical apertures **8** extending through the base. Between each group of four of these apertures **8** there is a substantially hemispherical cup shaped recess **9**. These recesses **9** are spaced equi-distant from each other and arranged in a manner which will be later described and are adapted to support and locate or register the bottom layer of refractory balls (shown at **10**, Figures 4 and 5) with the proper spacing to provide the maximum flue area through the checker structure. As is seen in Figures 4 and 5, downwardly extending perforated ribs **11** may be formed on the under side of the base **6** to strengthen it and provide the necessary rigidity. The apertures **12** which extend through the ribs **11** are preferably staggered as seen in Figures 4 and 5 and are intended to permit lateral flow of air or gas therethrough. As is best seen in Figure 5 the refractory balls **10** are so supported by the base **6** and the base is so formed that gases passing through the base may strike a relatively large surface area of the balls and the base will not restrict the flow of the gas through the spaces between the balls.

After the bottom layer of the balls **10** has been disposed in the cup shaped apertures **9** of the base **6** each succeeding layer of balls will necessarily have exactly the same center to center spacing as the bottom layer. This is illustrated in the plan view, Figure 6. Moreover, the refractory balls will be arranged in vertically spaced relation when viewed on the plane shown in Figure 7. When an oblique section is taken through the body of the refractory balls, as illustrated in Figure 8, the contacting arrangement of the balls is seen and this view illustrates the minimum flue area between balls.

In adapting my invention to hot blast stoves for blast furnaces, in which the stove may be 90′ or more in height and 20′ or more in diameter, with proportionately large heat exchanging chamber area, I have found that refractory balls approximately 6″ in diameter when arranged in layers with a horizontal center to center spacing of approximately 6⅞″ will give excellent over-all efficiency, taking into consideration flue passage area, volume of refractory material, surface area of the refractory material, cost, etc. This horizontal center to center spacing is approximately 1.146 times the diameter of the balls and with this horizontal spacing the vertical spacing between similarly placed rows is approximately 1.182 times the diameter of the balls. I have found by careful calculation that with this arrangement of spherical filler bodies the minimum flue passage area between spheres is approximately 21.5% of the total transverse area of the heat exchanging chamber of the checker work.

Although I have chosen 6″ diameter spheres as being the most suitable for hot blast stoves for blast furnace use, I have found that the above stated relations of horizontal and vertical spacing to sphere diameter will result in the optimum arrangement, in so far as ratio of flue area to total transverse area is concerned, regardless of the size of the ball fillers which may be used. For example, in some instances and for smaller heat exchanging devices it may be found desirable to use spherical bodies of say 2″ in diameter. I have found that the highest ratio of minimum flue area to total transverse area of the checker work will be obtained when the horizontal spacing is approximately 1.146 diameters and the vertical spacing approximately 1.182 diameters when taken on the plane illustrated in Figures 6 and 7 of the drawings.

When the refractory balls are deposited in a heat exchanging chamber in casual or promiscuous arrangement and permitted to assume their natural positions the greatest ratio of minimum flue area to total transverse area of the checker work which can be obtained is approximately 12.5%. The small passages which result prohibit the use of this arrangement in hot blast stove practice, not only because of the excessive resistance to the flow of gas therethrough, but because the relatively small passages quickly become clogged with dust thus greatly reducing the efficiency of the apparatus.

The above figure on the natural or casual arrangement of the refractory balls results when the balls fall into an arrangement in which any one ball of a layer is surrounded by six other balls in a hexagonal arrangement. Somewhat better results can be obtained and somewhat greater minimum flue area secured if the balls are carefully arranged in rows so that any four balls will form a square, each ball contacting each adjacent ball. Such an arrangement however, is not natural for the balls to assume and they must be carefully disposed to retain this position. When the balls are so arranged but are not horizontally spaced from each other the minimum flue area will be approximately 16⅔% of the total transverse area of the chamber. It will be seen that this arrangement is an improvement over the natural or casual arrangement of the balls. However, with the arrangement illustrated in Figures 6, 7 and 8 and described above in which the balls of any horizontal layer are arranged in squares with a center to center spacing equal to approximately 1.146 times the diameter of the balls, the greatest possible minimum flue area is obtained.

It will be understood, of course, that the spacings herein set forth do not have to be maintained with absolute accuracy in order to obtain successful operation. However, they should be approached as far as is practically possible but I do not wish to be limited to the exact spacing noted. Moreover it will be seen by those skilled in the art that various types of bases or supports for the bottom layer of refractory balls may be provided and I do not, therefore, wish to be limited to the specific base shown and described herein and I claim as my invention all embodiments thereof coming within the scope of the appended claims.

I claim:

1. In apparatus of the type described, a heat exchanging chamber having a plurality of layers of balls of refractory material, the balls of each of said layers being arranged with a horizontal center-to-center spacing between each pair of adjacent balls equal to approximately 1.14 to 1.15 times the diameter of the refractory balls.

2. In apparatus of the type described, a checker brick structure comprising a plurality of substantially horizontal layers of spherical balls, the balls of each layer being arranged so that the center-to-center spacing of adjacent balls is greater than the diameter of the balls.

3. In a heat exchanger of the type described, a plurality of layers of registered refractory balls, a base for maintaining the balls of the bottom layer in registered position, all of said balls being of substantially the same diameter and arranged with a horizontal center-to-center spacing between approximately 1.14 and 1.15 times the ball diameter and a vertical center-to-center spacing between vertically aligned balls of alternate layers of between approximately 1.175 and 1.185 times the ball diameter.

4. In apparatus of the type described, a plurality of layers of spherical refractory balls, a supporting base for said balls, said base having passages extending therethru and having spaced recesses adapted to support and locate the refractory balls of the bottom layer in spaced relation to each other.

5. In apparatus for the type described, a plurality of layers of spherical refractory balls, a supporting base for said balls, said base having passages extending therethru and having spaced recesses adapted to support and locate the refractory balls of the bottom layer in spaced relation to each other with a center-to-center spacing of between approximately 1.14 and approximately 1.15 times the diameter of the balls.

JOHN P. IRWIN.