July 22, 1947. A. T. SIERON 2,424,336

APPARATUS FOR VAPORIZING SULFUR

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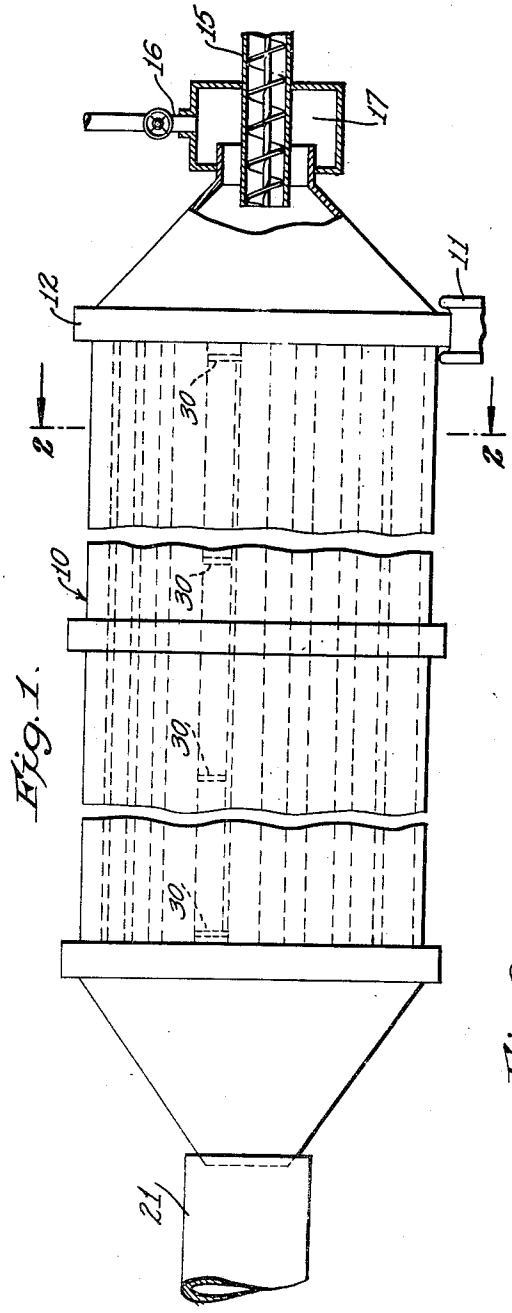


Fig. 1.

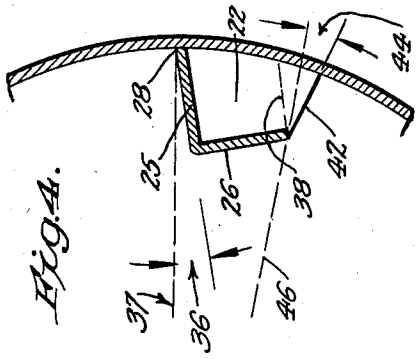


Fig. 4.

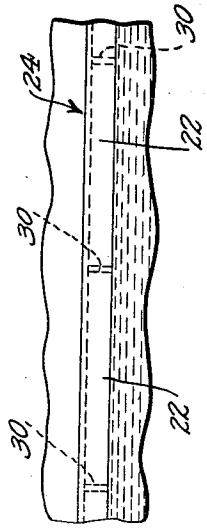


Fig. 3.

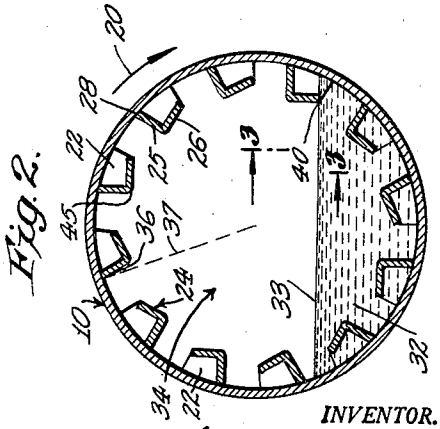


Fig. 2.

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APPARATUS FOR VAPORIZING SULFUR

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1 Claim. (Cl. 23—278)

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This invention relates to means for vaporizing sulfur.

In commercial practice, vaporization of sulfur is effected by burning a portion of a body of molten sulfur to form sulfur dioxide, and utilizing heat thus generated to vaporize the balance of the sulfur. The aim of a vaporization process is to form an off-gas which contains a maximum of vaporized sulfur and a minimum of SO_2. Attainment of this result entails minimizing sulfur combustion and making maximum use of the heat developed by oxidation of sulfur to SO_2. Some grades of commercial brimstones contain such a substantial amount of impurities that, after a period of operation, there accumulates on the surface of the molten sulfur an asphalt-like scum which in some instances smothers combustion and in any case adversely affects sulfur oxidation and vaporization. To overcome this deficiency, commercial practice has developed in such a way that a large and probably a major proportion of the brimstone used in the industries concerned is vaporized in the known rotary type furnace. While this kind of apparatus, by reason of the continual agitation imparted to the sulfur pool by rotation of the furnace, effectively breaks up the scum and eliminates its deterrent effect, the rotary furnace process has a marked disadvantage in that the major portion of sulfur combustion and vaporization takes place off the surface of the pool of molten sulfur and off the surface of the film of molten sulfur which adheres to the inner unsubmerged portion of the furnace wall. Consequently, most of the heat is generated in the gas space above the molten sulfur and not within the liquid sulfur pool itself at which place most efficient utilization of heat might be had. These circumstances impose substantial limitations on the rotary furnace method with respect to production of an off-gas having a high vaporized sulfur to burned sulfur ratio, and as to capacity per unit of apparatus.

The principal object of this invention lies in the provision of means which retain the advantages of the rotary furnace process with respect to prevention of a scum layer on the molten surface, but which overcome the deficiencies referred to above. The present improvements are particularly applicable to vaporization operations in which at least an appreciable amount of the total heat generation takes place in the gaseous atmosphere above a subjacent pool of molten sulfur.

The invention, its objects and advantages may be understood from the following description

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taken in connection with the accompanying drawing showing apparatus in which one embodiment of the present improvements may be carried out, Fig. 1 being an elevation of a sublimer, Fig. 2 a transverse cross-section on the line 2—2 of Fig. 1, Fig. 3 a fragmental elevation on the line 3—3 of Fig. 2, and Fig. 4 an enlarged detail in cross-section.

On the drawing, 10 indicates a horizontally elongated, cylindrical furnace mounted for rotation about its horizontal axis on rollers 11 and tracks 12. Brimstone is fed into the furnace by conveyor 15, and the air needed drawn in thru valve-controlled pipe 16 and bustle 17 surrounding the inlet end of the furnace. The gas outlet end of the furnace projects into a conduit 21 which conducts the sulfur vapor-SO_2 gas mixture to a point for further processing, e. g. a combustion chamber not shown. The furnace is usually operated under negative pressure induced by a suction fan located at some point in the exit gas stream.

I have found that, with respect to a sulfur vaporizing operation of the kind under consideration, the capacity of a given apparatus may be increased from 25 to 50% and that the ratio of vaporized to burned sulfur in the gas produced may be substantially increased by continuously carrying into the pool of molten sulfur portions of gaseous atmosphere existing in the gas space above the sulfur pool, releasing these portions of gas within the pool, and preferably also maintaining in the gas space a substantial amount of molten sulfur in relatively dispersed condition.

Apparatus devised for accomplishing these objects is illustrated more particularly in Figs. 2 and 3, the arrow 20 (Fig. 2) indicating the direction of rotation of furnace 10. Placed about the inner circumference of the furnace are a plurality of traps 22. In the embodiment shown, one edge of a right-angled angle iron 24, having legs 25 and 26 of about equal length and having an overall length approximately equal to that of the cylindrical portion of the furnace, is welded as at 28 to the inside of the furnace shell. At spaced points within the angle iron are baffle plates 30 which, in conjunction with the angle iron and the adjacent inner surface of the furnace shell, form the elongated traps 22 which in effect extend horizontally substantially the full length of the cylindrical section of the furnace.

For any given furnace, there is an optimum maximum depth for the pool of molten sulfur, such depth being usually about one third the furnace diameter. For purpose of illustration,

the surface level of the molten sulfur pool **32** is shown in Fig. 2 by the horizontal line **33**. To obtain the fullest advantages afforded by the present improvements, positioning of the outer walls **25** and **26** (the legs of an angle iron) of the traps is of importance. The objectives of the conformation of the traps **22** are twofold, namely to entrap and carry into a pool of molten sulfur a maximum amount of gas from the gas space **34**, and to carry up and maintain in the gas space a maximum amount of molten sulfur in dispersed condition. These purposes may be served, particularly when using a right-angled angle iron, by welding the iron to the shell in such a way that a leg **25** forms an appreciable angle **36** with a radial line **37**. This angle is preferably chosen so that when the advancing lip of a trap contacts the surface of the sulfur pool, the adjacent leg **26** of the angle iron is at approximately right angles thereto as shown at **40** in Fig. 2. Thus, the gas capacity of a trap at the point of submergence in the pool is approximately maximum. In the particular embodiment of apparatus illustrated, the cylindrical section of the furnace may be 20 feet long and have an internal diameter of 4 feet. In this instance, angle **36** (Fig. 4) may be between 9 and 10 degrees, and the distance along dotted line **38**, parallel to leg **25**, being about 5% the length of leg **25**, e. g. about 2½ inches in the case of use of 3 inch angle irons.

In operation, feed of brimstone and air and maintenance of a pool of molten sulfur in the furnace are as known in the art. The gas space, particularly near the furnace inlet end, is strongly oxidizing, although it becomes less so toward the outlet end. As rotation of the furnace proceeds in the direction of arrow **20**, portions of the atmosphere in the gas space are entrapped at the surface line **33** and are carried downwardly into the sulfur pool. During the period of entrapment, the gas is held at the outer periphery of the sulfur pool. As the head of liquid sulfur above an entrapped increment of gas increases, such gas is gradually displaced by liquid sulfur, released into the pool, and bubbles to the surface. The positioning of the traps relative to the furnace shell being such as described, all gas is not released from any particular trap until such trap has passed the vertical diameter of the shell and is well on its course of upward movement. Thus, release of gas is effected gradually along the outer periphery of a major portion of the sulfur pool. Particularly near the inlet end of the furnace, the gas released into the pool contains a large proportion of oxygen which burns to SO_2 within the sulfur pool and hence at a point where most efficient utilization of heat may be had, heat efficiency being much greater if generated in the liquid pool rather than in the gas space. Inert constituents of the gas released in the pool cause substantial ebullition at the surface of the sulfur pool, this condition substantially enhancing heat generation and sulfur vaporization at and near the surface of the pool of molten sulfur.

When all gas is released from a given trap, the trap has become filled with liquid sulfur which is carried up into the gas space. As shown particularly in Fig. 4, the advancing edge **42** of preferably all the baffles **30**, and of at least the baffles at the ends of the cylindrical section of the furnace, are formed so that on emergence of a trap edges **42** about coincide with the surface **33** of the pool of molten sulfur. By this means,

a trap **22** withdraws a maximum of molten sulfur from the pool, and further the arrangement is such that immediately on emergence of a trap, molten sulfur begins to spill over the advancing lip of the angle iron and back into the pool. These results are accomplished by shaping the baffles so that an edge **42** forms an appreciable angle **44**, say 8–10 degrees, with a radial line **46**, as shown in Fig. 4, e. g. the length of an edge **42** may be about the same as the length of line **38**.

As the furnace rotates, molten sulfur spills over the advancing lip of a trap until such trap is appreciably above the horizontal diameter of the furnace, and since heel **45** of a trap is spaced from the inner drum surface a distance greater than the advancing lip, the trap does not become completely emptied of liquid until such trap is beyond the vertical diameter of the furnace and well on its course of downward movement. Liquid sulfur is accordingly showered downwardly into a major portion of the gas space while in a relatively well dispersed condition which markedly enhances whatever combustion and vaporization takes place within the gas space. Hence, the procedure of the invention not only greatly increases the molten sulfur surface area available for combustion and vaporization, but also effects a substantial amount of combustion within the pool of molten sulfur itself.

The advantages afforded by practice of the invention may be appreciated from the following. In one operation, the apparatus employed was a commercial installation, the cylindrical section of the rotary furnace being 20 feet long and 4 feet in internal diameter. The inside of the furnace was smooth and not provided with angle irons or any other comparable elements. Maximum permissible depth of the sulfur pool in the furnace was 18 inches, and rotation was at a rate of 0.8 R. P. M. Solid commercial brimstone and the required amount of air were introduced into the inlet end of the furnace, and when operating this particular furnace under optimum conditions, the maximum amount of brimstone which could be fed to the furnace was 50,000 pounds per 24 hours. There was produced an exit gas in which 3% by weight of the sulfur fed into the furnace was in the form of vaporized sulfur, and 97% was in the form of SO_2. In another operation, typical of practice of the present invention, the same equipment was employed except that the inside of the furnace was equipped with **12** equally spaced 3 x 3 x ¼ inch right-angled angle irons welded to the shell at approximately the angularity previously discussed. Each angle iron extended thru the cylindrical length of the furnace and was provided on each end with a baffle plate and with 4 intermediate baffle plates, thus forming a total of 60 gas traps 22 in the furnace. Otherwise operation was the same as described above. However, in this instance, the amount of brimstone fed to the furnace was 75,000 pounds per 24 hours, and there was produced an exit gas in which 20% by weight of the brimstone fed to the furnace was in the form of vaporized sulfur and 80% in the form of SO_2. Thus, application of the principles of the invention afforded an increased furnace capacity of 50%, and the vaporized sulfur to burned sulfur ratio in the off-gas was increased about 700%.

I claim:

In a horizontal rotary sulfur vaporizer, the improvements which comprise a plurality of circumferentially spaced angular members disposed on

the inner circumference of the vaporizer and extending substantially the entire length of said vaporizer, baffles within said angular members forming in conjunction with said members a plurality of elongated traps, each angular member being so disposed that the leg thereof adjacent the circumference of the vaporizer forms an appreciable angle with a radial line drawn to the point of contact of said leg with said circumference, whereby when the downwardly advancing lip of an angular member contacts a chord, drawn perpendicular to a diameter at a point about one third of the distance on said diameter from the nearest point of contact thereof with the inner circumference, the lip-bearing leg of said angular member is at approximately right angles to said chord; and the said baffles within an angular member being disposed so that when the upwardly advancing lip of such angular member contacts a chord as described above, the edges of such baffles substantially coincide with such chord.

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