Dec. 15, 1942. H. E. TREICHLER ET AL 2,305,209

METHOD AND APPARATUS FOR SOLIDIFYING MOLTEN SULPHUR

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Fig. 1.

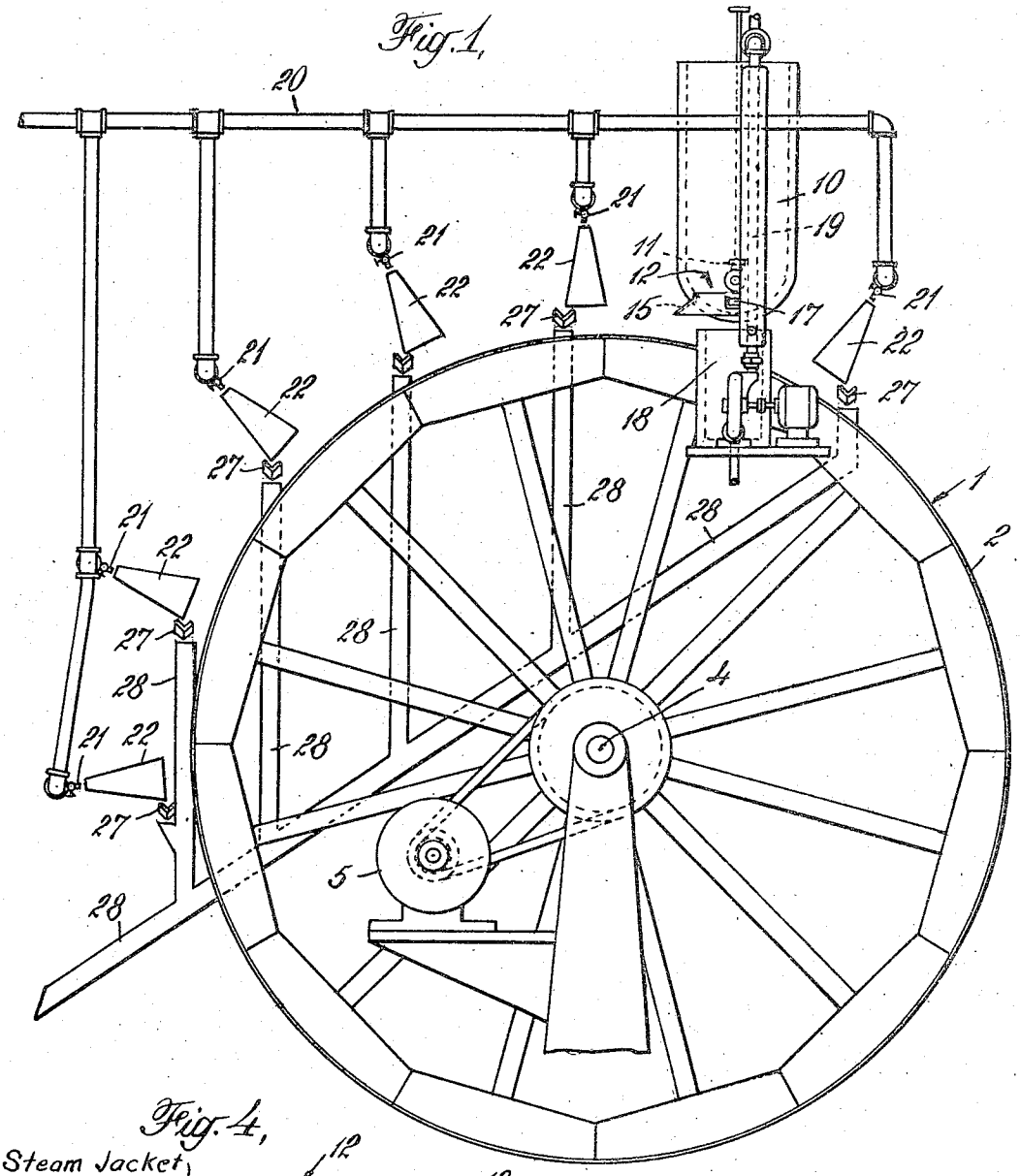


Fig. 4.

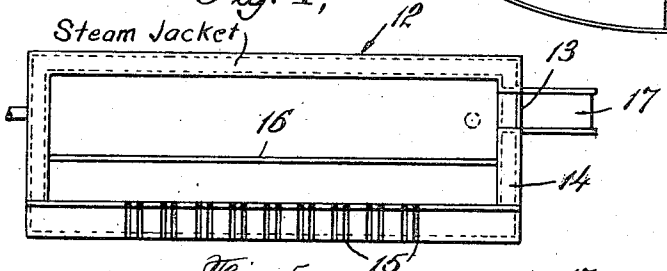


Fig. 5

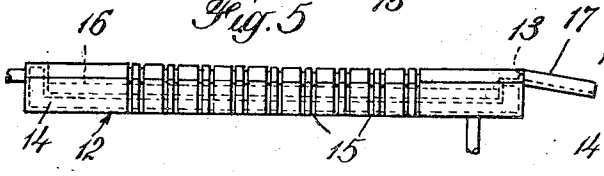
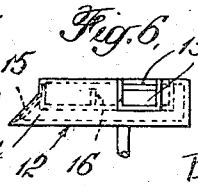


Fig. 6.



INVENTORS
Herbert E. Treichler,
Harry A. Swem,
James W. Schwab
BY
Dennis, Davis, Marvin & Edmonds
ATTORNEYS

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Fig. 2,

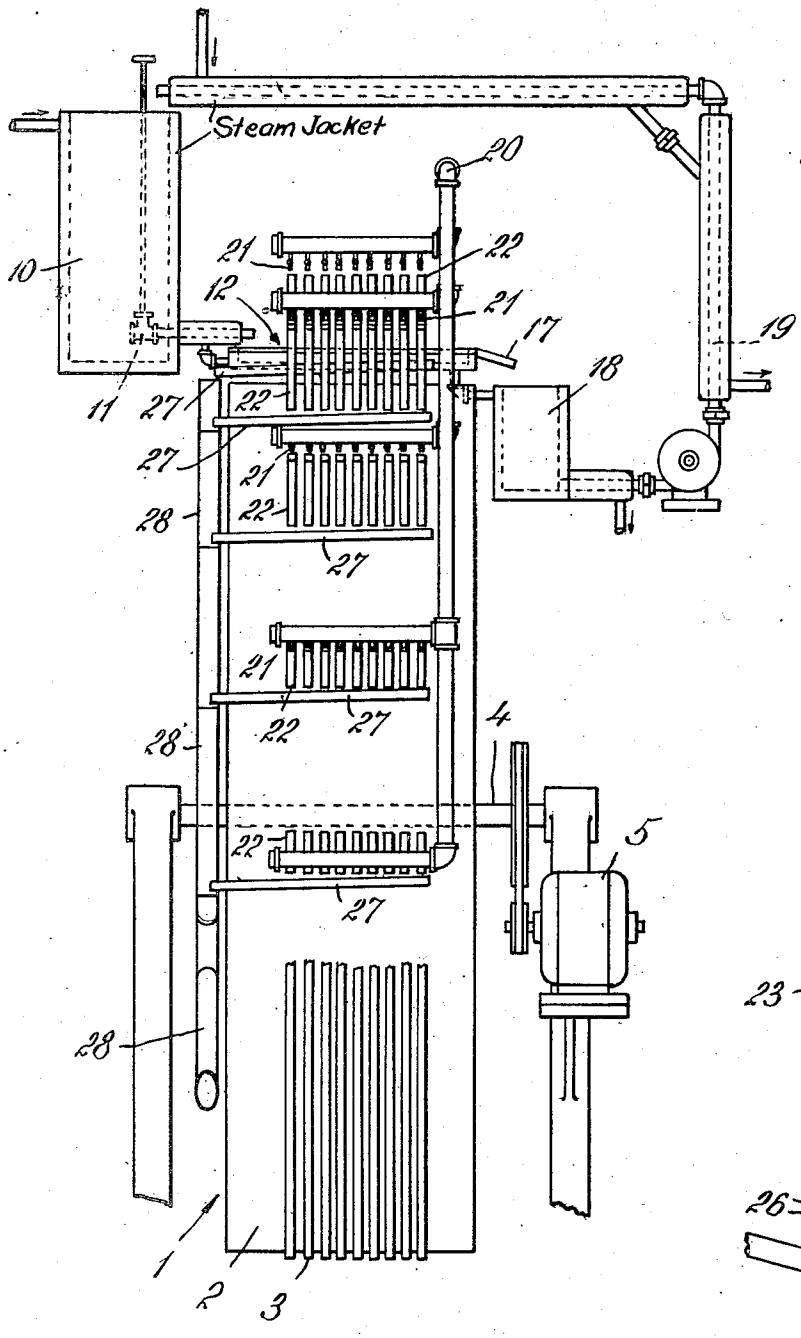
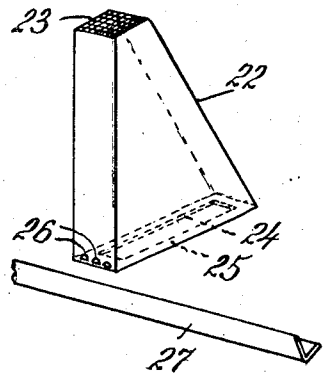


Fig. 3,



INVENTORS
Herbert E. Treichler
Harry A. Swem
James W. Schwab
BY
Pennie, Davis, Marvin & Edmonds
ATTORNEYS

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METHOD AND APPARATUS FOR SOLIDIFYING MOLTEN SULPHUR

Herbert E. Treichler, Harry A. Swem, and James W. Schwab, Newgulf, Tex., assignors to Texas Gulf Sulphur Company, Houston, Tex., a corporation of Texas

Application October 31, 1940, Serial No. 363,672

6 Claims. (Cl. 18—26)

This invention relates to the solidification of molten sulphur and has for its object an improved method of and apparatus for the rapid solidification of molten sulphur in the form of relatively small castings. The invention particularly contemplates the provision of an improved method of solidifying molten sulphur in which the sulphur solidifies so rapidly that a considerable portion of the solid sulphur is in the amorphous state. The molten sulphur is advantageously cooled in the form of narrow strips in which only a relatively small surface thereof is in contact with a supporting surface upon which the sulphur solidifies. In accordance with the invention the molten sulphur is poured in one or more small streams over a supporting surface in a plurality of overlying layers, one layer being cooled to non-flowing consistency, for example to a more or less solid state, before the next layer is applied.

Sulphur mined by the Frasch process is in a liquid state and must be solidified for shipment. While many proposals have been made for the rapid solidification of sulphur in small solid bodies, none has been successful and the present practice involves cooling the sulphur in bins or vats. The vats are usually of such size that it takes many months to fill and cool them and as a result the interval between mining and shipping is often a year or longer. Sulphur is a poor conductor of heat and in large bodies it cools so slowly that it contains only a trace of amorphous sulphur. The sulphur is accordingly in a friable state and not in a state which can be broken into lumps without an appreciable loss in fines. The casting of sulphur in small molds, where the cooling is rapid enough to form a considerable proportion of the amorphous modification, has not been a success because the shrinkage is small and the sulphur sticks to the mold. As the size of the casting is increased, the tendency to stick to the mold surfaces is more and more offset by the increased effect of shrinkage. But while the larger castings overcome some of the tendency for sulphur to stick to the mold, the freezing is so slow that the amorphous sulphur forms in decreasing proportions as the size of the castings increase. The larger castings accordingly lack the desirable tough dense structure of rapidly cooled sulphur.

This invention contemplates the provision of an improved method of and apparatus for overcoming the aforementioned difficulties and aims to solidify molten sulphur sufficiently rapidly to give it such a dense structure that it is strong enough to utilize the contraction due to cooling to free itself from the medium on which it is solidified. We have found that when molten sulphur is applied in a number of overlapping layers on a supporting surface in the form of elongated narrow bodies or strips with accompanying cooling, that a larger part of the sulphur solidifies to the amorphous state, and also that the shrinkage in the longitudinal direction of the strips aids in freeing the solid sulphur from the surface. We may use any suitable surface that will support or contact the sulphur on one side, and we provide relative motion between the surface and the stream of sulphur so that the sulphur will be spread over the surface in a plurality of superposed layers. We have found that a suitable supporting surface is advantageously in the form of a large wheel or rotatable cylinder. The molten sulphur is preferably poured out of one or more stationary spouts in thin narrow streams onto the rotating exterior surface of the cylinder. The rate of speed of the surface and the rate of flow of sulphur are so controlled, together with the conditions of cooling, that a plurality of overlying layers of sulphur are built up in the form of long strips on the supporting cylindrical surface. The sulphur is preferably poured onto the cylinder near the top thereof and the conditions are so controlled that by the time the sulphur reaches the under portions of the cylinder it has reached non-flowing consistency and, generally, has solidified. The sulphur on the cylinder is cooled as quickly as practically possible and means are preferably provided to charge a heat-absorbing fluid, such as steam or atomized water, in contact with the sulphur on the cylinder and also to cool the cylinder itself, preferably on the inside. As the cylinder continues to rotate and the sulphur to be deposited on the exterior surface, one layer or film over another, long circular strips which are approximately rectangular or square in cross section are built up on the supporting surface. On cooling, there is a considerable shrinkage in the longitudinal direction of the strips which cracks them in sections and an internal force causes them to try to straighten out so that they fall from the cylinder.

The apparatus of the invention comprises means for passing one or more streams of molten sulphur onto a moving surface, advantageously a rotating cylindrical surface, and means for directing a cooling fluid in contact with the sulphur to increase the rate of cooling.

These and other novel features of the inven-

tion will be better understood after considering the following discussion taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a side view of apparatus embodying the invention;

Fig. 2 is a front end view of the apparatus of Fig. 1;

Fig. 3 is an enlarged view of a fluid distributor;

Fig. 4 is a plan view of a sulphur feeder;

Fig. 5 is a side view of the feeder of Fig. 4; and

Fig. 6 is an end view of the feeder of Fig. 4.

The apparatus illustrated in the drawings is especially efficacious in a practice of the invention and comprises a wheel or cylinder 1 having an exterior supporting surface 2 for solidifying the sulphur strips 3. The surface 2 is made of any suitable thin gage sheet metal which will radiate heat rapidly and is resistant to the action of sulphur and does not form black sulphides, such as galvanized steel, aluminum or stainless steel. The cylinder is rotatably driven on the shaft 4 by the variable speed motor 5. The apparatus for pouring a plurality of uniform thin streams of molten sulphur over the surface 2 comprises a steam jacketed sulphur storage tank 10, a valve controlled pipe 11 for passing sulphur into the feeder 12 which has an adjustable weir 13 for maintaining a uniform level of sulphur, a steam jacket 14 and a plurality of spaced spouts 15 for pouring the sulphur onto the surface 2. The baffle 16 aids in distributing the sulphur and the excess of sulphur flows over the weir 13, through the spout 17 and into the overflow tank 18 from which it is pumped back into the storage tank through the pipe system 19.

The strips of sulphur may be cooled indirectly by cooling the inside of the cylinder or directly by charging a heat-absorbing fluid thereover. This may be done with cold air, if the velocity is such that liquid sulphur is not blown from the strips, or with atomized water, if atomization is sufficiently fine so that no globules of water are enclosed in the strips. As shown in the drawings, the cooling means is especially intended for cooling with steam and comprises a steam header 20 for supplying steam to a plurality of circumferentially spaced steam jets 21 arranged to discharge the steam into housings 22. One row of cooling devices is provided for cooling the strip of sulphur issuing from each of the spouts 15. The steam is diffused by the screen 23 and expands in the housing forming a fine mist which passes through the opening 24 to the sulphur. There is a lip 25 inside the housing for catching the larger drops of water and drain holes 26 permit these to drop into the trough 27 which leads to the condensed-water drain 28.

In carrying out a method of the invention in apparatus such as that illustrated in the drawings, molten sulphur such as is pumped out of the earth in the Frasch process flows into the sulphur storage tank 10. The valve 11 is adjusted to permit enough sulphur to enter the feeder 12 to keep it filled to the proper level. The excess overflows the weir 13 and enters the tank 18 from which it is pumped back into the storage tank 10 and a constant uniform flow of sulphur is discharged in uniform thin streams from the spouts 15. As the cylinder 1 rotates, narrow films of sulphur are deposited around the surface 2. As the cylinder rotates, heat is dissipated from the sulphur as quickly as possible. While it is possible to adjust conditions so as to rely wholly on air cooling to solidify the films of sulphur, we prefer to accelerate cooling by the use of steam as just described.

As the cylinder rotates steam is charged out of the jets 21 into the housing 22 where it expands forming a mist which passes into contact with the sulphur strips. The cylinder is rotated at such a speed and the sulphur is applied at such a rate that with each rotation the films of liquid sulphur, which are applied near the top of the cylinder, freeze as the cylinder turns downward and are solid enough when they reach the bottom so that no liquid drips from the strips. As the cylinder rotates to a position where the layer of sulphur is about to be covered with another layer, the sulphur in the last completed layer has practically or completely solidified. The continued rotation piles one layer over another. In this manner the strips are gradually built up to form long circular castings, approximately rectangular or square in section, and supported by only one face.

When strips of the desired thickness have been built up, the flow of liquid sulphur is stopped and the strips are allowed to cool. Usually only a very few minutes are required for the sulphur to cool sufficiently to cause enough shrinkage in the circular castings so that, when broken, the strips separate readily from the supporting surface and fall from the wheel as it rotates.

Forces which are set up in the cooling of a long circular sulphur casting of this kind and which tend to separate it from the supporting surface, are apparent from watching the manner in which the casting frees itself from the metal surface as it cools. The casting first ruptures through its small section, then seems to straighten out as it is thrown tangentially from the cylinder. The greatest shrinkage force is obviously in the long dimension of the casting. This force contracts the casting and brings about rupture and decreased overall length. But in addition to this overall circumferential shrinkage, which makes the casting shorter, there is a slightly greater shrinkage in the longer top portion of the casting than in the shorter bottom portion which is in contact with the cylinder. This greater shinkage in the top portion tends to increase the radius of the casting after it has ruptured, and, particularly with thicker sections, seems to assist materially in completely separating it from the supporting surface.

In those casting methods in which small molds are used any sulphur which sticks to the mold after the casting is removed must be scraped from it before another casting is poured, for if it is left on the mold it serves to anchor the next casting firmly to it. In this method any bits of sulphur which may remain on the surface partially fuse into the next strips and are broken from the surface with them. It is not necessary to clean or buff sulphur from the supporting surface.

The application of steam to the cylinder has the additional advantage of keeping the surface moist. A moist surface is desirable when the castings are started as the film of moisture on the surface causes the first layer of sulphur applied to freeze so rapidly that most of it is separated for a time from the surface by a film of moisture. This procedure materially reduces the amount of shrinkage required to separate the castings from the surface and makes possible a shorter cooling period after the castings are completed. The operation is more effective when the supporting surface is a true cylinder and when it moves at a

uniform rate of speed with no back-lash to break the uniform forward motion.

The rate at which sulphur can be applied varies with the temperature of the liquid sulphur, the final cross sectional area of the sulphur castings desired, the diameter of the cylinder, the rate of rotation thereof, and the auxiliary means used to assist in cooling the sulphur. These variables can readily be adjusted experimentally for any particular installation. In one operation we used a cylinder 10 feet in diameter, 3 feet wide, rotated at a peripheral speed of 3.1 feet per second. Nine strips of sulphur were cast at one time, each 1½ inches thick and 1 inch wide from molten sulphur at 247° F. During 23 minutes the cylinder rotated 136 times and 350 pounds of sulphur were cast. In another operation using a similar cylinder which rotated 126 times in 25.5 minutes, three strips were cast at one time, each 1⅜ inches thick and 1⅜ inches wide, from sulphur at 240° F. to produce 156 pounds of castings.

The friability of the castings may be controlled by the methods used to cool the sulphur after it is broken from the wheel. If very tough sulphur is desired the castings are spread out and cooled as quickly as possible so as not to appreciably reduce the percentage of amorphous sulphur. If more friable castings are desired, the castings are allowed to cool slowly by placing them in a closed bin (insulated if necessary) so that the heat in the casting is dissipated slowly. Under these conditions, by varying the time and conditions of cooling, it is possible to control the percentage of amorphous sulphur in the product and, as friability varies more or less inversely with the percentage of amorphous sulphur, the degree of friability of the product. The most friable sulphur produced in this manner does not, however, form as great a porportion of fines as vat sulphur because of its uniformly dense non-porous structure.

We claim:

1. A method of solidifying molten sulphur which comprises applying a layer of molten sulphur over a supporting convex rigid surface, cooling the layer to non-flowing consistency, applying one or more other layers of molten sulphur over the first-mentioned layer and cooling each layer before the next layer is applied, thereby building up a body of solid sulphur of such size that it is subjected to considerable contraction, and permitting the solid body of sulphur to contract and free itself from the supporting surface.

2. A method of solidifying molten sulphur which comprises applying a plurality of superposed spaced narrow layers of molten sulphur over a supporting rigid surface and building up long narrow strips of sulphur, cooling each layer of sulphur before applying the next layer, solidifying the strips of sulphur, and permitting the strips to contract and separate from the supporting surface.

3. A method of solidifying molten sulphur which comprises pouring at the same time a plurality of separate narrow streams of molten sulphur over the exterior surface of a rotating rigid cylinder to form a plurality of separate layers of sulphur, said streams of sulphur being sufficiently spaced that the adjacent layers do not flow together, cooling the layers of sulphur sufficiently before the cylinder has completed one revolution that the sulphur does not flow, continuing to rotate the cylinder to apply one or more similar layers of sulphur over the aforementioned separate layers to build up a plurality of narrow strips of solid sulphur of the desired thickness, interrupting the pouring of molten sulphur and permitting the strips of sulphur to contract and free themselves from the cylinder.

4. Apparatus for the solidification of molten sulphur which comprises a rotatable cylinder, means for pouring a plurality of spaced thin streams of molten sulphur on the exterior surface of the cylinder at the same time, said cylinder being arranged to rotate a plurality of revolutions to deposit a plurality of superposed layers of sulphur one over the other, means for cooling each layer of sulphur, and valve means for interrupting the pouring of molten sulphur to permit the sulphur on the cylinder to cool and contract sufficiently to free itself from the cylinder.

5. Apparatus for the solidification of molten sulphur which comprises means for pouring a plurality of thin spaced streams of molten sulphur out of a body of molten sulphur, a supporting surface upon which the sulphur of each stream is deposited in a plurality of superposed layers, means for moving the surface relative to the pouring means, said streams being such distances apart that the sulphur builds up in the form of long narrow strips which are spaced from each other, means for cooling the layers of sulphur, and means for cooling the strips of sulphur after the last layer has been applied to permit the sulphur to contract and separate from the supporting surface.

6. Apparatus according to claim 5 in which the supporting surface is curved and the strips of sulphur are built up on the convex surface.

HERBERT E. TREICHLER.
HARRY A. SWEM.
JAMES W. SCHWAB.