

[54] APPARATUS FOR THE SOLIDIFICATION
OF MOLTEN SULPHUR

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23/312 S, 295; 62/72, 345

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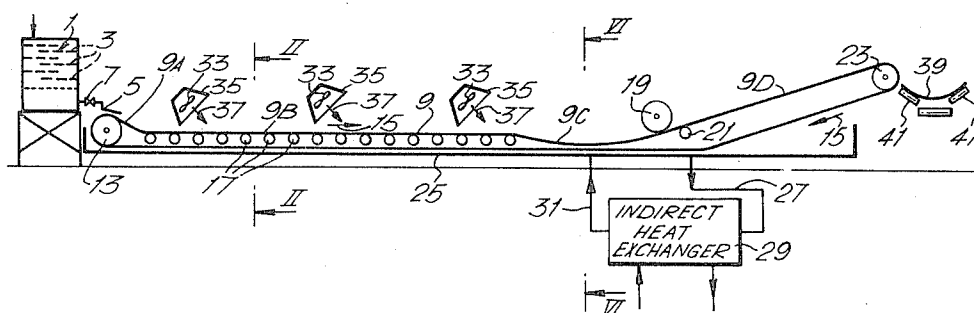
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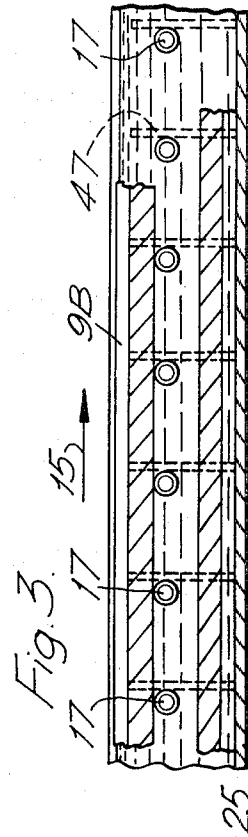
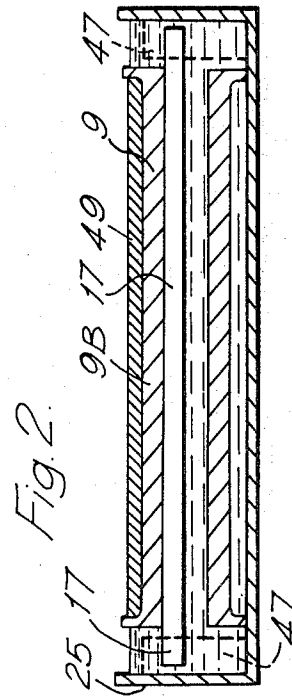
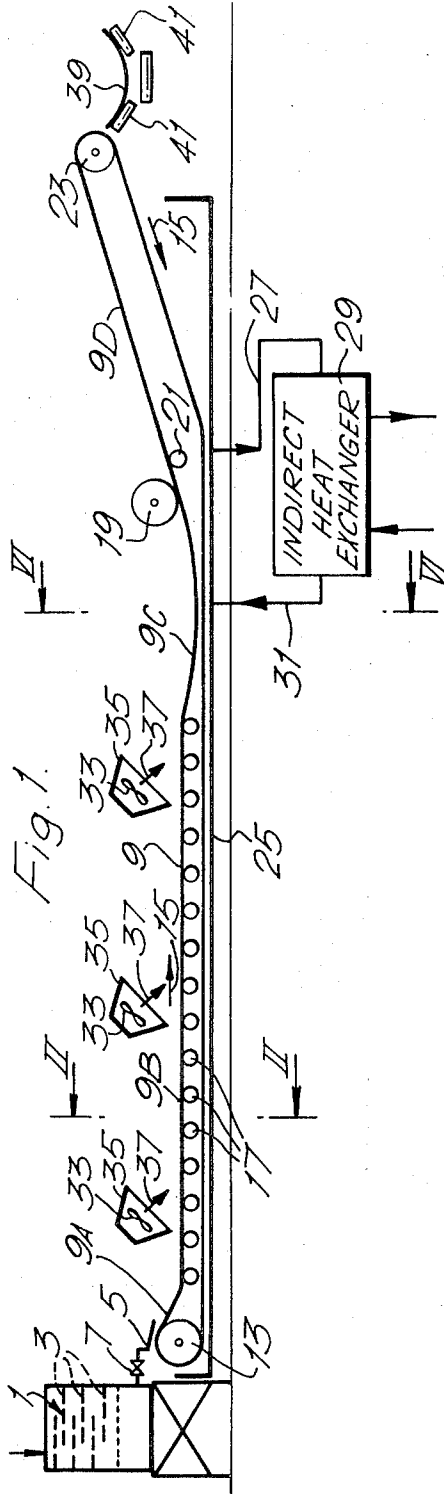
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[57] ABSTRACT

A thin layer of solidified sulphur is formed by discharging molten sulphur onto a conveyor belt supported on loosely retained rollers, and passing the belt on the rollers through a cooling zone, where the underside of the belt is cooled by cooling liquid. The rollers may be buoyant, or may be supported, to maintain the belt at a correct level relative to the level of the liquid.

9 Claims, 11 Drawing Figures





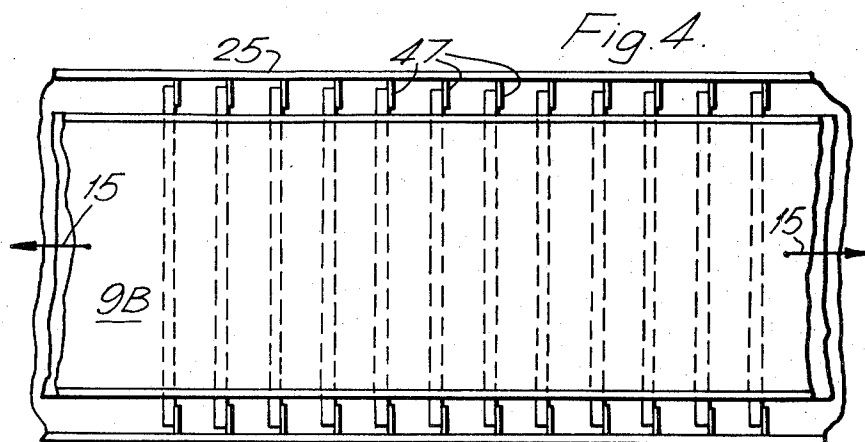
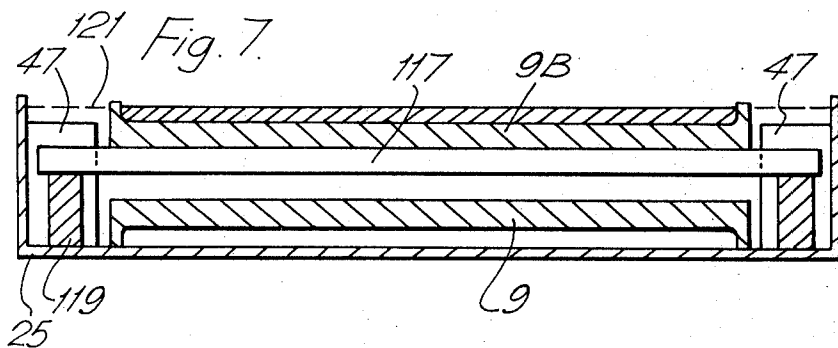
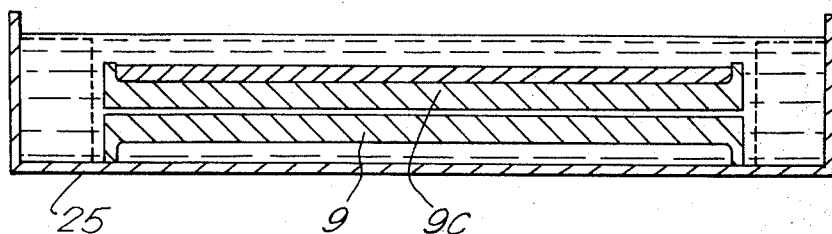


Fig. 6.



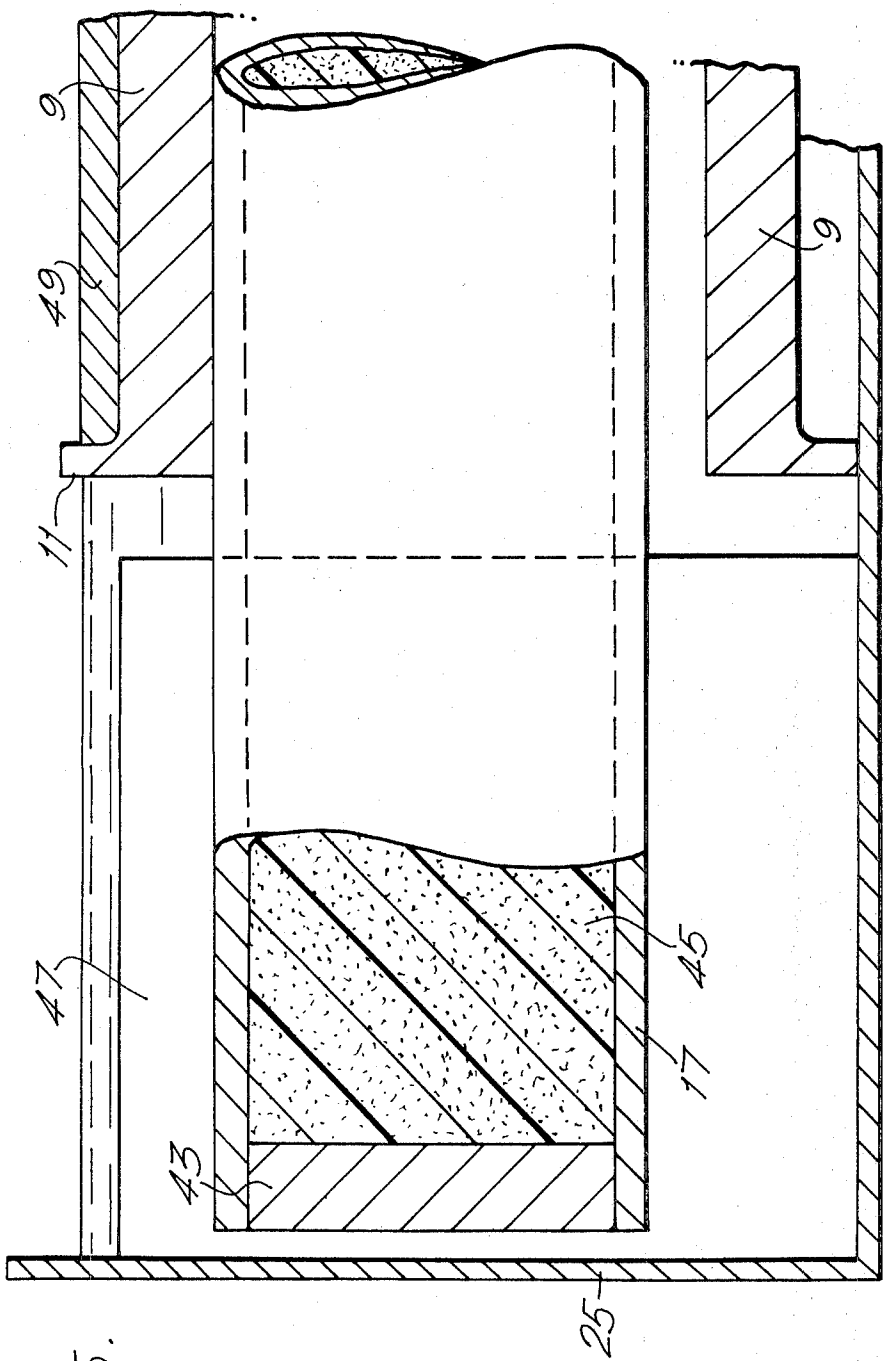
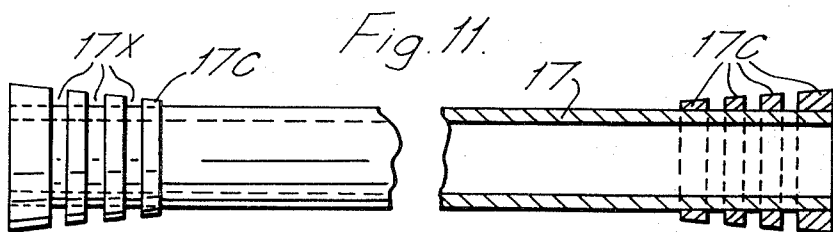
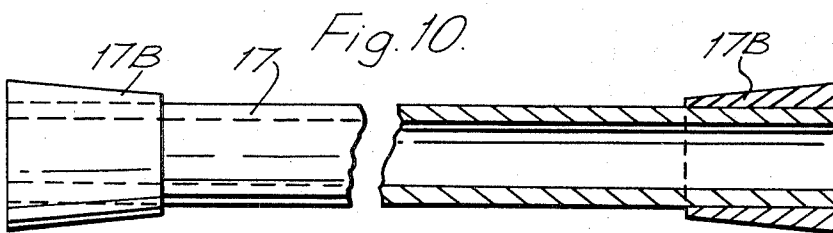
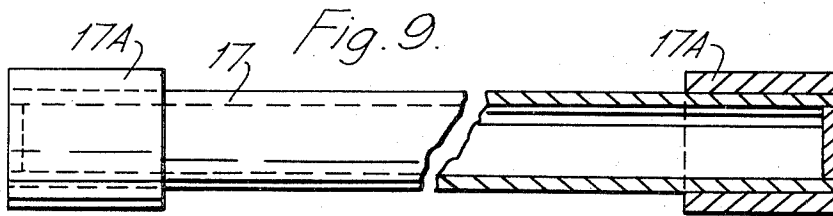
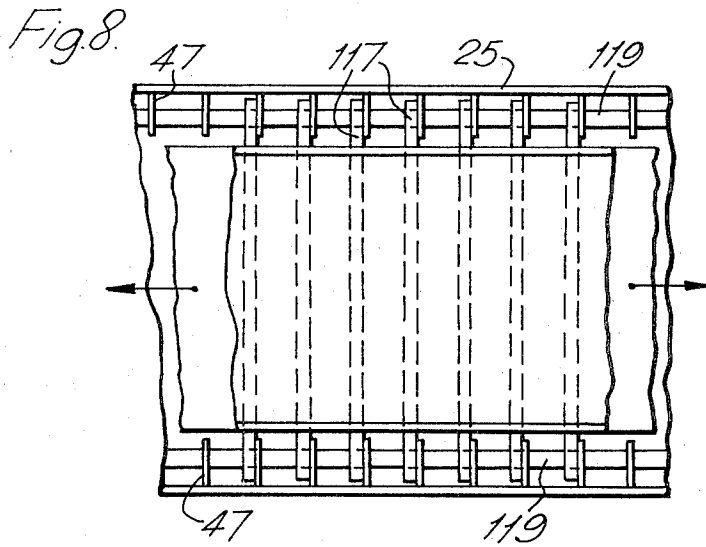


Fig. 5.



APPARATUS FOR THE SOLIDIFICATION OF MOLTEN SULPHUR

This invention relates generally to an improved method and apparatus for the cooling of molten sulphur, for example to produce solid sulphur in the form of relatively thin layer so that it can then be broken into fragments suitable for storage and transport.

The present invention is a further development of, and presents an alternative method and apparatus, to that which is specifically taught in the applicants' U.S. Pat. applications Ser. No. 3,558 filed Apr. 21, 1970, Ser. No. 158,076 filed June 29, 1971 and Serial No. 207,909 filed Dec. 14, 1971.

For many years, sulphur was reclaimed as a fine powder which presented a serious dust nuisance during storage, during handling, and during transportation. With increasing public consciousness of pollution, the dust clouds and surface coating arising when sulphur is handled in the form of a fine powder have become even less acceptable, and the patent applications referred to above, and the present application, relate generally to a process which results in the production of sulphur as a mass of flakes which are commonly referred to as "slates." These do not become airborne under any normal conditions, and thus the dust nuisance commonly associated with sulphur is essentially eliminated. The flakes are produced by the production of a thin layer of the solidified sulphur, which is then broken into flakes in any convenient manner, such as by discharge off an elevated conveyor belt.

An object of the present invention is the provision of improved apparatus for the formation of the desired thin layer of solidified sulphur, which can then be broken up into flakes as required.

According to the present invention, sulphur is discharged onto a flat conveyor belt and distributed evenly on the belt, which is moved in a horizontal direction through a cooling zone. The underside of the belt is subjected to cooling by liquid while the cooling zone is traversed by the belt, and is supported on loosely retained rollers. The upper surface of the molten sulphur is subjected to cooling by a current of cool gas while the cooling zone is traversed by the belt.

The invention will now be described, by way of example, with reference to the accompanying largely diagrammatic drawings, in which:

FIG. 1 is a sectional side elevation through a sulphur cooling and slating unit;

FIG. 2 is a transverse section taken on the line II—II of FIG. 1 and as viewed in the direction indicated by the arrows;

FIG. 3 is a sectional side elevation drawn to a larger scale than FIG. 1 and showing only that part adjacent section line II—II;

FIG. 4 is a plan view of that part of the unit shown in FIG. 3;

FIGS. 5 is a sectional transverse elevation of the right-hand side or end only of a roller shown in FIG. 2;

FIG. 6 is a transverse section taken on the line VI—VI of FIG. 1 as viewed in the direction indicated by the arrows;

FIG. 7 is a transverse sectional view similar to FIG. 2 but showing an alternative embodiment of the invention;

FIG. 8 is a plan view of the part of the unit shown in FIG. 7; and

FIGS. 9, 10 and 11 are side elevations, partly in section, of three alternative forms for rollers shown in the earlier Figures.

Referring first to FIG. 1, molten sulphur is fed to a cooling tower designated generally at 1 at an upper level, and flows downwardly through the tower in sinuous flow over a number of staggered horizontal floors or baffles 3. Cooling air is blown into the tower by a fan (not shown), and the molten but partly cooled sulphur is collected in a tank bottom of the tower 1. From there, it is pumped or is allowed to flow by gravity through a steam jacketed line 5 under the control of a valve 7 to the slating unit proper.

The slating unit includes an endless conveyor belt 9 having a length of 212 feet and a width of 60 inches, the belt being provided on its working face with upright flanges 11 extending respectively along the two edges of the belt and having a height of one-half inch. This is shown clearly in FIG. 5. The belt 9 at its forward end, i.e., near the tower 1, extends round a large roller 13 and then, in the direction of travel indicated by the arrow 15 in the various figures, slopes downwardly for a short distance at 9A before extending horizontally at 9B, supported on rollers 17. The extent of the horizontal portion 9B is 60 feet, and beyond the last of the rollers 17 the belt is allowed to sag to form the concave section 9C, having a horizontal extent of 20 feet, before passing under a large roller 19 and above a supporting roller 21 to extend at an upward inclination at 9D to pass over a driven roller 23. After passing over that roller 23, the belt returns under rollers 23, 21 and 17 to the roller 13.

A cooling pan 25 in the form of an open-topped trough containing cooling water contains also the rollers 17, the lower part of roller 13, and the parts 9B and 9C of the conveyor belt 9. The water level in the cooling pan 25 is maintained substantially constant by suitable control means, not shown, and the temperature of the water in the cooling pan is kept at a desired level by the continuous extraction of a suitable flow of the water through a pipe 27 leading to a heat exchanger 29, from which the cooled water returns through pipe 31 to the pan 25. The details and components of the devices needed to control both temperature and water level do not form part of the present invention, and will be clear to those skilled in the relevant art.

Disposed above the horizontal part 9B of the conveyor belt are three fans 33 enclosed in hoods 35 and provided with suitable air directing louvres at their air outlets. As indicated by the arrows 37 associated with these fans, each fan directs cooling air downwardly at an inclination in the direction of travel of belt part 9B, and the arrangement is such that the air so discharged is effective both to cool the liquid sulphur which as described below, is on the surface of belt part 9B, and to distribute that molten sulphur evenly from edge to edge over the belt surface. Although fans are shown, it would clearly be a suitable alternative to use a remote fan supplying air to ducts having outlet ports louvred and directed as described above.

Disposed beyond the roller 23 is a further belt conveyor 39 passing over troughing idler rollers 41 and arranged to collect material discharged by the belt 9 over the roller 23.

Referring now to FIGS. 2 through 5, these show in detail the arrangement of the belt part 9B and of the rollers 17 in the cooling pan 25. Each of the rollers 17 is formed from a 72 inch length of 3 inch Schedule 40 P.V.C. pipe. Such pipe has an internal diameter of three inches and an outside diameter of three and a half inches, and the two ends of the pipe length forming a roller are closed by plugs 43. It has been found desirable to fill the part of the pipe between the plugs with a closed-pore plastic material 45, since otherwise the pressure built-up in the pipe at its elevated operating temperatures may blow the plugs out of the end of the pipe. It is, of course, possible as an alternative to use evacuated pipe lengths, or provide other pressure accommodating means to avoid this difficulty.

Each roller 17 is buoyant, its overall specific gravity being 0.32 in the example given. Its length is such, compared with the width of the pan 25, that it can rotate freely but is capable of only very limited endwise movement. At the same time, since each roller is considerably longer than the width of the belt 9, the belt is substantially evenly placed on the roller at all times. The rollers 17 are kept at a desired spacing and in parallel arrangement, extending transverse to the direction of travel of the belt 9, by upright brackets 47 welded to the vertical side walls of pan 25. The brackets are arranged in pairs, one pair for each roller, and along each side of the pan 25 the brackets are spaced apart at a pitch of 12 inches. Since the brackets extend inwardly to a point close to the belt 9, and since they extend upwardly nearly to the top of the pan 25, they serve both to hold the rollers 17 in parallel spaced relationship and to centralize both the part 9B of belt 9 and the lower return run of that belt, in the pan 25.

In use of the apparatus described above, liquid sulphur is distributed evenly by pipe 5 onto part 9A of the belt 9. Its sideward flow off the belt is prevented by the two flanges 11. The part 9B of the belt is supported on the rollers 17, and in any particular installation these flotation rollers are designed to support the weight of the sulphur coated belt so that the rollers and the lower part of the belt part 9B are submerged in the water in the pan 25 (the water level is indicated at 49 in FIG. 5) but the water is excluded from the top of the belt part 9B by the flanges 11. This requires a careful analysis of all the relevant operating conditions and a suitable design both of the rollers and their distribution along the belt part 9B. Thus, it is necessary to consider the belt weight per foot run without any load; the sulphur load to be expected, e.g., 8 to 10 pounds per foot run; and the buoyancy and the number of spacing of the rollers 17. Further, excessive variations in water level and excessive turbulence in the water is to be avoided, and the brackets 47 tend to dampen ripples and waves in the water in the pan.

While passing along with the belt part 9B, the sulphur 49 is subjected to preliminary cooling by the air discharged by the fans 33, and this air discharge also tends to improve the even distribution of the cooling molten sulphur. The water in the water pan 25 cools the rollers 17 and the belt part 9B. The belt typically is travelling at 60 feet per minute, so that the air cooling lasts for about 1 minute, at the end of which time the belt 9 passes over the last of the rollers 17 and, under the weight of itself and its load, dips down so that the belt is gradually submerged into the cooling water. Belt tension, and the buoyancy of the belt and the sulphur,

keep the belt supported in the cooling water for a distance of 20 feet, after which it emerges as a relatively gentle inclination and, as belt section 9D, inclines towards roller 23.

During the period of about twenty seconds while the belt is passing up the incline at section 9D, water drains from the sulphur on the belt and further water evaporates from the partly solidified sulphur before it is dropped off the belt 9, as it passes over roller 23, onto the conveyor 39. Conveyor 39 conveys the sulphur, now broken into small plate-like pieces or slates, to a suitable storage pile.

It will be appreciated by those skilled in the art that considerable care is needed in putting the invention into practice. Thus, for example, the cooling water circulated through the pan 25 must be carefully controlled. Merely by way of example, in the arrangement which has been described generally above, it was found that for a group of six such units cooling water was circulated at a rate which varied between 250 to 600 U.S. gallons per minute, the system then working to produce slated sulphur at a rate of 15 long tons per unit, equal to 90 long tons per hour from the group of units. In that example, the water cooling system had a cooling capacity of 1,015,000 k Calories, assuming an average liquid sulphur system input temperature of about 250°F. For an installation in countries such as Canada, it is important to take into account the ambient air temperature, which may vary over the range -50°F. to +130°F. In a practical installation, a sophisticated control system to integrate all the relevant variables would be used, but such systems are well known in the art and do not in themselves form part of the present invention, and therefore are not described herein.

The apparatus described above in connection with FIGS. 1 through 6 has been found to overcome a number of difficulties experienced with the earlier proposals by the present applicant. In the original apparatus contemplated by the applicant, the belt carrying molten sulphur was arranged to slide over metal guide pans which supported the belt on the surface of the water and this presented three problems:

- the amount of power required to drag the belt with a sliding action over the fixed pans;
- if the water level in pan 26 became low, the belt would rise from the water and, no longer being cooled, becomes excessively hot, so interfering with the desired cooling of the sulphur; and
- the rubbing of the belt on the fixed pans caused excessive wear of the belt.

By the use of rollers to support the section 9B of the belt evenly at the proper position relative to the surface of the cooling water, even cooling of the belt was assured, and in addition, the friction involved was considerably reduced. As a result of the replacement of a sliding motion between the belt and its support with a rolling motion, wear on the belt was significantly reduced.

In the arrangement of FIGS. 1 through 6, buoyant rollers 17 were used, and this had the added advantage that no exact control of the water level in the pan 25 was required. However, many of the advantages of the embodiment of FIGS. 1 through 6 can be obtained with the arrangement shown in FIGS. 7 and 8. In that arrangement, the buoyant rollers 17 of the earlier embodiment are replaced with rollers 117 which are not buoyant, and can be made of any material suited to

their operating conditions. In this arrangement, the pan 25 is provided as before with brackets 47 which maintain the rollers 117 in the desired spaced parallel relationship, but additionally the floor of the pan 25 is provided with longitudinally extending support strips 119 extending respectively along side parts of the pan floor, and of such height that, when the rollers 117 rest on the strips 119 and the belt part 9B rests on the rollers 117, the top surface of the belt part 9B is at a predetermined level in the pan 25. It is of course necessary, with this arrangement, to provide means for the accurate control of the water level 121 in pan 25, but since this is, in any case, a requirement in the earlier proposals by the applicant, the embodiment of FIGS. 7 and 8 provides reduced power requirements and reduced wear without any further complication in the apparatus.

FIGS. 9, 10 and 11 show alternative forms for the rollers on which the belt 9 travels. In each case the roller 17 is formed from a tube having a nominal bore of 3 inches and an outside diameter of 3½ inches. At each end each roller is provided with an encircling sleeve having a length of 8 inches and an overall diameter of 4½ inches.

In the embodiment shown in FIG. 9, this sleeve 17A is a plain sleeve as shown, and serves as a bearing surface which engages the brackets 47.

In the embodiment shown in FIG. 10, this sleeve 17B tapers in thickness endwise of the roller 17, being of lesser diameter towards the centre of the roller.

The sleeve 17C shown in FIG. 11 is, in effect, the sleeve 17B but sectionalised by circumferential cuts 17X into a number of spaced sleeve parts.

The objective of using such modified ends on the rollers 17 is compensate for belt stretching and belt deformation in use. Further, it tends to improve the evenness of liquid sulphur distribution over the full width of the cooling belt. As mentioned above, by the use of replaceable sleeves, wear on the actual rollers can be eliminated.

It will be seen that by the apparatus of the present invention, the applicants have improved factors such as the performance and the rate of wear in the apparatus. It is found that a more consistent output can be obtained when, as described above, the sulphur is cooled on a horizontally moving belt which is subjected to water cooling on its underside while the sulphur is cooled by air directed downwardly on its upper surface.

We claim:

1. Apparatus for forming a thin layer of solidified sulphur which comprises:
 - a. a flat conveyor belt;
 - b. means for discharging molten sulphur onto said

belt;

- c. means arranged to distribute the molten sulphur evenly on said belt;
- d. driving means arranged to produce continuous lengthwise movement of said belt;
- e. vertically loosely retained roller means arranged to support said belt for movement in a horizontal direction through a cooling zone; and
- f. cooling means for subjecting an underside of said belt to cooling by a liquid while the cooling zone is traversed.

2. Apparatus as claimed in claim 1 further comprising means for submerging said belt in cooling liquid after leaving said cooling zone with its cooled sulphur.

3. Apparatus as claimed in claim 1, further comprising a container for cooling liquid in said cooling zone, means for guiding said belt in a horizontal direction through said container and means for inhibiting cooling liquid from flowing onto the molten sulphur.

4. Apparatus as claimed in claim 1, wherein said inhibiting means comprise upwardly extending parts at each side edge of said belt.

5. Apparatus as claimed in claim 1, further comprising a container for cooling liquid in said cooling zone and means for guiding said belt through said container, said loosely retained roller means comprising buoyant rollers free to float in the cooling liquid so that said belt is maintained at such a level relative to said liquid as to prevent cooling liquid from flowing onto the molten sulphur.

6. Apparatus as claimed in claim 5, wherein stops are provided in said container to limit movement of each of said rollers by action of the belt and to maintain the rollers in spaced parallel positions.

7. Apparatus as claimed in claim 1, wherein each of said rollers comprises a cylindrical shell formed of a suitable plastics material and filled with foamed plastics material.

8. Apparatus as claimed in claim 1, further comprising a container for cooling liquid in said cooling zone, means for guiding said belt through said container and means for supporting said loosely retained roller means so as to maintain said belt at a fixed level in said trough, whereby said belt is maintained at such a level relative to said liquid as to prevent said cooling liquid from flowing onto the molten sulphur.

9. Apparatus as claimed in claim 1, wherein means are provided in said cooling zone for discharging a flow of cooling gas onto the upper surface of the molten sulphur.

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