April 21, 1959 B. RAPSON **2,883,162**

CONDENSER WITH ROTARY SCRAPER

Filed Dec. 13, 1955 2 Sheets-Sheet 1

FIG. 1

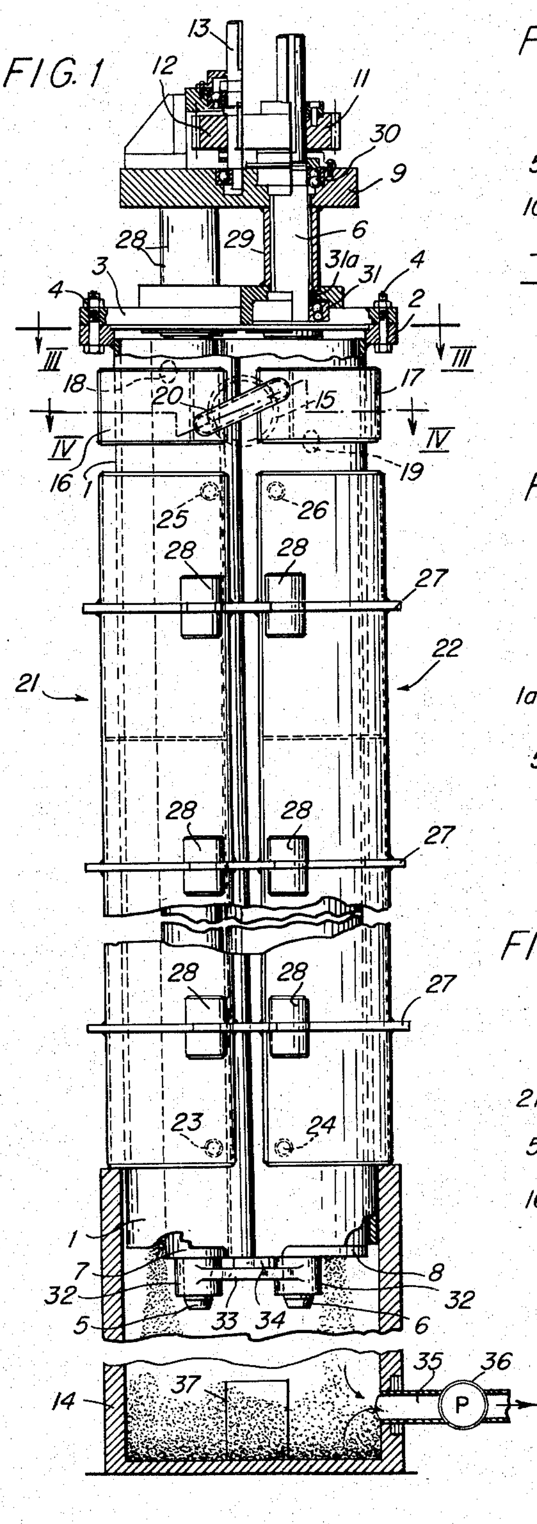


FIG. 2

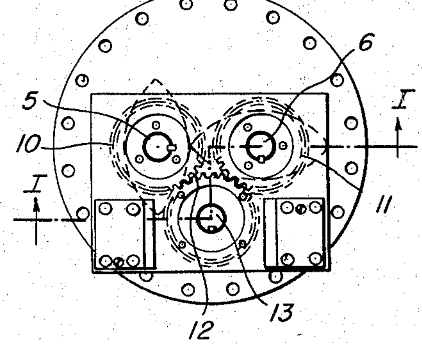


FIG. 3

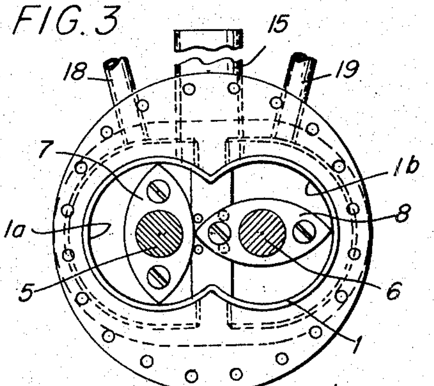
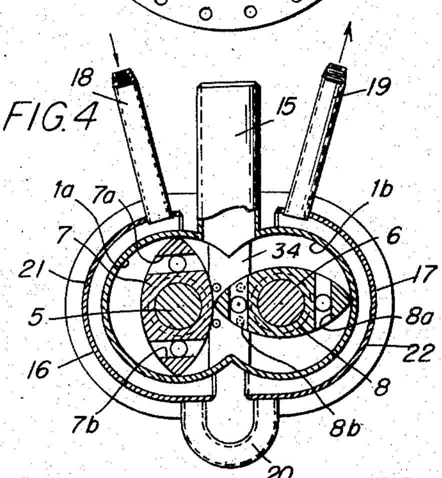


FIG. 4



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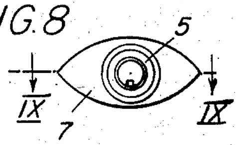
CONDENSER WITH ROTARY SCRAPER

Filed Dec. 13, 1955 2 Sheets-Sheet 2

FIG. 8



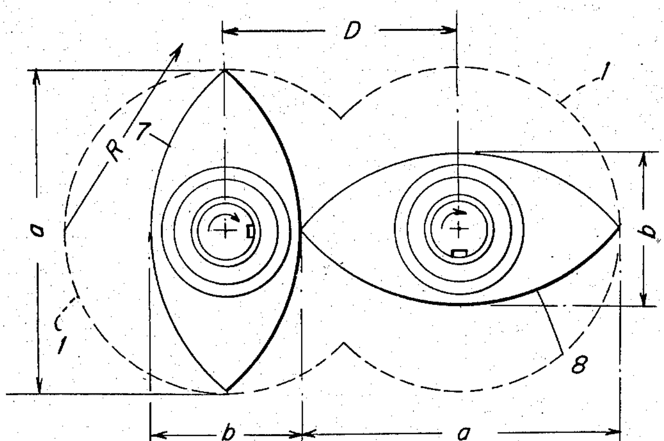


FIG. 5

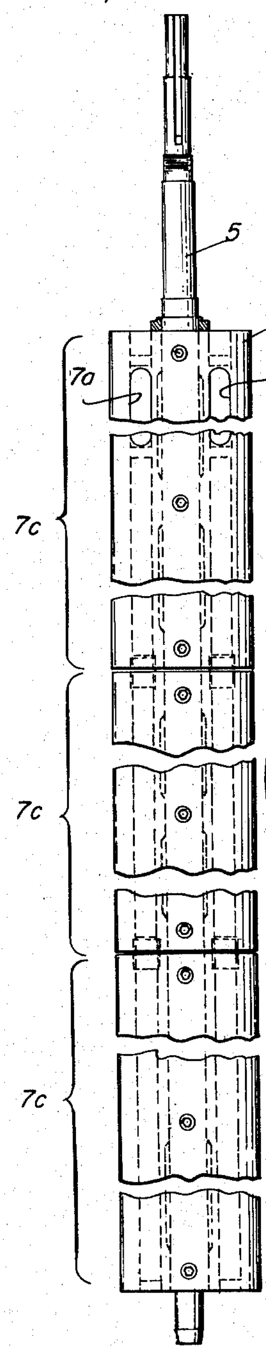
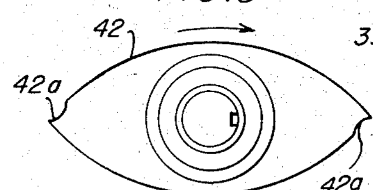


FIG. 7

FIG. 6



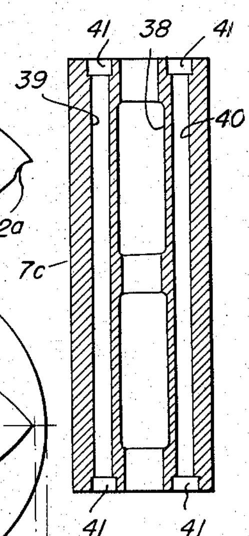


FIG. 9

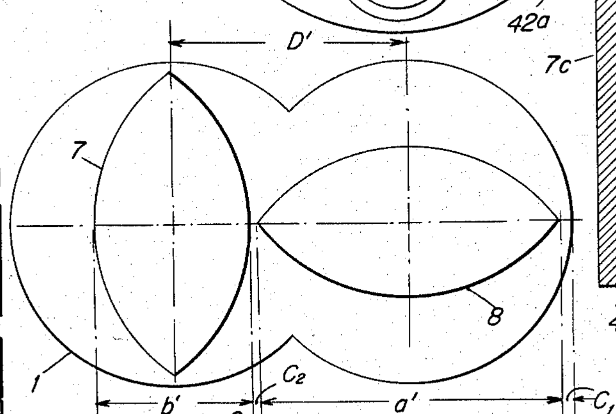


FIG. 10

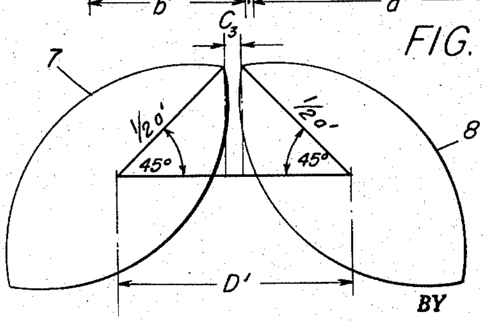


FIG. 11

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CONDENSER WITH ROTARY SCRAPER

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Application December 13, 1955, Serial No. 552,951

7 Claims. (Cl. 257—10)

This invention relates to condensers, and particularly to apparatus providing surfaces upon which solid material is to be deposited from a passing fluid. The invention is especially related to condensers, having extensive cooled surfaces, for use with gaseous fluids which condense to the solid state, and to that end, certain presently preferred embodiments have been particularly intended for use in the condensation of aluminum chloride from its vapor, although such apparatus is useful for any material coming within the broad class stated above.

Certain materials are very difficult to handle when being condensed into the solid state. The condensing process requires a cool surface upon which solid material is deposited. In many cases, the solid materials so deposited build up very hard coatings on the condenser surfaces, impairing the efficiency of heat transmission through those surfaces, and hence impairing the efficiency of the condenser. The coatings so built up are in many cases very difficult to remove. It has been proposed to displace such coatings by means of mechanical scrapers and by various types of impact mechanisms, e.g., loose chains, to pound and pulverize the coating so that it breaks loose from the condenser surface.

In the condensers of the prior art, where such scraper or impact devices are used, the condensed material may tend to condense on the surface of the scraping or impact mechanism. In such cases, the efficiency of the scraping or pounding operation is impaired so that the apparatus must be shut down periodically to clean the scraper or cleaning apparatus. Indeed, accumulation of solids on the removal device, whether by condensation or by being caught in falling from the condenser wall, e.g., as sometimes occurs with helical scrapers, may even become such as to block the movement of the device completely.

An object of the present invention is to provide a condenser of the type described with scrapers which not only clean the cooled condenser surfaces, but which also clean the scraper surfaces, so that the apparatus can run continuously for long periods without being shut down for cleaning the scrapers.

Another object is to provide improved scraper structure for a condenser of the type described.

Further objects are to provide improved gas inlet structure for a scraper of the type described, and to afford other structural improvements, in the support and arrangement of the scraping means, for reliability of operation and especially for the free, non-interfering removal, and ready collection, of dislodged condensate.

The foregoing objects are attained in the apparatus described herein, by providing a condenser arrangement comprising an upright, e.g., vertical or substantially vertical, shell having a cross-sectional contour defined by the external portions of a plurality of intersecting circles, together with vertically elongated scraper elements rotating on upright axes concentric with the circles and each having a lenticular shape in cross-section, arranged

for jointly affording a scraping or sweeping of the interior surface of the shell and of the surfaces of the rotating elements. More specifically, an effective and simple device of the invention comprises, in combination with means for directing gas (from which material is to be condensed) vertically lengthwise in the shell on all sides of the scrapers, and in combination with receptacle means at the bottom of the shell for collecting the solid material which falls as it is removed by the scrapers, a vertical condenser shell having a horizontal cross-section in the shape of two abutting generally circular segments, each segment being greater than a semi-circle. Within the shell, two scrapers are mounted for rotation about vertical axes, the two axes being at the centers of the two segments. Each of the scrapers has a horizontal cross-section which is generally lens-shaped, and is defined by two arcs having radii approximately equal to the distance between the centers of the segments and having centers of curvature at diametrically opposite points on or approximately on the circumference of the surface of the segment within which the given scraper turns. The two scrapers are connected to a common drive for rotation in the same direction and are spaced angularly by 90° about their respective axes.

When so constructed, each scraper continuously scrapes the inside of its associated segment of the shell and intermittently scrapes the surfaces of the other scraper, so that no condensed material may build up within the shell, either on the shell surface or on the scraper surfaces.

Cooling jackets or equivalent means are provided on the outside of the shell, so that material tends to condense on the inside. The scraper elements can be made longer than the shell cooling jackets, i.e., if such arrangement is desirable, to make sure there is no condensation of material at any point on the shell not covered by a scraper.

An inlet for gaseous material to be condensed is located adjacent the upper end of the condenser and passage means is provided for distributing the entering gas to all parts of the shell cross-section, thereby avoiding the building up of pressure differences on the opposite sides of the scrapers. A heater jacket may advantageously be placed around the condenser shell adjacent the inlet, in order to prevent condensation in or adjacent to the inlet passage and the fluid distributing passages.

Other objects and advantages of the invention will become apparent from a consideration of the following description and claims, taken together with the accompanying drawings.

In the drawings:

Fig. 1 is a view partly in section on line I—I of Fig. 2 and partly in elevation, and with certain portions broken away, of a condenser including a scraper mechanism constructed in accordance with the invention;

Fig. 2 is a plan view of the condenser of Fig. 1;

Fig. 3 is a sectional view taken on the line III—III of Fig. 1;

Fig. 4 is a sectional view taken on the line IV—IV of Fig. 1;

Fig. 5 is a diagrammatic view showing the profiles of the two scrapers and illustrating the geometry of those profiles;

Fig. 6 is a view showing somewhat diagrammatically a modified form of scraper profile constructed in accordance with the invention;

Fig. 7 is an elevational view, with portions broken away, showing a complete scraper constructed in accordance with the invention;

Fig. 8 is a plan view of the scraper of Fig. 7;

Fig. 9 is a vertical sectional view taken on the line

IX—IX of Fig. 8, showing the details of construction of one section of the scraper of Fig. 8;

Fig. 10 is a diagrammatic view similar to Fig. 5, illustrating the geometry involved in determining certain dimension of actual physical apparatus, with clearances; and

Fig. 11 is a diagrammatic view similar to Fig. 10, illustrating the geometry involved in connection with another clearance requirement.

Referring to the drawings, there is shown in Fig. 1 a complete condenser including a shell **1**, whose cross-section, as best seen in Figs. 3 and 4, is in the shape of two abutting, generally circular segments **1***a* and **1***b*. The shell **1** extends vertically. The upper end of the shell has a flange or ring **2** welded to its periphery. A cover plate **3** is mounted on the flange **2** by any suitable means such as bolts **4**. The cover plate **3** supports, by means of a bearing structure to be described more completely below, two vertically extending shafts **5** and **6**, which extend downwardly throughout the length of the shell **1**.

Fixed on the shafts **5** and **6** are a pair of scrapers **7** and **8**. Each scraper has a generally lens-shaped cross-section, as shown in Figs. 3 and 4.

The geometry of the cross-sections of the scrapers **7** and **8** is described more completely below in connection with Fig. 5. For the present, it is considered sufficient to point out that each of the scrapers **7** and **8** has a cross-section defined by two arcs whose radii are equal to the distance between the centers of the shafts **5** and **6**, said arcs, for each scraper, having centers of curvature at diametrically opposite points on the circumference of the circle which defines that one of the segments **1***a* and **1***b* with which the axis of rotation of the scraper is coaxial. The angular position of scraper **7** within the segment **1***a* of the shell is spaced 90° from the angular position of scraper **8** within the segment **1***b* of the shell.

The shafts **5** and **6** extend upwardly through the plate **3** and through another supporting plate **9**. Above the plate **9**, the shafts **5** and **6** carry gears **10** and **11**, respectively, both of which mesh with a driving gear **12** carried on a drive shaft **13**, which may be driven from any suitable source of power. Note that this driving arrangement is such that both the shafts **5** and **6** turn in the same direction.

As the scrapers **7** and **8** rotate, their edges continuously scrape the insides of the segments **1***a* and **1***b*. Furthermore, the edges of the scraper **8** intermittently scrape and clean the curved surfaces of the scraper **7**, and vice versa. In consequence, no solid material deposited either on the inside of the shell **1** or on the surface of the scrapers **7** and **8** may remain there but is removed by the scraping action and drops downwardly through the space between the shell **1** and the scrapers into a suitable receptacle or other means for recovery and removal of the materials. For simplicity of illustration, the example of such receptacle shown in the drawings is a condensate trap cylinder generally indicated at **14**. The condenser can be mounted at or on the top of the trap **14**, by suitable means not shown.

The gas or vapor to be condensed enters the apparatus through an inlet conduit **15**, best shown in Fig. 4 and located at the rear of the apparatus as it is viewed in Fig. 1. The inlet conduit **15** opens into the middle of the rear side of the shell **1**. At the level opposite the inlet conduit **15**, the scrapers **7** and **8** are provided with openings **7***a*, **7***b* and **8***a*, **8***b*. See Figs. 4 and 7. These openings allow the entering fluid to pass through the scrapers so that the fluid may pass downwardly through the condenser on all sides of the rotating scrapers and no pressure differential is developed across either of the scrapers.

Around the peripheries of the two segments of the shell **1**, at the level of the inlet conduit **15**, there are provided two jackets **16** and **17**. These jackets serve as heating jackets, being supplied with heating fluid through an inlet pipe **18**, an outlet pipe **19** and a **U**-shaped connecting pipe **20** which connects the front ends of the two jackets. The inlet pipe **18** is supplied with a heating fluid which may be, for example, superheated steam or a eutectic mixture of diphenyl and diphenyl oxide, which is commercially available under the name Dowtherm. This heating fluid is maintained at a temperature above the boiling point of the gaseous fluid entering the shell **1**. The object of the heating of the shell adjacent the inlet **15** is to prevent any condensation of the gaseous material on the surface of the inlet **15**, around the upper ends of the scrapers, or in the passages **7***a*, **7***b*, **8***a*, **8***b*. If the heating were not employed, condensation might take place sufficient to clog these passages.

It might be considered that, by virtue of the presence of the heating jackets, the scrapers **7** and **8** are unnecessary adjacent the inlet **15** and their upper ends could be terminated below that point. However, if such a construction is used, there might be condensation on the shafts **5** and **6**, since they would be somewhat separated from the heating influence and their remaining parts below are in effect cooled. Since there is no mechanism for cleaning the upper ends of those shafts, the condensation could build up on them until it reached a point where it would impede the operation of the apparatus.

A pair of cooling jackets **21** and **22** are located on the outside of the shell **1**, with their upper ends a short distance below the jackets **16** and **17** and extending downwardly to a point somewhat above the lower ends of the scrapers **7** and **8**. The jackets **21** and **22** are provided with cooling fluid inlets **23** and **24** respectively at their lower ends and with outlets **25** and **26** at their upper ends. The jackets **21** and **22** are constructed in sections, the sections being separated by reinforcing plates **27**. Small by-pass conduits **28** extend through the reinforcing plates outside the main jacket structure so as to provide a continuous path for cooling fluid through the jackets. Any suitable cooling fluid may be used, for example, water.

It is important that the scrapers **7** and **8** extend to and preferably below the bottoms of the cooling jackets **21** and **22**, to make sure that no condensation takes place on any unscraped surface on the inside of the shell **1**. To the same end, it is desirable that the scrapers extend above the tops of the cooling jackets.

The shafts **5** and **6** which carry the scrapers extend through the end plate **3** and thence through a pair of sleeves **28** and **29** and are journaled in the bearing plate **9** by means of ball bearings **30**. Above the ball bearings **30**, the shafts **5** and **6** carry the gears **10** and **11** by which the shafts are driven from the gear **12** on the drive shaft **13**.

The bearings **30** are combined guide and thrust bearings and support the entire weight of the shafts **5** and **6** and their associated scrapers **7** and **8**. The shafts **5** and **6** are also guided by guide bearings **31** located in the end plate **3** and by lower guide bearings **32** which are mounted on a crossbar **33** fixed on a bar **34** which spans the cylinder **14** below the scrapers **7** and **8**. Lower guide bearings **31** are surmounted by suitable gas-tight rotary seals, such as the one generally indicated at **31***a*.

The condensate trap **14** is provided with an outlet pipe **35** leading to a pump **36** by means of which the uncondensed vapor or gas is drawn off. The trap **14** may be provided with a suitable door **37** for the purpose of removing the condensate material.

It is desirable to make the condenser rather long, particularly where the vaporized material enters at a very high temperature and must be cooled substantially before it leaves the apparatus in order to condense substantially all the available material. In such an elongated condenser it is desirable for manufacturing purposes to make the scrapers in a sectional arrangement, as illustrated in Figs. 7 and 9. As there shown, the scraper **7** comprises three sections 7*c*, one of which is shown in longitudinal section in Fig. 9. Each section *c* is a casting having a central cored passage 38 to receive the shaft 5 and cored side passages 39 and 40. In the two lower sections 7*c*, the cored passages 39 and 40 simply serve to reduce the weight of the scraper. These passages are closed at their ends by means of plugs 41 so that the material being condensed cannot enter. In the upper section 7*c*, the openings 7*a* and 7*b* are drilled through into the passages 39 and 40 so that those passages serve as parts of the passages 7*a* and 7*b*. The passages 39 and 40 in the upper section 7*c* are blocked by plugs above and below the openings 7*a* and 7*b*.

Figure 5

The geometry of the profile of the scrapers 7 and 8 is illustrated in Fig. 5. Each of the scrapers has two arcuate surfaces. The radius of curvature R of each arcuate surface is equal to the distance D between the axes of rotation of the scrapers 7 and 8. On each scraper, the centers of the curvature of the two arcuate surfaces are located diametrically opposite each other, and on the periphery of the circle defined by the path of rotation of the edges of the scrapers.

The diameter or major axis a of each scraper profile is equal to $R\sqrt{2}$. The thickness b or minor axis of each scraper is equal to $(\sqrt{2}-1)a$ or $0.4142a$. The distance D equals half the sum of the major and minor axes, viz., $\frac{1}{2}(a+b)$. As indicated, R is equal to D and by geometry, also equal to

$$\frac{a\sqrt{2}}{2}$$

The inside radius of each circular segment of the casing or shell is by theory

$$\frac{a}{2}$$

If these relationships are followed, the edges of the scrapers will effectively scrape the interior surfaces of the shell 1 and will also scrape the exterior surfaces of each other.

Figure 6

This figure illustrates a scraper 42 having a slightly different profile from the scrapers 7 and 8. This scraper 42 has a notch or curved recesses 42*a* in the leading face of each of its scraping edges. This arrangement in effect sharpens the leading edges of the scrapers, reducing any tendency to crush the condensed material instead of scraping it, and thereby reducing the power requirements of the condenser. There may be some slight tendency for condensate to accumulate in the notches 42*a*, but in general it is swept out effectively by solid condensate particles which break off in front of the advancing scraper edge. Note that a scraper having the profile shown in Fig. 6 may be used only in one direction of rotation, as indicated by the arrow. The more general scraper profile shown in Fig. 5 may be rotated in either direction, as long as both of the scrapers rotate in the same direction.

It will be noted that with the basic design of Fig. 5, the angle of contact between the tip of one scraper and the condensate layer on the other scraper ranges between 0° and 90° twice for every complete revolution of the scraper. The angle of contact between the scraper tip and the cooled condensing surface of the shell is a constant 45°. At no point, however, in either path of the scraper tip is there any tendency to compress the condensate, and effective removal of condensate is achieved at all localities, by a combination of shearing and wedging effects. Although the scraper shape of Figs. 1 to 5 has been found satisfactory, the structure of Fig. 6 has (as explained above) certain advantages, including some reduction in power requirements to turn the scrapers through some regions where the contact angle between them would be close to zero degrees with the design of Fig. 5.

Tests have been made with apparatus of the type described in Figs. 1 to 5 with the scrapers rotating alternately in opposite directions, i.e., both first in one direction and then in the other, reversing the scrapers every two minutes. Tests have also been made successfully with the scrapers operating continuously in one direction.

In one test the direction of rotation of the two scrapers was reversed every two minutes with an "off-period" of five seconds. The condenser and scrapers effectively condensed and converted to powder form aluminum chloride vapor (i.e. aluminum trichloride, $AlCl_3$) at the rate of 100 pounds per hour for 6.5 hours, 200 pounds per hour for 5.8 hours and 300 pounds per hour for 4.3 hours, all at an absolute pressure of 100 mm. of mercury.

In a second test, the scrapers were operated continuously in one direction condensing 200 pounds of aluminum chloride per hour for 4.3 hours and 300 pounds per hour for 4.3 hours. The power input required to drive the two scrapers while condensing 300 pounds per hour of aluminum chloride at 100 mm. absolute pressure ranged from 1.2 to 1.4 kilowatts. After these tests only a light scale of aluminum chloride was observed to cover the scrapers and the inside of the condenser shell. The product appeared to be entirely powder form. The scrapers were free to move and were easily set in motion by hand or by the motor drive. Operation of the scrapers was smoother when reversing direction of rotation every two minutes as compared to continuous rotation in one direction only.

It will be understood that the dimensions of the condenser and of the scraper elements may vary considerably with requirements of use. It is particularly desirable, however, that the condenser be of relatively elongated shape, for example such that the vertical length of each scraper is equal to at least several times (for instance, six to twelve times) its major transverse axis. By way of example, the condenser utilized in the above tests, which was essentially as shown in the drawings, had a shell in which the inside diameter of each segment was ten inches and the total length of each scraper was approximately 7 feet 8 inches, being constructed of three endwise-abutted sections of equal length.

Although the theoretic proportioning of the scrapers and the enclosing shell is as shown in Fig. 5 and mathematically defined hereinabove, it is preferable to provide a small clearance between the scrapers and between each scraper and the shell. For example, in the specific device described above, the centers of the shafts upon which the scrapers were mounted were separated by a distance of approximately $\frac{1}{16}$ inch greater than half the sum of the major and minor transverse axes a and b of the scrapers, while the internal diameter of each of the cylindrical segments of the shell was about $\frac{1}{8}$ inch greater than the major transverse axis a of the scraper.

It may also be noted that where appropriate clearances are afforded, as of the order stated, it is permissible and even advantageous because of the clearance, to adopt a slight departure of the scraper contour from the precise mathematical relationships above. Thus in the described embodiment of the equipment, the major transverse axis a of each scraper was 9.842 inches and the minor transverse axis b had a length of 4.532 inches. While the spacing of the shafts, which was 7.25 inches, represented a distance equal to half the sum of the transverse scraper axes increased by $\frac{1}{16}$ inch clearance, it will be noted that the length of the minor axis, relative to the major axis, is slightly larger than the theoretical formula requires. By the same token, it was found convenient to design the scraper sides with a radius of curvature of 6.477 inches, which is a little shorter than would be derived by theory from the value of the major axis a. These values nevertheless represent substantial compliance with the defined proportions, varying only in a minor way and for structural or operating convenience in minor respects. As the tests showed, moreover, the clearances actually embodied in the device were in no way detrimental to its effective, intended mode of operation.

While the condenser shown has two generally circular segments and, correspondingly, two scrapers, similar condensers could be constructed having a greater number of segments and condensers. These might be arranged in a row, or otherwise. For example, four segments and scrapers might be arranged with their centers at the corners of a square.

Figs. 10 and 11

These figures illustrate diagrammatically, a method of determining those dimensions of the scrapers which establish the clearances between the scrapers, and between each scraper and the condenser wall.

By selecting three clearances more or less arbitrarily, all other dimensions of the scrapers may be determined. Those three clearances are: C_1, the clearance between the tip of each scraper blade and the cylinder wall (Fig. 10); C_2 the clearance between the edge of one blade and the middle of one side of the other at the time when the major axis of the one blade is aligned with the minor axis of the other (Fig. 10); and C_3, the clearance between the edges of the blades when both blades are at an angle of 45° with respect to the line between the blade centers (Fig. 11).

In a condenser having an inside diameter of 10.000 inches, the following clearances were selected:

$C_1=0.0781$ in.
$C_2=0.625$ in.
$C_3=0.288$ in.

Considering the dimensions a, b, D and R, defined in connection with Fig. 5 above, as being the theoretical (no clearance) dimensions, the respectively corresponding actual dimensions, a', b', D' and R', may then be determined from those theoretical dimensions and the clearances selected, according to the following equations:

a'=Internal diameter of condenser $-2C_1$

$$b'=b+2(C_3-C_2)$$

$$D'=D+C_3$$

$$R'=R-\frac{a'(C_3-C_2)}{b'}$$

These equations may be derived mathematically from the geometrical relationships illustrated in Figs. 5, 10 and 11.

While I have shown and described a preferred embodiment of my invention, other modifications thereof will readily occur to those skilled in the art, and I therefore intend my invention to be limited only by the appended claims.

I claim:

1. A condenser for fluids which condense to the solid state, comprising a vertically elongated shell having a cross-section in the shape of a plurality of abutting generally circular segments, each segment being greater than a semi-circle, a corresponding plurality of vertically elongated scrapers, each concentric with one of said segments and extending lengthwise of said shell, each scraper being defined by two curved surfaces extending vertically throughout the full length of each scraper, and each scraper having a cross-section whose contour is generally lens-shaped and is defined by two arcs having radii approximately equal to the distance between the centers of said segments and having centers of curvature at diametrically opposite points approximately on the circumference of the circles of said segments, means connecting said scrapers in an angular relationship such that the major axes of the cross-sections of the scrapers intersect at an angle of 90° in space, means for rotating said scrapers in the same direction, the edges of each scraper contacting the vertical inner surfaces of the shell and the vertical surfaces of the other scrapers and being effective during such rotation to scrape the inside of its associated shell segment and the vertical surfaces of the other scrapers, to remove condensed material from the shell and the scrapers, fluid inlet means adjacent the upper end of the said shell for admitting fluid to the parts of the shell on both sides of each scraper, heating jacket means on the outside of the shell adjacent the fluid inlet means and effective to maintain the temperature of the fluid in the shell adjacent said inlet means above the boiling point of the entering fluid and thereby inhibit deposit of condensed material in the inlet means, cooling jacket means on the outside of the shell below the inlet means and the heating jacket means and effective to cause condensation on the inside surfaces of the shell, fluid outlet means adjacent the bottom of the shell and below said cooling jacket means, and a condensate trap at the bottom of the shell.

2. A condenser as defined in claim 1, in which said scrapers extend beyond the ends of said cooling jacket means.

3. A condenser as defined in claim 1, in which said scrapers extend above said inlet means, and said inlet means comprises means defining apertures in the shell, and means defining apertures extending through said scrapers at the level of said shell apertures, said heating jacket means being effective to inhibit deposit of condensed material in all said apertures.

4. A condenser as defined in claim 1, including shafts for supporting said scrapers, each said scraper comprising a plurality of aligned sections separately attached to said shaft.

5. A condenser for fluids which condense to a solid state comprising a vertically elongated shell having a cross-section in the shape of two abutting generally circular segments, each segment being greater than a semicircle, two vertically elongated scrapers, each concentric with one of said segments and extending lengthwise of said shell, each scraper being defined by two curved surfaces extending vertically throughout the full length of each scraper, and each scraper having a cross-section whose contour is generally lens-shaped and is defined by two arcs having radii approximately equal to the distance between the centers of said segments, each said scraper cross-section having a major axis approximately equal to the square root of 2 times said distance and a minor axis approximately equal to the square root of 2 minus 1 times said distance, means connecting said scrapers in an angular relationship such that the major axes of the cross-sections of the scrapers intersect at an angle of 90° in space, means for rotating said scrapers in the same direction, the edges of each scraper contacting the vertical inner surfaces of the shell and the vertical surfaces of the other scraper and being effective during such rotation to scrape the inside of its associated shell segments and the vertical surfaces of the other scraper, to remove condensed material from the shell and the scrapers, fluid inlet means adjacent the upper end of said shell for admitting fluid to the parts of the tube on both sides of both scrapers, heating jacket means on the outside of the shell adjacent the fluid inlet means and effective to maintain the temperature of the fluid in the shell adjacent said inlet means above the boiling point of the entering fluid and thereby inhibit deposit of condensed material in the inlet means, cooling jacket means and the heating jacket means on the outside of the shell below the inlet means and effective to cause condensation on the inside surfaces of the shell, fluid outlet means adjacent the bottom of the shell and below said cooling jacket means and a condensate trap at the bottom of the shell.

6. A condenser for fluids which condense to the solid state, comprising shell means having vertically elongated upright condensing surfaces cross-sectionally defined in general by the external portions of a plurality of intersecting circles having center spacing equal approximately to

the circular radius multiplied by the square root of two, upright vertically elongated scrapers having a cross-sectionally lenticular shape and defined by two curved surfaces extending vertically throughout the full length of said scrapers and disposed in the shell means to rotate on central axes substantially at the centers of the circles, means mounting the scrapers for simultaneous rotation in the same direction and in an angular relationship such that the major axes of the cross-sections of the scrapers intersect at an angle of 90°, said scrapers being shaped so that their edges contact the vertical inner surfaces of the shell and the vertical surfaces of the other scrapers and collectively scrape all said condensing surfaces and all upright surfaces of each other during rotation, inlet means for directing fluid from which solid is to be condensed vertically lengthwise in the shell means on all sides of the scrapers, heating jacket means on the outside of the shell adjacent the fluid inlet means and effective to maintain the temperature of the flud in the shell adjacent said inlet means above the boiling point of the entering fluid and thereby inhibit deposit of condensed material in the inlet means, cooling jacket means on the outside of the shell below the inlet means and the heating jacket means and effective to cause condensation on the inside surfaces of the shell, and collecting means for receiving condensed solid material removed and falling from the aforesaid condensing and scraper surfaces.

7. A condenser for fluids which condense to the solid state, comprising an upright vertically elongated shell having a cross-sectional contour generally defined by the external portions of a plurality of intersecting circles, a corresponding plurality of vertically elongated scraper elements disposed to rotate on upright axes substantially concentric with said circles, each scraper having a generally lenticular shape in cross-section, constituted by two curved surfaces extending vertically throughout the full length of said scrapers and intersecting to provide substantially diametrically opposed scraping edges, the cross-section of each scraper having a major axis from edge to edge and a minor axis perpendicular thereto, the radius of each circle of the shell contour being approximately equal to half the major axis of the corresponding scraper, and the centers of the said circles being spaced by approximately one half the sum of the major and minor scraper axes, means mounting the scrapers for simultaneous rotation in an angular relationship such that the major axes of the cross-sections of the scrapers intersect at an angle of 90°, said scrapers being shaped so that their edges contact the vertical inner surfaces of the shell and the vertical surfaces of the other scrapers and collectively scrape all upright scraper and inside shell surfaces during rotation, inlet means for directing fluid from which solid material is to be condensed vertically lengthwise in the shell on all sides of the scrapers, heating jacket means on the outside of the shell adjacent the fluid inlet means and effective to maintain the temperature of the fluid in the shell adjacent said inlet means above the boiling point of the entering fluid and thereby inhibit deposit of condensed material in the inlet means, cooling jacket means on the outside of the shell below the inlet means and the heating jacket means and effective to cause condensation on the inside surfaces of the shell, and means at the foot of the shell for receiving condensed solid material removed from the scraper and shell surfaces.

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