May 30, 1961 R. E. KRAMIG, JR 2,986,379

HEAT EXCHANGER

Filed June 4, 1957 3 Sheets-Sheet 1

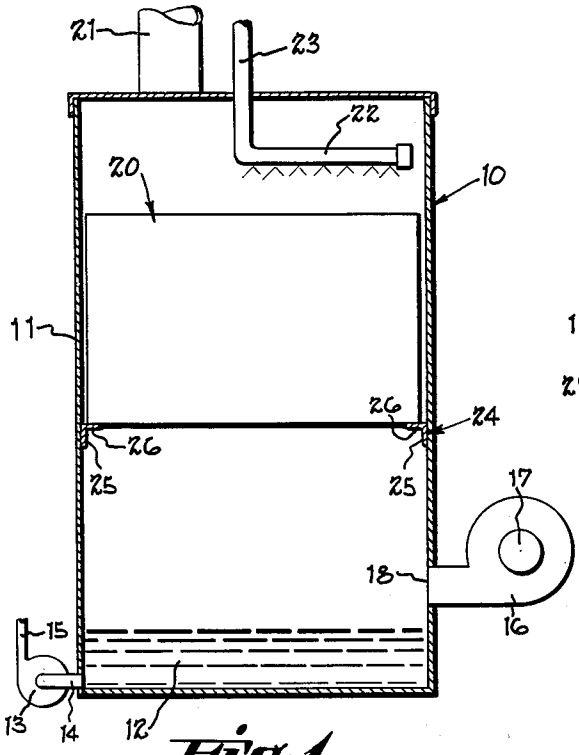


Fig. 1

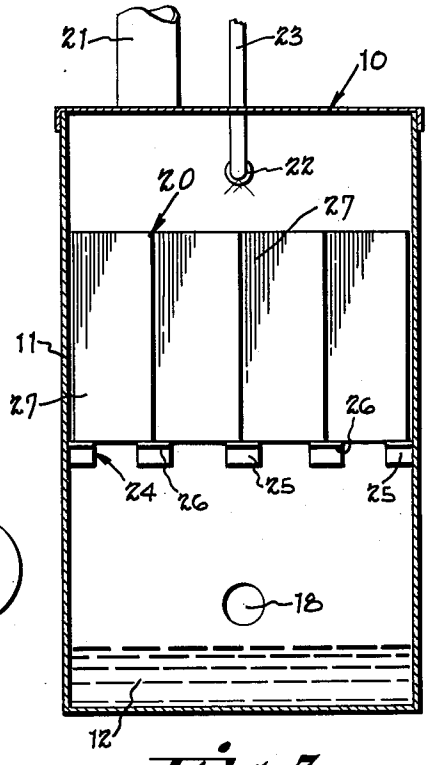


Fig. 3

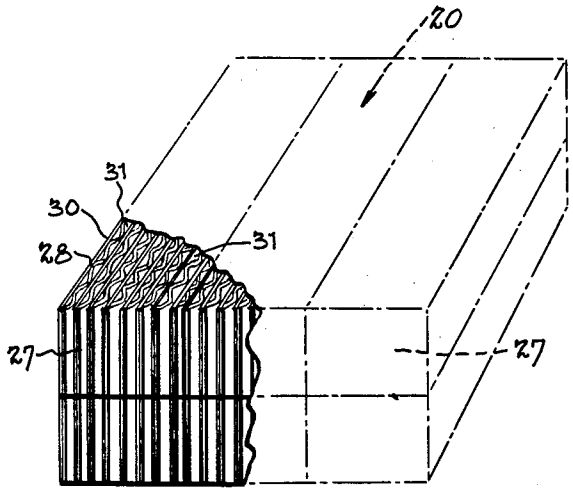


Fig. 2

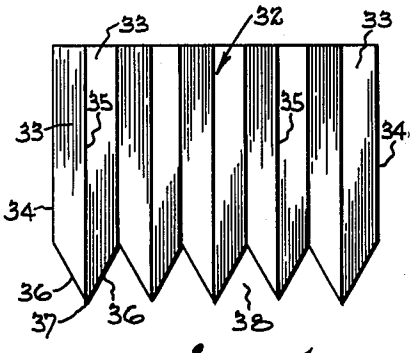


Fig. 4

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HEAT EXCHANGER

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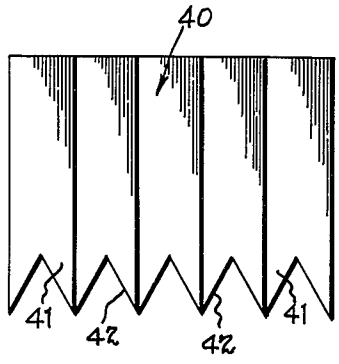


Fig. 5

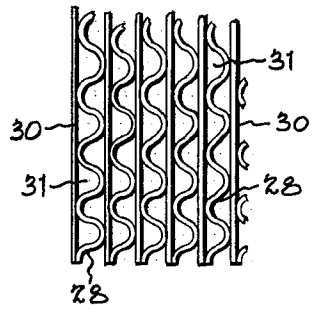


Fig. 11

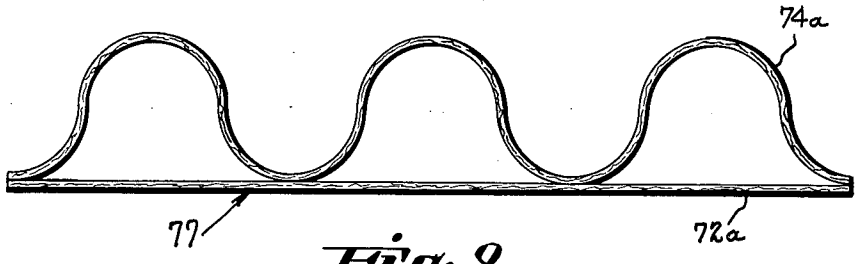


Fig. 9

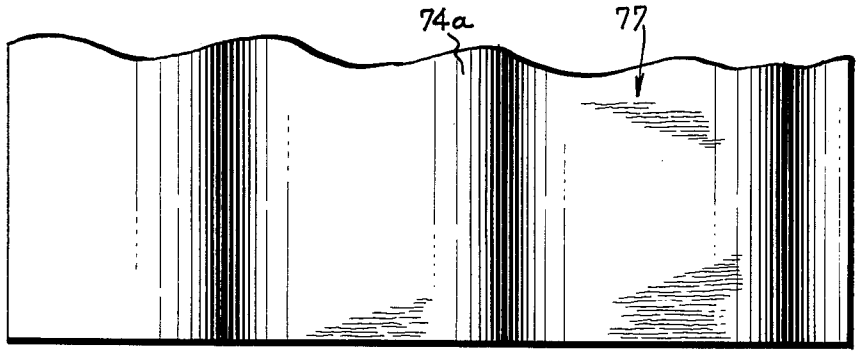


Fig. 10

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HEAT EXCHANGER

Filed June 4, 1957 3 Sheets-Sheet 3

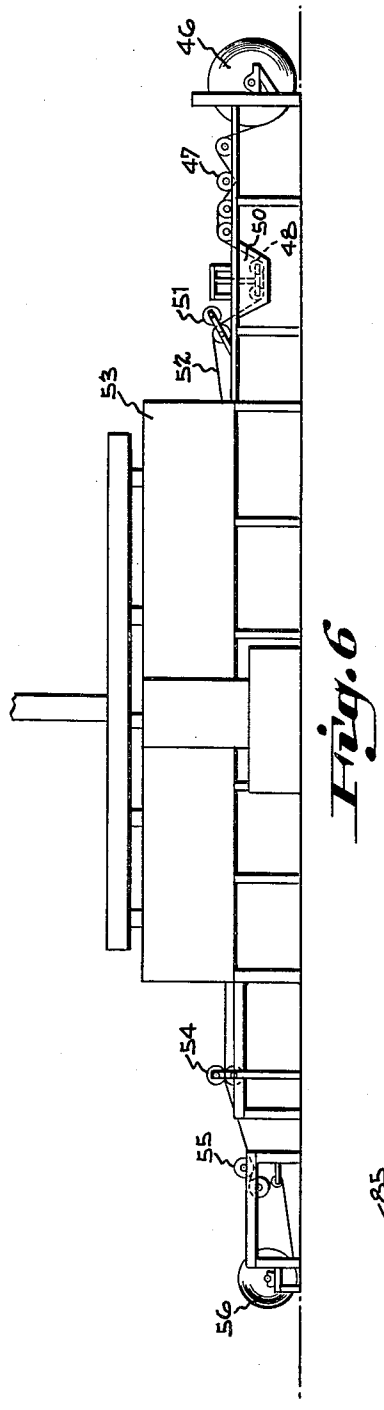


Fig. 6

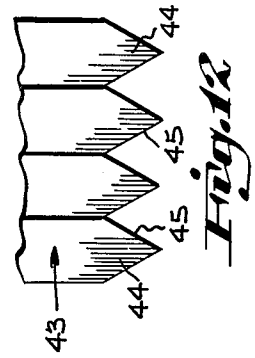


Fig. 12

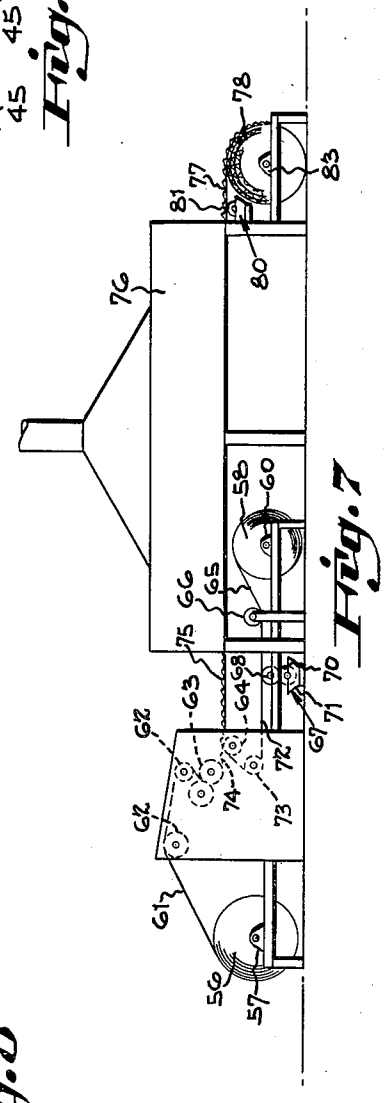


Fig. 7

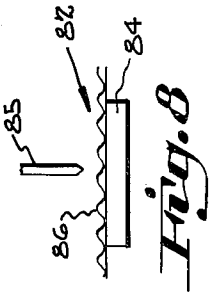


Fig. 8

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Patented May 30, 1961

2,986,379

HEAT EXCHANGER

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Filed June 4, 1957, Ser. No. 663,544

8 Claims. (Cl. 261—28)

This invention relates to heat exchangers and is particularly directed to novel core units for use in water cooling towers and to a method of fabricating such core units.

Heretofore, many different types of heat exchangers have been proposed for use in connection with water cooling towers. In such devices, it is conventional to introduce air at the bottom of the exchanger and water at the top of the exchanger so that the water drips downwardly through a core member. At the same time, air is forced upwardly through the core to create a counter current flow in which the water is cooled by evaporative action.

The principal object of the present invention is to provide a novel core for use in water cooling towers of this general type which will provide a maximum amount of cooling action in a minimum space and which even after extended periods of use, will not deteriorate or become covered with fungus growth.

More particularly, the present invention contemplates a heat exchange core comprising a plurality of sinuous, or corrugated, sheets separated by generally planar divider sheets. In the preferred embodiment, the corrugated sheets and divider sheets are formed of an asbestos paper impregnated with a phenolic resin which is thermally set. The corrugated sheets and divider sheets define a plurality of vertical tubular passageways, the sheets being oriented so that the asbestos fibers extend transversely of the passageways. In use, water is sprayed onto the core and flows downwardly through the tubular passageways. This water is contacted and cooled by streams of air flowing upwardly through the same passageways.

A heat exchange core of this type is substantially more efficient than comparable heating cores formed of wood, metal or the like. I have determined that this increased efficiency is due in part to the excellent wetability of an asbestos sheet impregnated with a thermally set phenolic resin. I have further determined that the orientation of asbestos fibers transverse to the passageways also contributes to the increased efficiency, since the transverse fibers tend to break up any stream of water causing the water to flow in a thin film over the entire surface of the sheet. Thus, the rate of water passage is retarded and a maximum surface of water is exposed to contact with the counter current air stream.

A heat exchanger of the present invention is also highly advantageous since it can be kept in use for an indefinite length of time without cleaning or repair. The resin impregnated asbestos sheets are not affected by contact with water and do not rot, corrode or deteriorate in any other manner.

Moreover, I have discovered that an asbestos sheet having a thermally set phenolic resin is self-disinfecting; that is, the material inhibits fungus or other microorganic growth so that no slime coating forms on the heat exchanger in use. This self-cleaning action of the core is extremely important since it prevents the water and

air passageways from becoming clogged so that the efficiency of the heat exchanger does not decrease with age.

A still further advantage of the present heat exchange unit is that it is economical to manufacture and install. In the present process of producing heat exchangers, commercial asbestos papers having fibers running parallel to the length of the paper, is first impregnated with a phenolic resin, such as Bakelite. The impregnated sheet is then heated sufficiently to partially set the resin after which the sheet is corrugated. Subsequently, this corrugated sheet is brought into contact with a similarly impregnated flat sheet, a layer of adhesive, such as polyvinyl acetate or a phenolic glue being applied between the two sheets. The two sheets are pressed together with the adhesive between them and are heated in any suitable manner, such as by means of an infra-red heat oven to a sufficiently high temperature to fully set the phenolic resin. The composite corrugated and flat sheets are then cut to proper size for assembly into a contact core. The contact core is fabricated by placing a plurality of composite sheets next to one another, the sheets being arranged so that the corrugated and flat sheets are alternated. Adjacent sheets are secured together by means of a suitable adhesive to produce a core sub-unit. Finally, these core sub-units are stacked together to form a heat exchanger core of any desired dimension. Alternatively, large sections of the composite sheets are stacked and glued together after the sheets have been finally set. The large sheet sections which are secured together in this manner form a large unit which can be sawed or otherwise cut to produce cores of the desired size.

Cores fabricated in this manner are very light in weight and may be preassembled at the factory and readily transported to the installation site, where they can be erected by a relatively small labor force. The cores are inherently rigid and self-supporting so that it is only necessary to support the edges of the core within the tower, eliminating the need for expensive supporting structure including perforated platforms or the like. Consequently, the present cores are not only economical to produce, but they are economical to install as well.

These and other objects and advantages of the present invention will be more readily apparent from a consideration of the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawings:

Figure 1 is a vertical cross sectional view in diagrammatic form of a water cooling tower constructed in accordance with the present invention;

Figure 2 is a partial perspective view of a typical water-air contact core to be used in a tower, such as the tower shown in Figure 1;

Figure 3 is a vertical cross sectional view of a tower similar to the one shown in Figure 1, the section being taken at right angles to the section of Figure 1;

Figure 4 is an end view of a modified form of contact core which may be used in a tower such as that shown in Figure 3;

Figure 5 is an end view of a second modified form of contact core;

Figure 6 is a diagrammatic view of equipment for the practice of the initial steps of the method of preparing phenolic resin impregnated asbestos paper according to this invention;

Figure 7 is a diagrammatic view of equipment for the practice of further steps in the manufacture of the contact core, utilizing paper made by the initial steps disclosed in Figure 6;

Figure 8 shows diagrammatically a cutting mechanism

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which may be placed at the right end of the apparatus shown in Figure 7 in lieu of the rolling mechanism;

Figure 9 is an enlarged side elevational view of the phenolic resin impregnated composite sheet as it emerges from the oven in Figure 7;

Figure 10 is a top plan view of the sheet shown in Figure 9;

Figure 11 is an enlarged top plan view of a typical portion of any of the cores shown in Figures 1–5; and

Figure 12 is an end view of a third modified form of core.

One preferred form of evaporating water cooling tower embodying the present invention is shown in Figure 1. As there shown, cooling tower **10** comprises a housing **11** of rectangular or other suitable cross section. A water sump **12** is located at the bottom of the casing to receive and temporarily store the cooled water. Water is withdrawn from the sump and is delivered to the place of use by means of a pump **13** having an intake line **14** connected to the sump and discharge line **15** leading to the apparatus (not shown) requiring cooling water. Such apparatus may be a water cooled condenser for a refrigerating system, air conditioning system or the like.

Air is forced upwardly through housing **11** by any suitable means, such as blower **16** having an air intake **17** and an air discharge conduit **18** leading to the lower end of the housing. The air rises upwardly through the housing and passes upwardly through a core **20**, the construction of which is explained in detail below. After the air has passed through core **20**, it is eventually discharged from housing **11** through an exhaust stack **21**.

Water is distributed or sprayed over the top of core **20** in any suitable way, such as by means of a rotatable spray head **22** which is turned at a predetermined rate to provide proper distribution of water over the top of the core. Water is supplied to the spray head through an inlet pipe **23** which is connected to a source of water, such as the outlet connection of the condenser mentioned above. Contact core **20** extends over substantially the entire cross section area of the housing and is supported at two or more of its edges by means of mounting brackets **24**. In the embodiment shown, these mounting brackets are in the form of angle irons having a depending leg **25** secured to the inner wall of the housing and an inwardly extending leg **26** forming a support for the core. These angle irons may either extend continuously along the side of the tower or may be in the form of a plurality of separate spaced angle irons, as shown in Figure 3.

One preferred form of contact core **20** is best shown in Figures 2 and 11. As there shown, contact core **20** comprises a plurality of assembled sub-core units **27**. These sub-units **27** may be firmly adhered together as by gluing or by some suitable mechanical securance means; or alternatively, they may be assembled loosely together and held in place by the walls of housing **11**. If desired, core **20** can be constructed as a single unitary structure.

As shown in Figure 2, each of the sub-units **27** comprises a plurality of sinuous or corrugated sheets **28** separated by generally planar divider sheets **30**. The divider sheets and corrugated sheets are joined together by means of any suitable adhesive, such as a polyvinyl acetate adhesive or a phenolic resin glue. Corrugated sheets **28** and dividers **30** define a plurality of vertical passageways **31**. The upper ends of the passageways are open to receive water from the spray head **22** and the lower ends of the tubular passageways are open to discharge water into sump **12** and to receive air from blower **16**. Both corrugated sheets **28** and divider sheets **30** are formed from asbestos paper impregnated with a phenolic resin, such as Bakelite, which as explained below, is thermally set to form a hard durable sheet. The fibers in corrugated sheets **28** and divider sheets **30** preferably extend at right angles to passageways **31**, i.e. in a horizontal direction. The exact size of the corrugations is not critical; however, I have determined that good results are obtained when

sheets **28** are bent to form from two to eight corrugations per inch.

In operation, the water to be cooled flows downwardly through the passageways or interstices **31** formed between the corrugations and the adjacent divider sheets. The water thoroughly wets the sheets and is spread over the entire surface of the sheet by the transverse ridges formed by the horizontally oriented fibers. These fibers function very effectively to diffuse the water, to slightly impede its flow and to prevent the formation of any streams or rivulets. At the same time that water drips downwardly over the core surface, air flows upwardly through the passageways so that a heat transfer is effected between the air and water, and the water is further cooled by evaporative action.

A modified form of core is shown in Figure 4. As there shown, modified core **32** comprises a plurality of sub-core units **33** constructed in substantially the same manner as the sub-core units of core **20** shown in Figure 2. Each of the sub-cores includes alternate corrugated and planar sheets defining a plurality of vertical passageways as described above.

However, in modified core **32**, each of the sub-core units **33** has its lower surface cut in some suitable manner as by sawing along a downwardly extending inclined plane so that each of the sub-units includes a short vertical edge **34** and a long edge **35**. The sub-units are alternately joined together along their short and long edges to form depending ridges **36** from which water drops from the core unit. The function of the downwardly directed, or inverted, ridges **36** is to increase the efficiency of the blower by facilitating discharge of water from the core without interfering with air flow upwardly through the core passageways.

More particularly, when water passes through a core **32** having downwardly extending ridges which are preferably inclined approximately 60° from a horizontal plane, the water trickles from the lower edges of the tubular passageways and flows along the lower edges **37** of the sheets comprising the sub-core units until the water reaches the lowermost point of the ridge from which it drops in the form of enlarged drops into sump **12**. Thus, the water is not picked up by the air from blower **16** as that air flows along horizontal passageways **38** between the ridges and passes upwardly into the vertical passageways. It will be appreciated that the water is directed around the openings of the vertical passageways to the bottom edges **37** of the ridges so that the water does not form a film over the bottom of the vertical air passageways which might block or interfere with the upward air flow.

Figure 5 shows a second form of modified core **40** comprising component core units **41**. These component core units include alternate corrugated and planar sheets forming vertical air passageways, as described above. However, in modified core **40**, the lower surface of core sub-units **41** converges upwardly toward the center of the sub-units so that two downwardly directed semi-ridges **42** are formed. When the sides of adjacent sub-units **41** are brought together, complete ridges are formed which are generally similar to the ridges shown in Figure 4. The manner in which water is discharged from core **40** to eliminate interference with the upward flow of air is the same as that described above in connection with the description of modified core **32**.

A third modified form of core **43** is shown in Figure 12. As there shown, modified core **43** includes a plurality of sub-core units **44** which are glued or otherwise secured together. In this embodiment, the lower surface of each of the sub-core units **44** is sawed or otherwise cut to form a centrally disposed downwardly directed ridge **45**, the sides of which are preferably inclined at 60° from a horizontal plane. These ridges function to facilitate the discharge of water in the same manner as described above.

While the precise size of the overall core unit is not

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critical, it has been found that in some installations the core need be only fifty percent as large as previous cores of the same capacity. For example, for one three-ton air conditioning unit, a core of adequate capacity is 11½ inches by 27¾ inches by 27¾ inches, or about 5.12 cubic feet in size. Water is circulated through this unit at approximately ten gallons per minute. For a five ton refrigerating unit, the core size is 16 inches by 27¾ inches by 27¾ inches. It is to be understood, of course, that these dimensions are merely given by way of example and that cores or other sizes may be employed.

The manner in which heat exchanger cores are constructed by the present method is best illustrated in Figures 6 and 7. As there shown, the starting material is in the form of a roll **46** of commercial asbestos paper. One preferred material is six pound asbestos paper, .015 inch thick having an asbestos stock fiber and a sulphite and starch binder constituting approximately 7% by weight of the paper, the remaining 93% being pure asbestos fibers which run lengthwise of the paper.

The paper is fed from roll **46** through guiding rollers **47** and undere rollers **48** mounted within bath **50**. This bath contains an initially soluble phenolic resin, preferably a phenol formaldehyde condensation product, commercially known as Bakelite, dissolved in isopropyl alcohol in the proportion of two parts of phenolic resin to one part of 91% isopropyl alcohol.

The absorption of the phenolic resin solution in the asbestos paper is controlled by the squeezing action of a pair of squeeze rolls **51**. These rolls squeeze out a portion of the solution absorbed by the paper and return it to bath **50** so as to leave a predetermined amount of phenolic resin absorbed in the paper. When the paper reaches its final stage, later to be described, the phenolic resin in the paper is between 25% and 40% by weight of the final product. A ratio now preferred is 34%. Such phenolic resin is an irreversible thermo setting compound, which after the final stage is water insoluble, and coacts with the asbestos paper to prevent the formation of fungus slime when such product is used in a water-air contact core.

The impregnated sheet **52** leaving rolls **51** enters an oven **53** where the phenolic resin within the paper is heated and cured to a "B" stage, the paper remaining in a relatively flexible condition. For example, in one installation, the paper remains approximately three minutes in the oven and is heated to a temperature of 285° F. After the paper leaves oven **53**, it passes through pinch rolls **54** and thereafter passes guiding rolls **55**. Finally, the impregnated sheet is rolled into a roll **56** in which form it can be stored for future use in the method as disclosed in Figure 7.

Rolls **56** are used as a starting material for the process steps disclosed in Figure 7. One such roll **56** is rotatably mounted in any suitable manner at **57**. Another roll **58** which is preferably but not necessarily of the same weight and texture and impregnated and cured in the same manner as roll **56** is rotatably mounted at **60**. The "B" stage sheet **61** drawn from roll **56** passes over various guiding rolls **62**, and then passes through the hot corrugating rolls **63**, where the paper is corrugated and the resin is partially set. The rolls preferably are maintained at 350° F. to 400° F. The paper, which is corrugated to form 2 to 8 corrugations per running inch leaves the rolls **63** and passes over a support roll **64**.

Meanwhile, the impregnated sheet **65**, leaving the roll **58**, passes under guiding roll **66** and travels over an adhesive applicator **67** which includes an applying roll **68**, a dipping roll **70** and an adhesive container **71**. The cement or ahesive in container **71** may be a polyvinyl acetate adhesive, or a phenolic resin glue of any suitable type. The paper with the adhesive applied thereto, and now indicated by the numeral **72**, passes around roll **73** and over support roll **64**. Sheet **72** passes between roll **64** and the corrugated sheet **74** and is pressed against the corrugated sheet **74**, with the adhesive being disposed between the sheets. The sheets are firmly adhered or glued to each other, to form a composite sheet **75** which enters oven **76** where the phenolic resin in the papers is brought to the final fully set or "C" stage. For this purpose, oven **76** may be an infra-red oven which heats the composite sheet to a temperature of approximately 400° F. The composite sheet, now indicated by the numeral **77** leaves the oven **76** and is rolled into a roll **78** for future use.

Alternatively, if it is desired to use roll **78** as a cylindrical contact core, another adhesive applicator **80**, similar to applicator **67**, is placed at the end of the oven. Its applying roll **81**, applies an adhesive to the underside of the composite sheet **77**, so the various layers of the composite sheet within the roll **78** are glued to each other, and such roll can be used as a cylindrical contact core, or may be sawed to different lengths for use as shorter contact cores.

It is to be understood that roll **81** is omitted when it is desired to subsequently unwind roll **50** to produce cores of a rectangular cross section. Roll **81** is also omitted when it is desired to make a cylindrical core which is held in assembled relationship by a mechanical means, such as tie bands. More specifically, such a core is formed by winding composite sheet **77** convolutely upon itself to form a cylinder of the desired diameter. The material is then held in this cylindrical shape by applying tie bands or bails formed of aluminum or the like around the circumference of the cylinder.

As a further alternative, cutting mechanism **82** shown in Figure 8 may be substituted for applicator roll **81** and winding means **83** at the right end of oven **76**. In such an installation, sheet **77** leaving oven **76** is fed directly to the cutting mechanism **82** of Figure 8 which may include a longitudinally movable anvil **84**, and a longitudinally and downwardly movable knife **85**, which moves down against composite sheet **77** to cut it into the desired lengths as determined by the frequency of operation of the knife **85**. The longitudinal movement of the anvil **84** and knife **85** is in the same direction and at substantially the same speed of travel as composite sheet **77**, so that there is no relative movement between these elements. Such cutting mechanism, per se, are well known in the art and need not be further described.

The composite sheet **77** leaving the oven **76** is shown in enlarged scale, in Figures 9 and 10. The corrugated sheet **74** and the uncorrugated sheet **72** which entered oven **76** are now indicated by the numerals **74*a*** and **72*a*** respectively in Figures 9 and 10. The right angled relationship of the ridges formed by the asbestos fibers at the surface, with respect to the corrugation **86** of the paper **75*a***, is apparent in these enlarged figures. The ridges increase the relative surface area of the paper and hence the film of water wetting the paper, and also insure a thorough distribution of the water as it descends through the core. The composite sheet **77** is relatively stiff and self-supporting and can be glued to form sub-core units **27** and cores **30** or the modified sub-cores and cores as described above.

Having described my invention I claim:

1. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising a plurality of composite sheets adhered together side by side, each of said composite sheets comprising two asbestos sheets, one of said asbestos sheets being corrugated, the other being substantially planar, each of said sheets being impregnated with a phenolic resin heated and cured in the sheet to an advanced stage of thermo setting.

2. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said contact

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core comprising a plurality of asbestos sheets disposed side by side and impregnated with thermally set phenolic resin, alternate sheets of said core being corrugated to form a plurality of parallel passageways through said core, and the asbestos fibers in the said asbestos sheets being oriented at substantially right angles to the passageways to form ridges within the passageways.

3. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising sheets of asbestos paper impregnated with a phenolic resin, said sheets being alternately corrugated and planar and being secured in assembled relationship to form a plurality of vertical passageways through the core of the size for the flow of gas and liquid therethrough.

4. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising sheets of asbestos paper impregnated with a phenolic resin, the surface of said sheets substantially retaining the surface roughness of the asbestos paper prior to impregnation, said sheets being alternately corrugated and planar and being secured in assembled relationship to form a plurality of vertical passageways through the core of the size for the flow of gas and liquid therethrough.

5. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising sheets of asbestos paper impregnated with a resin, said sheets substantially displaying the surface roughness of the unimpregnated asbestos paper, whereby the surfaces of said sheets are wettable and are effective to retard liquid flow, said sheets being alternately corrugated and planar and being secured in assembled relationship to form a plurality of vertical passageways through the core of the size for the flow of gas and liquid therethrough.

6. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising sheets of asbestos paper impregnated with a thermally set phenolic resin, the surface of said sheets substantially retaining the surface roughness of said unimpregnated asbestos paper, said sheets being configurated and secured in assembled relationship to form a plurality of vertical passageways through the core of the size for the flow of gas and liquid therethrough.

7. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising sheets of asbestos paper approximately .015 inch thick impregnated with a thermally set phenolic resin, said sheets being alternately corrugated and planar and being secured in assembled relationship to form a plurality of vertical passageways through the core of the size for the flow of gas and liquid therethrough.

8. In a gas and liquid contact apparatus, the combination with the elements of such an apparatus of a contact core and means for passing a gas and liquid through said core in intimate contact with one another, said core comprising, a mass consisting essentially of paper arranged in plies, at least some of the plies being corrugated, and the corrugations of such plies being arranged in parallel alignment, and the corrugations of the corrugated plies cooperating with an adjacent ply to form passageways extending continuously from an upper surface of the mass to a lower surface of the mass through which passageways liquid and gas may flow in contact with one another, the said plies being constituted of thin asbestos-fiber paper, the said paper being impregnated with a resin bonding together the asbestos fibers of which the paper is made, thereby rendering the paper physically inert to liquid to which said mass is exposed during use, but with the surfaces of the corrugations of said paper conforming substantially to the surface texture of conventional unimpregnated asbestos paper, whereby the fibers relatively exposed at the surfaces of said asbestos paper present obstructions to films of liquid flowing over such surfaces and thereby promote the wettability of the surfaces of said corrugations by said liquid to increase the exposure of the liquid flowing through said passageways to gas also flowing through said passageways.

References Cited in the file of this patent

UNITED STATES PATENTS

639,523	Chapin	Dec. 19, 1899
869,747	Starr	Oct. 29, 1907
941,605	Baekeland	Nov. 30, 1909
1,695,912	Brown	Dec. 18, 1928
2,035,970	MacIldowie	Mar. 31, 1936
2,104,060	Spafford	Jan. 4, 1938
2,231,088	Richardson	Feb. 11, 1941
2,434,466	Marc	Jan. 13, 1948
2,609,314	Engel et al.	Sept. 2, 1952
2,661,197	Norman	Dec. 1, 1953
2,793,017	Lake	May 21, 1957
2,809,818	Munters	Oct. 15, 1957

FOREIGN PATENTS

550,561	Great Britain	Jan. 14, 1943
571,510	Great Britain	Aug. 28, 1945

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