Jan. 12, 1932. A. H. DAVIS, JR 1,840,834

APPARATUS AND METHOD FOR REMOVING SCALE FROM LIQUID EVAPORATION SURFACES

Filed Jan. 29, 1929 3 Sheets-Sheet 1

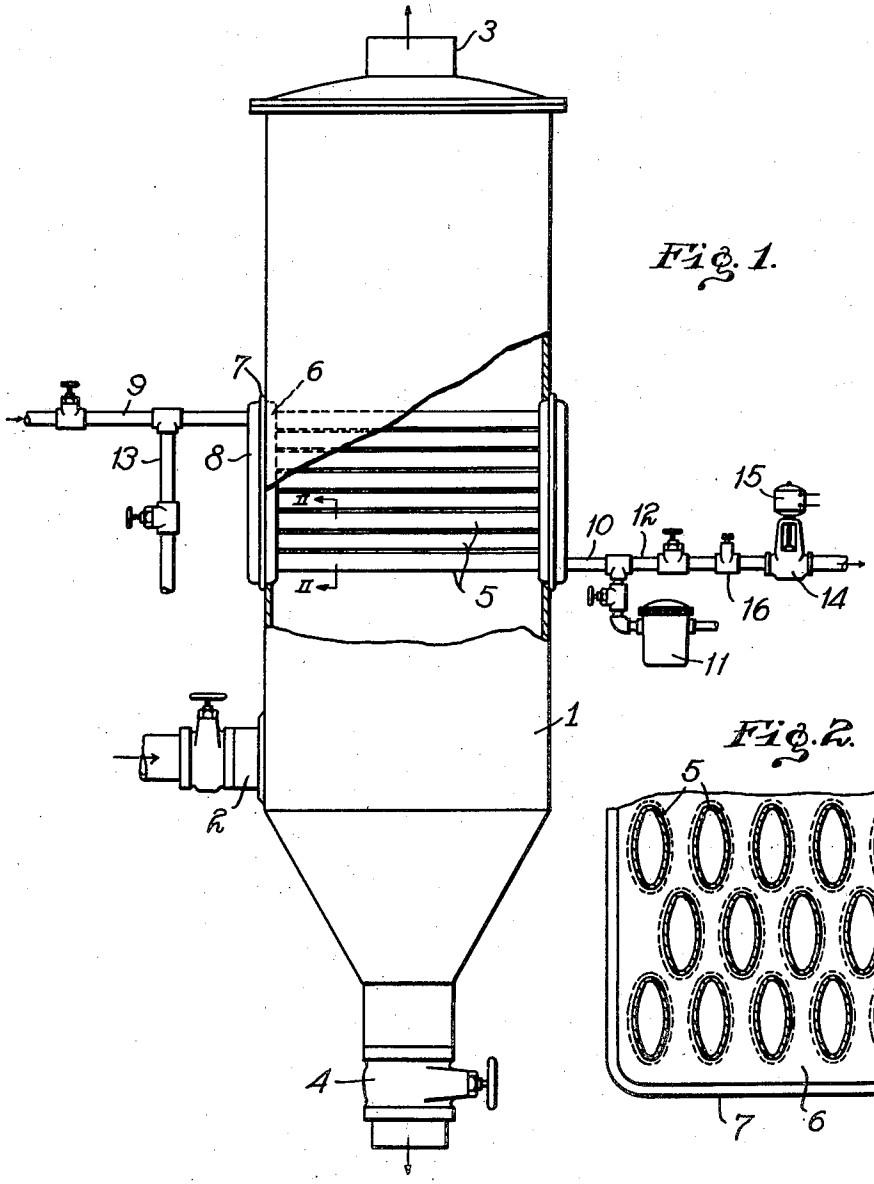


Fig. 1.

Fig. 2.

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Filed Jan. 29, 1929 3 Sheets-Sheet 2

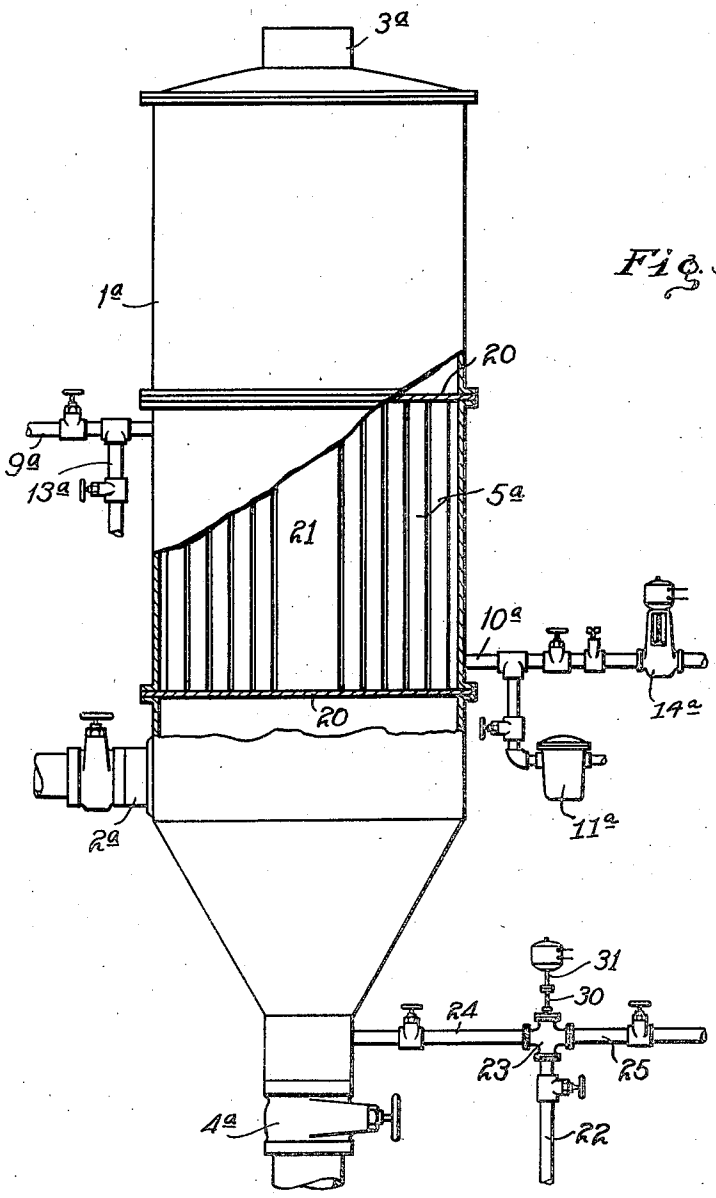


Fig. 3.

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Filed Jan. 29, 1929 3 Sheets-Sheet 3

Fig. 4.

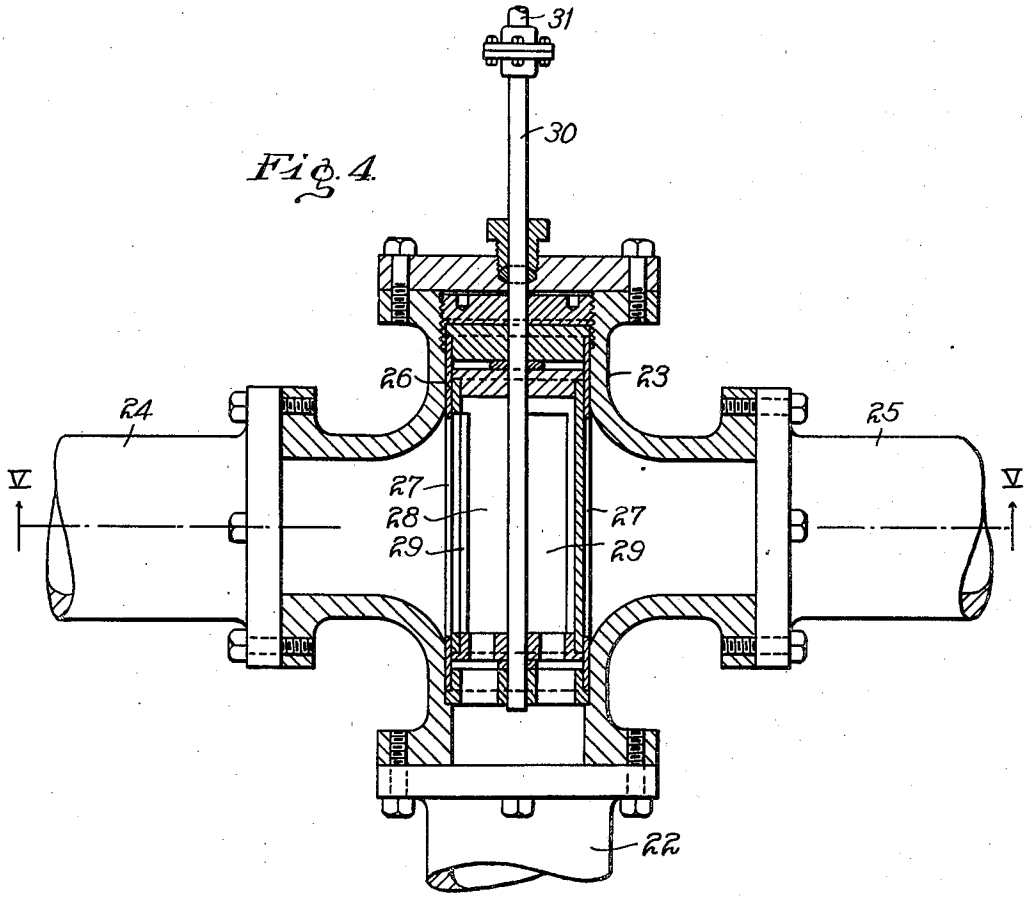
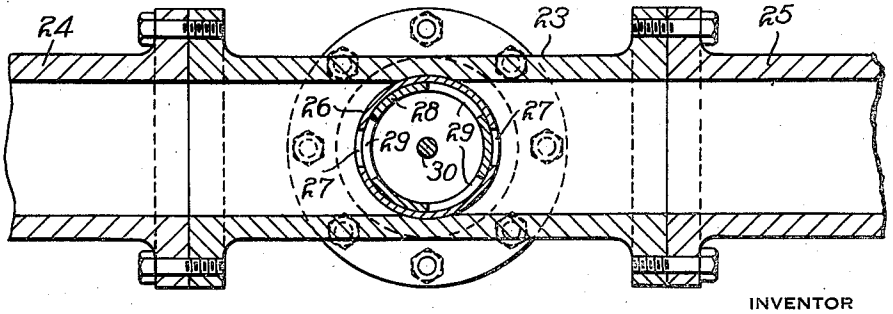


Fig. 5.



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UNITED STATES PATENT OFFICE

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APPARATUS AND METHOD FOR REMOVING SCALE FROM LIQUID EVAPORATION SURFACES

Application filed January 29, 1929. Serial No. 335,785.

This invention relates to the removal of scale from heat-exchanging surfaces, and especially to its removal from the tubes of liquid evaporation apparatus.

The removal of scale from the tubes of evaporators, hot water heaters, fire and water tube boilers, heating and cooling coils used in chemical processes, and similar apparatus is necessary for efficient operation because the scale reduces the rate of heat transfer and thus decreases evaporation capacity. Heretofore, scale has usually been removed by scraping the surfaces with a mechanical cleaner, or in some cases by means of a vibrating hammer applied to the tubes. All of such means have involved cleaning one tube at a time, and consequently scale removal has been a tedious and time-consuming procedure. Furthermore, it has been necessary to design such apparatus so that all of the heat-exchanging surfaces were accessible, which in some instances increases construction costs and may be otherwise undesirable.

An object of this invention is to provide a method of removing scale from heat-exchanging surfaces which is efficient, simple, rapid, involves no complications in apparatus design, causes simultaneous cleaning of the entire scaled surface, decreases cleaning costs, and makes possible more frequent cleaning of the apparatus.

Another object is to provide liquid evaporation apparatuses similar to those now in use in which the heat-exchanging surfaces are modified to provide for simultaneous cleaning of the entire surface, in which the apparatus may be cleaned without being taken out of service, and in which the modification does not in any way interfere with the operation of the apparatus.

Still another object is to provide tubular liquid evaporation apparatus of the type referred to in which no provision need be made for access to the individual tubes.

The invention is illustrated in the accompanying drawings, in which Fig. 1 is a vertical elevation of an evaporator embodying the invention, parts being broken away for clarity of illustration; Fig. 2 is a fragmentary cross section through the tube radiator, taken on line II—II, Fig. 1; Fig. 3 is an elevation of another form of evaporator showing a modification of the invention; Fig. 4 is a vertical section through one form of rotary valve adapted to be used in the practice of the invention; and Fig. 5 is a horizontal section of the valve taken on line V—V, Fig. 4.

The invention is applicable to liquid evaporation apparatus comprising tubular heat exchanging elements, and to heating and cooling elements used with chemicals, for example in crystallization apparatus. In the use of apparatus of the general types mentioned the tubes become incrusted by solids deposited by the liquid. Although it is of value in any heat exchanging device in which scale forms on one side of the heating surface, it is especially adapted for use with evaporators, and will be described in its application thereto.

Fig. 1 conventionally shows a form of evaporator comprising a cylindrical shell 1, liquor inlet 2, vapor outlet 3, and bottom draw-off 4 through which solids formed in concentration of the liquor, or the concentrated liquor itself, may be withdrawn. Heat for evaporation is supplied from a fluid passed through tubes horizontally disposed inside of the shell in contact with the liquid. In the prior forms of apparatus tubes circular in section have been used, but in accordance with this invention, these heat-exchanging tubes are of non-circular cross section, and preferably they are elliptical, or flattened ellipses.

The tubes may be mounted in any suitable or desired manner, for example in tube sheets in accordance with the customary practice. It is preferred, however, to use a radiator of the type disclosed in United States Patent No. 1,320,652 to C. Sonneborn, dated November 4, 1919. According to that patent, the ends of oval tubes 5 are welded to pan-shaped headers 6 having a peripheral flange 7 to which is connected, preferably by welding, a similar header section 8, as shown in Fig. 1. One of header sections 8 is connected to a steam line 9, and the other is connected to

a pipe 10 leading to a steam trap 11. Other heating fluids than steam may, of course, be used. In the use of this apparatus, any scale deposited by the liquid forms on the outside of tubes 5.

According to the invention, the scale is removed by simultaneously distorting the section of all of the tubes. Preferably this is accomplished by creating pressure pulsations in a fluid, such as steam, or water, inside the tubes. This operation flexes the walls of the tubes, causing them to change their sectional form, and causes the scale to flake off.

The intermittent variation in fluid pressure may be accomplished by a variety of means. For example, a water hammer may be created in the tubes. They may be flooded and supplied with water from a reciprocating pump without an air chamber, or the water hammer may be produced in other ways available to those skilled in the art.

It is preferred however, to accomplish the flexing in the manner shown in Fig. 1. Outlet pipe 10 is provided with a branch 12 for discharging water supplied to the radiator from a water line 13 connected to inlet 9. The tubes are flooded with water under pressure, and the water pressure maintained while a discharge valve is intermittently opened and closed. Preferably a valve 14 disposed in line 12 and driven by a motor 15 is used. In this manner the pressure of the water is relieved when the valve opens, and is built up as it closes, thus producing a pulsating fluid pressure within the tube which flexes the walls sufficiently to thoroughly and rapidly break off the scale.

The amount of scale deposited will depend upon the character of liquid being evaporated and the interval between cleaning steps, and its adherence will also be effected by these factors. For this reason it may be desirable to regulate the intensity of tube vibration, and this is in part dependent upon the velocity of the water supplied from line 13. By making this line of considerable length, the water flowing into the tubes reaches them at high velocity, and the effect is greater than when water at low velocity is used. The intensity of tube flexing may thus be varied by adjusting the length of pipe 13, and it may also be done by providing an adjustable orifice 16, of any suitable type in line 12 intermediate the radiator and valve 14. The orifice limits the maximum flow of water when the valve is wide open, and in this manner the force of the pulsations is readily regulable.

Another form of evaporator is shown in Fig. 3, in which a tube basket comprising elliptical tubes 5*a* connected to tube sheets or headers 20, is disposed in the shell 1*a* with the tubes vertical, a large central tube providing the usual downcomer 21 to assist in circulation of liquid. In this form, steam from line 9*a* circulates around the tubes, the liquid circulating up through the tubes, and then reversely through the downcomer. The inside of the tubes becomes scaled in this apparatus.

As in the preceding apparatus, steam is discharged to a trap 11*a* through an outlet 10*a*. The scale formed on the tubes may be removed as before by pulsations in water supplied from a line 13*a*, caused by opening and closing the motor-operated valve 14*a*. In both this and the preceding case the pressure pulsations are applied to the unscaled side of the tubes, but in this case that is the exterior of the tubes.

In some instances it may be desirable or necessary to apply the pressure against the scaled side. This may be accomplished by the apparatus shown in Fig. 3 as follows. Water from a line 22 is passed into the bottom of the evaporator through an intermittently opened valve 23 and pipe 24. In the apparatus shown, the upper ends of the tubes cannot conveniently be sealed, and the most suitable manner of pulsatingly flexing the tubes is to vary the velocity of water flowing through them, so as to utilize the inertia of the water head to hold the pressure for an instant while the tube walls are being distorted.

In this modification, the inertia of the mass of water in the apparatus momentarily opposes pressure applied to it when the pressure is applied quickly, with blow-like force, to give a sort of water hammer effect and produce the desired tube-flexing impulses. If the water is passed intermittently to the apparatus through an ordinary valve, an appreciable interval is necessary each time the valve opens, before the water flow comes up to maximum velocity. This lag is such that the pressure is applied relatively slowly to the water in the apparatus and does not cause tube-flexing pulsations. To overcome this lag effect of ordinary valves, and to rapidly supply water at high velocity to the apparatus, it is preferred to use a three-way rotary valve in which the flow of water is constant, the direction of flow through the side arms being reversed in such manner that the water always is at maximum velocity. In this manner, water at full velocity is intermittently applied to the apparatus in such manner as to produce the pulsations which distort the tube section.

A suitable valve of this type is that shown at 23, Fig. 3, and on an enlarged scale in Figs. 4 and 5. This valve comprises a flanged cross mounted in the position shown in Fig. 3. The horizontal arms are connected to the evaporator intake 24 and to a discharge line 25, and one of the vertical arms is connected to water supply line 22. A fixed sleeve 26 having ports 27 leading to the side arms is mounted within the cross, as shown in Figs. 4 and 5. Mounted for rotation within the

sleeve is a valve member 28 comprising a cylinder having ports 29 which permit water to flow alternately through ports 27 to lines 24 and 25, but so arranged as to provide substantially continuous flow. The valve is keyed to a shaft 30 disposed in the other vertical arm and connected to shaft 31 of a motor, not shown. Suitable bearings, packing glands and the like are provided, as will be understood.

The resultant effect of this means of removing scale is similar to that described hereinabove. Water is admitted to pipe 22 and valve 23 is rotated rapidly. Water from the valve alternately enters the evaporator through one port of the valve and passes to waste through the other port. When the tubes have become filled, the pressure of water entering the apparatus is applied inside them, causing pulsating distortion of the tubes. The valve is designed so that water from line 22 flows continuously. That is, at the instant when one port closes, the other opens, and at no time is the flow of water cut off. Consequently, the water flowing through both ports is always at maximum velocity and there is no lag of the type referred to above. In this manner, when the port leading to the evaporator opens, the high velocity of the water causes application of pressure so suddenly to that in the apparatus, that there is no time for it to be absorbed, and consequently, pulsation results. As in the preceding modification, it is desirable to make water line 22 of considerable length, so that the water enters the valve at its highest velocity.

The valve just described may be modified to vary the effects produced, and the same general type of valve may be used for valves 14 and 14*a*. In the latter case, a T could be used, the connection to an external source of water being unnecessary.

In the form of apparatus just described, there may be greater distorting tendency at the lower ends of the tubes, especially where the tubes are long. Although very slight vibration of the tube walls will usually be effective, it may be desirable to create uniform distortion throughout the tubes. This may be accomplished by increasing the ratio of the major to the minor axes of the tube section progressively from the bottom to the top. This gradual flattening of the tube then produces uniform pressure distribution.

The invention is, of course, applicable to other forms of liquid evaporation apparatus, such as boilers. Various other means of pulsatingly-deforming the tubes may also be employed, since pressure pulsations in a fluid may be set up in a number of ways. Also, pulsating fluids other than water may be made use of. Thus, steam may be passed into tubes flooded with water, or pulsating air pressure may be used.

The apparatus may be descaled in accordance with the invention without disassembly, as has usually been necessary in the past for which reason and because of the simplicity and ease of cleaning, the tubes may be freed from scale more frequently than has been the custom. All of the tubes are cleaned at once, effectively, and at small cost. Furthermore, there being no need for access to the individual tubes, apparatus may be designed for greater efficiency or at lower construction costs. All of these factors combine to give greater evaporating capacity and lower operating costs, and the invention goes far to eliminate the prior disadvantages and difficulties which attended the removal of scale from liquid evaporation apparatus.

I claim:

1. In a liquid evaporation apparatus, the combination of tubular members of non-circular cross section for conducting heat applied on one side of the tubes to a liquid in contact with the other, and means for repeatedly applying changing hydrostatic pressure to one side of the tubes to distort the tube section substantially simultaneously along the length thereof.

2. In a liquid evaporation apparatus, the combination of tubular members of non-circular cross section for conducting heat applied on one side of the tubes to a liquid in contact with the other, and means for applying pulsating fluid pressure to one side of the tubes to remove scale deposited by the liquid.

3. In a liquid evaporation apparatus, the combination of tubular members of elliptical cross section for supplying heat from a fluid on one side of the tubes to a liquid in contact with the other, and means for removing scale deposited on the tubes comprising means for intermittently varying the pressure of a fluid in contact with the unscaled side of the tubes.

4. In a liquid evaporation apparatus, the combination of a radiator comprising headers and a plurality of tubes of non-circular cross section connecting the headers, connections for supplying a heating fluid to one side of all of the tubes, connections for supplying a liquid to be evaporated to the other side, and pulsating means for causing the tubes to change section.

5. In an evaporator, the combination of a radiator comprising tubes of non-circular cross section, steam inlet and discharge connections to one side of the tubes, a connection for supplying liquid to be evaporated to the other side of the tubes, and scale-removing means associated with one of said connections comprising means for supplying a fluid to one side of the tubes, and means for pulsatingly varying the pressure of said fluid upon the tubes.

6. In an evaporator, the combination of a radiator comprising tubes of non-circular

cross section, steam inlet and discharge connections to one side of the tubes, a connection for supplying liquid to be evaporated to the other side of the tubes, a valve in one of said connections, and means for supplying water under pressure through said valve to the tubes, and a motor adapted to intermittently open and close the valve whereby to pulsatingly vary the pressure of the water on the tubes.

7. In an evaporator, the combination of a radiator comprising tubes of elliptical cross section, steam inlet and discharge connections to one side of the tubes, a connection to the other side of the tubes for supplying liquid to be evaporated, a motor-operated rotary valve in one of the connections, and means for supplying water under pressure to the valve, intermittent opening and closing of the valve, applying pulsating pressure to the unscaled side of the tubes whereby to remove scale deposited by the liquid.

8. In an evaporator, the combination of a radiator comprising tubes of elliptical cross section, steam inlet and discharge connections to one side of the tubes, a connection to the other side of the tubes for supplying liquid to be evaporated, a motor-operated three-way valve connected to a source of water having one port connected to one side of the tubes and another port connected to a waste line, the flow of water through said valve being continuous but alternated between said ports to cause pulsating distortion of the tube walls.

9. The method of removing scale from heat-exchanging tubes of non-circular cross section comprising placing a fluid in contact with the tubes, and creating pulsating pressure waves in the fluid to vary its pressure on the tube walls.

10. The method of removing scale from heat-exchanging tubes of non-circular section comprising filling the space on one side of the tubes with a fluid under pressure, and intermittently varying the pressure on the fluid to pulsatingly flex the tube walls.

11. The method of removing scale from heat-exchanging tubes of elliptical section comprising filling the space on the unscaled side of the tubes with water under pressure, and intermittently varying the pressure on the water to pulsatingly flex the tube walls.

12. A method of removing scale from heat-exchanging tubes of non-circular cross section comprising rapidly repeatedly creating a changing pressure difference on opposite sides of the tubes to cause them to change in cross sectional form substantially simultaneously along the length thereof.

13. A method of removing scale from substantially straight heat-exchanging tubes of non-circular cross section comprising repeatedly abruptly applying a fluid to the unscaled walls of the tubes to flex the walls rapidly by changing hydrostatic pressure and cause them to change in sectional form.

In testimony whereof, I sign my name.

ARCHIBALD H. DAVIS, JR.