S. M. LILLIE.

MULTIPLE EFFECT EVAPORATING APPARATUS.

APPLICATION FILED JAN. 31, 1907.

984,226. Patented Feb. 14, 1911.

2 SHEETS—SHEET 1.

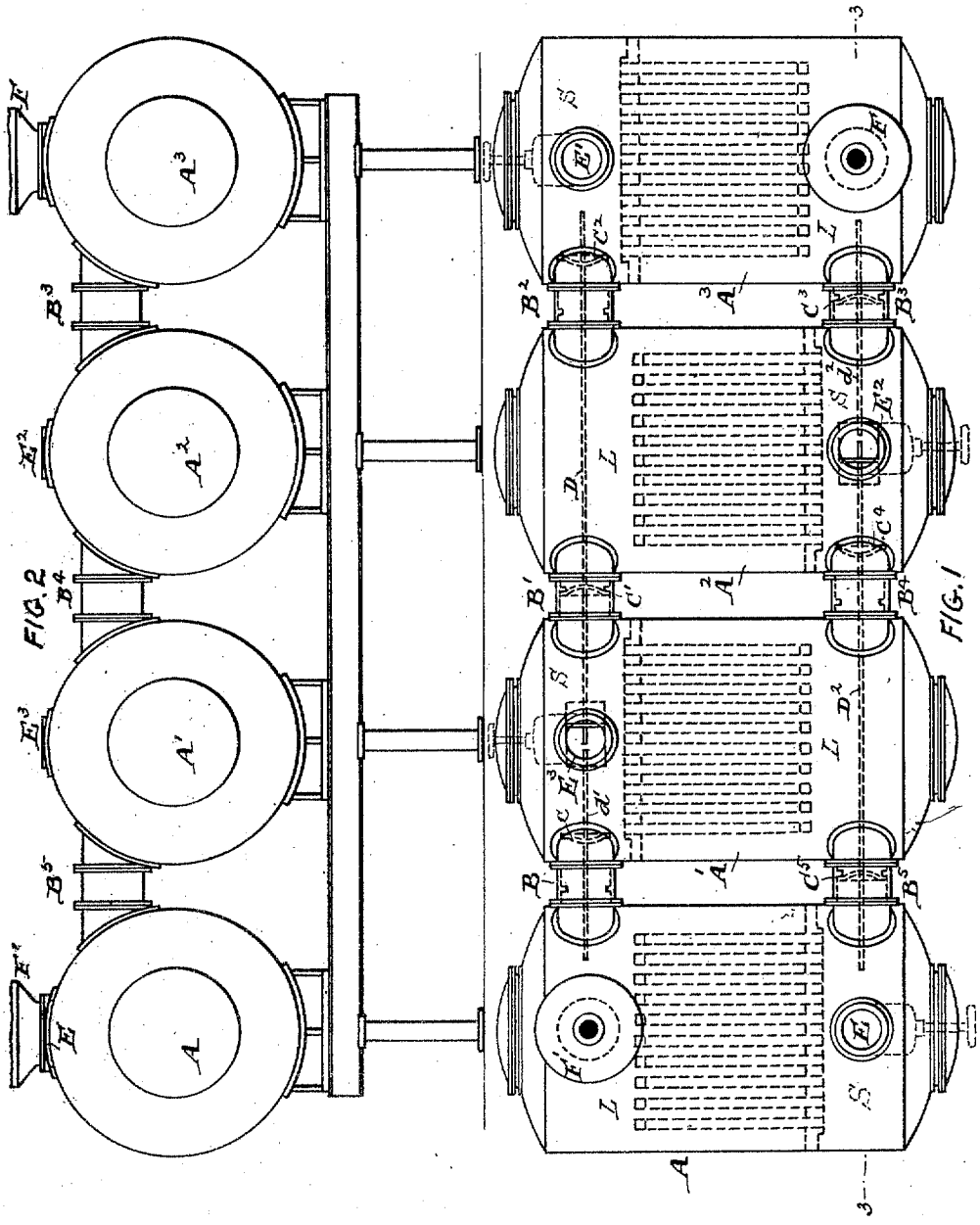

FIG. 2

FIG. 1

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FIG. 3

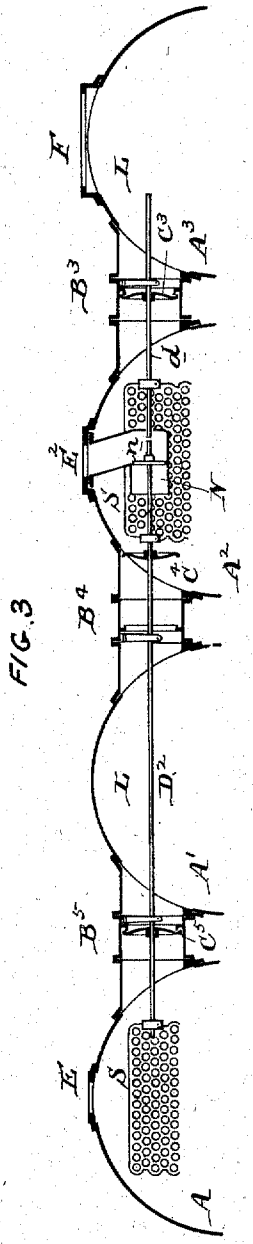


FIG. 5

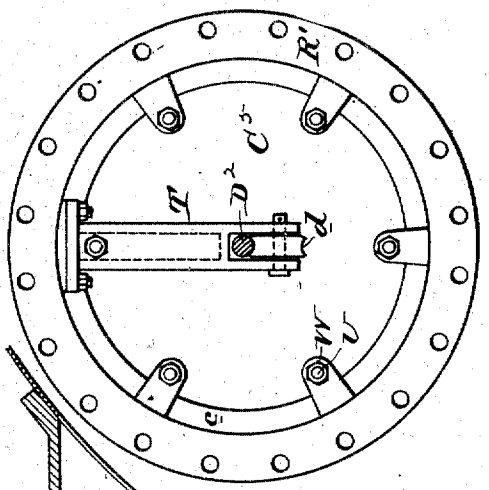
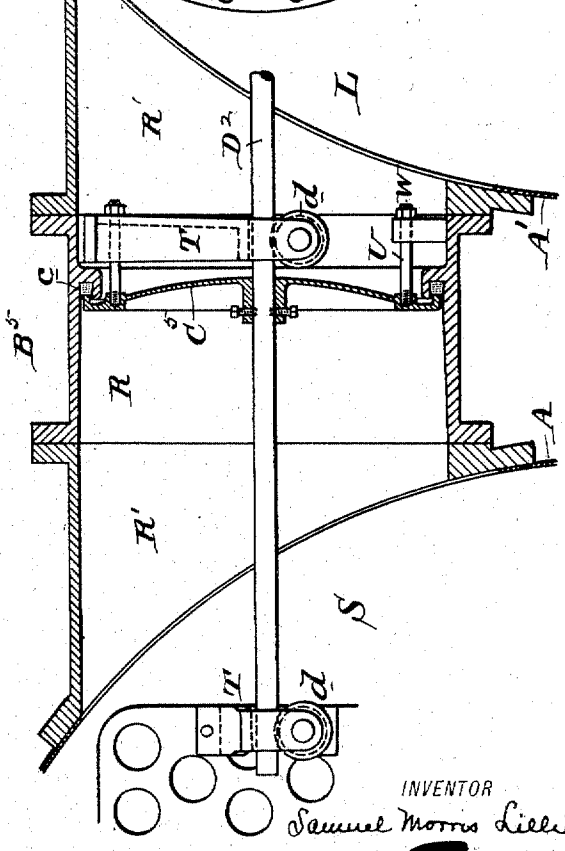


FIG. 4



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MULTIPLE-EFFECT EVAPORATING APPARATUS.

984,226. Specification of Letters Patent. Patented Feb. 14, 1911.

Application filed January 31, 1907. Serial No. 354,988.

To all whom it may concern:

Be it known that I, SAMUEL MORRIS LILLIE, of the city and county of Philadelphia, State of Pennsylvania, have invented an Improvement in Multiple-Effect Evaporating Apparatus, of which the following is a specification.

My invention has reference to multiple-effect evaporating apparatus and consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawings which form a part thereof.

In multiple-effect apparatus of the "Lillie" type, it has been customary to provide a series of single effects connected for reversal, and which is more fully disclosed in Letters Patent of the United States, No. 777,114, granted to me on December 13th, 1904, the said reversal being in not only for changing the direction of the heat through the series whereby each reversal makes what was before the hottest effect the coolest effect, and vice versa, but also preferably reversing the direction of passage of the liquor in the several effects as a series. In the preferred form of my said apparatus, I have usually employed a series of parallel cylindrical effects, the steam chamber of any effect being adjacent to the evaporating chambers of the next effects at the corresponding end and said steam chambers and evaporating chambers of the respective ends of the several effects being connected in series by valved passages, said valved passages corresponding at opposite ends of the effects in the inverse order. Moreover, the valves controlling these passages are designed to be so adjusted that a passage communicating between a steam chamber of one effect and the evaporating chamber of the next effect at one end is closed when the corresponding passage between the same effects at the other end is open, and vice versa, according to the direction in which the heat and vapors are required to pass.

My present invention more particularly refers to automatic means in conjunction with the aforesaid valves controlling the passages between the several effects, whereby the mere change in the point of supply of the steam, to what is to be the hottest effect, will automatically cause the valves to adjust themselves to their seats in the proper order at each end of the series of effects to insure the normal circulation of the heat through the apparatus.

My improvements are more particularly for use in multiple-effect apparatus of the reversal type, but minor features of the improvement may be employed for special applications of evaporating apparatus generally.

Broadly considered, my invention consists in providing two or more communicating passages connecting a series of effects with valve seats, combined with valves carried upon a common shaft or other operating means whereby said valves are caused to move in opposite directions with respect to their seats, and steam actuated motor means located so as to cause the said valves and their connecting rod to close the valve or valves adjacent to the chamber in which the steam is supplied and open the valve controlling the passage between the next two adjacent effects.

My invention also consists in the combination of the communicating passages between the several effects, with valve devices to control them, the movable valves of said valve devices acting as pistons and coöperating with cylindrical portions adjacent to the valve seats whereby the passage of vapor through one passage acting upon one valve will move the other valve in its cylinder so it may be acted upon by the vapor to continue its movement to its seat and simultaneously move the first mentioned valve out of its cylinder and away from its seat.

My invention also consists in providing a series of effects with means to admit steam to the first and next to last effects of the series, combined with valved passages operated in unison for controlling the vapor passages between the series of effects to which the steam is supplied, and independent valve mechanism for controlling the passage of vapor between the end effect and the effect next to it to which steam may be supplied.

My invention further consists in a reversal multiple-effect apparatus of the character herein set out in which means is provided for admitting steam to the steam chambers of all of the effects, combined with valves for controlling the heat and vapor between the adjacent effects at each end, connecting means for the two valves between the means

for supplying steam to the two effects at one end, means connecting the two valves arranged between the means for supplying steam to the two effects at the other end, a separate independent valve for controlling the passage of vapor between the vapor chamber of the first effect and the steam chamber of the next adjacent effect, and a separate valve device for controlling the passage of vapor from the steam chamber of the next to the last effect and the vapor chamber of the last effect. This feature of the invention will permit the effects to be operated as single, double, triple or quadruple effect apparatus.

My invention also comprehends details of construction which, together with the features above specified, will be better understood by reference to the drawings, in which, for purposes of illustration, I have shown an evaporating apparatus of the "Lillie" type hereinbefore referred to.

In the drawings: Figure 1 is a plan view of a multiple-effect apparatus embodying my invention; Fig. 2 is an elevation of the same; Fig. 3 is a longitudinal sectional elevation of the same on line 3—3 of Fig. 1; Fig. 4 is a sectional side elevation of one of the valves and passages between the adjacent effects; and Fig. 5 is an end elevation of the same.

A, A′, A^2 and A^3 are four effects, and, as arranged, have the steam chambers S of adjacent effects at opposite ends.

L represents the evaporating and liquor chambers. The details of construction of the effects for evaporating and circulating the liquid are not described in this application as they may be similar to what is shown in my Letters Patent No. 777,114 aforesaid. The several effects A to A^3 are connected as shown at each end by the passages B to B^5. The various passages B to B^5 are controlled by valves, such as shown at C to C^5 respectively; for example, the valves in the passages B, B^2 and B^4 being open and the valves in the remaining passages closed, or vice versa. The liquor may be supplied to the several effects in series, beginning with either effect A or A^3, by suitable pipes. The circulation of the liquor through the several effects and its reversal is fully set out in my aforesaid Letters Patent, and in lieu of specific description here, reference is made thereto.

As shown in Fig. 1, the steam is supplied by valve pipe E to the steam-chamber S of effect A. The vapors from the evaporating chamber L of effect A pass through passage B into the steam chamber S of effect A^2. The vapors from the evaporating chamber L of this effect pass by passage B^4 into the steam chamber S of effect A^2. The vapors from effect A^2 pass by passage B^2 into the steam chamber of effect A^3, and the vapors of the evaporating chamber L of this last effect are condensed by a suitable condenser F. When the system is to be reversed, the liquor is preferably circulated in the reverse direction. The flow of the liquor having been reversed through the several effects, the valves in the passages B to B^5 are reversed also, and then the vapors pass as follows: Steam is shut off by valve E and admitted to the steam chamber S of effect A^3 by steam valve E′, where it is condensed. The vapors generated in the evaporating chamber L of this effect pass through passage B^3 into the steam chamber to effect A^2 and are condensed. The vapors of the evaporating chamber L of effect A^2 pass by passage B′ into the steam chamber of effect A′ and are condensed. The vapors from this effect A′ pass by passage B^5 into the steam chamber of effect A and are condensed, and the vapors of the evaporating chamber L of effect A are condensed by a suitable condenser F′.

Ordinarily, in the full operation of the multiple-effect apparatus, steam would be admitted either by the valve E or E′, according to the direction of operation, (it being admitted by the valve E in the particular positions of the valves in the passages communicating between the several effects) and the last evaporating chamber of the effect A^3 is in communication with condenser at F. In the reversal of the apparatus, the steam is supplied by the valve E′ and the vapors from the evaporating chamber of the effect A will then be in communication with the condenser F′, but in this case the several valves between the various effects will be reversed, that is to say, those which are open in Fig. 1, will be closed and those which are closed will be open. Of course either condenser F or F′ is respectively cut out, dependent upon whether the steam is admitted by valve E′ or E.

In the preferred form of my apparatus, I provide the steam chambers of the second and third effects also with valved steam inlets so that in this manner steam may be supplied as desired to any one of the effects of the series. I have indicated the steam supply to the effects A′ at E^3 and to effect A^2 at E^2.

In Fig. 3 is shown the arrangement of the steam passages and valved passages between the adjacent effects of the series in the preferred form of my invention, and these valves and steam passages are the same at both ends of the effects, but in the inverse order. It will therefore only be necessary to describe the details of one set, as indicated in Fig. 3, to fully understand the construction of both sets.

The detail character of the passages between the adjacent effects is indicated in Figs. 4 and 5. In the construction here

shown, I have a central cylinder part R having the annular valve seat c with which the disk valve C^5 coöperates. This cylinder part R is intermediate of flanged tubular portions R′ R′ which are connected with the walls of the adjacent effects. It will be observed that the diameter of the part R is less than the diameter of the part R′ communicating with it on the side in which the valve moves, so that when the valve C^5 moves to the left and just about to leave the cylindrical part R, there will be the greatest clearance around it for the passage of vapor. To secure this result, the cylindrical internal diameter of the part R is preferably tapered, being of the smallest diameter adjacent to the seat c. This reduction in the diameter of the part R as compared with the part R′ is for the purpose of making the valve act as a piston to the part R as a cylinder in the automatic operation of the valve. The valve is carried upon a reciprocating rod D^2 which is guided on suitable rollers d carried in brackets of any suitable character T. In this manner, the valve is held central of the cylindrical portion R and yet is free to move longitudinally therein under very slight variations in pressure. When the valve is fully open it moves, not only out of the cylinder portion R, but also out of the flanged portion R′ as is indicated in the second valve to the right in Fig. 3, so as to leave a fully unobstructed passage for vapor through the connecting passage between the adjacent effects.

In the above description, it has been assumed that the valve and valve rod were free to move and this, of course, was with the understanding that the clamping bolts U shown in Figs. 4 and 5 were not employed. These bolts are only used under special conditions and will be referred to farther on. It will also be observed that the two valves C^5 and C^4 are connected on the valve rod D^2 at a distance apart greater than the distance between the valve seats, and furthermore, are caused to be placed in opposite direction so that when one of these is closed upon its seat the other is open or away from its seat, and vice versa; and moreover, the distance apart is also such, that when the valve C^5 is just about to leave the parts R R′, the valve C^4 will just begin to enter its corresponding similar part. From this, it will be observed that if the pressures of the vapors in the vapor chamber of the effect A′ act upon the valve C^5 to impart thereto a movement in the direction of opening the passage B^5, it will also move the valve C^4 toward its seat and when it reaches the cylindrical part R the pressure in the steam chamber S of the effect A^2 acting upon said valve C^4 will force it to its seat and this action will complete the opening of the valve C^5. In this manner, the valves are coupled in pairs and coöperate, each one performing in part the duty of shifting the rod D^2 and the connected valves.

If we assume that the valve C^3 is open and the valve C^4 is closed, it is evident that if steam is admitted by the valve pipe E, the valve C^5 should be at once closed and the valve C^4 open, and this will be automatically accomplished by the steam passing through the passage B^5 and vapor chamber of the effect A′ and acting upon the valve C^4 to move it into the position indicated in Fig. 3. However, as soon as valve C^5 enters its cylindrical portion R, the steam in the steam chamber of the effect A directly acts upon this valve C^5 to force it to its seat, and complete the final opening movement of the valve C^4 through the rod D^2. In the case of the valve C^3 in the passage B^3 between the effects A^2 and A^3, this valve is supported upon a short length of rod d^2 in alinement with the rod D^2 and which abuts on the end thereof. The valve C^3, in closing the passage B^3, moves in the same direction as the valve C^5, so that when the valves C^4 and C^5 are moved to the position shown in Fig. 3, it is evident that the valve C^3 will also have been moved to approximately close its seat, and that the action of the vapor in the steam chamber S of the effect A^2 will automatically close the said valve tight upon its seat, leaving a very slight gap between the rods D^2 and d^2, as shown. When the rods D^2 d^2 and their valves move in the opposite direction the same general action results but in the reverse order, and in this case the vapors of the evaporating chambers L directly or through the chambers S when charged with such vapors, operate to move all of the valves C^3, C^4 or C^5 to the left in Fig. 3. The severing of the connecting rod for the valves into the parts D^2 d^2 obviates the necessity of nice calculations and adjustment of the valves C^3 and C^5 to insure both seating themselves at the same moment. There is another advantage in this dividing of the rod which will be referred to later on.

So far, I have described my invention under the assumption that steam is only to be admitted at E and E′, that is at either end of the series of effects. The steam chambers S of the effects A′ and A^2 are preferably each provided with a valved steam inlet, respectively marked E^3 and E^2, the latter being fully shown in Fig. 3. These inlets have a pipe extending into the steam chambers and terminating in horizontal cylinders N in which pistons n work. These pistons are respectively secured to the rods D^2 D, the latter being the rod carrying the valves C^2 and C^3 at the opposite end of the effects and coöperating with the short rod d' carrying the other valve C. These cylinders are short so that the pistons may move

longitudinal a distance sufficient to pass out of them for the purpose of permitting the free passage of steam into the steam chamber after giving an initial movement to the rods D or D^2. Referring to Fig. 3, it will be seen that upon admitting steam to the port E^2 the piston *n* and rod D^2 will move to the left. Just as the valve C^4 enters its passageway B^4, the piston *n* leaves the cylinder N. The steam then acts directly upon the valve C^4 and moves it to its seat and moves valve C^5 fully open. It also keeps the valve C^3 tight upon its seat and cuts the effect A^3 out of action. The same results will take place when steam is admitted by the steam inlet E^3 to effect A′ but in this case the valves will move in the reverse order and it will be effect A which will be cut out of action.

It will be seen that the severing or dividing of the valve rods enables this operation of the valves to put out of action either of the two end effects at will. When either of such effects is to be kept out of operation for some time either for repairs or otherwise, the valves C^3 or C^5 may be secured in closed position by means of the bolts U and nuts W shown in Figs. 4 and 5. Such bolts and nuts may also be used in connection with the valves C, C′ C^4 and C^5 at any time except when the operation of the apparatus as a reversal multiple-effect apparatus.

By the use of the means herein described I may operate the effects A, A′, A^2 and A^3 as a quadruple effect in one direction or reversible; I may operate the effects A, A′ and A^2 or the effects A′, A^2 and A^3 as triple effects in one direction or reversible; I may operate the effects A A′ as a pair and effects A^2 A^3 as another pair as double effects; and I may operate either of the effects A or A^3 as single effects or open them for cleaning or repairs while the triple effects are in operation. In the case of some weak solutions which have to be brought to a high density, it is customary to complete the evaporation in two stages. By the first stage about ninety per cent. of the total evaporation is done and in the second stage, the remainder. In the case of such solution, the apparatus is used as a quadruple effect for the first stage and when a fair quantity of the product of this stage is accumulated, one of the end effects is then operated by itself in bringing this product to the final density while the remaining three effects are continued in operation as a triple effect on the dilute solution, bringing it to the condition of the product of the first stage. When the first stage product has been worked through the single effect, said effect may be put in service with the other three effects as a quadruple effect for treatment of more of the first stage liquor.

I do not restrict myself to the minor details of construction as it is evident that such parts may be modified as will be apparent to those skilled in the art.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a multiple effect evaporating apparatus, valved controlled apertures between the steam chambers and evaporating chambers of the several effects, a steam inlet to the steam chamber of one of the effects, and steam actuated devices operable by the pressure of the steam entering through the steam inlet into the steam chamber for positively and automatically operating the valves of the valve passages immediately before the admission of steam to the multiple effect apparatus.

2. In a multiple effect apparatus, four effects and communicating passages between the steam chambers and vapor chambers of the several effects to connect them in series, combined with means for supplying steam to the steam chambers of two effects adjacent to one end of the series, condensers in communication with the vapor chambers of the two end effects of the series, valves for connecting the effects as a quadruple effect or as a triple effect and one single effect according to their adjustment, and automatic means in connection with the steam inlet of the effect next to the end of the series for positively operating the valve immediately before the admission of the steam to the steam chamber of the said effect for causing the said valves to couple the effects as a triple effect and as a single effect with respect to the two condensers.

3. In a multiple effect evaporating apparatus, four effects arranged with their steam and evaporating chambers connected by vapor passages, combined with valves in the vapor passages and arranged wholly within the apparatus and adapted to be automatically operated to reverse the direction of the passage of the heat through the apparatus by the admission of steam to the first or last effects of the series, means for admitting steam to the steam chambers of the first and last effects, condensers in connection with the vapor chambers of the first and last effects of the series, means for admitting steam to the steam chamber of one of the middle effects of the series, and means operated by the steam being admitted to the said middle effect for positively moving the vapor valves for dividing the quadruple effect automatically into a triple effect and a single effect both in operative relation to the condensers.

4. In a multiple effect apparatus, a series of four effects each having valve inlets for independently supplying steam to the steam chambers thereof, and condensers in connection with the vapor chambers of the two

end effects, combined with automatically controlled valve passages between the evaporating chamber and steam chamber of the respective adjacent effects, power devices in connection with the valve inlets of the two intermediate effects arranged to be operated by the steam being admitted to the said effects, and connections between power devices and the valves of the valved passages for operating them in two sets, whereby the apparatus may be automatically transformed from a multiple effect apparatus into a triple effect and a single effect in connection with the respective condensers and for reversing the apparatus while maintained as a triple and single effect combination

5. A multiple-effect evaporating apparatus having means for supplying steam to each effect at will, vapor passages between the adjacent effects, combined with reversible positive steam actuated valve devices in the several vapor passages for controlling the flow of the vapors from the evaporating chambers to the steam chambers of adjacent effects and coöperating to simultaneously and automatically control the several effects whereby they may be changed from triple to quadruple effect apparatus or vice versa and the heat and vapors caused to flow in either direction with respect to the series of effects.

6 In a multiple-effect evaporating apparatus, the combination of a series of effects, vapor passages connecting the steam chambers of the several effects with the evaporating chambers of adjacent effects having cylindrical valve casings, valves for controlling the several passages whereby they may operate to move into and out of the cylindrical casings under the pressure of the steam and vapors, and when in the casings act as pistons thereto, means for admitting steam to the steam chambers of the first and last effects of the series whereby the valves may be caused to automatically readjust themselves upon the admission of steam to the first or the last effect of the series and thereby reverse the flow of the heat and vapors.

7. In a multiple-effect evaporating apparatus, the combination of a series of effects, vapor passages connecting the steam chambers of the several effects with the evaporating chambers of adjacent effects having cylindrical valve casings, valves for controlling the several passages whereby they may operate to move into and out of the cylindrical casings under the pressure of the steam and vapors and when in the casings act as pistons thereto, a steam motor device for giving the valves an initial movement for starting their reversal movement, means for admitting steam to the steam chambers of effects of the series whereby the valves may be caused to automatically readjust themselves upon the admission of steam to the first or the last effect of the series.

8. In a reversible vapor multiple effect evaporating apparatus, the effects of which each have an evaporating chamber and a steam chamber and in which the steam chamber of each intermediate effect is connected by vapor passages with the evaporating chamber of each adjacent effect, a vapor valve in each of the said passages one of which valves is closed and the other open or vice versa according to the direction in which the vapors or heat is moving through the effects as a series, a valved steam inlet to the steam chamber of an intermediate effect, and means operable to close the open valve of the vapor passage by steam entering through said inlet on opening the valve in the same, whereby the intermediate effect becomes a vapor generator using extraneous steam to furnish vapor to another effect.

9. In a reversible vapor multiple effect evaporating apparatus comprising four or more effects having steam and evaporating chambers in which the steam end of each intermediate effect has leading into it vapor passages from the evaporating chamber of each adjacent effect, a vapor valve in each of said vapor passages one of which valves is open and the other closed or vice versa according to the direction in which the vapors or heat is moving through the effects as a series, steam inlets to the steam chambers of two intermediate effects, valve in said steam inlets, and means operable by steam entering through the said steam inlets to close the open vapor valves in the said vapor passages leading into the steam chambers of the said two adjacent intermediate effects, whereby each of the said intermediate effects becomes the hottest effect of a series of effects operating as a multiple effect.

10. In a multiple-effect evaporating apparatus, a series of effects having the evaporating chamber of one effect connecting with the steam chambers of the adjacent effects by tubular passages having valve seats, combined with a rod extending through evaporating chamber and the tubular passageways, valves secured to the rod and separated a distance much greater than the distance between the two valve seats whereby one valve is out of the tubular passageway when the other valve is on its seat and vice versa, the said valves operating as pistons alternately and both coöperating in succession with their respective tubular passageways to shift the rod and the said valves secured thereto in the same direction.

11. In a multiple effect evaporating apparatus, a plurality of effects each having a steam chamber connected by cylindrical vapor passages with the vapor chamber of adjacent effects, valves for the cylindrical pas-

sages acting as pistons, connections between the valves to cause them to move in unison, and means to positively move the valves a total distance which is greater than the distance of their travel when they are within their respective cylindrical passages, whereby the steam or vapor may pass through one cylindrical passage and steam chamber of the next effect to open the valve of the cylindrical passage leading to the vapor chamber of the effect beyond and then close the first mentioned passage by its valve.

12. In a multiple effect evaporating apparatus comprising a plurality of effects each of which has a steam chamber and an evaporating chamber, and in which the hottest effect has a steam supply connection to its steam chamber and the coolest effect has a vapor escape from its vapor chamber, and in which further one or more of the intermediate effects are provided with a vapor main from the vapor chamber of each effect of the series save the coolest effect and to the steam chamber of the next coolest effect, combined with a valved steam inlet to the steam chamber of one of the intermediate effects, a vapor valve in the vapor main leading to said effect from next hotter effect, and means to close said vapor valve in said vapor main operable by steam when entering by the said valved steam inlet to thereby cause the said intermediate effect to be shut off from the vapor chamber of the next hotter effect and to become the hottest effect of the series consisting of itself and the effects lower than it in the series.

13. In a reversible multiple-effect evaporating apparatus, a series of effects arranged with the steam ends adjacent to the vapor ends of adjacent effects, tubular passages between the several effects at each end, valve seats in the several passages, valves for said valve seats, rods connecting two of the valves at each end of the effects to cause them to move in opposite directions with respect to opening and closing their respective valve seats, guides for the rods, two additional rods in line respectively with the aforesaid rods and adapted to be moved thereby, and valves secured to the additional rods for controlling the remaining vapor passages of the effects.

14. The combination in a multiple-effect apparatus, of the tubular vapor passages B^3 B^4 and B^5 having valve seats, the valves C^3 C^4 and C^5 respectively for said passage, a rod D^2 connecting valves C^4 C^5 and holding them at a greater distance apart than the distance apart of their seats, rod d^2 secured to valve C^3 and abutting with the rod D^2 whereby the movement of rod D^2 in adjusting its valves will also move rod d^2 and its valve and at the same time will permit valve C^3 to be given a final movement independently to close it tightly upon its seat.

15. In a reversible vapor multiple effect evaporating apparatus of which the bodies of each effect have a steam chamber and an evaporating chamber, the combination of three consecutive effects, a vapor passage between the steam chamber of each end effect of the three and the vapor chamber of the intermediate effect, a section of each vapor passage formed as a cylinder, a piston for the cylindrical section adapted to be moved into the cylinder to close its vapor passage and out of the cylinder to open its vapor passage, and intermediate connections between the two pistons operating to compel the pistons to move in unison the one piston toward and out of the end of its cylinder and the other toward the mouth and into its cylinder whereby an increase in the pressure in the vapor chamber of the intermediate effect above that in the steam chamber on the other side of the closed cylinder will cause the piston of the latter to be forced by the increasing pressure to the end of its cylinder and bring the piston of the other cylinder to the entrance of its cylinder.

16. In a reversible vapor multiple effect evaporating apparatus, the effects of which have each an evaporating and a steam chamber, the combination of three effects, a vapor passage from the steam chamber of each of two of the three effects to the evaporating chamber of the third effect, a valve in each vapor passage which moves toward the steam chamber to open the passage and toward the evaporating chamber of the third effect to close the passage, intermediate connections between the valves, and means whereby an increase in pressure in one of the said steam chambers above the pressure in the other of the said steam chambers positively moves the connected pair of valves by the full power of the increasing pressure to close the valve between the first steam chamber and the vapor chamber and fully open the valve between the vapor chamber and the other steam chamber.

In testimony of which invention, I have hereunto set my hand.

S. MORRIS LILLIE.

Witnesses:
JOHN J. WALTER,
COLIN D. SMITH.