No. 777,114. PATENTED DEC. 13, 1904.

S. M. LILLIE.

MULTIPLE EFFECT EVAPORATING APPARATUS.

APPLICATION FILED OCT. 14, 1904.

NO MODEL. 2 SHEETS—SHEET 1.

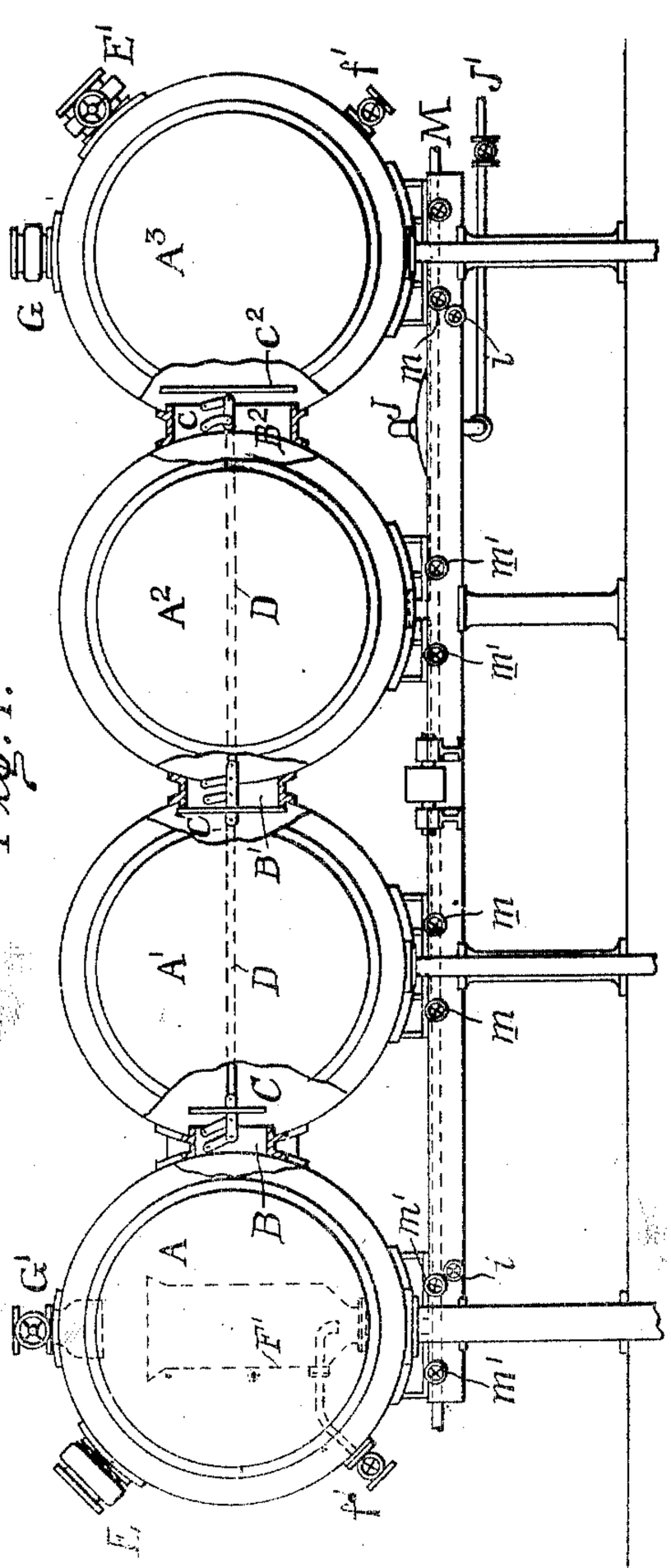

Fig. 1.

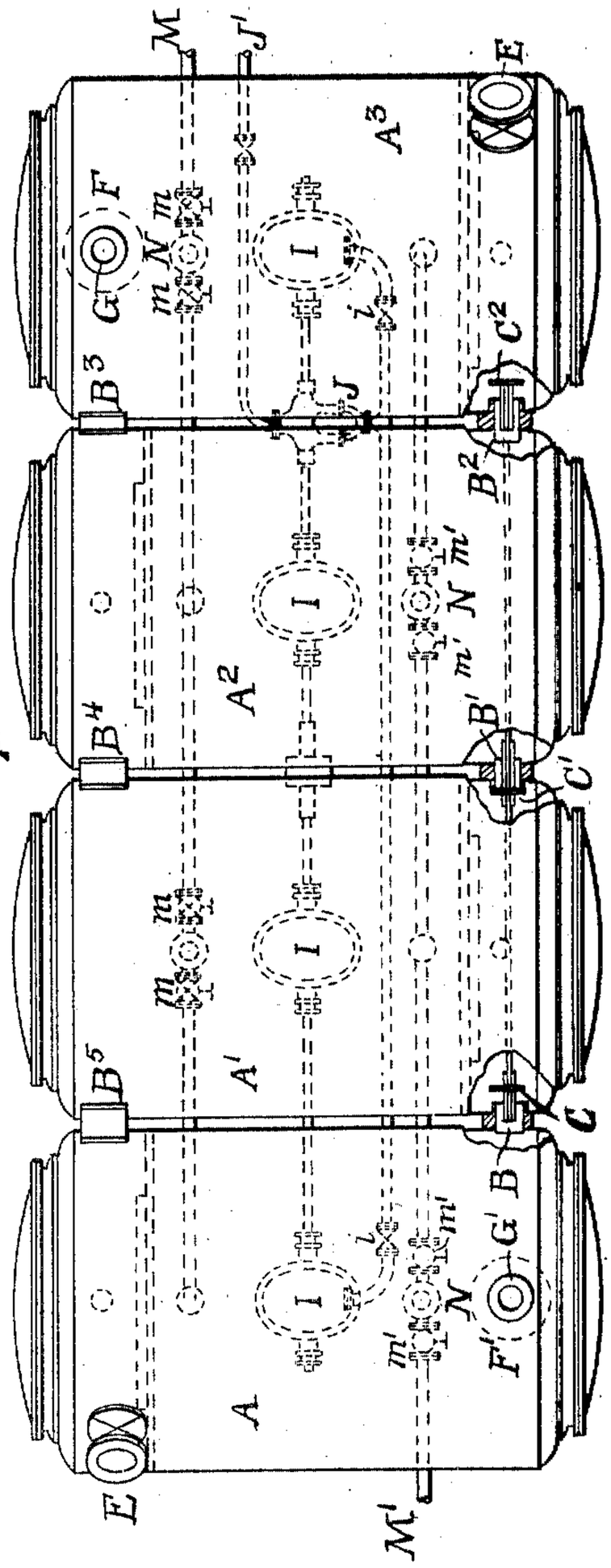

Fig. 2.

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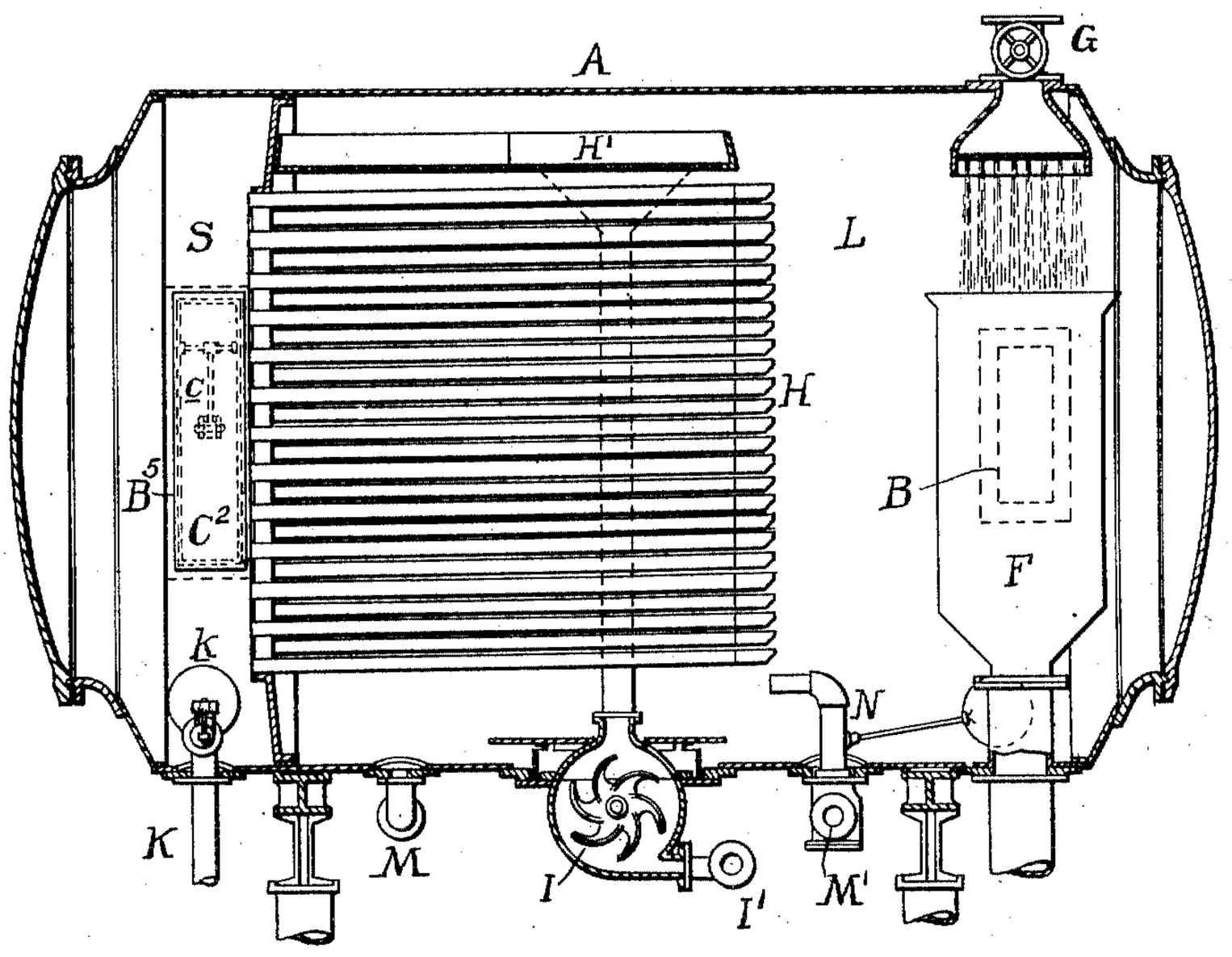
Fig. 3.



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UNITED STATES PATENT OFFICE.

SAMUEL MORRIS LILLIE, OF PHILADELPHIA, PENNSYLVANIA.

MULTIPLE-EFFECT EVAPORATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 777,114, dated December 13, 1904.

Application filed October 14, 1904. Serial No. 228,441. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL MORRIS LILLIE, of the city and county of Philadelphia and 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 it consists of certain improvements, which are fully set forth in the following specification and shown in the accompanying drawings, which form a part thereof.

Multiple-effect evaporation and apparatus for practicing it are well known in the arts, and it is unnecessary here to give explanation of either in detail other, perhaps, than to say that the same is used repeatedly in a series of evaporators or "effects," as usually, and as hereinafter termed, in which the temperatures range between certain extremes. The heat (commonly contained in steam) is used for evaporation first in the hottest effect, while the vapors from the coolest effect usually pass to a condenser. As a rule one solution is evaporated in the series and is taken into the hottest effect and after passing through the intermediate effects in succession, suffering evaporation in each, due to the vapors from the next hotter effect, it passes into the coolest effect and away from it concentrated to the desired degree. When the liquid being concentrated contains in solution scale-forming materials, incrustations are usually formed on the heating-surfaces in one or all of the effects. Usually the incrustations are the greater the greater the degree of concentration in the solution, and consequently following the above-described sequence they increase in the effects from the hottest to the coolest. Sometimes they are largely confined to the last or coolest effect.

The object of my invention is to prevent the adherence of incrustations to the heating-surface by frequently varying the temperatures in the several effects, which I accomplish by reversing the direction of the heat through the series, each reversal making what was before the hottest effect the coolest effect and what was before the coolest effect the hottest effect, the heat passing through the series in the reverse order to which it passed before reversal. My object is further promoted by arranging apparatus to reverse the direction of the solution being concentrated at the same time the direction of the heat is reversed, as a result of which the dilute solution after reversal enters the effect that was before the coolest and contains the heaviest incrustations. The purpose of this is to take advantage of what is often the fact that a dilute solution has a solvent effect upon the incrustations from it in the concentrated state.

In carrying out my invention I provide in a multiple effect two vapor-passages between each pair of adjacent effects, one passage connecting the vapor-chamber of one effect with the heating-chamber of the other and the other passage connecting the heating-chamber of the one with the vapor-chamber of the other and combine therewith valves, whereby either passage may be opened or closed at will.

My invention also includes the provision of supply-pipes for the heating medium to the steam ends of the two most distantly-separated effects, so that it may be supplied to either end of the system as required. The heating medium is usually steam.

Another feature of my invention is the employment of means for condensing the vapors of the evaporating-chambers of the two extreme effects, and preferably said effects are each provided within them of a suitable condenser, one of which is in operation, according to the direction of flow of the vapors through the effects.

In addition to the above features of construction my invention also comprehends the employment of pipes for supplying and passing the liquid to be evaporated from effect to effect in either direction, so as to be reversible to correspond to the reversibility of the apparatus in the circulation of the vapors.

My invention also embodies details of construction, which, together with the above features of invention, will be better understood by reference to the accompanying drawings, which for purposes of illustration I have shown an evaporator of my own invention commercially known as a "Lillie" type.

In the drawings, Figure 1 is an elevation of a multiple-effect evaporating apparatus embodying my invention. Fig. 2 is a plan view of same, and Fig. 3 is a longitudinal sectional elevation through one of the effects.

A, A′, A², and A³ are four effects and, as arranged, have the steam-chambers S of adjacent effects at opposite ends.

L represents the evaporating and liquor chambers and contain the evaporating-tubes H. The liquor to be evaporated is pumped from the bottom of the chamber by the circulating-pump I and forced upward and sprayed from the perforated pan H′ down upon the evaporating-tubes. The pumps I of the effects A and A³ are connected by a tube I′, having valves *i i*, and this pipe between the valves is connected with the discharge-pump J, which is employed to discharge the condensed liquor by pipe J′. The liquor is supplied to the several effects in series, beginning with either effect A or A³, by pipes M′ and M, respectively. When the effect A is to receive the thin liquor, it is supplied by pipe M′ through a valve *m′* and by a regulating float-valve into the bottom of the evaporating-chamber. From this effect the liquor passes by a pipe M through a valve *m* and by a similar float-valve N into the bottom of the effect A′. The passage of the liquor in a gradually more concentrated condition passes in a similar manner from effect A′ to effect A² and from it to effect A³, whence it is discharged through the pump I, pipe I′, valve *i*, and discharge-pump J. During the time the liquor is flowing, as thus described, the steam is supplied by valved pipe E to the steam-chamber S of effect A and the water of condensation is conveyed away by pipe K through a steam-trap *k*. The vapors from the evaporating-chamber of effect A pass through passage B into the steam-chamber S of effect A′. The vapors from the evaporating-chamber L of this effect A′ pass by passage B′ into the steam-chamber S of effect A². The vapors from effect A² pass by passage B² into the steam-chamber of effect A³, and the vapors of the evaporating-chamber L of this last effect are condensed by the condenser F, into which cold water is sprayed by a valve *f*. The air is exhausted from the condenser through valve-pipe *f′*. The various passages are controlled by valves, such as shown at C and C², for example, and which are open to allow the vapors to pass freely through the passages above referred to. When the system is to be reversed, the liquor is circulated in a similar manner to that described, but in the reverse direction, being fed into effect A³ by pipe M and then passed successively through the several effects under the control of the float-valves until it is finally discharged through the discharge-pump J, which draws from the pump I of the effect A. The several valves *m* are adjusted to insure the proper direction of circulation of the liquor. As shown, the pipe M communicates directly with effects A and A² and indirectly through the float-valves N with effects A′ and A³. The valves *m′ m′* permit the flow of liquor from pipe M through float-valves N, but not beyond said valves. The same is true of the pipes M′ and valves *m′*. The flow of the liquor having been reversed through the several effects, the valves in the passages B to B⁵ 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 A³ by steam-valve E′, where it is condensed, and the water of condensation escapes by the steam-trap as before. The vapors generated in the evaporating-chamber of this effect pass through passage B³ into the steam-chamber of effect A² and are condensed. The vapors of the evaporating-chamber of effect A² pass by passage B′ into the steam-chamber of effect A′ and are condensed. The vapors from this effect pass by passage B⁵ into the steam-chamber of effect A and are condensed, and the vapors of the evaporating-chamber of effect A are condensed by condenser F′.

The various passages B to B⁵ are controlled by suitable valves, which may be automatic or otherwise. As shown, they are automatic, and consist of flat valves hinged from links *c* and connected by bars D, so as to normally close the valves C and C² and open valve C′ in the passages B, B², and B′, respectively, or vice versa. In the other passages, B³, B⁵, and B⁴, a similar arrangement of valves is employed. The effect of this is that the pressure of the steam or vapor operates the valves automatically to regulate the opening of the passages. Thus if the steam is supplied at E the vapors from effect A force open valve C, close valve C′, and open valve C², and at the same time the valves in passages B⁵ and B³ are closed and in passage B⁴ the valve is open. If the system is reversed, the pressures of steam and vapors automatically operate the valves in the manner required to secure proper circulation. The valves and passages are made larger when the vapors passing are less dense, so as to secure the greater area to properly operate with the lower pressures.

While I have indicated the valves *m m′* as hand-valves, it is evident that they may be simple check-valves with the direction of opening arranged to suit the flow of the liquor.

I have shown my invention applied to a type of multiple effect known to the trade as the "Lillie" effect; but it is to be understood that my invention is equally applicable to any type of multiple effect.

While for convenience of construction I have arranged the steam ends alternately at opposite ends of the effects, I do not limit myself to such an arrangement.

The various valves in the passages between the steam and vapor chambers of the several

effects may be constructed and operated in any manner desired so long as they control the circulation and permit it to be reversed in the manner set out.

While the construction set out is excellently adapted for the employment of my invention in practice, I do not limit myself to the details, as they may be modified without departing from the spirit of the invention.

In this specification and in the following claims the expression "adjacent effects" is used to designate consecutive effects in the course of the vapors—*i. e.*, one of the adjacent effects either receives vapor from the other or yields vapor to the other, depending upon whether the series is operating with the vapors (heat) passing through is in one direction or in the other.

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

1. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which multiple effect the adjacent effects have their steam-chambers located on opposite ends.

2. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, and valved passages between the steam-chambers and evaporating-chambers of adjacent effects.

3. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, and valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends.

4. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, valved vapor-passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, and valved pipes to supply a heating agent to the steam-chambers of the first and last effects of the series.

5. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, and condensers for the evaporating-chambers of the end effects of the series.

6. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, and pipes and valves for supplying liquor to both the end effects and to cause it to flow through the series of effects in succession in either direction.

7. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, pipes and valves for supplying liquor to the end effects and to cause it to flow through the series of effects in succession in either direction, means for discharging the liquor from either of the end effects and valves to restrict the discharge from either end effect of the series.

8. In a multiple-effect evaporator two vapor-passages between each pair of adjacent effects, one passage connecting the vapor end of the one effect with the steam end of the other and the second connecting the steam end of the one with the vapor end of the other and valved whereby either passage may be closed or opened at will.

9. In a multiple effect the combination of a series of effects having steam and evaporating chambers, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, and condensers in the evaporating-chambers of the end effects of the series.

10. In a multiple effect the combination of a series of effects having steam and evaporating chambers, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, and pipes and valves for supplying liquor to the end effects and to cause it to flow through the series of effects in succession in either direction.

11. In a multiple effect the combination of a series of effects having steam and evaporating chambers, valved passages between the steam-chambers and evaporating-chambers of adjacent effects at both ends, valved steam-pipes to supply steam to the steam-chambers of the end effects of the series, pipes and valves for supplying liquor to the end effects and to cause it to flow through the series of effects in suc-

cession in either direction, means for discharging the liquor from the end effects and valves to restrict the discharge from either end effect of the series.

12. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which the adjacent effects have their steam-chambers located on opposite ends, passages connecting the steam and evaporating chambers of adjacent effects, valves for said passages, connections between the valves of the passages so as to cause adjacent valves to operate on their valve-seats in opposite directions to cause the passage-ways to be opened and closed alternately.

13. The combination of three or more effects provided with passages from the steam-chamber of one effect to the evaporating-chambers of two adjacent effects, and valves to open one of said passages and close the other or vice versa.

14. The combination of three or more effects provided with passages from the steam-chamber to the evaporating-chambers of two adjacent effects and valves to open one of said passage-ways and close the other or vice versa, and connections between the valves whereby they operate as a unit.

15. In a multiple effect the combination of a series of effects comprising horizontal and parallel vessels having steam and evaporating chambers and in which multiple effect the adjacent effects have their steam-chambers located on opposite ends and a vapor-passage between the steam-chamber of each effect and the evaporating-chamber of the next hottest effect, means for supplying heat to the hottest effect, and means for taking away vapors from the coolest effect.

In testimony of which invention I hereunto set my hand.

S. MORRIS LILLIE.

Witnesses:
ERNEST HOWARD HUNTER,
R. M. KELLY.