PROCESS AND APPARATUS FOR DE-SALTING SEA WATER

This invention relates to the de-salting of sea water by freezing.

Fig 1. shows one example embodying one of the features of the invention. In this figure container 1 and container 2 communicate through the middle piece 3 and (in the first phase of the batch process) sea water is alternately moved by means of a pump located in the middle piece 3 from container 1 to container 2 and visa versa. These two movements alternate every few seconds. In container 1 there is located a sheet made of plastic or some other suitable material which is coiled up in the form of a spiral, that is co-axial with the container 1. Subsequent turns of the sheets are spaced a few milimetres apart. A similar spiral 5 is located in container 2.

The sea water level in the two containers is made to oscillate between two extreme positions, one in which the level in container 1 roughly coincides with the top of ~~sheet~~ spiral 4 and the level in container 2 roughly coincides with the bottom of ~~sheet~~ spiral 5 and another position in which the level in container 1 roughly coincides with the bottom of ~~sheet~~ spiral 4 and the top in container 2 roughly coincides with the top of ~~sheet~~ spiral 5.

On top of the sea water in containers 1 and 2 each there floats a layer of a liquid which is non-missable with water. For instance a layer of straignt-chain hydrocarbon (one containing about 10 to 12 carbon atoms for instance). The depth of these layers is somewhat larger than the height of the spirals 4 and 5. The hydrocarbon layer 6 (in container 1) is cooled by coil 7 which represents the evaporater of a refrigerater and similarly the hydrocarbon layer 8 (in container 2) is cooled by coil 9 which represents the evaporater of the same refrigerater.

As the sea water is moved back and forth between the two containers 1 and 2, the cooled hydrocarbon layer follows the sea water level in its movement axially through spirals 4 and 5. As the sea water level moves axially downward through spiral 4, the

Leo Szilard

Witness Nancy Reid Sept 30, 1954

hydrocarbon layer also moves axially downward through the spiral and cools the sheet spiral. As the motion is reversed and the sea water moves axially upward through spiral 4 it is now cooled by the sheet spiral so that a thin layer of ice is deposited on the ~~spiral~~ sheet. The same thing happens in spiral 5 in container 2. In this manner layer upon layer of ice is deposited on the spiral sheets.

After an amount of ice has been formed which corresponds to say 1/3 ~~or~~ to 2/3 of the amount of sea water in the container, the sea water is drained off through valve 10 and fresh water is admitted in its place through valve 11.

In the second phase of the batch process, the fresh water is now moved back and forth between the two containers with the hydrocarbon layers floating on the top of the fresh water columns. These hydrocarbon layers are warmed by the coils 12 and 13 which represent the condensers of a refrigerater. In this manner the ice layer deposited on the spiral sheets 4 and 5 is molten. After a period long enough to permit the melting of all the ice, the fresh water is drained off through valve 11, ~~and~~ sea water is admitted in its place through valve 10 and the cycle begins again.

Fig 1-B is an apparatus identical with that shown in Fig 1-A and the two are connected in the following manner. The coil 21 in container 14 represents the evaporater of the same refrigerater of which 13 represents the condenser and the coil 22 represents the condenser of the same refrigerater of which 9 represents the evaporater. The coil 23 represents the evaporater of the same refrigerater of which 12 represents the condenser and the coil 24 represents the condenser of the same refrigerater of which the coil 7 represents the evaporater. The two machines, the one represented in Fig 1-A and the other represented in Fig 1-B always work in opposite phase. When sea water is frozen in the first machine, ice is molten in the second machine. During this phase the coils in the first machine ~~connected to~~ representing the evaporaters are in action and the coils representing the condensers are shut off, while in the second machine the coils representing the condensers are in action and the evaporaters are shut off. In the next phase, when in machine B there is sea water

Leo Szilard

Witness Nancy Reil
Sept 30 - 1954

and ice is formed and in machine A there is fresh water and ice is molten, then in machine A the condensers are in action and the evaporaters are shut off, while in machine B the evaporaters are in action and the condensers are shut off.

25 and 26 are cooling coils connected with the evaporater of an auxiliary refrigerater which lifts enough heat from the temperature at which freezing units A and B operate to the temperature of the sea(the condenser of this auxiliary refrigerater is cooled by sea water) to maintain ~~the freezing~~ units A and B at low temperature. This auxiliary refrigerater is much smaller than the refrigeraters which move heat between the two units A and B.

The temperature difference between the hydrocarbon layers in unit A and B might be around 15° centigrade in onde direction or the other depending on the phase of the batch operation. Whereas the auxiliary refrigerater which either cools unit A through the coil 25 or unit B through the coil 24, has to lift heat from about -10° centigrade to the temperature of the sea water.

The apparatus shown in Fig 2 differs from that shown in Fig 1. in the following respects. Here the hydrocarbon which is used to cool or heat the spiral sheets ~~are~~ is cooled or heated directly by being evaporated or condensed right inside the units A and B. In this case ~~pentan or~~ butan (or pentane) may be used as the hydrocarbon (rather than one of the heavier hydrocarbons).

In one phase of the operation when the unit A freezes and the unit B melts ice the compressor 27 draws butan vapor from the unit A where butan evaporates and pushes into the unit B where the butan condenses. In the opposite phase of the operation when unit B freezes and unit A melts ice, the action of the compressor is reversed, butan is evaporated in unit B and is condensed in unit A. An auxiliary refrigerater is provided here the same way as in the case of the operation described in connection with Fig 1.

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Witness
Nancy Reed

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(In place of butane, either pentane or propane may be used as a refrigerant).

As may be seen from Fig 2. when the valves 29 and 30 are open, while the valves 31 and 32 are closed, compressor 27 draws butane vapor from the unit A and pushes it into unit B. When this phase of the operation is terminated and the valves 29 and 30 are closed and the valves 31 and 32 are opened, then compressor 27 draws butane vapor from unit B and pushes it into unit A.

During the first phase of the operation, unit A contains sea water which is moved back and forth between container 1 and container 2 through the action of pump 3. When the sea water level stands at the lowest in container 1 and at the highest in container 2, its level is shown in Fig 2. by the line FF in container 1 and the line EE in container 2. The sea water level is then just below the bottom of the sheet spiral 4 and just above the top of the sheet spiral 5. The butane level in container 1 is shown by the line DD and in container 2 by the line GG. In this position the depth of the butane layer on top of sheet spiral 4 is perhaps 1/3 or 1/2 of the height of the sheet spiral 4 itself.

Prior to the onset of this phase of operation, all the sea water was withdrawn from unit B and no fresh water was pumped into unit B to replace the sea water and the butane level in unit B is indicated by the lines CC in Fig 2. The butane level is thus below the lower end of the sheet spiral leaving a gap that has a height of perhaps 1/2 of the height of the sheet spirals 16 and 17.

In this phase of operation pump 3 moves the sea water back and forth between containers 1 and 2 in unit A but pump 18 in unit B is out of action and allows the butane to equilibrate between containers 14 and 15 so that the butane level is the same in both containers as indicated by the line CC. In this phase of operation compressor 27 draws butane vapor from unit A and the vapor condenses on the ice layer that has been deposited in the preceding phase of operation on the spiral sheets 16 and 17. As the ice melts, the water drops down and accumulates below the butane in containers 14 and 15.

When this phase of the operation is completed, the water is drawn off through the valve 20 from unit B.

Witness Henry Reid. Oct 4, 1954

In unit A ice was formed during this phase of the operation on the spiral sheets 4 and 5 and at the end of this phase of operation the sea water is drawn off from unit B through valve 10.

In the next phase of operation butane will evaporate in unit B and will condense in unit A and melt the ice formed there. Before this next phase of operation begins, sea water is let into unit B through valve 19 and the action of the compressor 27 is reversed by opening valves 32 and 31 and closing the valves 29 and 30.

Whenever we shift from one phase of operation to the other, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B and vice versa. After the sweet water and the sea water have been drained off from units A and B, the butane can be drained off from these units across the valves 33 in unit A and 34 in unit B.

In Fig 2. the coils 35,36,37 and 38 represent the evaporator of the auxiliary refrigerator the function of which was discussed in the description of Fig. 1. In place of using these coils for the auxiliary cooling we might use an auxiliary compressor which will suck butane vapor in one phase of the operation (when butane is evaporated in unit A) through the valve 38 out of unit A and compress it so that it condenses in a sea water cooled condenser and the liquid butane re-enters unit A through the valve 39. In the next phase of operation, the valves 38 and 39 are closed and the valves 40 and 41 opened. The auxiliary compressor sucks then butane vapor through the valve 40 from unit B and the condensed butane is returned as a liquid through valve 41 into unit B.

Leo Szilard

Nancy Reid
Witness
October 4, 1954

Corrections and additions to text on pages 4 and 5.

Contrary to what might appear from the foregoing text, it is better to operate unit A and B in such a manner that the sea water level does not rise above the top of the sheet spirals but stops each time a few inches below the top. This way it is easier to maintain the separation between the butane and the sea water, particularly if the period of oscillation of the sea water between containers 1 and 2 is ~~fast~~ short. Also in this way we avoid ice formation in the sea water above the top of the sheet spirals. Accordingly, in Fig 1. the sea water level shown in containers 1 and 14 ought to be lower. Similarly, in Fig 2. the sea water level designated by EE in container 2 ought to be drawn lower and correspondingly the butane level GG in container 2 ought to be drawn lower.

As mentioned on page 5, whenever we shift from one phase of operation to the next one, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B, and vice versa. Fig 3. shows how this can be conveniently accomplished if a plant is composed of several units A and B. In Fig 3. there are a number of units A and B and, in addition, a container designated as 46 and another container 47.

When we shift from a phase of the operation in which the ~~containers~~ units A were used as evaporators and the ~~containers~~ units B as condensers to the next phase of operation, the butane is pumped from the container B, which is adjacent to ~~the~~ container 47, into that container, as indicated by the arrow, and then we pump, as indicated by the arrows, the butane content of each unit into the adjacent unit and finally we pump the butane from container 46, as indicated by the arrow, into the adjacent unit A.

If, however, we shift from a phase of operation in which the units B served as evaporator and the units A served as condensers to the next phase of operation, then we pump the butane content of the last unit B into the adjacent container 46, as indicated by the double arrow, and then pump the butane content of each unit into the adjacent unit and finally, as indicated by the double arrow, we pump the butane content of ~~the~~ container 47 into the adjacent unit A.

It should be noted that in this mode of operation there is no mixing of the butane contained in the adjacent units but each time butane is pumped from a unit into another unit which has been emptied of butane. It should also be noted that container 47 always receives butane which comes from a unit that served as condenser and that container 46 always receives butane from a unit which served as an evaporator. Container 47 can, therefore, be maintained at a higher temperature than container 46 and it is not necessary fully to empty either of them after each phase of operation but they can serve as a reservoir of butane.

With respect to the last paragraph on page 5, instead of saying "In place of using these coils for auxiliary cooling we might use an auxiliary compressor which will suck butane vapor, etc", it is better to say definitely that such an auxiliary compressor is used in place of the coils shown in Fig 2. Further it is of advantage to have the auxiliary compressor suck butane through valve 40 (or 45 and 44) from unit B when this unit is used as the condenser rather than when the unit is used as the evaporator and similarly it is of advantage to let the auxiliary compressor suck butane vapor from unit A through the valve 38 (or the valves 42 and 43) when unit A is used as a condenser rather than when it is used as an evaporator.

This is the end of corrections and additions to pages 4 and 5.

Fig 4. shows a modification of the units shown in Fig 2. In this figure the lower part of unit A is shown on twice the scale of that used in Fig 2. Container 1 and container 2 of unit A are here connected not by middle piece 3 which contains a pump, but simply by a tube 48. Two propellers 49 and 50 driven by the shafts 51 and 52, both pump butane downwards. Depending on which of the two shafts 51 or 52 is driven faster, butane will be driven from container 1 through tube 48 into container 2, or it will be driven from container 2 through tube 48 into container 1. If the shafts 51 and 52 are driven by electric motors and if for a second, or a few seconds, the voltage on the motor driving shaft 51 is kept raised, while the voltage applied to the motor driving shaft 52 is kept lowered, and if subsequently for the next few seconds the voltage on the motor driving shaft 52 is raised and the voltage on the motor driving shaft 51 is lowered, then we will have alternatingly the butane level fall in container 1

Witness having Read Oct 8, 1934 [illegible]

down to just below the level of propeller 49 while it rises correspondingly in container 2 and subsequently fall in container 2 just below the level of propeller 50 while it rises correspondingly in container 1.

The guide piece 53 in container 1 leaves an annular gap free between this guide piece and the wall of container 1 and the propeller 55, which is ~~driven by~~ attached to the shaft 51, drives throughout the whole phase of operation (during which unit A acts as evaporator) butane upward through this annular gap to the top edge of the guide piece where the butane flows into the interior of the guide piece. A perforated plate 57 between the propeller 55 and the top of the spiral 4 in container 1 prevents the turbulence caused by propellers 49 and 55 from propagating into the space within the sheet spiral.

After this phase of operation is completed and during the next phase of operation when unit A serves as condenser and unit B serves as evaporator, the shafts 51 and 52 are kept at a standstill and the corresponding shafts in unit B are kept in rotation.

In place of alternately changing the speed at which we rotate the shaft 51 and 52, it is preferable alternately to change the pitch of propellers 49 and 50. For a second or so, for instance, the pitch of propeller 49 is set in such a manner as to drive the liquid butane downwards, whereas the pitch of propeller 50 is set at zero (i.e. neutral position). Subsequently, propeller 49 is also set in the neutral position and allowed to remain so for a second or so; during this period neither propeller will move any liquid butane. Next the pitch of propeller 50 is set so as to drive the liquid butane downwards while propeller 49 remains in the neutral position and after a second of so propeller 50 is set in the neutral position and propeller 49 is again set in the position where it drives the liquid butane downwards. This completes the cycle which is continuously repeated. If the interval which we assumed here to be one second is long enough each time propeller 49 or propeller 50 may draw the level of the liquid butane layer all the way from its original high position down to the level of the propeller itself but no further than that.

The sheet spiral repeatedly discussed above, which serves as vehicle of heat transfer, may be made of any suitable plastic material. It is of advantage though to make it out of a plastic sheet which is wetted by water, or of copper sheet which is gold plated.

If gold plated copper sheet is used, then there is very little crystal formation in the sea water and ice adheres well to the sheet. Scale can be removed by dipping the sheet spiral into weak acid.

Witness Nancy Reid
Oct 10 - 1954

The fresh water and the brine which are drawn off from the units are allowed to pass into a tank each. These tanks are connected to a compressor which will boil of butane vapor that is dissolved in the aqueous phase. This is a batch operation and the pressure maintained over the aqueous phase will fall off in each phase of operation from the beginning of the phase toward the end of the phase. The pressure is not allowed to drop to the point when the water would boil in the absence of butane.

The butane vapor sucked off is compressed, condensed and allowed to return into the plant.

After the removal of the butane vapor, the sweet water passes through a heat exchanger in counter-current fashion against the incoming sea water, and similarly the brine passes through a heat exchanger in counter-current fashion against the incoming sea water.

Alternatively, the sweet water can go through a heat exchanger in counter-current fabhion against a straight chain hydrocarbon (containing about 10 or more carbon atoms) and this hydrocarbon in turn can pass through a heat exchanger in counter-current fashion against the incoming sea water, and a similar device is used for such indirect heat exchange between the brine and the incoming sea water. Such indirect heat exchange is adequate only if there is physical contact between the hydrocarbon and the aqueous phase. In that case we have a counter-current liquid liquid extraction system in which there is heat exchange between the hydrocarbon and the aqueous phase and at the same time butane dissolved in the aqueous phase will pass into the hydrocarbon phase. The butane taken up by the hydrocarbon can be removed by distillation and returned to the plant.

Leo Szilard

Witness Nancy Reid
Oct 10 - 1954

Corrections and additions to text on pages 4 and 5.

Contrary to what might appear from the foregoing text, it is better to operate unit A and B in such a manner that the sea water level does not rise above the top of the sheet spirals but stops each time a few inches below the top. This way it is easier to maintain the separation between the butane and the sea water, particularly if the period of oscillation of the sea water between containers 1 and 2 is fast. Also in this way we avoid ice formation in the sea water above the top of the sheet spirals. Accordingly, in Fig 1. the sea water level shown in containers 1 and 14 ought to be lower. Similarly, in Fig 2. the sea water level designated by EE in container 2 ought to be drawn lower and correspondingly the butane level GG in container 2 ought to be drawn lower.

As mentioned on page 5, whenever we shift from one phase of operation to the next one, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B, and vice versa. Fig 3. shows how this can be conveniently accomplished if a plant is composed of several units A and B. In Fig 3. there are a number of units A and B and, in addition, a container designated as 46 and another container 47.

When we shift from a phase of the operation in which the containers A were used as evaporators and the containers B as condensers to the next phase of operation, the butane is pumped from container B, which is adjacent to the container 47, into that container as indicated by the arrow and then we pump, as indicated by the arrows, the butane content of each unit into the adjacent unit and finally we pump the butane from container 46, as indicated by the arrow, into the adjacent unit A.

If, however, we shift from a phase of operation in which the unit B served as evaporator and the unit A served as condensers to the next phase of operation, then we pump the butane content of the last unit B into the adjacent container 46 as indicated by the double arrow and then pump the butane content of each unit into the adjacent unit and finally, as indicated by the double arrow, we pump the butane content of the container 47 into the adjacent unit A.

It should be noted that in this mode of operation there is no mixing of the butane contained in the adjacent units but each time butane is pumped from a unit into another unit which has been emptied of butane. It should also be noted that container 47 always receives butane which comes from a unit that served as condenser and that container 46 always receives butane from a unit which served as an evaporator. Container 47 can, therefore, be maintained at a higher temperature than container 46 and it is not necessary fully to empty either of them after each phase of operation but they can serve as a reservoir of butane.

With respect to the last paragraph on page 5, instead of saying "In place of using these coils for auxiliary cooling we might use an auxiliary compressor which will suck butane vapor, etc", it is better to say fefinitely that such an auxiliary compressor is used in place of the coils shown in Fig 2. Further it is of advantage to have the auxiliary compressor suck butane through valve 40 (or 45 and 44) from unit B when this unit is used as the condenser rather than when the unit is used as the evaporator and similarly it is of advantage to let the auxiliary compressor suck butane vapor from unit A through the valve 38 (or the valves 42 and 43) when unit A is used as a condenser rather than whhn it is used as an evaporator.

This is the end of corrections and additions to pages 4 and 5.

Fig 4. shows a modification of the units shown in Fig 2. In this figure the lower part of unit A is shown on twice the scale of that used in Fig 2. Container 1 and container 2 of unit A are here connected not by middle piece 3 which contains a pump, but simply by a tube 48. Two propellers 49 and 50 driven by the shafts 51 and 52, both pump butane downwards. Depending on which of the two shafts 51 or 52 is driven faster, butane will be driven from container 1 through tube 48 into container 2, or it will be driven from container 2 through tube 48 into container 1. If the shafts 51 and 52 are driven by electric motors and if for a second, or a few seconds, the voltage on the motor driving shaft 51 is kept raised, while the voltage applied to the motor driving shaft 52 is kept lowered, and if subsequently for the next few seconds the voltage on the motor driving shaft 52 is raised and the voltage on the motor driving shaft 51 is lowered, then we will have alternatingly the butane level fall in container 1

down to just below the level of propeller 49 while it rises correspondingly in container 2 and subsequently fall in container 2 just below the level of propeller 50 while it rises correspondingly in container 1.

The guide piece 53 in container 1 leaves an annular gap free between this guide piece and the wall of container 1 and the propeller 55, which is driven by the shaft 51, drives throughout the whole phase of operation during which unit A acts as evaporator butane upward through this annular gap to the top edge of the guide piece where the butane flows into the interior of the guide piece. A perforated plate 57 between the propeller 55 and the top of the spiral 4 in container 1 prevents the turbulence caused by propellers 49 and 55 from propagating into the space within the sheet spiral.

After this phase of operation is completed and during the next phase of operation when unit A serves as condenser and unit B serves as evaporator, the shafts 51 and 52 are kept at a standstill and the corresponding shafts in unit B are kept in rotation.

In place of alternately changing the speed at which we rotate the shaft 51 and 52, it is preferable alternately to change the pitch of propellers 49 and 50. For a second or so, for instance, the pitch of propeller 49 is set in such a manner as to drive the liquid butane downwards, whereas the pitch of propeller 50 is set at zero (i.e. neutral position). Subsequently, propeller 49 is also set in the neutral position and allowed to remain so for a second or so, during this period neither propeller will move any liquid butane. Next the pitch of propeller 50 is set so as to drive the liquid butane downwards while propeller 49 remains in the neutral position and after a second of so propeller 50 is set in the neutral position and propeller 49 is again set in the position where it drives the liquid butane downwards. This completes the cycle which is continuously repeated. If the interval which we assumed here to be one second is long enough each time propeller 49 or propeller 50 may draw the level of the liquid butane layer all the way from its original high position down to the level of the propeller itself but no further than that.

The sheet spiral repeatedly discussed above,which serves as vehicle of heat transfer, may be made of any suitable plastic material. It is of advantage though to make it out of a plastic sheet which is wetted by water, or of copper sheet which is gold plated.

If gold plated copper sheet is used, then there is very little crystal formation in the sea water and ice adheres well to the sheet. Scale can be removed by dipping the sheet spiral into weak acid.

The fresh water and the brine which are drawn off from the units are allowed to pass into a tank each. These tanks are connected to a compressor which will boil of butane vapor that is dissolved in the aqueous phase. This is a batch operation and the pressure maintained over the aqueous phase will fall off in each phase of operation from the beginning of the phase toward the end of the phase. The pressure is not allowed to drop to the point when the water would boil in the absence of butane.

The butane vapor sucked off is compressed, condensed and allowed to return into the plant.

After the removal of the butane vapor, the sweet water passes through a heat exchanger in counter-current fashion against the incoming sea water, and similarly the brine passes through a heat exchanger in counter-current fashion against the incoming sea water.

Alternatively, the sweet water can go through a heat exchanger in counter-current fabhion against a straight chain hydrocarbon (containing about 10 or more carbon atoms) and this hydrocarbon in turn can pass through a heat exchanger in counter-current fashion against the incoming sea water, and a similar device is used for such indirect heat exchange between the brine and the incoming sea water. Such indirect heat exchange is adequate only if there is physical contact between the hydrocarbon and the aqueous phase. In that case we have a counter-current liquid liquid extraction system in which there is heat exchange between the hydrocarbon and the aqueous phase and at the same time butane dissolved in the aqueous phase will pass into the hydrocarbon phase. The butane taken up by the hydrocarbon can be removed by distillation and returned to the plant.

PROCESS AND APPARATUS FOR DE-SALTING SEA WATER

This invention relates to the de-salting of sea water by freezing.

Fig 1. shows one example embodying one of the features of the invention. In this figure container 1 and container 2 commmnicate through the middle piece 3 and (in the first phase of the batch process) sea water is alternately moved by means of a pump located in the middle piece 3 from container 1 to container 2 and visa versa. These two movements alternate every few seconds. In container 1 there is located a sheet made of plastic or some other suitable material which is coiled up in the form of a spiral, that is co-axial with the container 1. Subsequent turns of the sheets are spaced a few milimetres apart. A similar spiral 5 is located in container 2.

The sea water level in the two containers is made to oscillate between two extreme positions, one in which the level in container 1 roughly coincides with the top of sheet spiral 4 and the level in container 2 roughly coincides with the bottom of sheet spiral 5 and another position in which the level in container 1 roughly coincides with the bottom of sheet spiral 4 and the top in container 2 roughly coincides with the top of sheet spiral 5.

On top of the sea water in containers 1 and 2 each there floats a layer of a liquid which is non-missoble with water. For instance a layer of straignt-chain hydrobarbon one containing about 10 to 12 carbon atoms for instance. The depth of these layers is somewhat larger than the height of the spirals 4 and 5. The hydrobarbon layer 6 in container 1 is cooled by coil 7 which represents the evaporater of a refrigerater and similarly the hydrocarbon layer 8 is cooled by coil 9 which represents the evaporater of the same refrigerater.

As the sea water is moved back and forth between the two containers 1 and 2, the cooled hydrocarbon follows the sea water level in its movement axially through spirals 4 and 5. As the sea water level moves axially downward through spiral 4, the hydrocarbon also moves axially downward through the spiral and cools the sheet spiral. As the motion is reversed and the sea water moves axially upward through spiral 4 it is now cooled by the sheet spiral so that a thin layer of ice is deposited on the spiral sheet. The same thing happens in spiral 5 in container 2. In this manner layer upon layer of ice is deposited on the spiral sheets.

After an amount of ice has been formed which corresponds to say 1/3 or 2/3 of the amount of sea water in the container, the sea water is drained off through valve 10 and fresh water is admitted in its place through valve 11.

In the second phase of the batch process, the fresh water is now moved back and forth between the two containers with the hydrocarbon layers floating on the top of the fresh water columns. These hydrocarbon layers are warmed by the coils 12 and 13 which represent the condensers of a refrigerater. In this manner the ice layer deposited on the spiral sheets 4 and 5 is molten. After a period long enough to permit the melting of all the ice, the resh water is drained off through valve 11 and sea water is admitted in its place and the cycle begins again.

Fig 1-B is an apparatus identical with that shown in Fig 1-A and the two are connected in the following manner. The coil 21 in container 14 represents the evaporater of the same refrigerater of which 13 represents the condenser and the coil 22 represents the condenser of the same refrigerater of which 9 represents the evaporater. The coil 23 represents the evaporater of the same refrigerater of which 12 represents the condenser and the coil 24 represents the condenser of the same refrigerater of which the coil 7 represents the evaporater. The two machines, the one represented in Fig 1-A and the other represented in Fig 1-B always work in opposite phase. When sea water is frozen in the first machine, ice is molten in the second machine. During this phase the coils in the first machine connected to the evaporaters are in action and the coils representing the condensers are shut off, while in the second machine the coils representing the condensers are in action and the evaporaters are shut off. In the next phase when in machine B there is sea water and ice is formed and in machine A there is fresh water and ice is molten, in machine A the condensers are in action and the evaporaters are shut off, while in machine B the evaporaters are in action and the condensers are shut off.

25 and 26 are cooling coils connected with the evaporater of an auxiliary refrigerater which lifts enough heat from the temperature at which freezing units A and B operate to the temperature of the sea(the condenser of this auxiliary refrigerater is cooled by sea water) to maintain the freezing units at low temperature. This auxiliary refrigerater is much smaller than the refrigeraters which move heat between the two units A and B.

The temperature difference between hydrocarbon layers in unit A and B might be around 15° centigrade in onde direction or the other depending on the phase of the batch operation. Whereas the auxiliary refrigerater which either cools unit A through the coil 25 or unit B through the coil 24, has to lift heat from about -10° centigrade to the temperature of the sea water.

The apparatus shown in Fig 2 idffers from that shown in Fig 1. in the following respects. Here the hydrocarbon which is used to cool or heat the spiral sheets are cooled or heated directly by being evaporated or condensed right inside the units A and B. In this case pantan or butan may be used as the hydrocarbon (rather than one of the heavier hydrocarbons).

In one phase of the operation when the unit A freezes and the unit B melts ice the compressor 27 draws butan vapor from the unit A where butan evaporates and pushes into the unit B where the butan condenses. In the opposite phase of the operation when unit B freezes and unit A melts ice, the action of the compressor is reversed, butan is evaporated in unit B and is condensed in unit A. An auxiliary refrigerater is provided here the same way as in the case of the operation described in connection with Fig 1.

(In place of butane, either pentane or propane may be used as a refrigerant).

As may be seen from Fig 2. when the valves 29 and 30 are open, while the valves 31 and 32 are closed, compressor 27 draws butane vapor from the unit A and pushes it into unit B. When this phase of the operation is terminated and the valves 29 and 30 are closed and the valves 31 and 32 are opened, then compressor 27 draws butane vapor from unit B and pushes it into unit A.

During the first phase of the operation, unit A contains sea water which is moved back and forth between container 1 and container 2 through the action of pump 3. When the sea water level stands at the lowest in container 1 and at the highest in container 2, its level is shown in Fig 2. by the line FF in container 1 and the line EE in container 2. The sea water level is then just below the bottom of the sheet spiral 4 and just above the top of the sheet spiral 5. The butane level in container 1 is shown by the line DD and in container 2 by the line GG. In this position the depth of the butane layer on top of sheet spiral 4 is perhaps 1/3 or 1/2 of the height of the sheet spiral 4 itself.

Prior to the onset of this phase of operation, all the sea water was withdrawn from unit B and no fresh water was pumped into unit B to replace the sea water and the butane level in unit B is indicated by the lines CC in Fig 2. The butane level is thus below the lower end of the sheet spiral leaving a gap that has a height of perhaps 1/2 of the height of the sheet spirals 16 and 17.

In this phase of operation pump 3 moves the sea water back and forth between containers 1 and 2 in unit A but pump 18 in unit B is out of action and allows the butane to equilibrate between containers 14 and 15 so that the butane level is the same in both containers as indicated by the line CC. In this phase of operation compressor 27 draws butane vapor from unit A and the vapor condenses on the ice layer that has been deposited in the preceding phase of operation on the spiral sheets 16 and 17. As the ice melts, the water drops down and accumulates below the butane in containers 14 and 15.

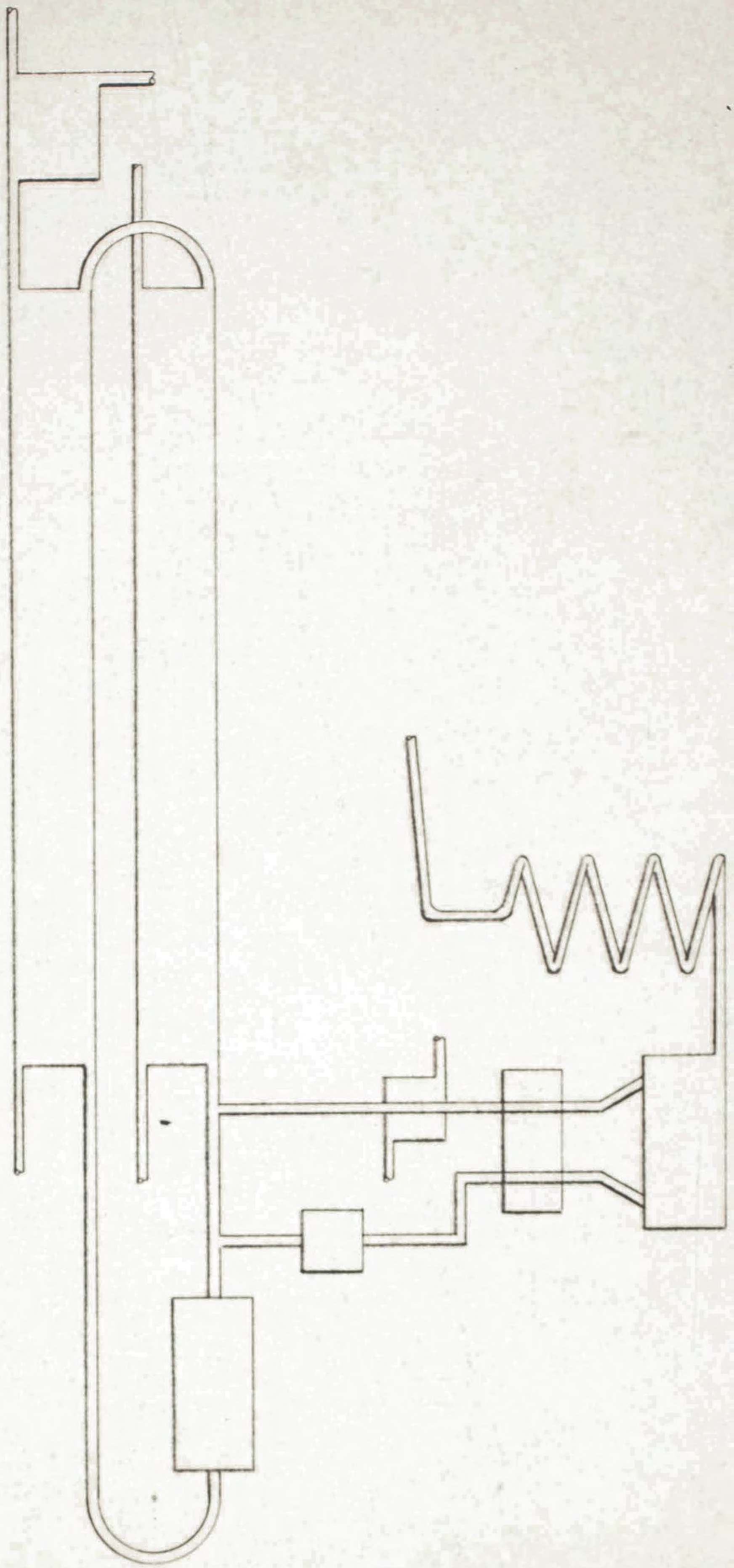
When this phase of the operation is completed, the water is drawn off through the valve 20 from unit B.

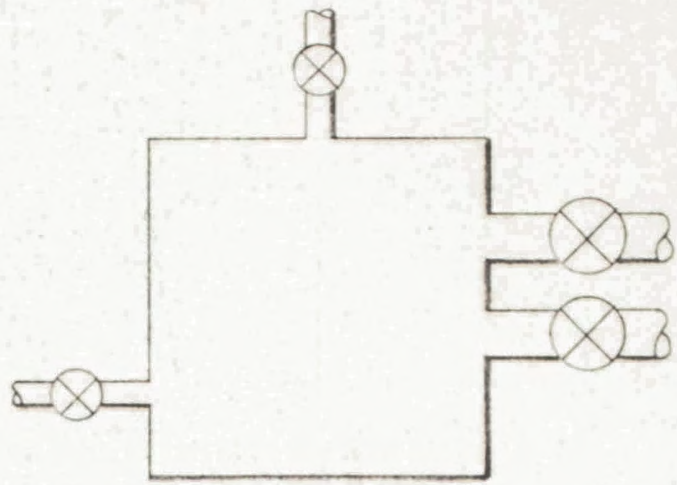
In unit A ice was formed during this phase of the operation on the spiral sheets 4 and 5 and at the end of this phase of operation the sea water is drawn off from unit B through valve 10.

In the next phase of operation butane will evaporate in unit B and will condense in unit A and melt the ice formed there. Before this next phase of operation begins, sea water is let into unit B through valve 19 and the action of the compressor 27 is reversed by opening valves 32 and 31 and closing the valves 29 and 30.

Whenever we shift from one phase of operation to the other, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B and vice versa. After the sweet water and the sea water have been drained off from units A and B, the butane can be drained off from these units across the valves 33 in unit A and 34 in unit B.

In Fig 2. the coils 35,36,37 and 38 represent the evaporator of the auxiliary refrigerator the function of which was discussed in the description of Fig. 1. In place of using these coils for the auxiliary cooling we might use an auxiliary compressor which will suck butane vapor in one phase of the operation (when butane is evaporated in unit A) through the valve 38 out of unit A and compress it so that it condenses in a sea water cooled condenser and the liquid butane re-enters unit A through the valve 39. In the next phase of operation, the valves 38 and 39 are closed and the valves 40 and 41 opened. The auxiliary compressor sucks then butane vapor through the valve 40 from unit B and the condensed butane is returned as a liquid through valve 41 into unit B.





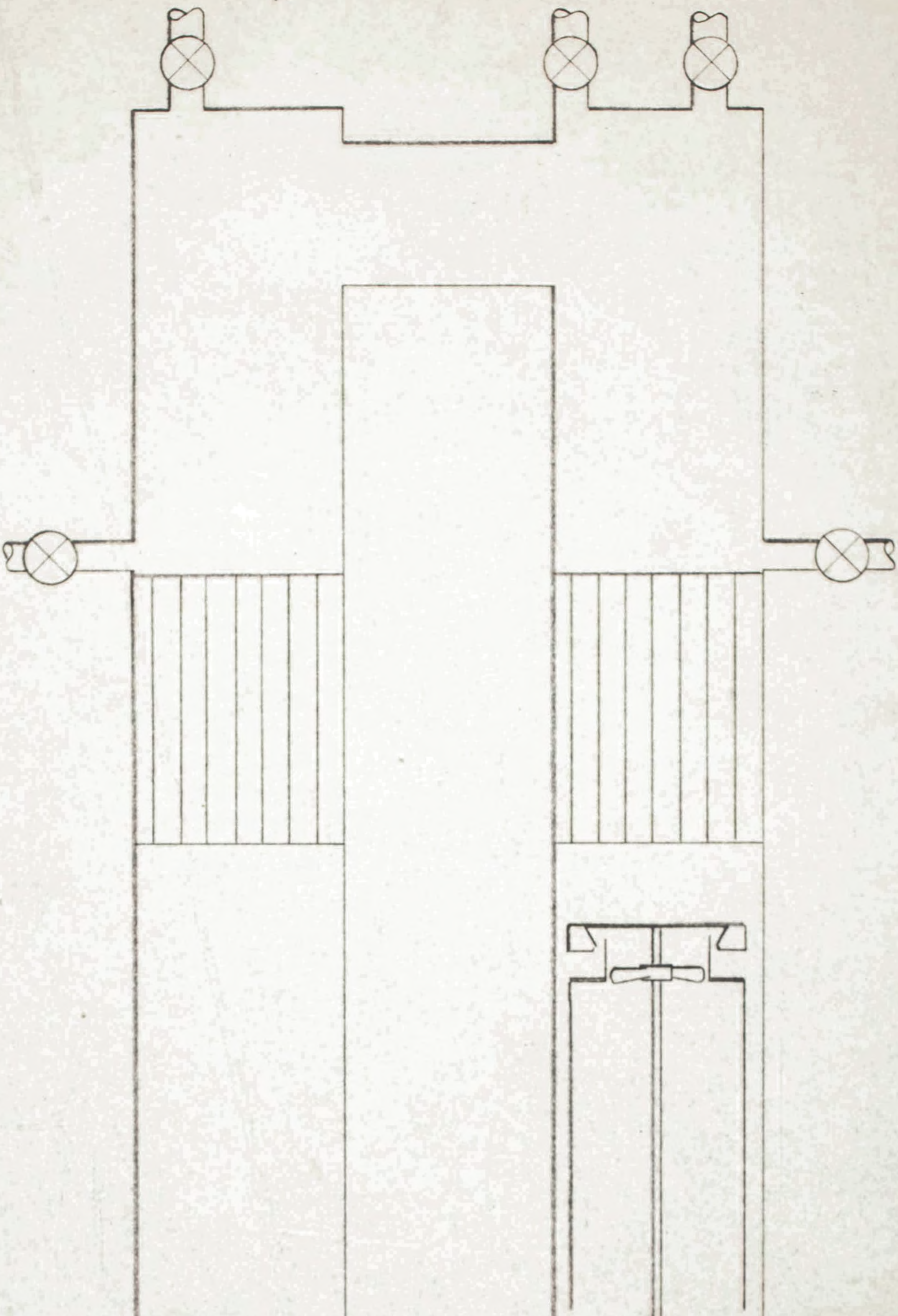


Fig 2

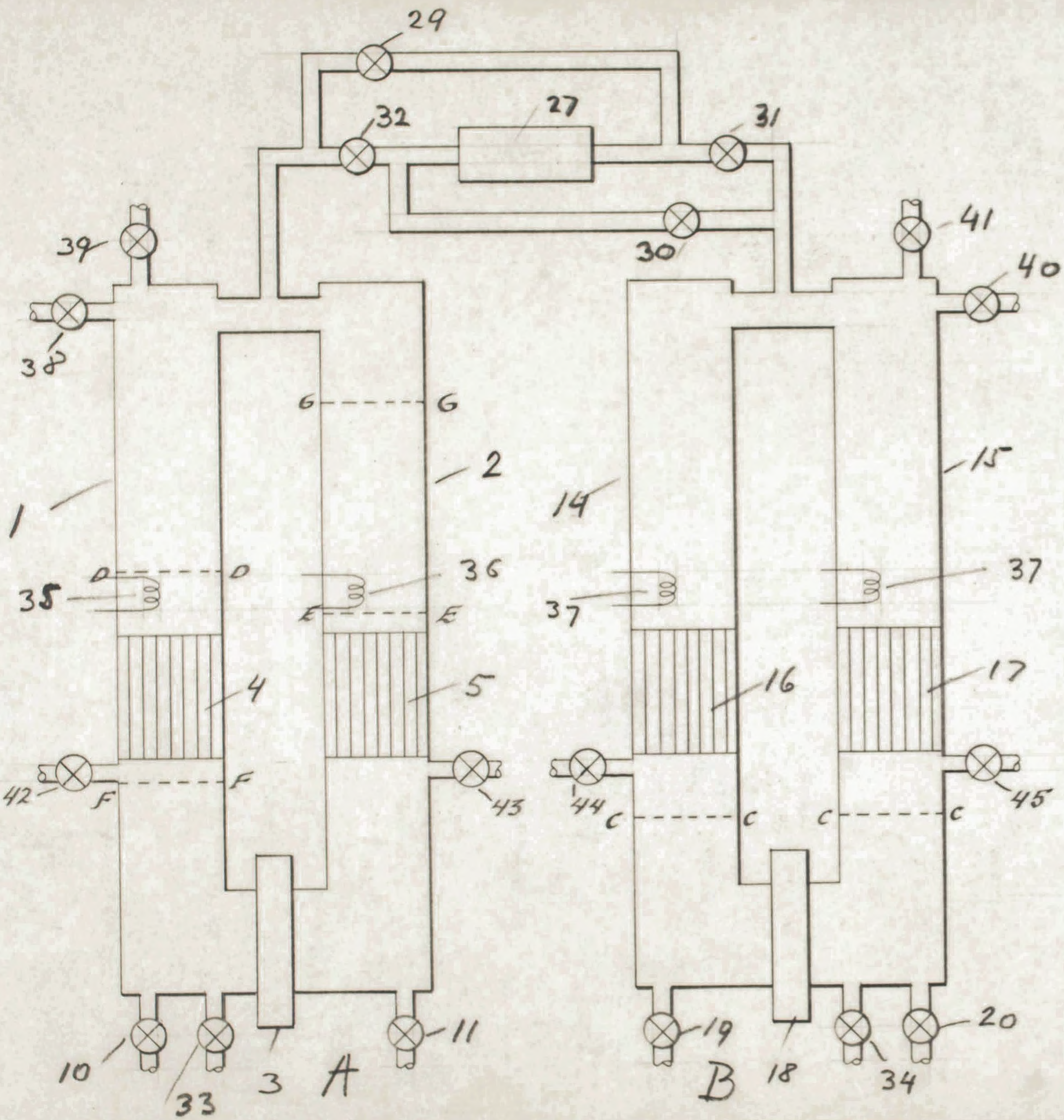

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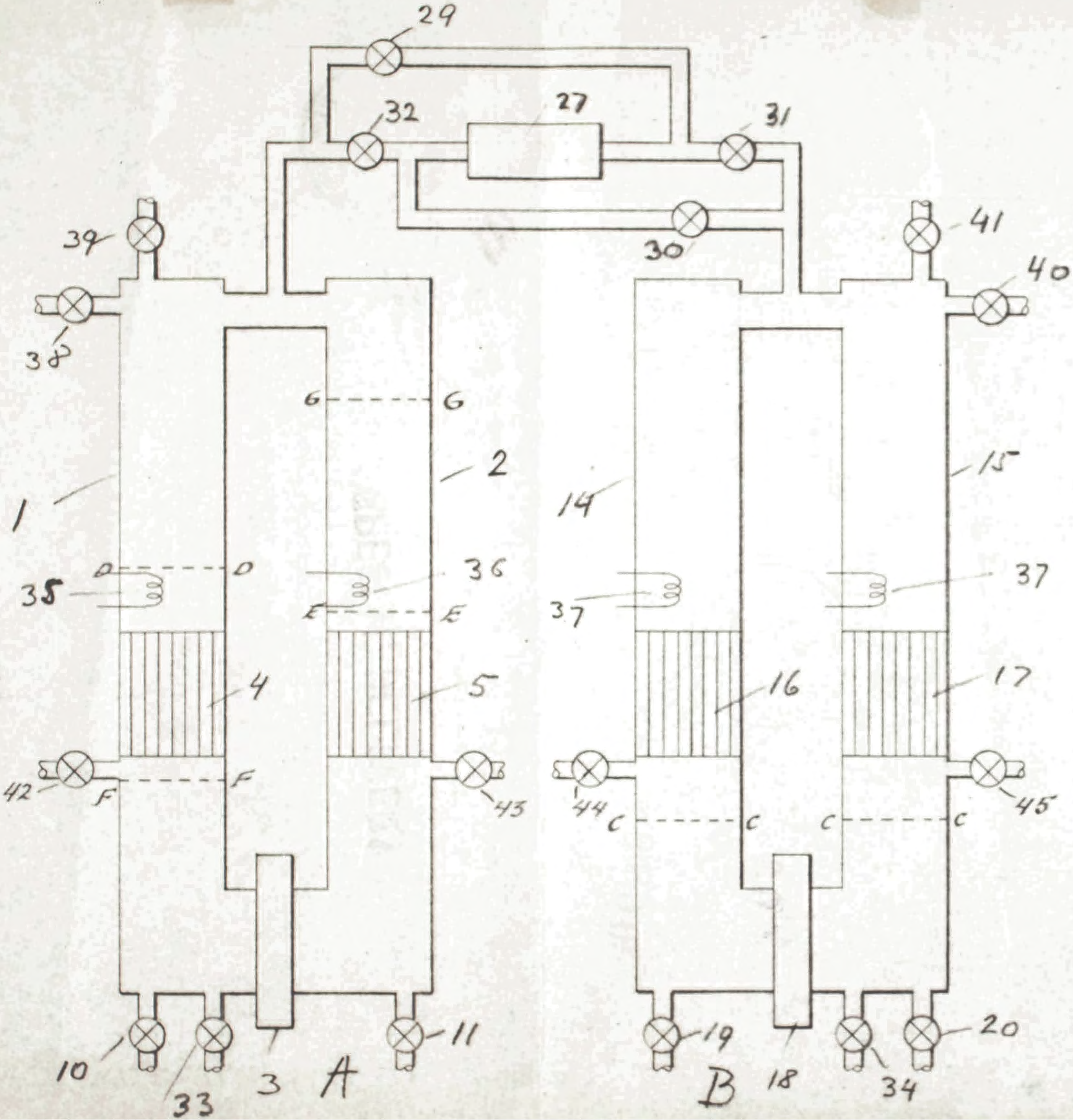
Fig 2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904

PROCESS AND APPARATUS FOR DE-SALTING SEA WATER

This invention relates to the de-salting of sea water by freezing.

Fig 1. shows one example embodying one of the features of the invention. In this figure container 1 and container 2 communicate through the middle piece 3 and (in the first phase of the batch process) sea water is alternately moved by means of a pump located in the middle piece 3 from container 1 to container 2 and visa versa. These two movements alternate every few seconds. In container 1 there is located a sheet made of plastic or some other suitable material which is coiled up in the form of a spiral, that is co-axial with the container 1. Subsequent turns of the sheets are spaced a few milimetres apart. A similar spiral 5 is located in container 2.

The sea water level in the two containers is made to oscillate between two extreme positions, one in which the level in container 1 roughly coincides with the top of ~~sheet~~ spiral 4 and the level in container 2 roughly coincides with the bottom of ~~sheet~~ spiral 5 and another position in which the level in container 1 roughly coincides with the bottom of ~~sheet~~ spiral 4 and the top in container 2 roughly coincides with the top of ~~sheet~~ spiral 5.

On top of the sea water in containers 1 and 2 each there floats a layer of a liquid which is non-missable with water. For instance a layer of straight-chain hydrobarbon (one containing about 10 to 12 carbon atoms for instance). The depth of these layers is somewhat larger than the height of the spirals 4 and 5. The hydrocarbon layer 6 (in container 1) is cooled by coil 7 which represents the evaporater of a refrigerater and similarly the hydrocarbon layer 8 (in container 2) is cooled by coil 9 which represents the evaporater of the same refrigerater.

As the sea water is moved back and forth between the two containers 1 and 2, the cooled hydrocarbon layer follows the sea water level in its movement axially through spirals 4 and 5. As the sea water level moves axially downward through spiral 4, the

Witness Nancy Reid Sept 30, 1954

N. Reid
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PROCESS AND APPARATUS FOR DE-SALTING SEA WATER

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hydrocarbon layer also moves axially downward through the spiral and cools the sheet spiral. As the motion is reversed and the sea water moves axially upward through spiral 4 it is now cooled by the sheet spiral so that a thin layer of ice is deposited on the ~~spiral~~ sheet. The same thing happens in spiral 5 in container 2. In this manner layer upon layer of ice is deposited on the spiral sheets.

After an amount of ice has been formed which corresponds to say 1/3 ~~or~~ to 2/3 of the amount of sea water in the container, the sea water is drained off through valve 10 and fresh water is admitted in its place through valve 11.

In the second phase of the batch process, the fresh water is now moved back and forth between the two containers with the hydrocarbon layers floating on the top of the fresh water columns. These hydrocarbon layers are warmed by the coils 12 and 13 which represent the condensers of a refrigerater. In this manner the ice layer deposited on the spiral sheets 4 and 5 is molten. After a period long enough to permit the melting of all the ice, the fresh water is drained off through valve 11, ~~and~~ sea water is admitted in its place through valve 10 and the cycle begins again.

Fig 1-B is an apparatus identical with that shown in Fig 1-A and the two are connected in the following manner. The coil 21 in container 14 represents the evaporater of the same refrigerater of which 13 represents the condenser and the coil 22 represents the condenser of the same refrigerater of which 9 represents the evaporater. The coil 23 represents the evaporater of the same refrigerater of which 12 represents the condenser and the coil 24 represents the condenser of the same refrigerater of which the coil 7 represents the evaporater. The two machines, the one represented in Fig 1-A and the other represented in Fig 1-B always work in opposite phase. When sea water is frozen in the first machine, ice is molten in the second machine. During this phase the coils in the first machine ~~connected to~~ representing the evaporaters are in action and the coils representing the condensers are shut off, while in the second machine the coils representing the condensers are in action and the evaporaters are shut off. In the next phase, when in machine B there is sea water

Leo Szilard

Witness Nancy Reid
Sept 30 - 1954

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Witness Nancy Reil
Sept 30 - 1954

and ice is formed and in machine A there is fresh water and ice is molten, then in machine A the condensers are in action and the evaporaters are shut off, while in machine B the evaporaters are in action and the condensers are shut off.

25 and 26 are cooling coils connected with the evaporater of an auxiliary refrigerater which lifts enough heat from the temperature at which freezing units A and B operate to the temperature of the sea(the condenser of this auxiliary refrigerater is cooled by sea water) to maintain ~~the freezing~~ units A and B at low temperature. This auxiliary refrigerater is much smaller than the refrigeraters which move heat between the two units A and B.

The temperature difference between the hydrocarbon layers in unit A and B might be around 15° centigrade in onde direction or the other depending on the phase of the batch operation. Whereas the auxiliary refrigerater which either cools unit A through the coil 25 or unit B through the coil 24, has to lift heat from about -10° centigrade to the temperature of the sea water.

The apparatus shown in Fig 2 differs from that shown in Fig 1. in the following respects. Here the hydrocarbon which is used to cool or heat the spiral sheets are cooled or heated directly by being evaporated or condensed right inside the units A and B. In this case ~~pentane or~~ butan (or pentane) may be used as the hydrocarbon (rather than one of the heavier hydrocarbons).

In one phase of the operation when the unit A freezes and the unit B melts ice the compressor 27 draws butan vapor from the unit A where butan evaporates and pushes into the unit B where the butan condenses. In the opposite phase of the operation when unit B freezes and unit A melts ice, the action of the compressor is reversed, butan is evaporated in unit B and is condensed in unit A. An auxiliary refrigerater is provided here the same way as in the case of the operation described in connection with Fig 1.

Leo Szilard

Witness:
Nancy Reid

Sept 30th - 1954

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Leo Szilard

Witness
Nancy Reid

Sept 30th - 1954

(In place of butane, either pentane or propane may be used as a refrigerant).

As may be seen from Fig 2. when the valves 29 and 30 are open, while the valves 31 and 32 are closed, compressor 27 draws butane vapor from the unit A and pushes it into unit B. When this phase of the operation is terminated and the valves 29 and 30 are closed and the valves 31 and 32 are opened, then compressor 27 draws butane vapor from unit B and pushes it into unit A.

During the first phase of the operation, unit A contains sea water which is moved back and forth between container 1 and container 2 through the action of pump 3. When the sea water level stands at the lowest in container 1 and at the highest in container 2, its level is shown in Fig 2. by the line FF in container 1 and the line EE in container 2. The sea water level is then just below the bottom of the sheet spiral 4 and just above the top of the sheet spiral 5. The butane level in container 1 is shown by the line DD and in container 2 by the line GG. In this position the depth of the butane layer on top of sheet spiral 4 is perhaps 1/3 or 1/2 of the height of the sheet spiral 4 itself.

Prior to the onset of this phase of operation, all the sea water was withdrawn from unit B and no fresh water was pumped into unit B to replace the sea water and the butane level in unit B is indicated by the lines CC in Fig 2. The butane level is thus below the lower end of the sheet spiral leaving a gap that has a height of perhaps 1/2 of the height of the sheet spirals 16 and 17.

In this phase of operation pump 3 moves the sea water back and forth between containers 1 and 2 in unit A but pump 18 in unit B is out of action and allows the butane to equilibrate between containers 14 and 15 so that the butane level is the same in both containers as indicated by the line CC. In this phase of operation compressor 27 draws butane vapor from unit A and the vapor condenses on the ice layer that has been deposited in the preceding phase of operation on the spiral sheets 16 and 17. As the ice melts, the water drops down and accumulates below the butane in containers 14 and 15.

When this phase of the operation is completed, the water is drawn off through the valve 20 from unit B.

Witness Henry Reid
Oct 4, 1954

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When this phase of the operation is completed, the water is drawn off through the valve 20 from unit B.

In unit A ice was formed during this phase of the operation on the spiral sheets 4 and 5 and at the end of this phase of operation the sea water is drawn off from unit B through valve 10.

In the next phase of operation butane will evaporate in unit B and will condense in unit A and melt the ice formed there. Before this next phase of operation begins, sea water is let into unit B through valve 19 and the action of the compressor 27 is reversed by opening valves 32 and 31 and closing the valves 29 and 30.

Whenever we shift from one phase of operation to the other, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B and vice versa. After the sweet water and the sea water have been drained off from units A and B, the butane can be drained off from these units across the valves 33 in unit A and 34 in unit B.

In Fig 2. the coils 35,36,37 and 38 represent the evaporator of the auxiliary refrigerator the function of which was discussed in the description of Fig. 1. In place of using these coils for the auxiliary cooling we might use an auxiliary compressor which will suck butane vapor in one phase of the operation (when butane is evaporated in unit A) through the valve 38 out of unit A and compress it so that it condenses in a sea water cooled condenser and the liquid butane re-enters unit A through the valve 39. In the next phase of operation, the valves 38 and 39 are closed and the valves 40 and 41 opened. The auxiliary compressor sucks then butane vapor through the valve 40 from unit B and the condensed butane is returned as a liquid through valve 41 into unit B.

Nancy Reid
Witness
October 4, 1954

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Nancy Reid
Witness
October 4, 1954

Corrections and additions to text on pages 4 and 5.

Contrary to what might appear from the foregoing text, it is better to operate unit A and B in such a manner that the sea water level does not rise above the top of the sheet spirals but stops each time a few inches below the top. This way it is easier to maintain the separation between the butane and the sea water, particularly if the period of oscillation of the sea water between containers 1 and 2 is ~~fast~~ short. Also in this way we avoid ice formation in the sea water above the top of the sheet spirals. Accordingly, in Fig 1. the sea water level shown in containers 1 and 14 ought to be lower. Similarly, in Fig 2. the sea water level designated by EE in container 2 ought to be drawn lower and correspondingly the butane level GG in container 2 ought to be drawn lower.

As mentioned on page 5, whenever we shift from one phase of operation to the next one, it is of advantage to drain off the butane from unit A and unit B and pump the butane which was in unit A into unit B, and vice versa. Fig 3. shows how this can be conveniently accomplished if a plant is composed of several units A and B. In Fig 3. there are a number of units A and B and, in addition, a container designated as 46 and another container 47.

When we shift from a phase of the operation in which the ~~containers~~ units A were used as evaporators and the ~~containers~~ units B as condensers to the next phase of operation, the butane is pumped from the container B, which is adjacent to ~~the~~ container 47, into that container, as indicated by the arrow, and then we pump, as indicated by the arrows, the butane content of each unit into the adjacent unit and finally we pump the butane from container 46, as indicated by the arrow, into the adjacent unit A.

If, however, we shift from a phase of operation in which the units B served as evaporator and the units A served as condensers to the next phase of operation, then we pump the butane content of the last unit B into the adjacent container 46, as indicated by the double arrow, and then pump the butane content of each unit into the adjacent unit and finally, as indicated by the double arrow, we pump the butane content of ~~the~~ container 47 into the adjacent unit A.

Submitted [illegible] Oct 8 1954 Leo Szilard

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Corrections and additions to text on pages 4 and 5.

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It should be noted that in this mode of operation there is no mixing of the butane contained in the adjacent units but each time butane is pumped from a unit into another unit which has been emptied of butane. It should also be noted that container 47 always receives butane which comes from a unit that served as condenser and that container 46 always receives butane from a unit which served as an evaporator. Container 47 can, therefore, be maintained at a higher temperature than container 46 and it is not necessary fully to empty either of them after each phase of operation but they can serve as a reservoir of butane.

With respect to the last paragraph on page 5, instead of saying "In place of using these coils for auxiliary cooling we might use an auxiliary compressor which will suck butane vapor, etc", it is better to say definitely that such an auxiliary compressor is used in place of the coils shown in Fig 2. Further it is of advantage to have the auxiliary compressor suck butane through valve 40 (or 45 and 44) from unit B when this unit is used as the condenser rather than when the unit is used as the evaporator and similarly it is of advantage to let the auxiliary compressor suck butane vapor from unit A through the valve 38 (or the valves 42 and 43) when unit A is used as a condenser rather than when it is used as an evaporator.

This is the end of corrections and additions to pages 4 and 5.

Fig 4. shows a modification of the units shown in Fig 2. In this figure the lower part of unit A is shown on twice the scale of that used in Fig 2. Container 1 and container 2 of unit A are here connected not by middle piece 3 which contains a pump, but simply by a tube 48. Two propellers 49 and 50 driven by the shafts 51 and 52, both pump butane downwards. Depending on which of the two shafts 51 or 52 is driven faster, butane will be driven from container 1 through tube 48 into container 2, or it will be driven from container 2 through tube 48 into container 1. If the shafts 51 and 52 are driven by electric motors and if for a second, or a few seconds, the voltage on the motor driving shaft 51 is kept raised, while the voltage applied to the motor driving shaft 52 is kept lowered, and if subsequently for the next few seconds the voltage on the motor driving shaft 52 is raised and the voltage on the motor driving shaft 51 is lowered, then we will have alternatingly the butane level fall in container 1

Witness Harry Reis Oct 8, 1954 Leo Szilard

It should be noted that in this mode of operation there is no mixing of the butane contained in the adjacent units but each time butane is pumped from a unit into another unit which has been emptied of butane. It should also be noted that container 47 always receives butane which comes from a unit that served as condenser and that container 46 always receives butane from a unit which served as an evaporator. Container 47 can, therefore, be maintained at a higher temperature than container 46 and it is not necessary fully to empty either of them after each phase of operation but they can serve as a reservoir of butane.

With respect to the last paragraph on page 5, instead of saying "In place of using these coils for auxiliary cooling we might use an auxiliary compressor which will suck butane vapor, etc", it is better to say definitely that such an auxiliary compressor is used in place of the coils shown in Fig 2. Further it is of advantage to have the auxiliary compressor suck butane through valve 40 (or 45 and 44) from unit B when this unit is used as the condenser rather than when the unit is used as the evaporator and similarly it is of advantage to let the auxiliary compressor suck butane vapor from unit A through the valve 38 (or the valves 42 and 43) when unit A is used as a condenser rather than when it is used as an evaporator.

This is the end of corrections and additions to pages 4 and 5.

Fig 4. shows a modification of the units shown in Fig 2. In this figure the lower part of unit A is shown on twice the scale of that used in Fig 2. Container 1 and container 2 of unit A are here connected not by middle piece 3 which contains a pump, but simply by a tube 48. Two propellers 49 and 50 driven by the shafts 51 and 52, both pump butane downwards. Depending on which of the two shafts 51 or 52 is driven faster, butane will be driven from container 1 through tube 48 into container 2, or it will be driven from container 2 through tube 48 into container 1. If the shafts 51 and 52 are driven by electric motors and if for a second, or a few seconds, the voltage on the motor driving shaft 51 is kept raised, while the voltage applied to the motor driving shaft 52 is kept lowered, and if subsequently for the next few seconds the voltage on the motor driving shaft 52 is raised and the voltage on the motor driving shaft 51 is lowered, then we will have alternatingly the butane level fall in container 1

Witness Nancy Rice Oct 8, 1954 Leo Szilard

down to just below the level of propeller 49 while it rises correspondingly in container 2 and subsequently fall in container 2 just below the level of propeller 50 while it rises correspondingly in container 1.

The guide piece 53 in container 1 leaves an annular gap free between this guide piece and the wall of container 1 and the propeller 55, which is ~~driven by~~ attached to the shaft 51, drives throughout the whole phase of operation (during which unit A acts as evaporator) butane upward through this annular gap to the top edge of the guide piece where the butane flows into the interior of the guide piece. A perforated plate 57 between the propeller 55 and the top of the spiral 4 in container 1 prevents the turbulence caused by propellers 49 and 55 from propagating into the space within the sheet spiral.

After this phase of operation is completed and during the next phase of operation when unit A serves as condenser and unit B serves as evaporator, the shafts 51 and 52 are kept at a standstill and the corresponding shafts in unit B are kept in rotation.

[illegible] with two drawings [illegible] Oct 8, 1954

down to just below the level of propeller 49 while it rises correspondingly in container 2 and subsequently fall in container 2 just below the level of propeller 50 while it rises correspondingly in container 1.

The guide piece 53 in container 1 leaves an annular gap free between this guide piece and the wall of container 1 and the propeller 55, which is ~~driven by~~ attached to the shaft 51, drives throughout the whole phase of operation (during which unit A acts as evaporator) butane upward through this annular gap to the top edge of the guide piece where the butane flows into the interior of the guide piece. A perforated plate 57 between the propeller 55 and the top of the spiral 4 in container 1 prevents the turbulence caused by propellers 49 and 55 from propagating into the space within the sheet spiral.

After this phase of operation is completed and during the next phase of operation when unit A serves as condenser and unit B serves as evaporator, the shafts 51 and 52 are kept at a standstill and the corresponding shafts in unit B are kept in rotation.

[illegible] Rec'd Oct 8, 1954

In place of alternately changing the speed at which we rotate the shaft 51 and 52, it is preferable alternately to change the pitch of propellers 49 and 50. For a second or so, for instance, the pitch of propeller 49 is set in such a manner as to drive the liquid butane downwards, whereas the pitch of propeller 50 is set at zero (i.e. neutral position). Subsequently, propeller 49 is also set in the neutral position and allowed to remain so for a second or so; during this period neither propeller will move any liquid butane. Next the pitch of propeller 50 is set so as to drive the liquid butane downwards while propeller 49 remains in the neutral position and after a second of so propeller 50 is set in the neutral position and propeller 49 is again set in the position where it drives the liquid butane downwards. This completes the cycle which is continuously repeated. If the interval which we assumed here to be one second is long enough each time propeller 49 or propeller 50 may draw the level of the liquid butane layer all the way from its original high position down to the level of the propeller itself but no further than that.

The sheet spiral repeatedly discussed above, which serves as vehicle of heat transfer, may be made of any suitable plastic material. It is of advantage though to make it out of a plastic sheet which is wetted by water, or of copper sheet which is gold plated.

If gold plated copper sheet is used, then there is very little crystal formation in the sea water and ice adheres well to the sheet. Scale can be removed by dipping the sheet spiral into weak acid.

Witness Nancy Reid
Oct 10 - 1954

26592

NEW YORK, N.Y. MANHATTANVILLE STA. REC'D.
OCT 12 6 AM 1954

NEW YORK N.Y.
OCT 12 1:30 AM
G.P.O.

N. Reid
c/o Mc Culloch
315 W 57th St
New York 19

Special Delivery

Dr Leo Szilard
Kings Crown Hotel
420 W. 116th St
New York 29
N Y

In place of alternately changing the speed at which we rotate the shaft 51 and 52, it is preferable alternately to change the pitch of propellers 49 and 50. For a second or so, for instance, the pitch of propeller 49 is set in such a manner as to drive the liquid butane downwards, whereas the pitch of propeller 50 is set at zero (i.e. neutral position). Subsequently, propeller 49 is also set in the neutral position and allowed to remain so for a second or so; during this period neither propeller will move any liquid butane. Next the pitch of propeller 50 is set so as to drive the liquid butane downwards while propeller 49 remains in the neutral position and after a second of so propeller 50 is set in the neutral position and propeller 49 is again set in the position where it drives the liquid butane downwards. This completes the cycle which is continuously repeated. If the interval which we assumed here to be one second is long enough each time propeller 49 or propeller 50 may draw the level of the liquid butane layer all the way from its original high position down to the level of the propeller itself but no further than that.

The sheet spiral repeatedly discussed above, which serves as vehicle of heat transfer, may be made of any suitable plastic material. It is of advantage though to make it out of a plastic sheet which is wetted by water, or of copper sheet which is gold plated.

If gold plated copper sheet is used, then there is very little crystal formation in the sea water and ice adheres well to the sheet. Scale can be removed by dipping the sheet spiral into weak acid.

Witness Nancy Reid
Oct 10 - 1954

The fresh water and the brine which are drawn off from the units are allowed to pass into a tank each. These tanks are connected to a compressor which will boil of butane vapor that is dissolved in the aqueous phase. This is a batch operation and the pressure maintained over the aqueous phase will fall off in each phase of operation from the beginning of the phase toward the end of the phase. The pressure is not allowed to drop to the point when the water would boil in the absence of butane.

The butane vapor sucked off is compressed, condensed and allowed to return into the plant.

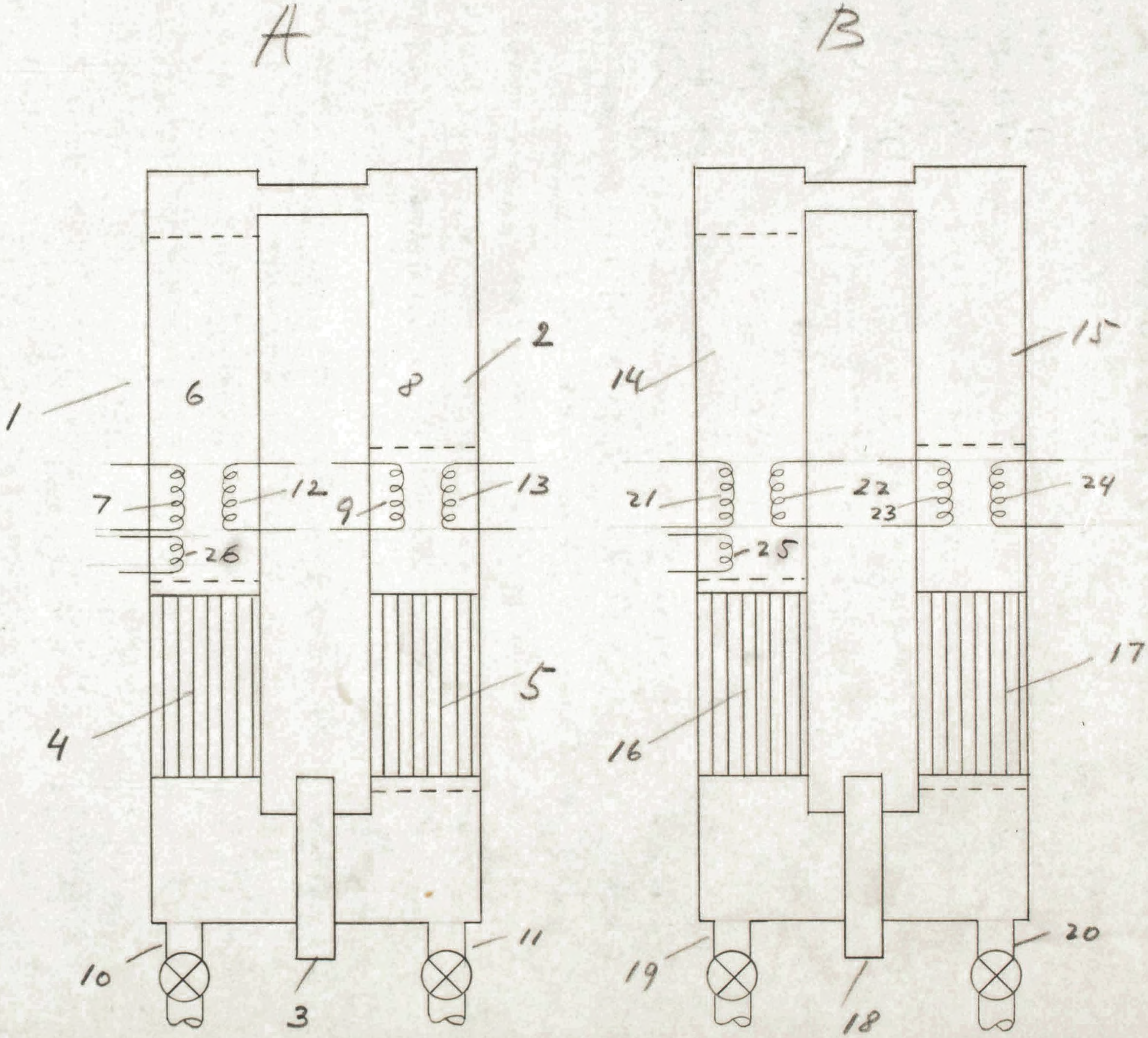
After the removal of the butane vapor, the sweet water passes through a heat exchanger in counter-current fashion against the incoming sea water, and similarly the brine passes through a heat exchanger in counter-current fashion against the incoming sea water.

Alternatively, the sweet water can go through a heat exchanger in counter-current fabhion against a straight chain hydrocarbon (containing about 10 or more carbon atoms) and this hydrocarbon in turn can pass through a heat exchanger in counter-current fashion against the incoming sea water, and a similar device is used for such indirect heat exchange between the brine and the incoming sea water. Such indirect heat exchange is adequate only if there is physical contact between the hydrocarbon and the aqueous phase. In that case we have a counter-current liquid liquid extraction system in which there is heat exchange between the hydrocarbon and the aqueous phase and at the same time butane dissolved in the aqueous phase will pass into the hydrocarbon phase. The butane taken up by the hydrocarbon can be removed by distillation and returned to the plant.

Leo Szilard

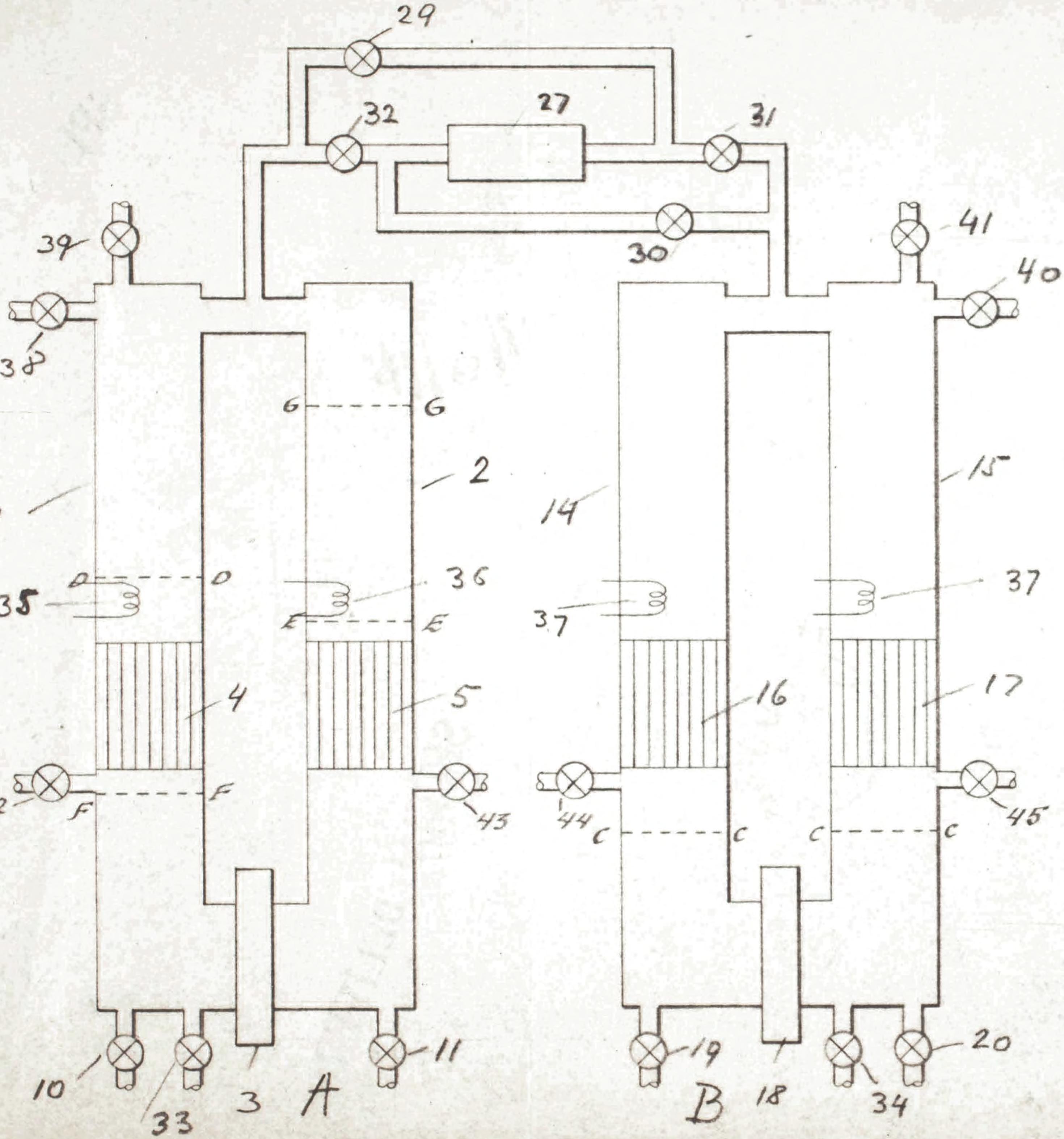
Witness Nancy Reid
Oct 10 - 1954

Fig 1



witness Nancy Reed
Oct 4 - 1954

Fig 2



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Special
Delivery

SPECIAL DELIVERY

First class

NEW YORK, N.Y.
OCT 6
1:30 AM
1954
GRAND CENTRAL

Dr Leo Szilard

420 W 116 Str
New York City 27

SPECIAL DELIVERY

G.C.

NEW YORK, N.Y. MANHATTANVILLE STA.
REC'D
OCT 6
6:30 AM
890

Fig

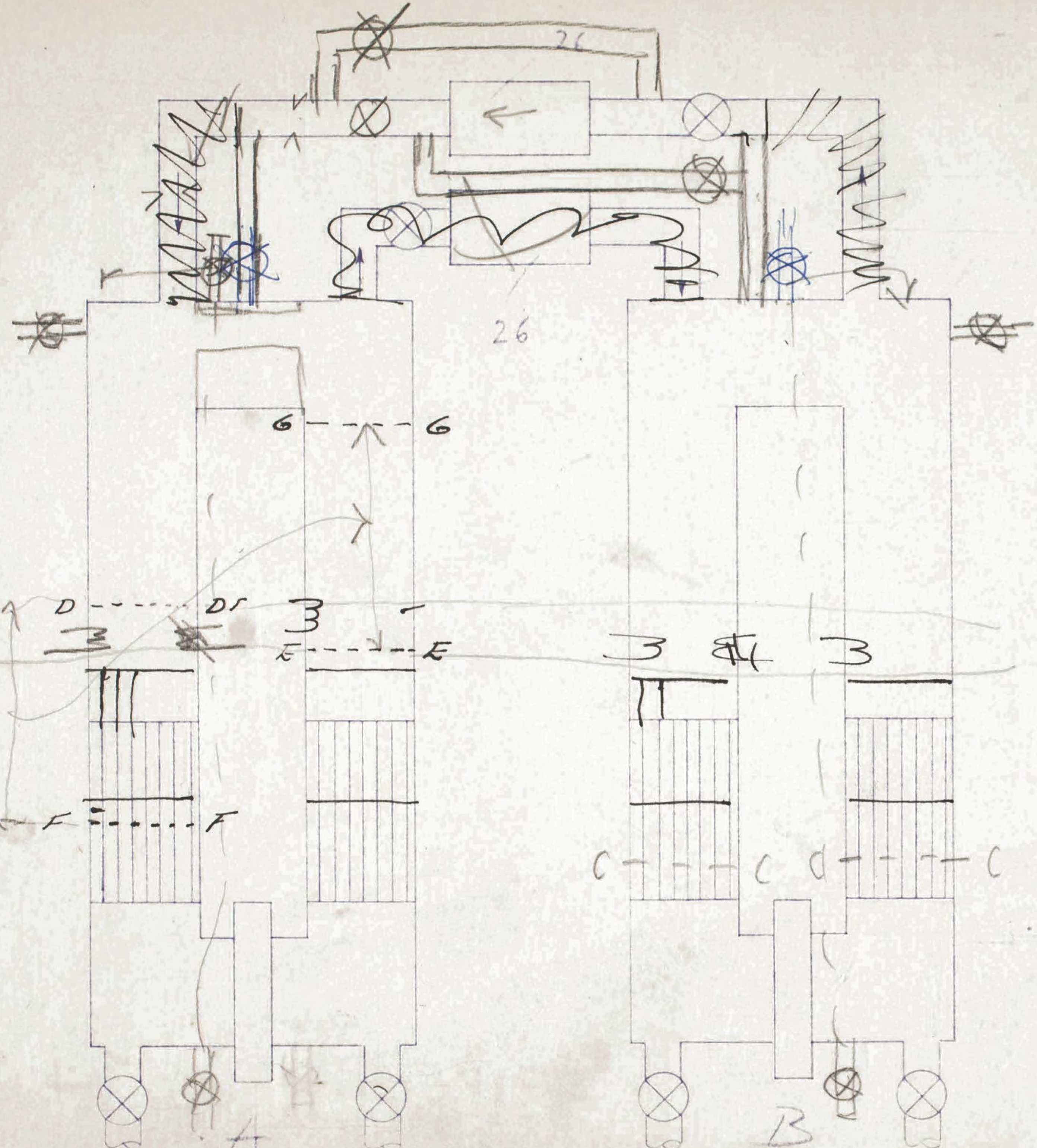
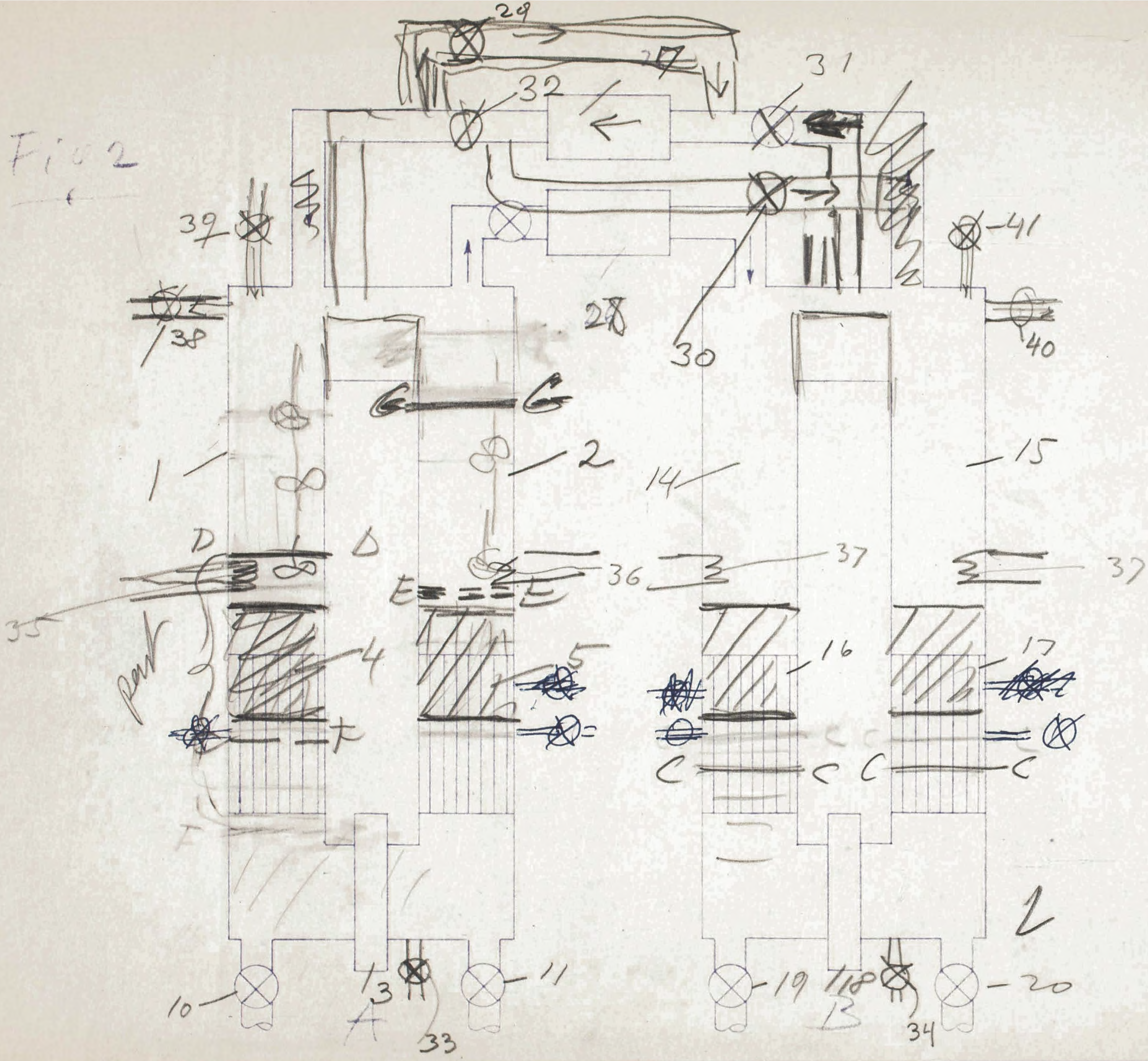


Fig 2



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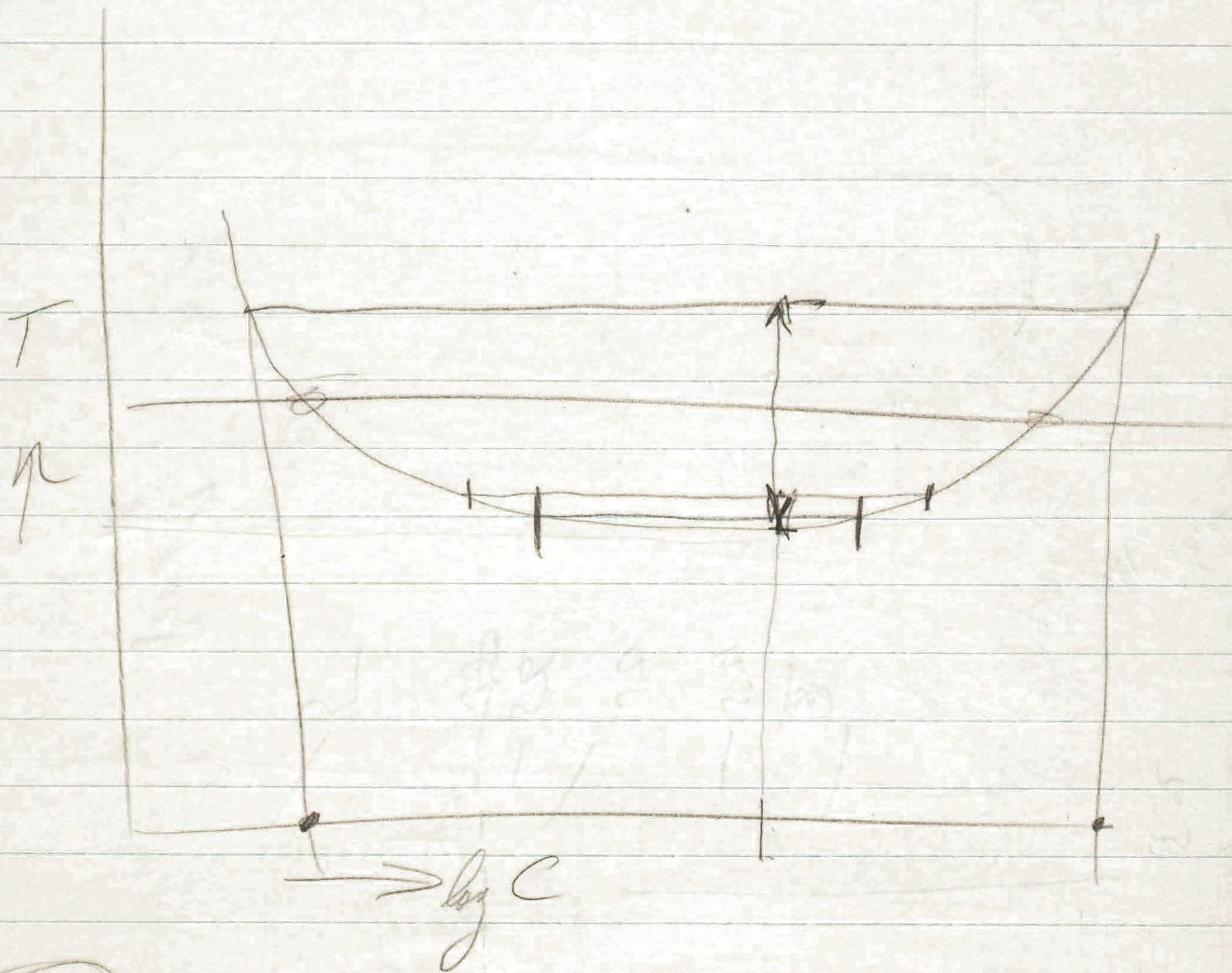
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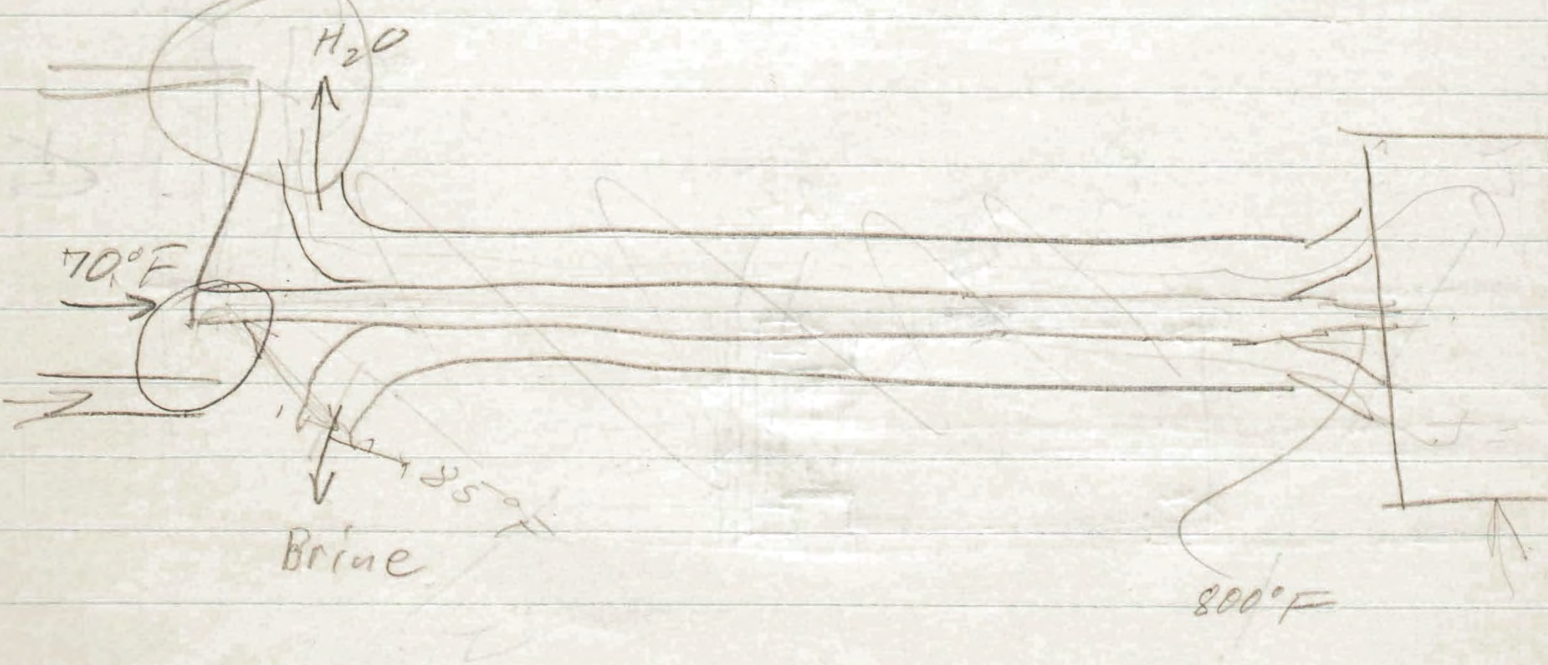
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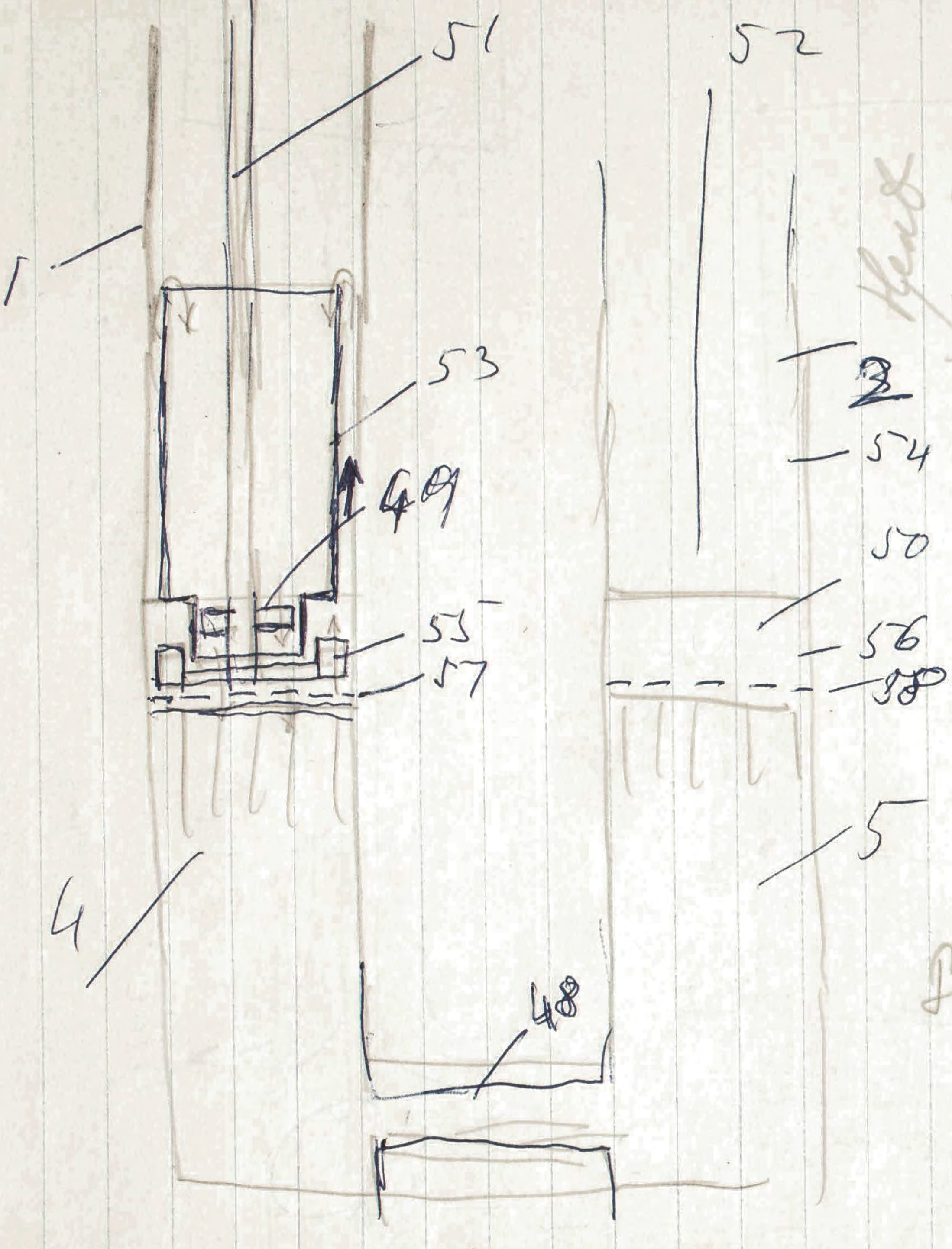
Brine
800°F



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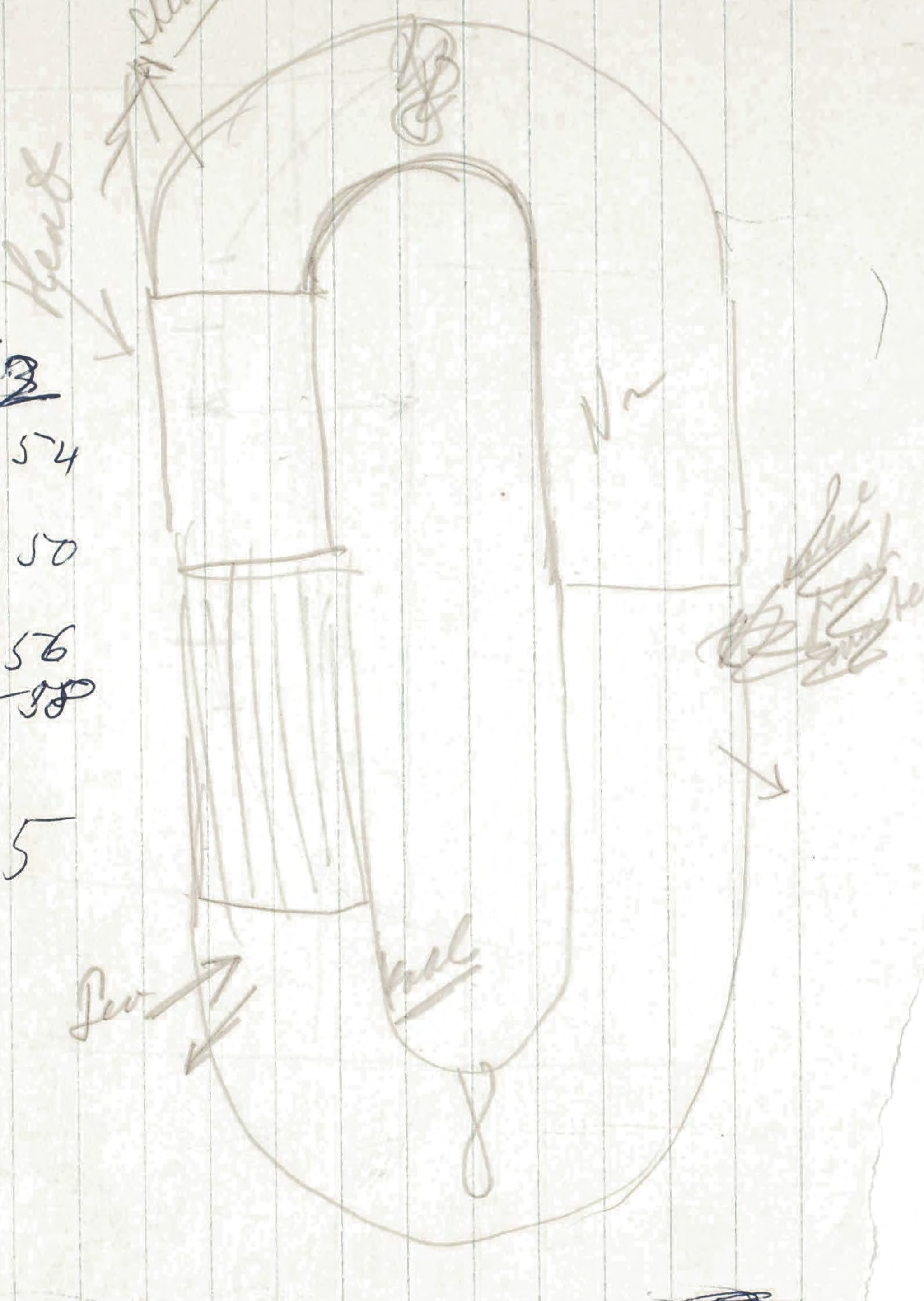
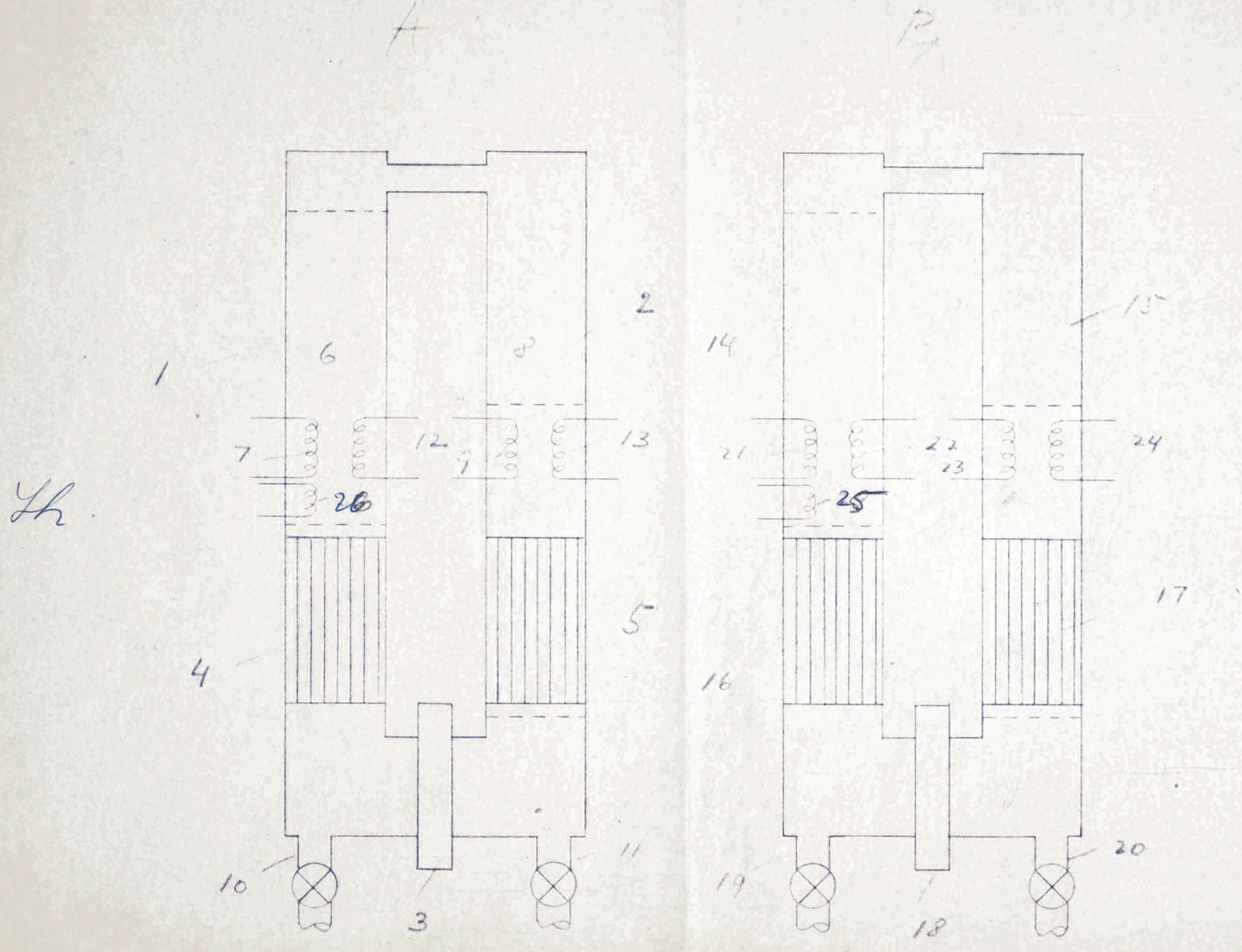


FIG 1



Leo Brilard

420 W 116 Str.
New York City 27

From Nancy Reed
315 W 57th Str.
New York City

Fig 1

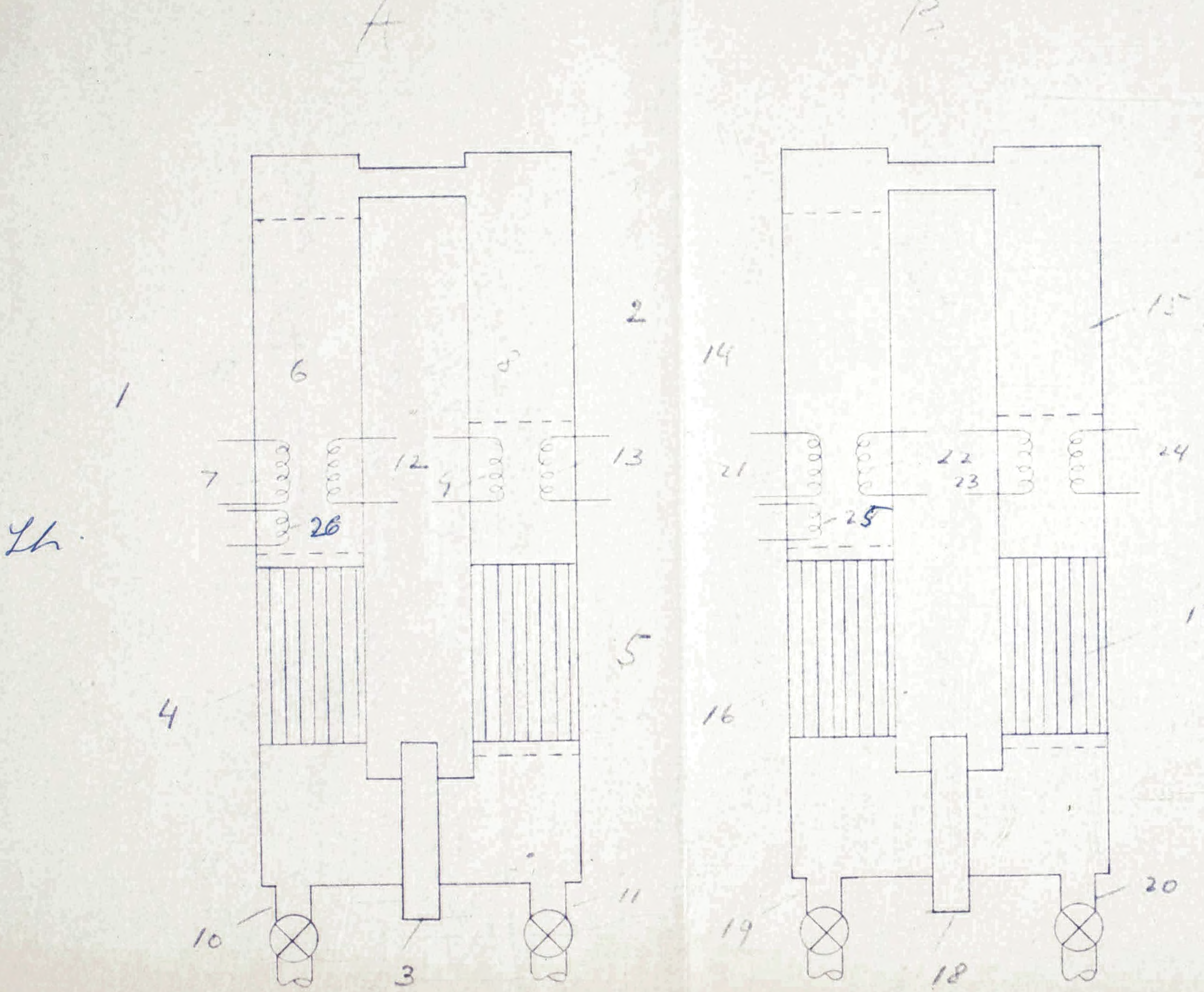
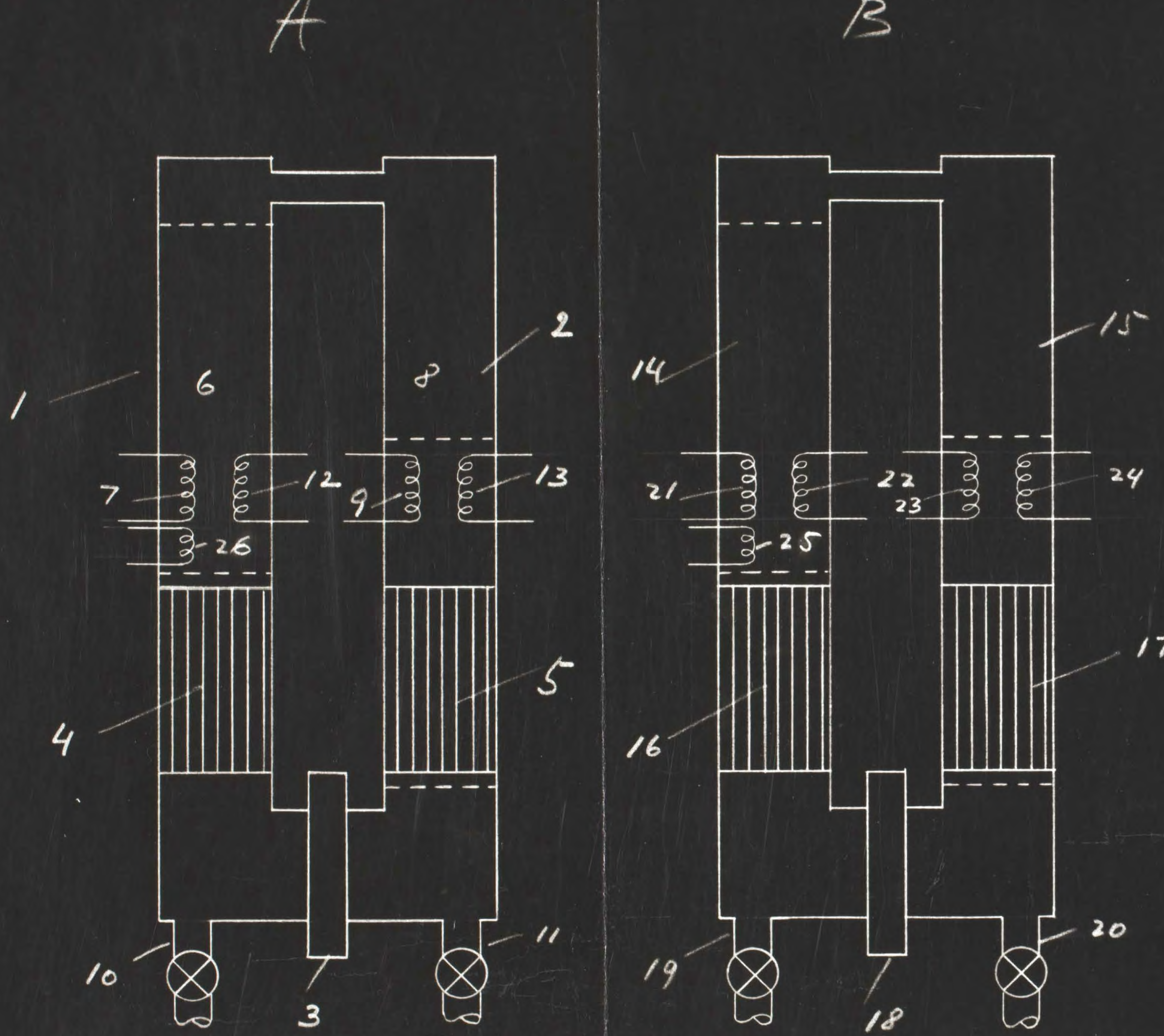


Fig 1



witness Nancy Reid
Oct 4-1954

22954

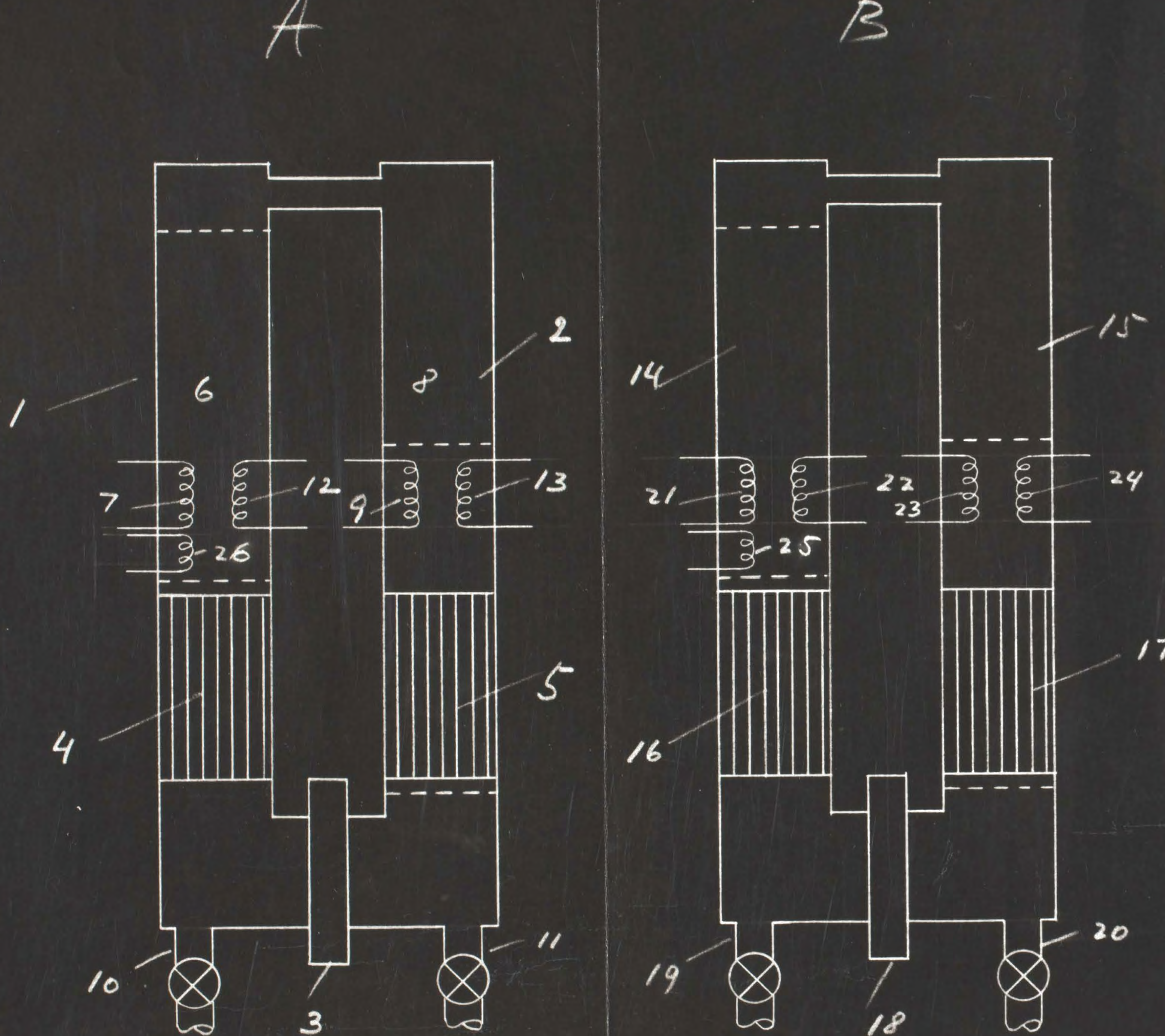
NEW YORK, N.Y. MANHATTANVILLE STA.
OCT 5
8 PM
1954
REC'D.

N. Reid
315 W 57th St
New York City

NEW YORK
OCT 5
4 PM
G.P.O.

Dr. Leo Szilard
King's Crown Hotel
420 West 116th St
New York City 27
N.Y.

Fig 1



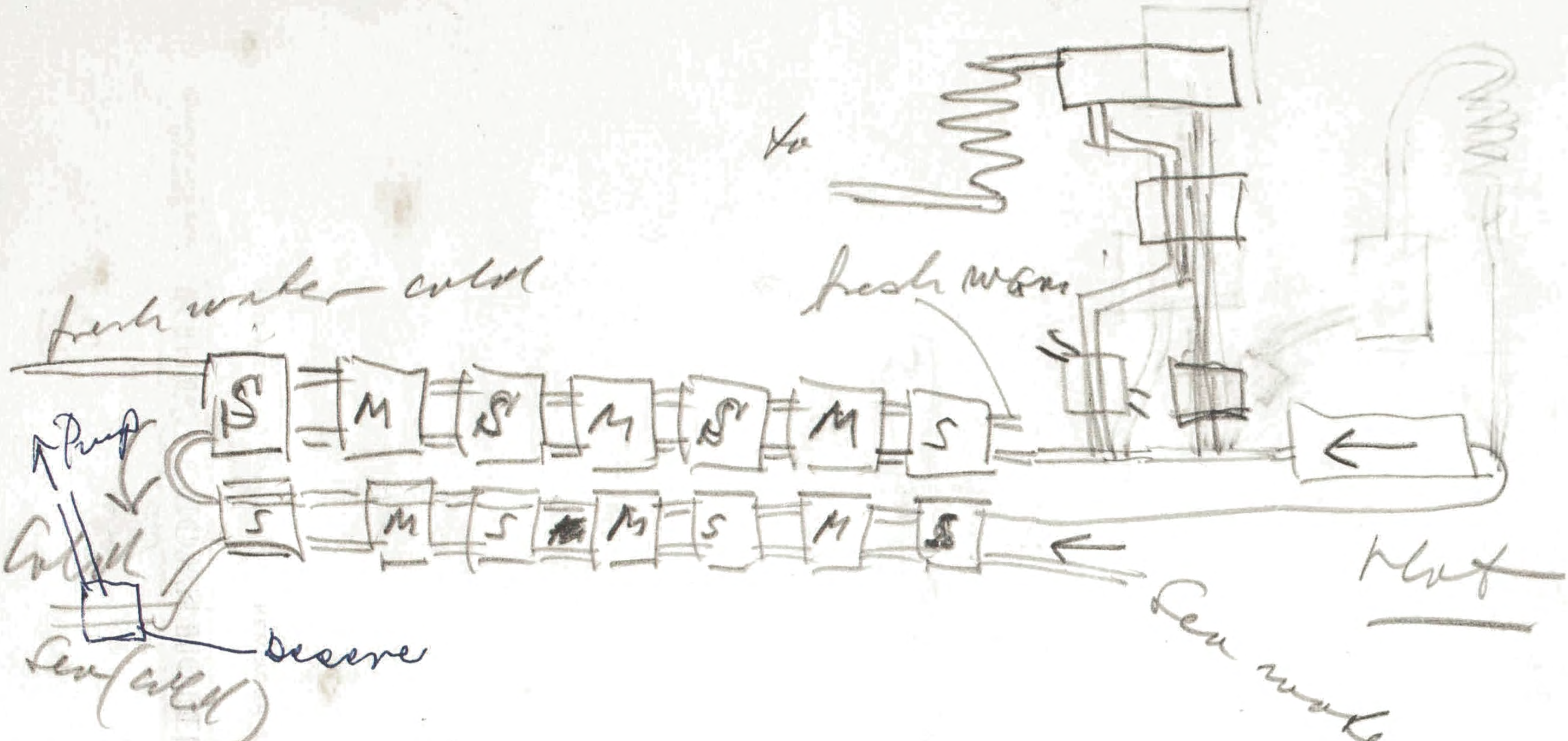
Witness Nancy Reid Oct 4-1954

TELEPHONE
UNIVERSITY 4 2700

KING'S CROWN HOTEL

OPPOSITE
COLUMBIA UNIVERSITY

420 WEST 116TH STREET, NEW YORK 27, N.Y.


to
fresh water cold
fresh warm
S
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Pump
Cold
Sea (cold)
Reserve
Heat
Sea water (warm

Fig 4