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Technical Report No. T58

by: T.A. Lawland and R. Alward

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Brace Research Institute
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INTRODUCTION

This report contains a series of plans and specifications for a solar distillation plant designed by the Brace Research Institute for a site at Source à Philippe, Ile de la Gonave, Haiti. The units were intended to provide an annual average of 200 U.S. gallons per day for the community. The project was sponsored by OXFAM Canada and was carried out in collaboration with the Eglise Methodiste of Haiti. The location of the stills is approximately 19°N. latitude. The stills have been in successful operation since May 1969. Other reports on operating performance have been issued by the university.

The extreme isolation of the site has influenced the design of the units. Solar stills are generally built in bays, the dimensions of which are determined by the availability of its principal components - the transparent cover and the basin liner. In this instance, it was decided for simplicity to adopt a single sloping glass cover design and to limit the length of the slope to thirty inches. The units are simply built and, apart from plumbing, are composed of four components, concrete curbs, a butyl rubber basin liner, glass panes for the transparent cover and a silicone glass sealant.

It is hoped that these plans and specifications might be of some use to other communities in a similar type of region. A set of specifications and operating instructions have been drawn up along with the accompanying work plans (see drawing number D-60-09-001 figures 1 to 12)

SPECIFICATIONS FOR GLASS AND CONCRETE SOLAR STILLS

Selection of Site

It is critical that a suitable site be chosen for the installation of a solar still in order to avoid undue complications during normal operation. Reference should be made to the Brace Research Institute Do-It-Yourself Leaflet No. 1 - How to Build a Solar Still (Plastic Covered) for additional information. In general, the site selected should be:

- 1) on firm, well-drained, reasonably level land,
- 2) unobstructed from the sun during most of the day,
- 3) as square in area as possible to reduce heat losses from the edges, with one edge running nearly in an east-west direction,
- 4) reasonably close to the saline water source, but not so close as to be covered with spray on windy days,

5) not excessively exposed or windy.

Preparation of the Site

All vegetation should be cleared from the area and the roots removed or destroyed. If the ground is rocky, the crevices should be filled in with stones and sea sand, preferably. The entire area should be doused liberally with sea water in order that the vegetation can be effectively killed. Finally, the site should be levelled and treated with a herbicide. It is essential that all traces of organic life be destroyed in order to prevent growth after the units have been built.

Preparation of the Foundation

The bays are generally laid out side by side (see Fig. No. 1). The sloping glass cover should face the Equator. Lines should be staked out for the curb walls allowing for an appropriate slope along the length of one foot in seventy five. This permits an adequate rate of withdrawal of distillate and rainwater, as well as allowing for the flow of brine within the basin. The formwork can be set out for a bay, according to the dimensions outlined in Fig. Nos. 3 and 7. The distance between the inside edges must be kept as exact as possible so that the glass can be placed evenly.

The foundations for the walls should be dug down to solid rock or firm ground to avoid subsequent shifting which might crack the glazing.

Casting the Curb Walls

Generally a 1:2:4 cement:sand:stone mix is recommended. In addition some reinforcing steel can be placed within the mass of the concrete latitudinally and can be tied into steel rods placed in the periphery walls, thus tying the foundations more solidly together. This reinforcing steel can also be used to anchor short pieces of steel rod, which should be placed vertically every three feet along the length of each curb. These can be used to anchor the concrete block course laid on the curb walls, as illustrated in Fig. No. 3. In the same manner, the courses of blocks forming the external brine and rainwater troughs, (Fig. No. 5) should also be tied into the curb. These tie rods should be bent over 90 degrees at the top and cemented firmly to the blocks.

The concrete mixture should be poured into the formwork, and it is advisable to cast each curb wall at one time. Where possible, the concrete should be vibrated or tamped to ensure greater strength.

It is essential that the concrete be kept wet for two weeks. The concrete should be poured to just below the level of the gutters. Then, a special form of pipe to mold the gutters on the upper face of the curb can be set down and the concrete mixture forced in and around the pipe. In this manner the distillate and rainwater collection troughs can be cast. The course of concrete blocks should be laid after keying the surface sufficiently. It must be stressed that adherence to the given dimensions is critical so that the glass will fit properly. Particular attention must be paid when applying the waterproofed plaster coat (1:2 cement:sand mixture with a suitable waterproofing additive, e.g. Pudlo or Sika), that the dimensions, levels, etc. are strictly followed. Care must also be taken once the plaster coating has been applied that it be kept moist to allow it to reach maximum strength. The top of the blocks should be covered with a layer of plaster as well, covering as much of the block airspaces as possible to retard the rate of heat loss from this wall.

When casting the end walls care must be taken to line the slope up precisely with the two adjacent curb walls. It would be preferable to cast the end component in a special mold. In each section care must be taken to include the grooves, pipes and openings for entrance to the stills. Two views are given of these sections (Fig. Nos. 5 and 6). In all cases a waterproof plaster coat should be applied to both faces.

Preparation of the Basin

Once the curb walls have been cast the area within the walls should be filled with sea or beach sand. If an inexpensive, durable insulation material, such as coconut husks, is available, it should be placed on the sand and blended with additional sand to form a smooth surface (see Fig. Nos. 3 and 7). The basin should be split up into a number of six foot ponds. The preparation of the basin surface has been outlined in greater detail? Basically, boards should be set up so that the sand can be levelled first in the direction between the curb walls and then along the length of the pond. A small dam should be built between each pond, the height of the dam will regulate the depth of water in the basin. It is desirable to use the shallowest depth possible for the greatest efficiency. Depths below one inch are difficult to maintain in practice with the result that dry spots will form. Hence it is recommended that the dam height be $1\frac{1}{2}$ " to 2" above the horizontal, level floor of the pond. The basin ponds have been illustrated in Fig. No. 7.

Installation of the Basin Liner

Once the ponds have been satisfactorily prepared the basin liner, butyl rubber sheet 36 inches wide by 75 feet long, can be carefully laid in place on the basin surface. The edges of the sheeting should be lapped over the concrete curb wall to fill in the distillate trough, as indicated. On the north wall the butyl rubber should be lapped three inches and fixed in place with special rubber adhesive. The sheeting should be bonded firmly to the concrete wherever possible. It must be recalled that a firm foundation is necessary, otherwise the weight of the water in the pond will compress the sand and the butyl rubber will stretch when the basin heats up during operation. Hence an intended basin depth of two inches might very well be closer to three inches during operation if care is not exercised.

Finishing Curb Walls

Once the plaster coats have dried thoroughly and are properly cured it is necessary to paint a strip one inch wide on the north and south walls where the glass will be laid. This should be painted with a two-part epoxy which bonds satisfactorily to the concrete. The epoxy will act as a bonding surface for the silicone sealant used to fix the glass sheets to the concrete frame of the distillers. At the same time the inside north wall of the concrete curb can be painted down to the butyl rubber lining. This will effectively seal the interior of the distiller and will reflect some additional radiation into the basin during periods of lower solar altitude.

Laying Transparent Cover

The glass selected is single strength (18 ounce) and the maximum length should not exceed 30 inches. Lay glass panes over basin as illustrated in Fig. No. 3. Adjacent panes should be spaced 1/16 to 1/8 inch apart to allow for expansion and contraction of glass. Seal glass in place with silicone sealant.

Each glass pane requires four sealant joints, two with adjacent glass panes and two on the epoxy-painted concrete curb walls.

When the glass panes are applied, the evaporating ponds of the basin must be filled with water to prevent overheating of the panes. Once a bay has been completely glassed in, some water must always be left in the evaporators to prevent an excessive buildup of heat within the basin, which could crack a glass pane. If for some reason there is no water in the bay, both observation ports should be opened.

Piping Installation for the Solar Still

Saline Water Feed

The overall piping has been illustrated in Fig. No. 11. In this particular instance the use of windpowered Savonius rotor pumps,

Ref. No. 3, has been recommended to pump brackish water from the well to a saline water feed tank. In case the wind fails, a standby hand pump can be incorporated in the system. In the particular instance at Ile de la Gonave the feed may optionally be taken from the well or the sea directly. In general the following pointers should be observed in using this type of pumping equipment:

- (a) the pump should be located as close as possible to the saline water source,
- (b) the pump should be situated in such a manner that it does not cast a shadow over the stills,
- (c) owing to the rotating nature of the operation it would be advisable to separate the rotor from the distillation units as far as technically convenient in order to avoid damage to the transparent cover from the failure of one of the rotor sections.

The specific piping attachment to the feed section of the solar distillation units is illustrated in Fig. No. 8. In Fig. No. 7 a small sketch illustrates the installation of a sea water flow distributor. Plastic piping, 3/4 inch in diameter should be perforated and connected to the sea water inlet so that there is a reasonably even distribution of the feed. All perforations should face downwards, as it is imperative that no saline water be splashed on the inside glass surfaces.

Brine Discharge

The brine discharge from the solar stills is quite clearly indicated in Fig. No. 5. It is important that a water trap be formed and kept filled in order to reduce water vapour loss from the interior of the solar still. It would be best to bed the basin section of the brine drain pipe in concrete for added rigidity. The membrane liner should be pierced and a strip of butyl rubber attached by means of adhesive to the brine drain. This must be tested for leaks prior to installation of the transparent cover.

Distillate Piping

One effective method of removing distillate from the distillate troughs is to use a threaded plastic nipple, as indicated in Fig. No. 5, and to attach it to the basin liner by means of a gasket and plastic nut. The latter can easily be made by splitting a standard threaded coupling in two. Otherwise, a piece of plastic pipe should be well imbedded in concrete, the membrane liner pierced and the entire area heavily coated with rubber adhesive to effect as satisfactory a bond as possible. A two-inch header can be laid directly in the rain gutter which lies at the end of the curb walls, as in Fig. no. 5. The distillate can be piped to this line by means of the

funnel arrangement shown or a flexible hose connection fitting tightly over the distillate take off nipple. The funnel or flexible hose will normally be inserted loosely in the 2" diameter pipe, hence preventing the buildup of pressure within the units.

End Wall Connections

The feed end wall should be fitted with a section of 4-inch asbestos cement pipe cut to thickness of the wall, which can be suitably plugged and which can be used as an observation and clean-out port when necessary (see Fig. No. 6). The 3/4 inch feed pipe earlier described should be cast directly in the end wall, as indicated in Fig. Nos. 6 and 7.

A 4 inch diameter clean-out and observation port should also be installed in the brine discharge end wall, as indicated in Fig. Nos. 5 and 6. Care must also be taken to allow for the discharge of the rain water gutters and the 3/4 inch distillate discharge pipe.

Rainwater and Brine Discharge Troughs

A continuous rainwater trough is cast along the entire length of each curb wall (see Fig. No. 3). The trough must be lined with a waterproof plaster coat of cement. Each bay trough empties into a larger rainwater trough illustrated in Fig. No. 5. The outer edge of this trough can be cast in concrete and the inner walls plastered with a coat of waterproof cement rendering.

A course of blocks can be laid, as indicated in Fig. No. 5, tied into the concrete foundations by means of steel rods, and plastered as above. The brine discharge outlets must be laid carefully, as indicated in Fig. No. 5. Both the brine and rainwater gutters should be given a satisfactory slope so that there will be no holdup in the fluid flow. The brine can be lead away to the saline source (or the sea) for ultimate disposal. The distillate and rainwater should lead to a collection cistern for measurement and temporary storage.

Collection Cistern

The type of water storage cistern best used in conjunction with this installation has been illustrated in Fig. No. 10. The original design has been described in detail in Ref. No. 4. Basically this utilizes local materials, stone, sand, cement etc. and has proven quite successful in the island of Petit St. Vincent, West Indies.

Glass Protectors

In cases where the winds are extremely strong, it might be wise to install some cleats or wire hold-downs for each glass pane to

prevent lifting of the glass due to a suction effect of the wind. Often, the last glass pane on each bay can have a piece cut out and taped in such a manner that it will flop into the still when the pressure is excessive.

Precautions During Severe Storms

If strong winds and rain threaten the area of the still, it is advisable to flood the units with as much saline water as possible to buffer any damage from shattered glass.

The immediate area around the still should be cleared of matter which could be picked up by the wind and propelled against the glass surface. If some simple reed matting is available, laying it on the glass sheets will serve to cushion the effects of flying objects. During any threatened storm the covers on both observation ports should be opened to equalize pressures.

Some Pointers of Operation

The solar stills should be filled, preferably before 8 a.m. each morning, and the concentrated brine flushed out. Where saline water supplies are plentiful, as complete a change as possible in the residual water should be undertaken.

Periodically, the amount of distillate produced by each bay should be determined in order that faults can be detected. The total amount of distillate produced per day should be measured in the collection cistern. This should be compared to any indicated amount of solar radiation intensity available to determine the efficiency of operation of the distillation units.

The glass covers should be kept as clean as possible. Care must be taken not to cover the stills with any obstruction which would cause shading. The area around the still must be kept neat and clean. Preferably a gravel or paved walkway should be laid down on the outside edges to serve as a service way.

Glass breakage should be repaired rapidly, although the stills will continue to function even if several panes are broken.

When loading the stills with fresh saline water, the inlet valves to each bay must be adjusted in order to equalize the amount of water entering each bay. The settings on these valves should remain in this position and the flow regulated by the output valve on the saline water cistern.

It would be preferable to meter the rain water and distillate separately, if possible. Care must be taken to pump distillate out during periods when it will not interfere with production measurement.

List of References

- 1) Brace Research Institute, Publications List, No. L-1,
How to Make a Solar Still (Plastic Covered), 9 p., January 1965.
- 2) Memo to File 41/04, The Preparation of the Basin for a Solar Still,
Brace Research Institute, T. Lawand, 3 p., August 1965.
- 3) Brace Research Institute, Publications List, No. L-5,
How to Construct a Cheap Wind Machine for Pumping Water, 12 p.,
February 1965.
- 4) Memo to File 60/08, The Construction of a Simple Rain Water
Collection Cistern, Brace Research Institute, T. Lawand, 3 p.,
September 1968.

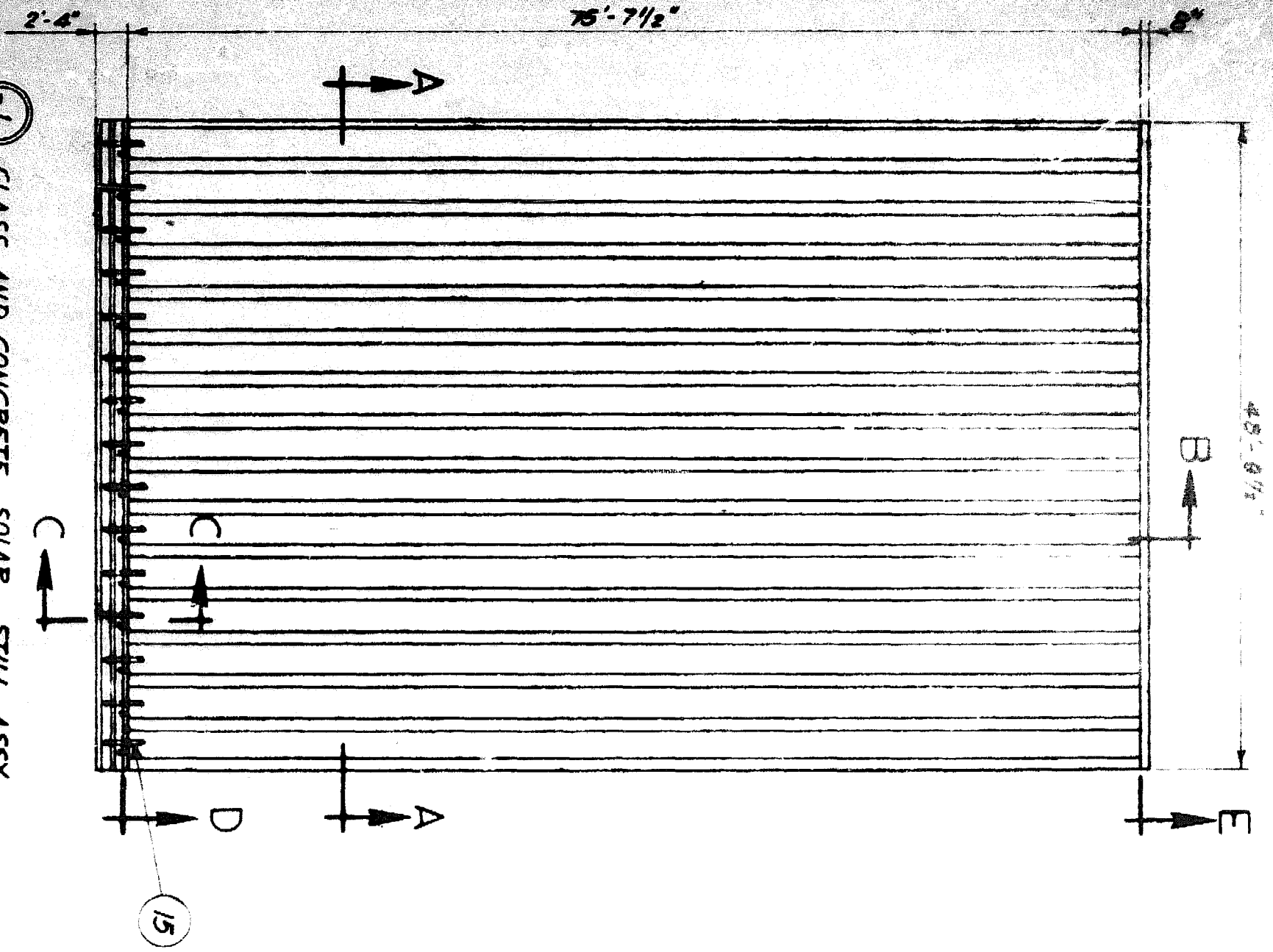
NOTE: These plans have been revised in specific sections to make use of information gathered from experiences with the La Gonave solar still. More recent developments in solar still technology have also been incorporated in the current plans.

75' - 7 1/2"



45' - 0 1/2"

15

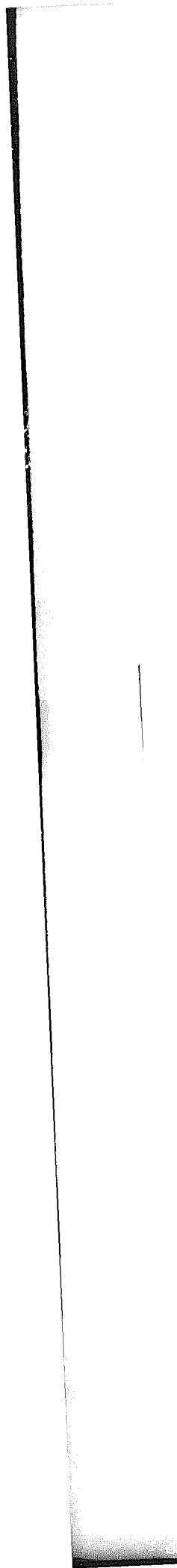


(1) GLASS AND CONCRETE SOLAR STILL ASSY.

SCALE 3/32" = 1'-0"







22	BRACKISH WATER WELL OR SEA				
21	2" DIA. PIPE TO DISTILLATE TANK				
20	SILICONE SEALANT		DOW CORNING OR GEN. ELECTRIC		
19	ACCESS PORT WITH COVER			4" DIA.	
18	REINFORCING ROD			1/2" DIA.	
17	FLEXIBLE HOSE		RUBBER OR PLASTIC	3/4"	
16	DISTILLATE TAKE-OFF NIPPLE			3/4"	
15	BRINE DRAIN PIPE AND FITTINGS		ABS PLASTIC TYPE 1	2"	
14	BUTYL RUBBER LINER		BLACK		
13	MORTAR (1:2)				
12	SAND				
11	INSULATION				
10	BED ROCK AND/OR SAND FILL				
9	CONCRETE CURB		STANDARD		
8	CONCRETE BLOCK				
7	WINDOW GLASS		GLASS	30" x 18 1/8"	
6	GENERAL SCHEMATIC OF AN OPERATING SOLAR DISTILLATION PLANT	SHT. 2 OF 2			
5	VIEW OF PIPING TO AND FROM SOLAR STILL	SHT. 2 OF 2			
4	PIPING DIAGRAM FOR SOLAR STILL AND ACCESSORIES	SHT. 2 OF 2		SUITABLE SIZE	
3	FRESH WATER STORAGE TANK	SHT. 2 OF 2			
2	SEA OR BRACKISH FEED TANK	SHT. 2 OF 2			
1	GLASS AND CONCRETE SOLAR STILL				
ITEM	DESCRIPTION	DWG. No.	MATERIAL	SIZE	QTY.

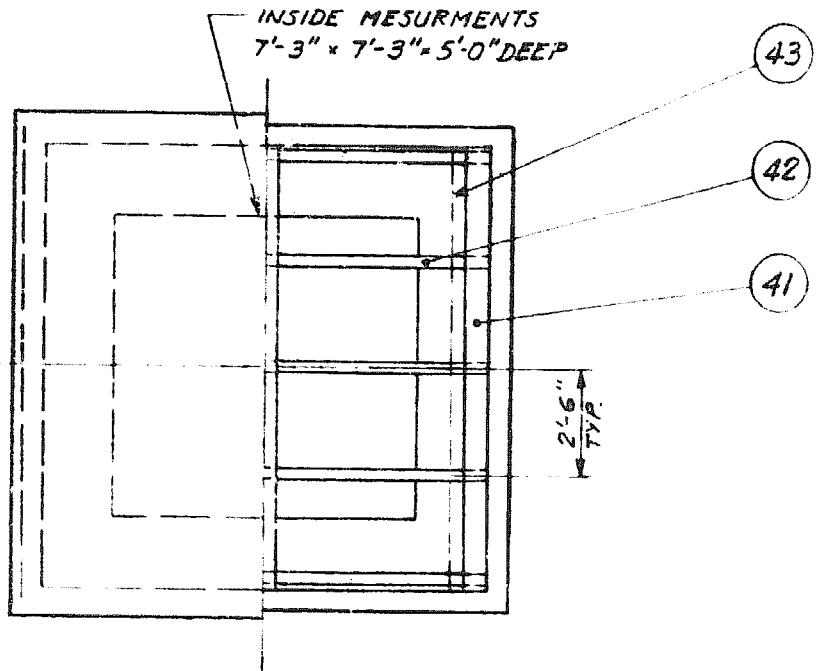
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STE. ANNE DE BELLEVUE
P.O., CANADA

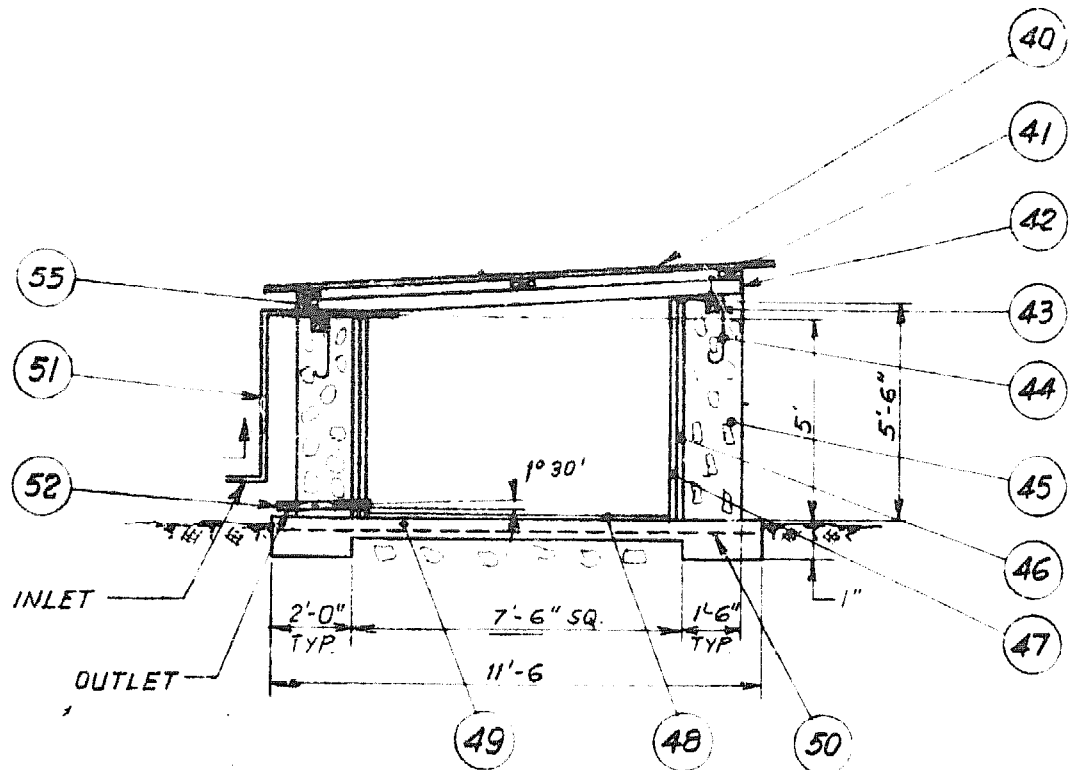
GLASS AND CONCRETE SOLAR STILL
(AVERAGE OF 200 U. S. GALLONS PER DAY)

DRAWN: Olga Galbraith Nov 75
CHECKED: RON ALLMAN DEC 75
ASSEMBLY
DWG. NO. D-6-062
SHEET 1 OF 2

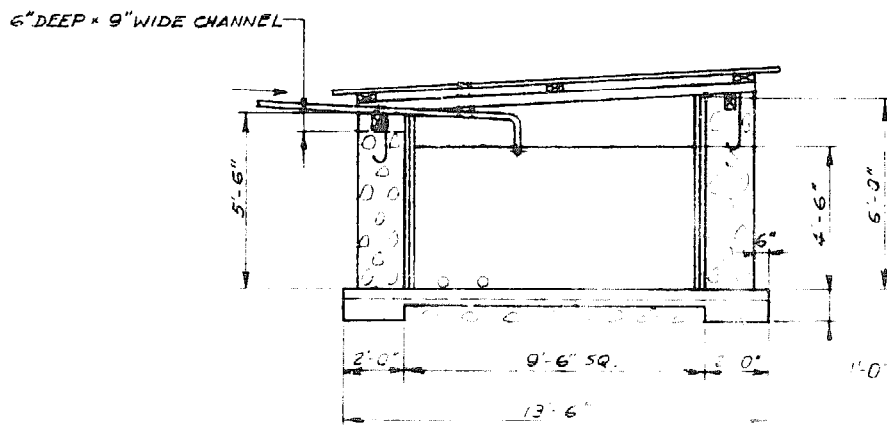
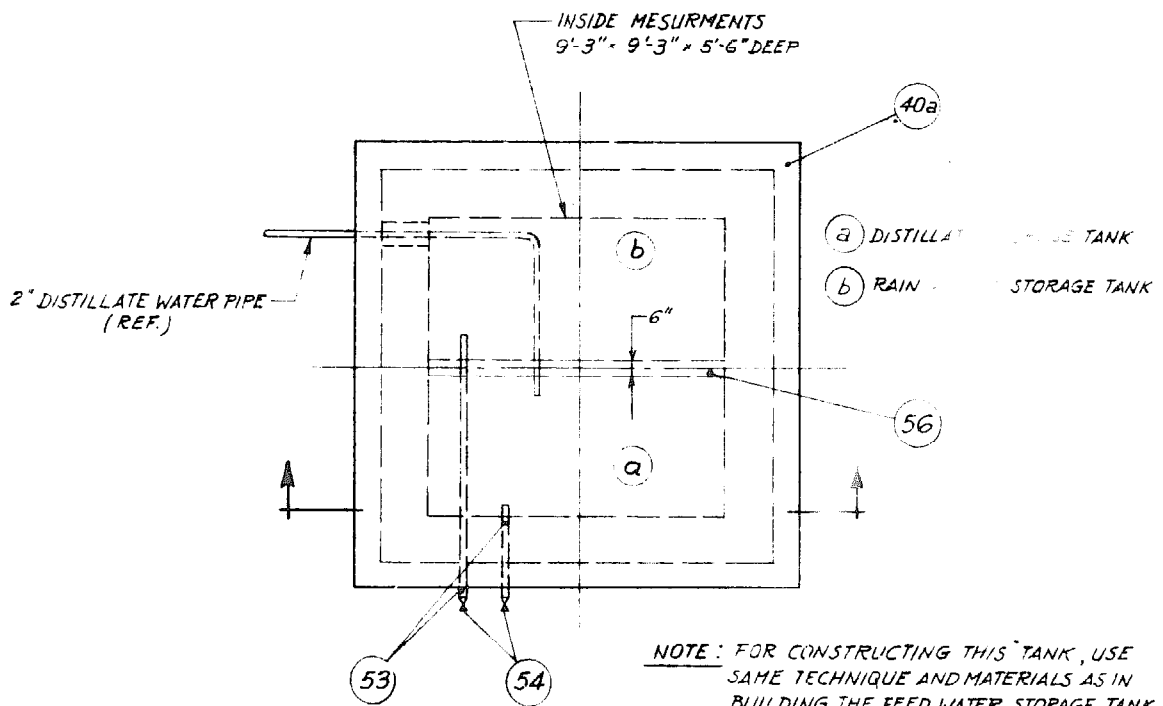
SCALE 3/32" = 1'-0" AND AS NOTED



BRACKET
1/2" FLAT STEEL
(Ω)



② SEA OR BRACKISH WATER FEED TANK
TOTAL CAPACITY APPROX 260 cu. ft.
SCALE 1/4" = 1'-0"

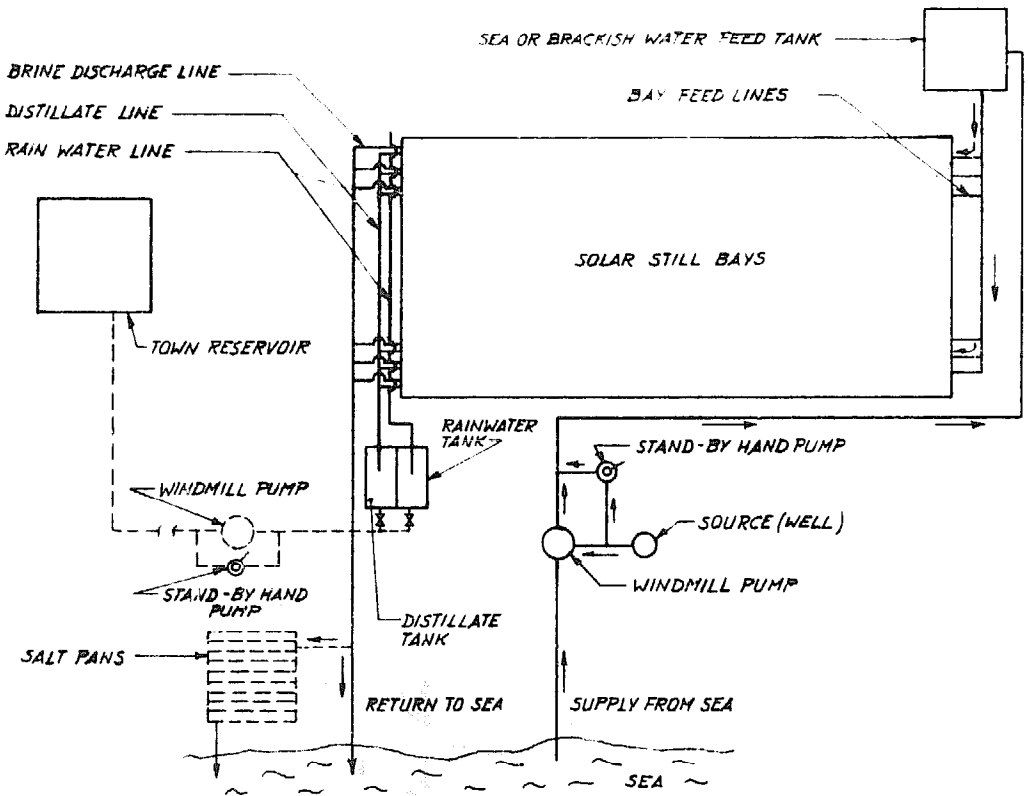


③ FRESH WATER STORAGE TANK

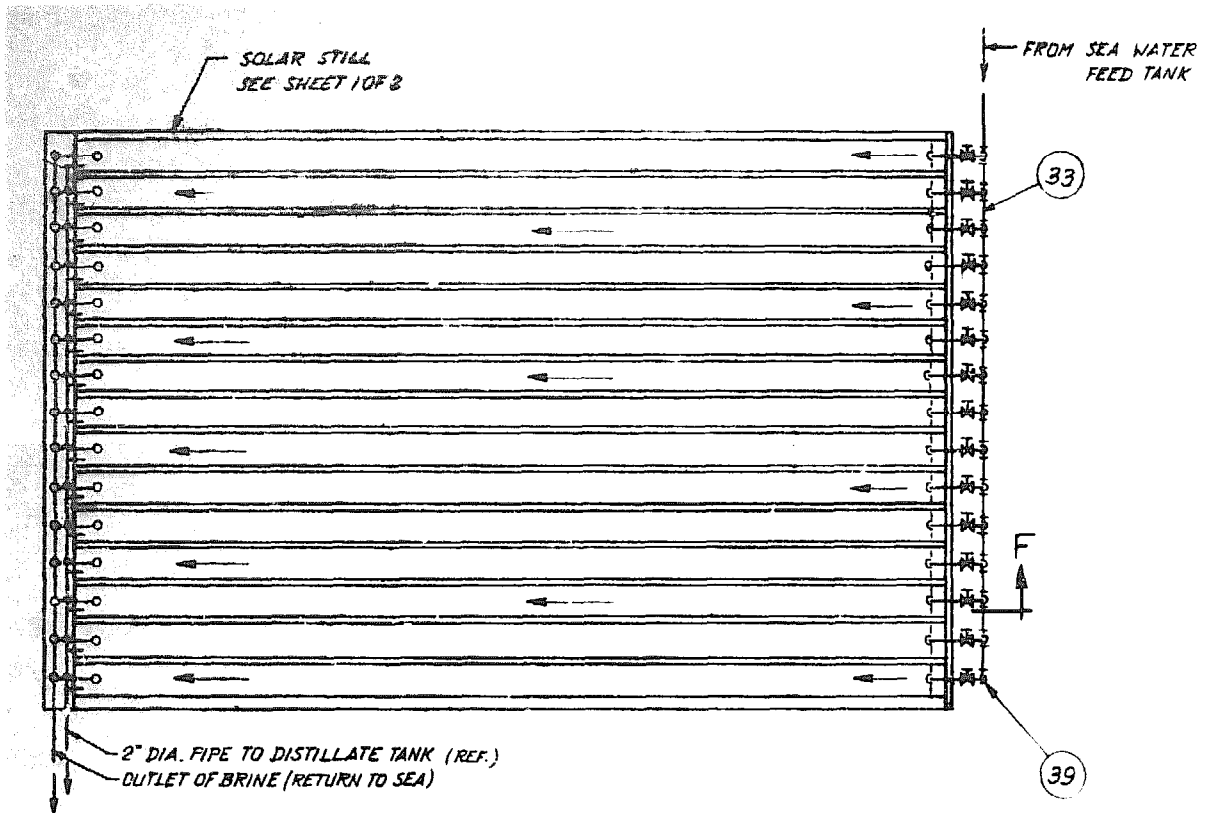
TOTAL CAPACITY APPROX 450 CU. FT.

SCALE 1/8" = 1'-0"

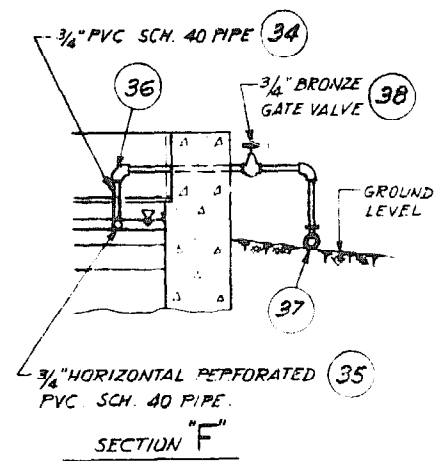
——— INITIAL INSTALLATION
 - - - - - POTENTIAL LINK-UP

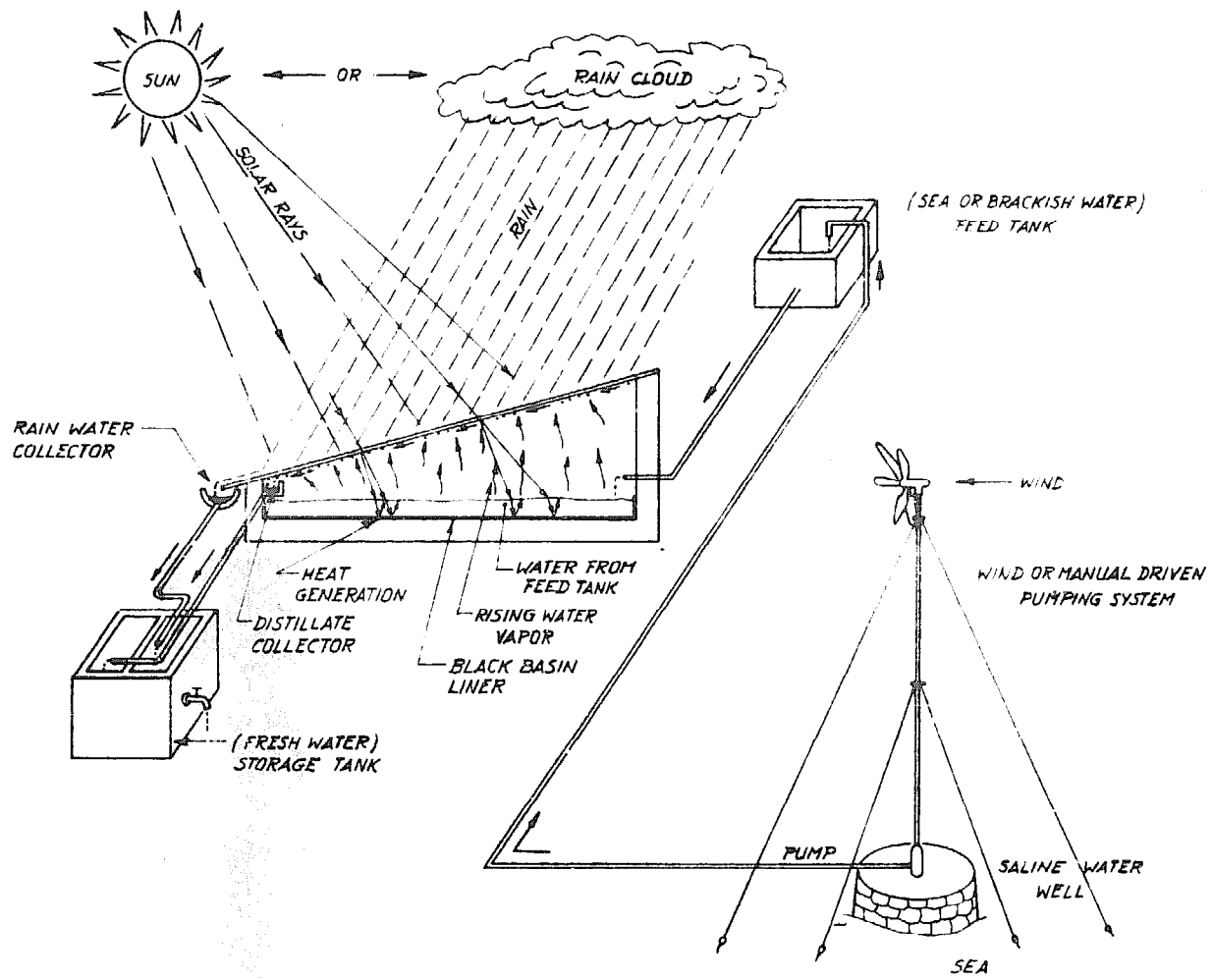


4 PIPING DIAGRAM FOR SOLAR STILL AND ACCESSORIES



5 VIEW OF PIPING TO AND FROM SOLAR STILL





6 GENERAL SCHEMATIC OF AN OPERATING SOLAR DISTILLATION PLANT

✓		56	STONE WALL SEPARATING TANK (a) AND (b)		6" THK.	
	✓	55	BRACKETS TO ANCHOR ITEM 42 TO ITEM 43		1/2" PLAT STL.	
✓		54	1" BRONZE GATE VALVE			
✓		53	PIPE		1" DIA.	
	✓	52	FEED PIPE TO BASINS			
	✓	51	FEED LINE FROM BRACKISH SOURCE			
✓	✓	50	BRC NET 3" MESH		#6 GAUGE	
✓	✓	49	CONCRETE (1:2:2)		6" THK.	
✓	✓	48	PLASTER WITH SIKA		1" THK.	
✓	✓	47	SECOND COAT OF PLASTER WITH SIKA		1/2" - 3/4" THK.	
✓	✓	46	FIRST COAT OF PLASTER		1" THK.	
✓	✓	45	STONE WALL		1'-6" THK.	
✓	✓	44	IRON ROD 3/8" 3'-0" LOOPED OVER ITEM 43 TO ANCHOR TO WALL		1/2" x 2'-0" LG.	
✓	✓	43	BEAM ROUGH P.P. TREATED WOOD	IMBEDDED IN WALL	2" x 4"	
✓	✓	42	BEAMS 3/4" 2'-6"		2" x 4"	
✓	✓	41	LATH ROUGH PITCH FINE		1" x 6"	
✓	✓	40	CORRUGATED GALVANIZED SHEET		12'-0" x 30' / 14'-0" x 30'	
	✓	39	1/4" TO 3/4" REDUCING ELBOW			
	✓	38	3/4" BRONZE GATE VALVE			
	✓	37	1/4" TO 3/4" REDUCING TEE			
	✓	36	3/4" ELBOW	PVC SCH. 40		
	✓	35	3/4" HORIZONTAL PERFORATED PIPE	PVC - SCH. 40		
	✓	34	3/4" PIPE	PVC - SCH. 40		
	✓	33	SEA WATER LINE - 1/4" HEADER	PVC - SCH. A		
		(3)	FRESH WATER CISTERN			
		(2)	FEED WATER STORAGE TANK			
		(5)	VIEW OF PIPING TO AND FROM SOLAR STILL			

ITEM	DESCRIPTION	MATERIAL OR DESCRIPTION	SIZE	QTY.
(3) (2) (5)	BRACE RESEARCH INS TUTE OF MCGILL UNIVERS Y		MACDONALD CAMPUS STE. ANNE DE BELLEVUE P.O. CANADA	
GLASS AND CONCRETE SOLAR STILL (AVERAGE OF 200 U.S. GALLONS PER DAY)		DRAWN <i>Olga Goldstein</i> Dec. 73		
SCALE 1/4" = 1'-0" @ N.T.S.		CHECKED <i>RON ALWARD</i> JAN 74		
		ASSEMBLY		
		DWG NO D-6-062		
		SHEET 2 OF 2		