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Comoros.

"PILOT PLANT : SOLAR ENERGY YLANG-YLANG FLOWERS ESSENTIAL OIL DISTILLATION DEVELOPMENT"

US/COI/79/256

THE ISLAMIC FEDERAL REPUBLIC OF THE COMOROS

FINAL REPORT *

Prepared for the Government of the Republic of the Comoros
by the United Nations Industrial Development Organization

Based on the work of Deane Evans, Principal of
Steven Winter Associates, Inc.
under UNIDO subcontract No. T81/41 to Steven Winter Associates, Inc.

3553

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SYNOPSIS

This report describes work undertaken for UNIDO Project No. US/CO1/79/256, "Pilot Plant: Solar Energy Ylang Ylang Flower, Essential Oil Distillation Development". pursuant to the provisions of Contract No. T81/41 between UNIDO and Steven Winter Associates, Inc. (the Contractor).

In accordance with the substantive Terms of Reference for the project, the Contractor's Project Team (Deane Evans, Richard Gebel, Thomas Hartman and Wilhelm Leibig) successfully completed the following tasks:

- Investigate the techno-economic aspects of the present system of essential oil distillation in small-scale sectors.

- Establish design parameters for a solar energy operated distillation unit.

- Design, fabricate, test, evaluate and produce 5 improved prototypes and conduct techno-economic analysis.

- Recommend ways and means of local fabrication and popularization.

Five pilot plants have been installed in the Federal Islamic Republic of Comoros in the following locations:

1. Riviere Site - Mitsamiouli, Grande Comore

2. Riviere Site - Mitsamiouli, Grande Comore

3. Patsy Site - Patsy, Anjouan

4. CADER Site - Serehini, Grande Comore

5. Mikidache Site - Kafouni, Grande Comore

The Project Team recommends that the following steps be taken to expand on the lessons learned from this pilot plant project:

1. Field test the demister provided with the three pilot plant stills on existing direct-fired stills to see if it has any effect on oil quality and/or energy consumption.

2. Determine the precise number, disposition and working condition of <u>all</u> artisinal stills in the country. Based on this information conduct feasibility studies to determine the most cost-effective methods for

organizing these stills into cooperatives utilizing centralized boilers and/or other more innovative methods of heat generation and transfer. Cooperation is recommended as the most important component in any attempt to improve efficiency and reduce energy consumption in the Ylang Ylang sector.

3. Determine the actual demand within the country for solar heated hot water. Based on this information conduct a techno-economic feasibility study on establishing a small scale industry to locally fabricate "breadbox" solar water heaters.

4. In order to reduce wood consumption throughout the country, develop technical improvements in domestic cookstoves. Concentrate on components that can be locally manufactured in the Comoros and that could form the nucleus of a small scale industry.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION AND BACKGROUND

This report describes work undertaken for UNIDO Project No. US/C01/79/256, "Pilot Plant: Solar Energy Ylang Ylang Flower, Essential Oil Distillation Development", pursuant to the provisions of Contract No. T81/41 between UNIDO and Steven Winter Associates, Inc. (the Contractor).

Per the Substantive Terms of Reference, dated 19 January 1981 and attached to Contract T81/41 as Annex D, the main purposes of the project are:

> "To help Comoros conserve wood, establish l w cost simple solar distillation unit requirements, provide healthy environmental conditions, and provide an opportunity for industrialization and entrepreneurship development."

In pursuit of these general goals the Contractor's Project Team (Deane Evans, Richard Gebel, Thomas Hartman and Wilhelm Leibig) developed and successfully completed a Work Plan based on the "Specific Requirements of Contractor" section of the Substantive Terms of Reference. The remainder of this report is organized to follow these Specific Requirements and is divided into five chapters, each of which discusses one of the five basic contractor activities required by the Terms of Reference.

In completing these activities and fulfilling the contract requirements the Project Team consistently endeavored to satisfy the general objectives outlined in the quotation above. It should be noted that these general goals coincide well with those recommended in a recent report by Louis Berreur entitled "Etude sur la Promotion des Exportations des Comores (Ylang-Ylang, vanille et girofle)". This report (hereafter referred to as the "Berreur report") was financed by the EEC through the Fond Europeen de Developpement (F.E.D.) and was published in April 1982. In its recommendations it gives highest priority to:

> "...la realisation d'economies dans la consommation d'energie pour la distillation de l'ylang-ylang."

The appropriateness of this report's recommended approaches to saving energy will be discussed further in the Recommendations chapter of this report. For the present it is sufficient to note the high priority given to energy consumption in the Ylang sector and the degree to which the goals of this UNIDO project conform to the recommendations of the Berreur report.

2. VISIT TO COMOROS

After careful review of UNIDO's "Rapport de Mission sur L'Installation Pilote, 16-21 Fevrier 1981" the Team Leader (Deane Evans) was briefed by UNIDO personnel in New York during the week of 29 August 1981. Concurrently the Project Team had assembled relevant background data on essential oil distillation, solar equipment, meteorological conditions, etc., and the Team members met in New York on 15 Sept. 1981 to prepare a work plan for the Comoros visit.

Mr. Evans arrived in Moroni for his fact-finding mission on 28 September 1981 and stayed for two weeks. During this time the distillation processes at both the artisinal and the industrial levels were observed and analysed.
In consultation with government officials four potential pilot plant sites were chosen: one in Grande Comore at the Riviere distillery in Mitsamiouli and three in Anjouan in the Nioumakele CADER ("Centre d'Appui au Developpement Rural"). It was assumed that one of these four sites would accomodate two pilot plants for the total of five required by the contract. Having selected the sites and studied the distillation process first hand Mr. Evans returned via Vienna to New York.

(It should be noted here that Mr. Evans' field investigations revealed far fewer existing artisinal stills than indicated by government statistics. These statistics, based on the last census, estimate that there are 250-300 stills on the three islands. Based on first hand experience this estimate seems very high, but Mr. Evans' mission was admittedly short and far from exhaustive. Nonetheless, the results of the new census and of an independent survey of artisinal stills by CEFADER ("Centre Federal d'Appui au Developpement Rural"), both currently being completed, should be carefully consulted before any further, large scale planning is undertaken in the Ylang-Ylang sector. This idea is discussed in more detail in the "Recommendations" Chapter.

3. DESIGN DEVELOPMENT

ESTABLISH DESIGN PARAMETERS

Based on the generalized goals of the Government of Comoros/UNIDO to directly aid the small-scale producer and not the large-scale, semi-industrialized concerns, the Project Team concentrated or design strategies for artisinal type distilleries. These installations are of the direct-fire type, usually with a single 1000 liter-capacity alembic for distilling 80-120 kg. flowers in 160-240 liters of water. Each artisinal still is extremely simple in concept and configuration and the Project Team fixed simplicity of design and ease of operation as two basic parameters for the pilot plant designs.

In its initial approaches the Team tried to maintain the commonly used direct-fire approach, inefficient though it was from an energy standpoint, and to provide solar input directly to the existing configurations. Such direct solar heating of the stills proved exceedingly impractical, however, and the Team was forced to consider some form of heat transfer mechanism for the solar input. The Team further recognized that, even utilizing some form of heat transfer, solar could not be effectively utilized to provide 100% of the energy contribution to a small-scale agro-industrial operation such as this. Due to the overall amount of energy required the array sizes, no matter what form of collector was used, would be enormous, difficult to maintain and, considering the budgetary restraints of the project, far too costly. The Team chose, therefore, a two level approach with solar providing a portion of the energy required and conventional sources providing the remainder. Based on preliminary cost estimates a solar contribution of 5kw was fixed, with conventional fuel providing 20-45kw depending on the still size.

Given this basic decision it became evident that methods for improving the efficiency of conventional sources of energy also had to be considered and the Team looked first at improving the fireboxes of the existing stills. In principle an improved firebox could have a dramatic effect on energy use. In fact, however, the existing fireboxes, although in a state of disrepair, were of basically sound design. It was determined that the openings could be better sealed and the fire doors insulated and made to fit better, but such repairs were judged to be of little benefit to overall energy consumption. The real problem was the small amount of heat transfer surface which the bottoms of the existing stills provide. Because this surface is small, it must be constantly heated to maintain boiling temperatures throughout the inside of the still. This means the fire is constantly being fed and that the fire door is almost always open anyway. Therefore any improvement in this door was determined to be of limited value. Schemes for circulating hot flue gases to maximize the use of the energy released from the fire were also investigated, but these involved radical changes in still design and were rejected as inappropriate models for wide scale application throughout the country.

The Team determined that the main mechanism for conserving energy and reducing wood consumption was an increase in heat transfer area which would, in turn, allow more effective control of the fire. As noted above, such control is virtually impossible in the direct-fire stills currently in use. The Team therefore began to investigate some form of alternative heat transfer system for the conventional fuel section of pilot plant, an approach which coincided well with that already taken for the solar portion of the plant. Specifically, it was decided that a boiler/steam coil system would be most appropriate for adaptation to existing stills. Such a system would be straightforward in design and easily understood by the small scale producers. In fact models for this type of configuration already exist in the larger scale operations in the country (Societe Anonyme de Grande Comore, Grimaldi et al.). The only difference, a crucial one from the standpoint of cost-effectivevess as will be noted in the Recommendations chapter, is that these large operations use one boiler to fire several stills. Because the project focuses on the artisinal level distilleries, a one boiler-one still relationship would need to be maintained.

To summarize, then, the initial pilot plant design parameters established by the Project Team were as follows:

- The pilot plants would closely resemble existing installations in size and configuration.

- The ability of the pilot plant equipment to adapt to existing stills and to be applicable on a larger scale was of prime importance.

- There would be mix of solar and conventional fuel energy input into each pilot plant.

- Both the solar and the conventional fuel input would be through some form of heat transfer mechanism.

- Each pilot plant would consist of only one still, with associated solar and conventional fuel inputs.

Having established these base parameters the Team proceeded to Preliminary Design Development.

PRELIMINARY DESIGN DEVELOPMENT

Following establishment of the basic design parameters, the Team began to concurrently investigate different still configurations and various solar collector systems. The main criteria for evaluating these systems were their compatibility with existing equipment, their adaptability to industrialization within the Comoros, and their energy efficiency.

In still design, the Team investigated pressurized systems that would allow lower temperatures and therefore a potentially greater efficiency for the solar contribution. Such systems were judged inappropriate, however, because existing stills cannot be adapted to pressurization and completely new equipment would be required. Because the Team assumed that any large scale project following the installation of these pilot plants would necessarily require <u>adaptation</u> and not replacement of existing stills, pressurized systems were rejected because they would not provide useful models for a large scale project. (As will be seen later the Team did, in the end, provide three new stills for the project, but these are of a design directly compatible with existing equipment and can serve as models for a larger scale expansion of the project.)

The Team also investigated using chemicals and/or solvents in the distillation process. However, these substances impart an odor to the essential oil which is unacceptable to the producer and are only used in the production of "concrete". Because the artisinal distilleries only produce essential oil and not "concrete", the use of chemicals or solvents was also rejected.

In the preliminary design stage the Team concentrated on standard still designs made of copper, with serpentine coils for heat exchange and copper tubing used throughout. Two capacities, one for 100 kg of flowers and one for 200 kg flowers, were studied. A fractionation column was also included on an experimental basis under the assumption that it could help improve the rapidity with which high quality oil was extracted, thereby reducing overall operating time and conserving energy.

Preliminary designs for the solar portion of the proposed pilot plants also went through a long evolution. The Team began by investigating five generic solar collector types: two axis concentrators, single axis concentrators, non-tracking concentrators, flat plate collectors, and evacuated tube collectors. A computer program was developed, utilizing meteorological data from the Comoros, to analyze the potential performance of each of these collector types. The code for this program is included as Annex A.

Analysis of the program results determined that all the proposed systems, with the exception of flat plates, would perform well under the meteorological conditions prevalent in the Comoros. The remaining systems were then subjected to a further set of evaluative criteria including system availability, ease of maintenance and operation, and potential risks. The results of this analysis, detailed in Annex A, are summarized below.

- Single Axis Concentrator (Parabolic Trough, Fresnel Lens, Fixed Focus Mirror)	Rejected - Very sensitive to loss of coolant flow with possible degradation or destruction of system as a result.
- Non-tracking Concentrators (Compound Parabolic, Reflector Augmented)	Rejected - Low current availability.
- Flat Plate Collector	Rejected - Required temperatures at outer limits of system capability; could actually cause negative heat flow in distillation unit.
- Two Axis Concentrator (Parabolic Dish or Power Tower)	Rejected - Complex mechanical systems required; improper operation can destroy system.
- Evacuated Tube Non-Concentrating Collector	Accepted - Readily available, easy to operate and maintain, high efficiency.

The evacuated tube system, although the clear choice based on the foregoing evaluation, had one disadvantage that the Team was now forced to resolve: stagnation (no flow) temperatures in such a system can be very high, in excess of 400 degrees c, and can actually damage the system. In order to avoid such stagnation the Team investigated a number of distribution subsystems for transferring heat gained by the solar collector to the point of use. A number of potential working fluids were investigated (see Annex A) and the special heat transfer fluid "Dowtherm" was selected. This fluid, which is very energy efficient and cost-effective, has the drawback that it requires a pump to ensure effective circulation through the distribution subsystem. The Team looked at a number of pump options, including heat engines and wind, and concluded that a photovoltaic system was the most practical. This system would be designed to operate only when the sun was shining, which is precisely the time when the Dowtherm would be heating up and need to be circulated

Having reached these design decisions for the solar input to one pilot plant prototype the Team investigated solar options for a second prototype in accordance with the Terms of Reference. The possibility of providing a very simple, unsophisticated system which would have relatively low energy input but potentially high applicability throughout the country was discussed with UNIDO personnel at a meeting in New York on April 22, 1982. The suggestion met with general approval and the Team proceeded to investigate the possibilities in this area, eventally determining that a simple "breadbox" solar collector should be used to preheat the still water. This would reduce distillation start-up time and thereby reduce energy consumption. Such collectors are extremely simple in concept and operation and lend themselves readily to fabrication in the Comoros.

DESIGN ELABORATION

During the months following completion of the preliminary designs described above the Team worked to prepare these designs for initial fabrication and testing. The step-by-step evolution of this development is described in detail in Progress Reports sent by the Team to UNIDO and only major decisions and changes are recorded here. During this period the Team was in contact with potential fabricators and suppliers so that cost and availability factors, together with purely technical considerations entered into the decision-making process.

The stills went through a number of design elaborations, representative examples of which are presented in Figures 3.1, 3.2, and 3.3. The major changes to the preliminary design are outline below.

1. The still material was changed from copper to stainlees steel, primarily for cost reasons.

2. The fractioning column changed first from a bell cup to a Raschig Ring system and then was replaced altogether with a simple demister. It was determined that this demister would perform the same function as the column, be easier to maintain, and be more adaptable to fabrication in the Comoros.

3. The still size was standardized at a 200 kg. flower/400 liter water capacity, the larger of the two sizes under consideration. It was determined that this size could more easily be adapted to large or small batch loads by varying the number of heat exchange coils installed.

4. The opening(s) for charging the still with flowers and for cleaning it out were first changed from two manholes, one side-mounted and one top-mounted, to one manhole on the side. Upon further consideration of the configurations of existing artisinal stills, the manhole was then eliminated altogether and the entire top was made removable. The new configuration now closely resembles those currently in use at all artisinal installations.

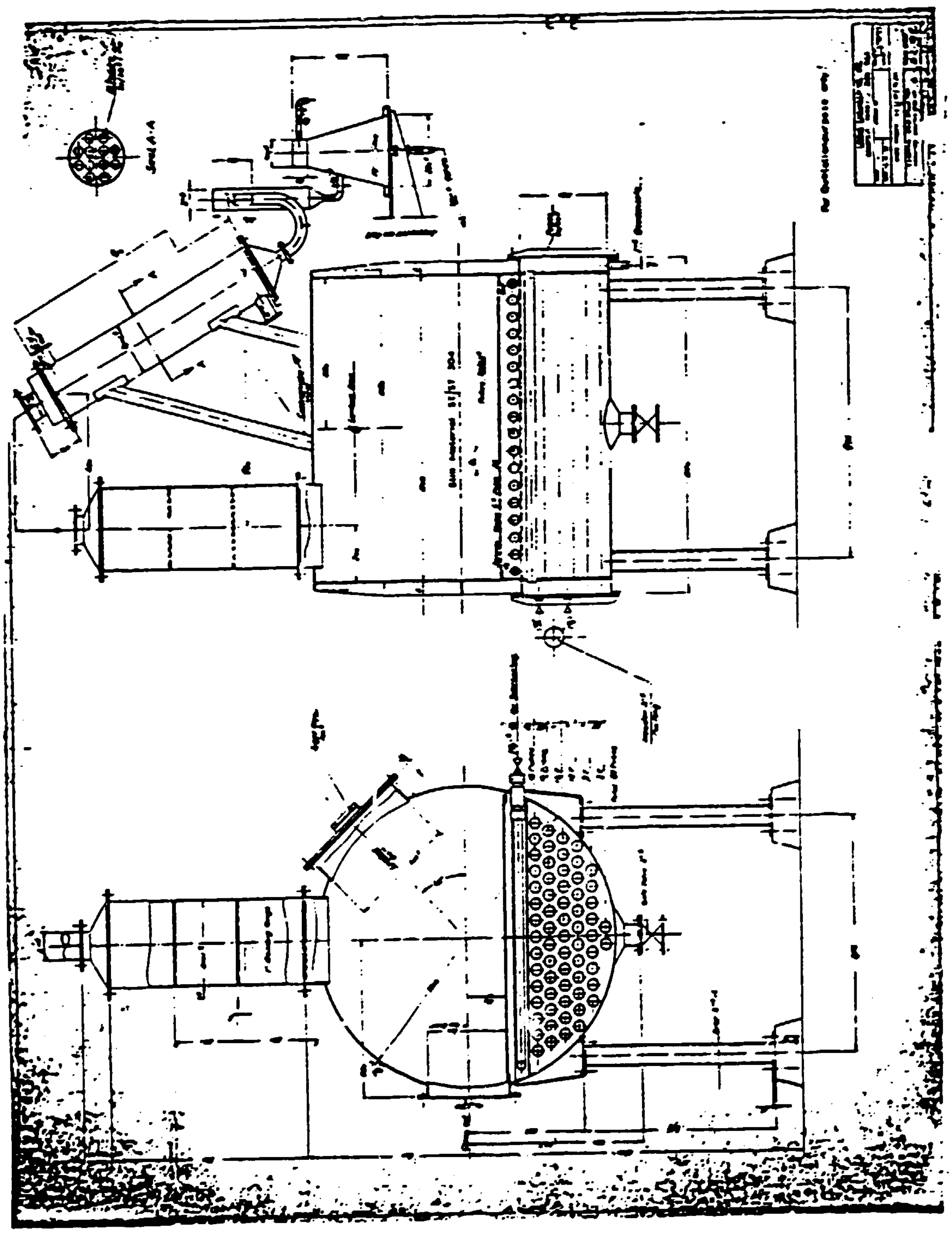


Figure 3.1: Still Design Modification

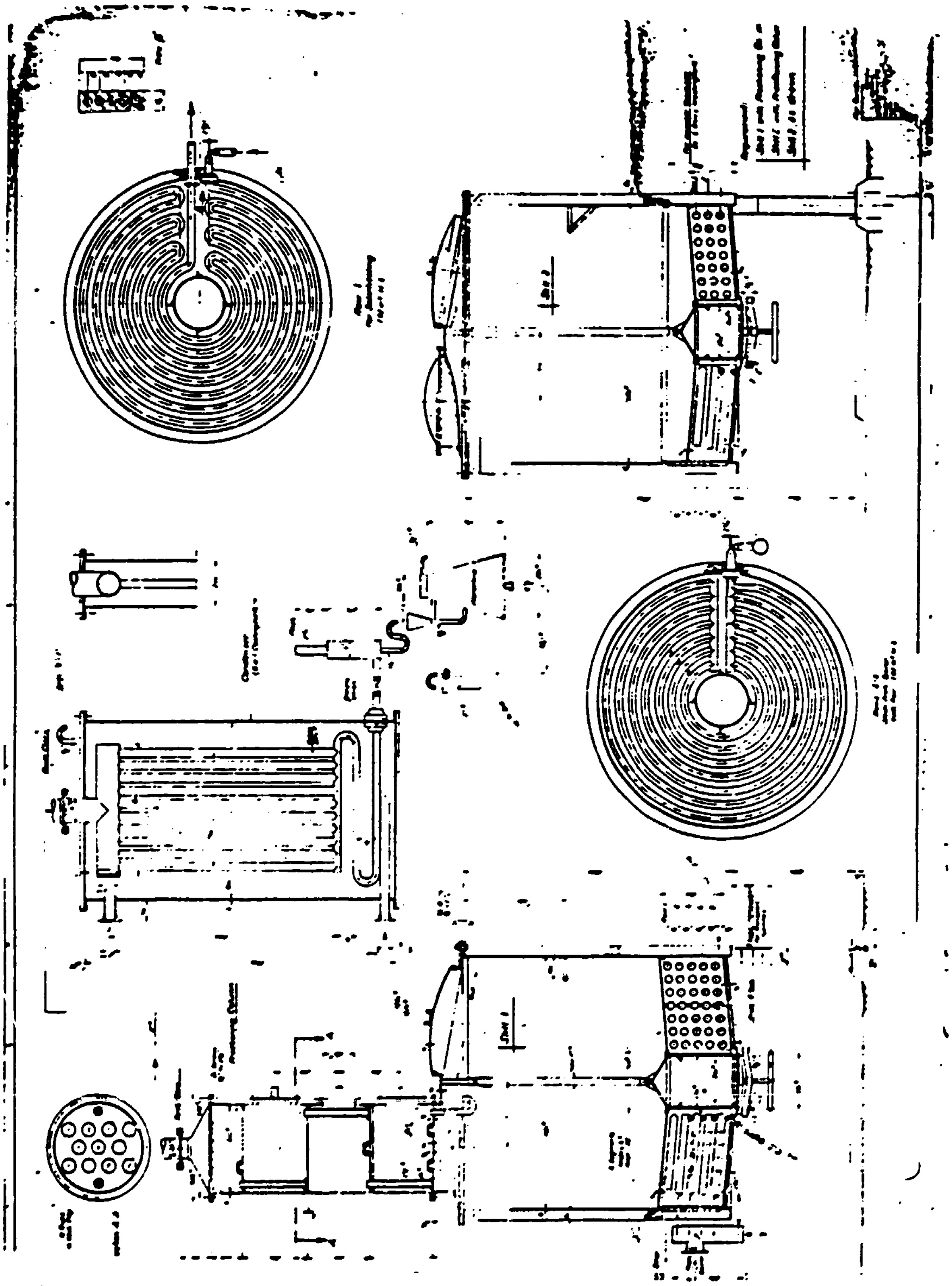


Figure 3.2: Still Design Modification

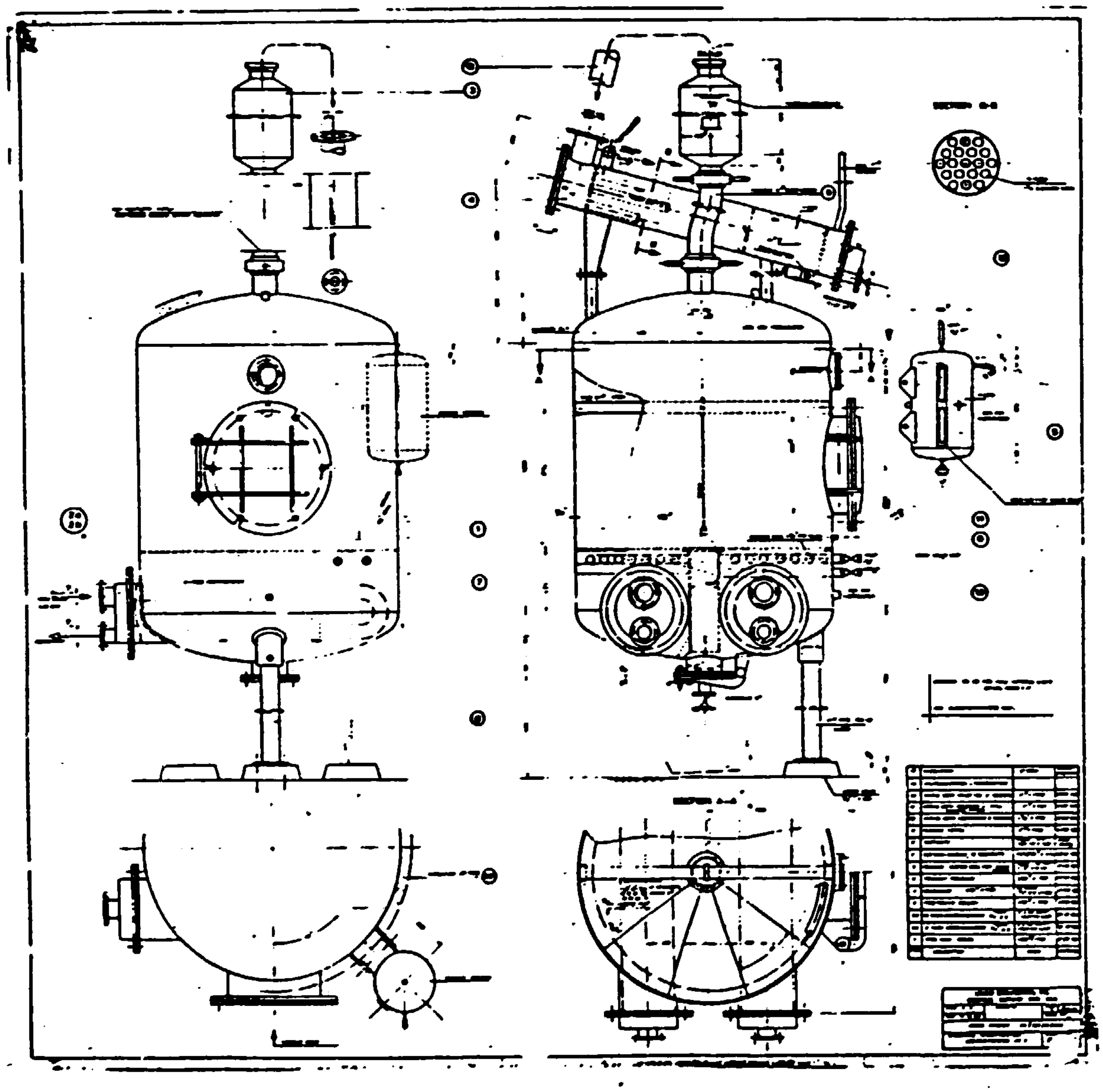


Figure 3.3: Still Design Modification

5. The condenser was changed from a flat to a round design and was moved from a top to a side mounting after the still top was made removable.

6. The heat exchange mechanism was changed from serpentine coils to u-tube bundles because of the far larger heat transfer area provided by the latter.

A number of boiler manufacturers were contacted to provide information on units that could provide heat in the 20-45 kw range required by the still in its current configuration. Based on simplicity of design, ease of installation and availability, cast iron boilers form the Slant/Fin corporation were chosen.

It was assumed that the breadbox weater heaters would be operated in a "batch" fashion bacause effective on-site storage facilities for hot water would probably not be available. The collector would simply by filled each day and completely emptied into the still on the following morning. As a consequence, configurations were investigated that would provide hot water in the 200-400 liter range required by the distillation process. The Team also decided that greater economies could be achieved by buying these heaters "off-the-shelf" rather than by fabricating them. Consequently, a number of manufacturers were contacted and, due to a combination of cost, transportability and ease of installation factors, the "PT-40" heater from Gulf/Thermal Corporation was chosen. This unit has a capacity of 150 liters which was determined to be sufficient input to the 100 kg. flower still. Two such units could, if necessary, be used for a 200 kg. flower still.

It was understood from the beginning that, due to cost and quality control considerations, the evacuated tube collectors would be bought "off-the-shelf" rather than fabricated by the Project Team. Several manufacturers were contacted (Owens-Illinois "Sunpak", Energy Design Corporation, American Solar King Corporation, et al.). Based on size, modularity and ease of handling considerations General Electric's "Solartron" TC-120 series collectors were selected.

A number of photovoltaic cell manufacturers were also contacted. Based on the specifications provided by the Team, the Solarex Corp. of Rockville, Maryland offered to provide a previously designed and tested package solar cell/ pump system which was available "off-the-shelf". This sytem was tentatively accepted by the Project Team.

To summarize, at the end of the Design Elaboration phase the Project Team had developed the following product and equipment specifications list:

o Stainless steel, 200 kg. flower capacity still with U-tube heat exchange coils, removable top and demister;

- o Slant/Fin Corporation Series 21 boiler;
- o Gulf/Thermal Corporation PT-40 series breadbox solar water heater;
- o General Electric "Solartron" TC-120 series evacuated tube collector;
- o Solarex Corporation photovoltaic powered system (using an A.Y. MacDonald Mfg. Co. pump).

Technical literature on the "off-the-shelf" equipment described above is included as Annex B.

Following this Design Elaboration phase the Project Team proceeded to obtain accurate cost estimates and to commence the Fabrication and Testing phase of the project.

4. FABRICATION AND TESTING

As detailed in the Progress Reports the Team had some difficulty in finding manufacturers willing to fabricate the stills as designed. Essentially the stills were too small to warrant interrupting or redirecting standard production line processes for their fabrication. As a consequence, delays were encountered before a suitable fabricator was found: Baeuerle and Morris, Inc. in King of Prussia, Pennsylvania.

Consultations with Baeuerle and Morris resulted in a series of minor adjustments to the still design resulting in the final configuration illustrated in figures 4.1 and 4.2.

Concurrent with this design development the Team was also obtaining price and availability information on the remaining pilot plant equipment. Based on this information and on the estimated costs of the stills, some of the original design decisions were reconsidered and a new combination of solar/conventional fuel input was developed. Specifically, the use of evacuated tube collectors was reevaluated with reference to the overall goals of the project. While this collector type remains the most technically effective for providing heat to the stills, the Team questioned whether its relatively high cost was justified. Even if the collectors contributed the full 5kw for which they were designed, the major source of energy savings in the pilot plants would still be the boiler/heat exchange system. In fact this boiler could provide all the energy required by the still with only a moderate increase in the amount of fuel consumed. This minor increase in consumption becomes justifiable when the high cost of the evacuated tube system is taken into account. The Team also looked critically at the potential for local fabrication of these collectors and judged this potential, like that for all the high heat collectors investigated, to be low. Finally, and perhaps most importantly, the Team questioned the adaptability of these or any high heat collectors to other uses when the stills weren't actually in operation. Due to the sophistication and relative fragility of these units, their heat distribution system, and their connections it was deemed highly unlikely that they could be easily adapted to other uses during the intermittent periods when the stills were not functioning. As a consequence they would not be able to serve as effective models for expanding the use of solar to other sectors of the Comorian economy.

As a result of these considerations the Project Team decided to modify the mix of solar/conventional fuel pilot plants to be supplied, and to concentrate on providing greater photovoltaic input. Specifically, the Project Team determined that a moderately sized (0.5kw) photovoltaic array, in combination with batteries and a small pump, could be used to provide heat to the stills as well as to circulate the condenser water. Furthermore, during periods when the stills were not in operation, the power

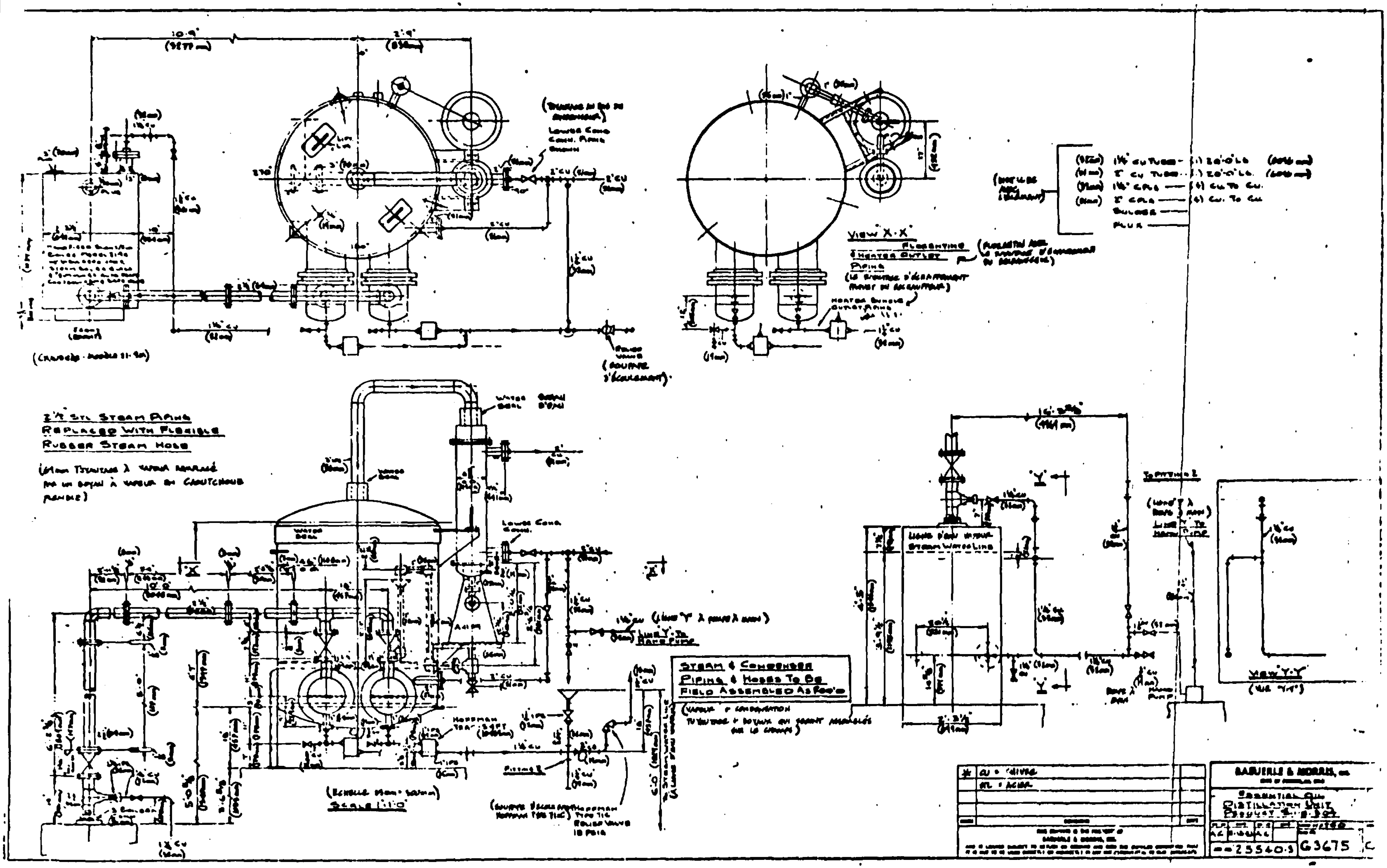


Figure 4.1: Final Still Design

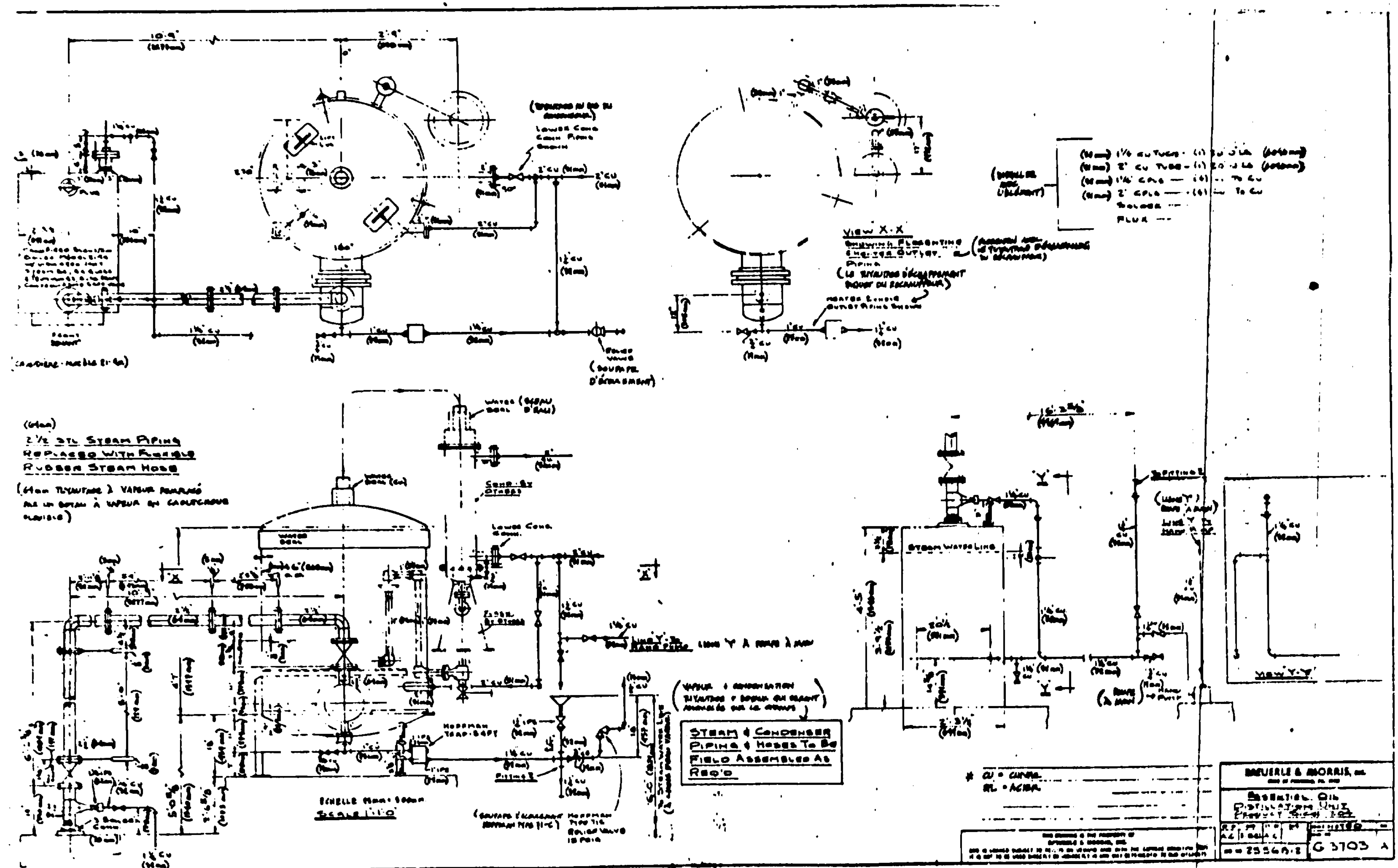


Figure 4.2: Final Still Design

generated by the photovoltaics and stored in the batteries could also be used to provide lighting or to operate the pump for other purposes. Weighing these positive gains against possible long term problems associated with the evacuated tube collectors, the Project Team decided to subsititute a photovoltaic powered heat/pumping system for the evacuated tubes. This change only marginally affected the design of the stills, requiring the elimination of the "pancake coil" heat exchanger and the substitution of a small, resistance-type heating element for use with the photovoltaic arrays. A schematic illustration of a typical installation is presented in Figure 4.3.

The use of this photovoltaic system was discussed with UNIDO by telephone on June 14, 1983. UNIDO gave the approval to this modification and to the following proposed combination of pilot plants:

- One complete, double size distillation unit with a 200kg. flower capacity (still, demister, condenser, florentine and all associated hardware and piping). One boiler. One photovoltaic solar system (0.5 kw array, battery, pump).

- Two distillation units with 100 kg. flower capacity to be adapted to existing condenser/florentine arrangements in field. Two boilers. Two photovoltaic solar systems. Piping and hardware.

- One U-tube heat exchanger designed for use with existing still. One boiler. One breadbox solar water heater. Piping and hardware.

- One breadbox solar water heater for use with existing still.

Based on this approval the Project Team placed final orders for all outstanding equipment and material and completed fabrication of the stills.

Preliminary testing of the stills took place in King of Prussia on June 3, 1983. The tests were successful and fabrication continued without modification. Final testing occurred on July 7, 1983 and, once again, all equipment performed successfully. Protocols for these tests are included as Annex C.

It should be noted that Ylang Ylang flowers were not imported for the tests due to their extremely short "shelf" life (4-8 hours unless very carefully tended) once they are picked. Instead, tests were made with water to establish that the units were fully operational and functioned efficiently. The only aspect not adequately tested was the effect, if any, of the demister on the quality of the oil. This element was to be field tested in the Comoros and was designed in such a way that, if it proved ineffective it could be easily removed.

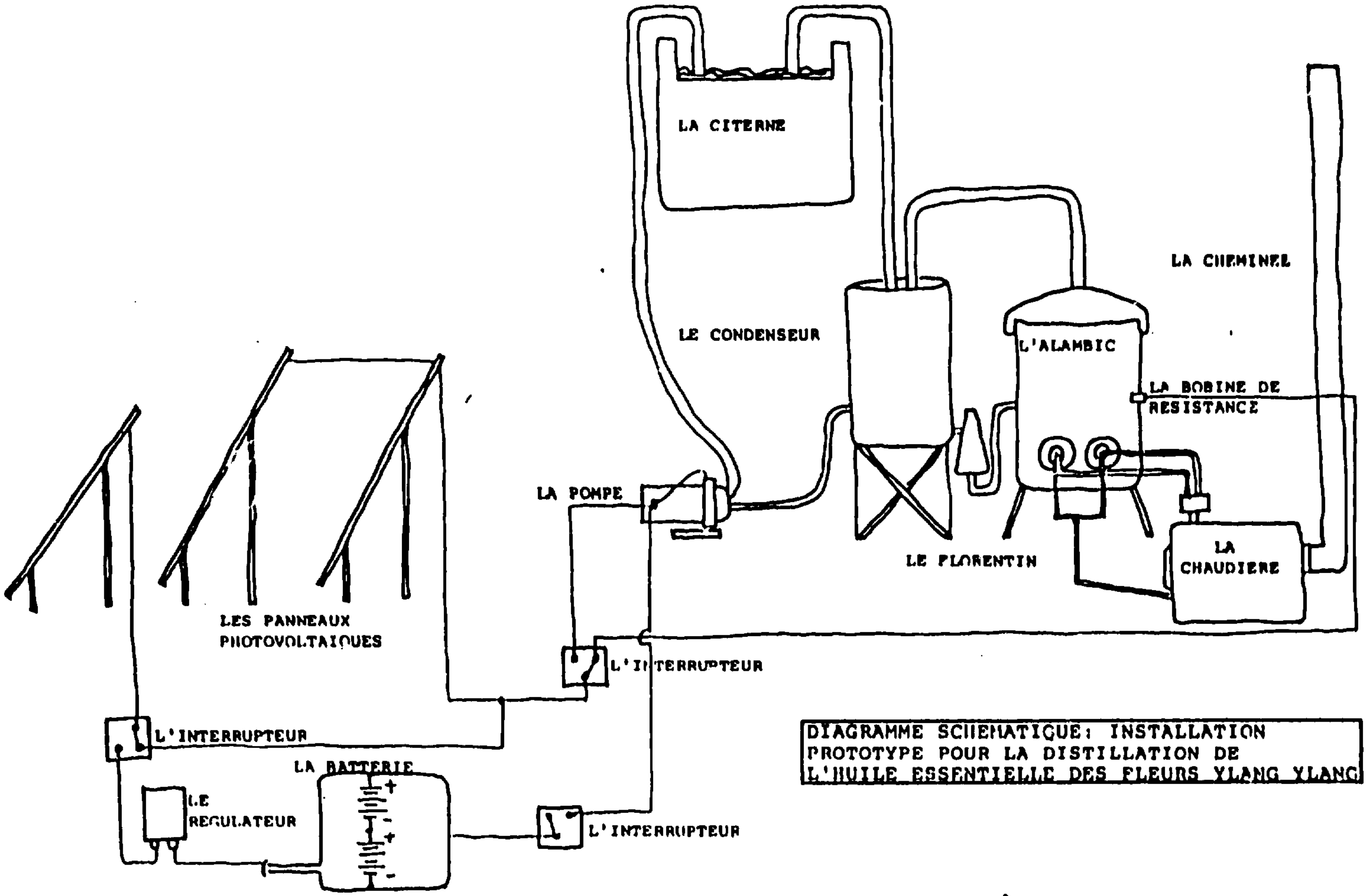


Figure 4.3: Schematic Illustration of Typical Installation

Following successful completion of the tests an instruction manual was prepared for use in the Comoros. This manual for "Le Fonctionnement et le Maintien d'Une Installation Prototype pour la Distillation de l'Huile Essentielle des Fleurs Ylang Ylang" is included in this report as Annex E.

5. SHIPMENT

All the equipment listed above was consolidated into 22 parcels and was shipped from New York July 17, 1983 on the SS MORMACDRACO. Due to a variety of problems, transshipment from Durban to Moroni was delayed several months and the Team was forced to cancel their proposed mission to the Comoros, originally scheduled for October 08, 1983.

Final confirmation that the shipment had arrived in Moroni reached Steven Winter Associates, Inc. in October 27, 1983. Customs clearance and arrangements for inter-island transportation took place over the next three months and SWA was kept informed of developments by telex. During this time a consignment of miscellaneous space parts and tools was asembled and air shipped to Moroni on January 15, 1984.

Based on reports from UNDP, Moroni, stating that all equipment had arrived in the island and was ready for installation, the Project Team rescheduled their mission for mid-February 1984.

6. INSTALLATION AND COMMISSIONING

The Project Team (Deane Evans and Rick Gebel) arrived in Moroni on Saturday, February 18, 1984. On Sunday, February 19, they visited the Mitsamiouli site of Adrien Riviere. All the equipment (PV panels, boiler, and still) had arrived but was still crated. During the next days the photovoltaic array was assembled and a crane was ordered to move the heavy equipment to its final location on the site. On Wednesday, Feb. 22, Deane Evans went to Anjouan to search for a new site on this island. The 3 Nioumakele distilleries originally chosen during the investigation mission had shut down and the government desired to have a new site close to Mutsamudu. A number of locations were preoposed and one in Patsy, just outside Mutsamudu, was chosen for technical and logistical reasons.

Upon return to Grande Comore the crane was procured and the first Riviere installation was put in place. At the suggestion of the government, it was decided at this time that a second Grande Comore installation, using an existing still and condenser, would also be installed at the Riviere site. Piping and connections for the first set of equipment (still with 2 U-tubes, boiler and PV array) were put in place.

In the meanwhile, a site for a third installation was chosen at Serehini, in a new CADER ("Centre d'Appui au Developpement Rural") being formed there. The site has adequate water and, most important, adequate supervision as it will be the headquarters of this new CADER. Some masonry work was required to make the site usable and workers and materials were procured.

Having set-up the Riviere equipment, the team left for Anjouan on Thursday, 10 March. A chimney connection was still lacking at Riviere and the team felt it was better to work in Anjouan while this connection was procured and to delay firing the system until UNIDO Representative who visited the country from March 3 to March 10, 1984, could be at site.

In Anjouan, there were a variety of problems, including some missing material, connected with the way the equipment had been shipped and off-loaded. The team managed to overcome these with the help of Travaux Publiques and the installation was complete by Monday March 5. Mr. Evans returned to Grande Comore on this day. Mr. Gebel stayed in Anjouan until Wednesday to test fire the installation. This firing started at 1:30 pm on Tuesday March 6 and finished at 5:30 am on Wednesday, March 7. Approximately 2.75 cubic meters of wood were used. Mr. Gebel monitored the test and the result was one liter of "premiere" grade oil. The workers were extemely pleased with the result, which is especially gratifying considering that this installation had no chimney, was burning very wet wood, and had an uninsulated still. The workers involved understand that a chimney and roof are needed and are in the process of procuring the necessary materials. They also typically burn dry wood but such wood was not available on the day of the test. In the future, it will be. Based on the foregoing the team judged the Anjouan site an unqualified success and Mr. Gebel returned to Grande Comore.

It should be noted that a photovoltaic pump for circulating condenser water was not installed in Anjouan. The water situation in Anjouan is such that conservation is not a problem. In fact, in existing stills condenser water, after cooling the distillate, is simply allowed to run out continuously onto the ground.

Based on these observations, providing a pump for circulating condenser water was considered to be unnecessary on Anjouan. The situation is quite different on Grande Comore where water is rigorously conserved in cisterns. Because of this difference, the Team decided that the PV pump would be much more valuable on Grande Comore and shipped it back.

Back in Mitsamiouli the final preparations were made at the Riviere site and the system was fired at noon on Friday 09 March. Based on experience of the test in Anjouan a large initial fire was built. However, because there was good wood and a chimney at Riviere's this proved to be too much fire and the system had to be damped down. Once smooth operation was achieved (at 2:30) the boiler/still unit performed extremely well from an energy standpoint. There were problems, however, with vapor flow through the new "swan's neck", resulting in a very slow distillate flow. At 4:15 pm the top of the still was taken of and the demister was removed. By 6:30 pm a very strong flow through the condenser was achieved, but even distilling until midnight yielded very little oil. This may have been due to the fact that some oil was lost during the period of shutdown and when the top was taken off to remove the demister. It is also likely that the fire was allowed to burn too low in the boiler during periods when the Project Team was not actually at the site. The importance of maintaining the fire at a constant level was subsequently explained to the operators. However, as this was the very first firing at this site certain mistakes and omissions were to be expected.

Testing continued at the Riviere site. On March 13 and March 16 tests were conducted to monitor temperature flows through the system under various operating conditions and to determine the optimum modes of start-up and operation. Copies of field notes for these tests are reproduced as Figures 6.1 and 6.2.

EQUIPMENT PERFORMANCE TEST: MARCH 13, 1984 RIVIERE SITE

TIME	PRESSURE (PSI)	TEMP STILL (DEG. C)	TEMP "SWAN" (DEG. C)	TEMP U-TUBE (DEG. C) LEFT	TEMP U-TUBE (DEG. C) RIGHT
1:20	FIRE BOILER				
1:30	0	35	-	34.90	34.90
1:45	4	35	-	35	35
2:00 (OPEN U-TUBES)	5	35	-	35	36
2:15	2	40	-	38	76
2:30 (CLOSE U-TUBES)	0	46	-	38	84
2:45 (OPEN U-TUBES)	5	44	-	42.5	92
2:50 (DRAINED LEFT U-TUBE)	8	58.7	35.2	42	94
3:05	0	62.6	51.4	67	95
3:20	4.2	70	58.2	89	100
3:30 (STEAM RISING FROM STILL)	5	79	61	101	101
3:45 (MOVE TOP INTO PLACE)	4.5	84	63	100	103
3:50	5	90	63.5	101	104
3:55 (MODERATE DISTILLATE FLOW)	4	91	69.5	101	103
4:15	TEST TERMINATED				

FIGURE 6.1: FIELD TEST NOTES

EQUIPMENT PERFORMANCE TEST: MARCH 16, 1984 RIVIERE SITE

TIME	PRESSURE (PSI)	TEMP STILL (DEG. C)	TEMP "SWAN" (DEG. C)	TEMP U-TUBE (DEG. C) LEFT	RIGHT
11:15	-0-	35	36.5	39	39
11:30	-0-	5	36.5	39	39
11:45	1	1	36.5	39	39
12:00	4	35	36.5	39	39
12:05 (OPEN U-TUBE VALVES)	7	35.5	36.5	39	39
12:15	4	37	36.5	78	97.6
12:30	4	40	36	79	99.8
12:45 (ADD WATER)	4	44.2	38	81	98.
1:00	4	53.1	40.5	80	100.7
1:15	4	53.1	43.2	84	100
1:30	5	68.9	43.5	86	99
1:45	5	77	46.8	79	99
1:55	MODERATE DISTILLATE FLOW - TURN ON CONDENSER WATER				
2:00	5	81	51	79	101
2:15	5	77	57.5	76	99
2:30	4.5	70	54	71	97
2:45	4.5	70	52	79	97
3:00	5	74	57	98	100
3:15	4	60	54	75	98
3:30	2	63	49.5	67	93
3:45	TEST TERMINATED				

FIGURE 6.2: FIELD TEST NOTES

The results of these tests indicated that a fairly large fire is necessary until the water in the still is brought to a boil. At this point, the fire can be allowed to diminish, but a minimum pressure of 4 to 5 psi should be maintained. Maintaining this pressure will automatically control the amount of wood consumed.

The firing process can be started with the top of the still on or off. Both methods were tried and both performed equally well.

Vapor locking problems in the steam supply hose for the left U-tube were discovered and the supports for this hose were changed to make the steam path more direct and thereby allow continuous, even flow.

Rain was also observed to have a significant detrimental impact on heat flow. Because the still is currently uninsulated and unprotected from the weather even a moderate rainfall causes substantial dissipation of heat over the entire surface area of the still. As a result of this heat loss a larger fire, and therefore more energy consumption, is required to maintain the distillation process.

The importance of insulating and covering the stills and boilers is clearly understood by the personnel at all the sites, and plans have been made to provide roofs and effective insulation in the near future. The Team itself did not install the insulation it had brought because the sites had not been adequately prepared to protect the insulation from the elements. Without such protection the insulation would quickly degrade and require replacement. Once conditions improve and adequate insulation is provided the performance of these units, while encouraging now, is expected to be substantially better.

Following these two interim tests, the Team performed a final test (again with water because no flowers were available) on March 17, 1984 at the Riviere site. The purpose was to verify that the principles of operation developed in the previous tests were easily implemented and effective. Field notes for this test are presented in Figure 6.3. Of interest in these notes is the extremely rapid rise in the temperature of the "swan's neck" from 11:05 A.M., when it was covered with a cardboard box, to 11:11 A.M. when strong distillate flow was observed. If a simple box can effect performance this substantially, it is clear that proper insulation of the equipment will dramatically improve performance.

In this test roughly 1 1/4 cubic meters of wood were consumed. The major portion (more than 1 cubic meter), being used during the 2 1/2 hour start-up period. In one hour of actual distillation the unit yielded 18 liters of distillate, a result Adrien Riviere considered to be extremely good. During this one hour period, only two or

EQUIPMENT PERFORMANCE TEST: MARCH 17, 1984 RIVIERE SITE

TIME	PRESSURE PSI	TEMP STILL (DEG. C)	TEMP "SWAN" (DEG. C)	TEMP U-TUBE (DEG. C) LEFT	RIGHT
8:45	FIRE BOILER				
9:00	5	32.7	-	27.7	27.9
(ADD H20 TO STILL TO 1" ABOVE GRILL)					
9:10	OPEN LEFT U-TUBE AND BOILER VALVE				
9:11	OPEN RIGHT U-TUBE				
9:15	6	32.2	-	27.7	27.8
9:16	5	32.2	-	27.7	99
(SHUT DOWN RIGHT U-TUBE)					
9:18	6	32.2	-	98	95
9:30	2.5	41	-	92	96
9:45	6	52.6	-	90	100
(SOME STEAM FROM STILL)					
9:55	9	66	-	105	100
(REOPEN RIGHT U-TUBE)					
9:59	DAMP DOWN FIRE - MORE STEAM VISIBLE AT STILL				
10:00	MOVE TOP INTO PLACE				
10:15	9	82	-	92	101
10:21	11	85.5	-	92	99
10:25	MODERATE BOIL				
10:30	12.5	86	35.4	100	108
10:45	13	88.5	53.5	107	111
10:50	LIGHT RAIN				
11:02	11.5	90(89)	35	100	106
11:05	"SWANS NECK" COVERED				
11:07	MODERATE DISTILLATE FLOW				

FIGURE 6.3: FIELD TEST NOTES

TIME	PRESSURE PSI	TEMP STILL (DEG. C)	TEMP "SWAN" (DEG. C)	TEMP U-TUBE (DEG. C) LEFT	RIGHT
11:11	12		82.5	101	105
(STRONG DISTILLATE FLOW - TURN ON COND. WATER)					
11:30	11	90.5(86)	87.6	102	105
11:36	STEAM OUT OF FLORENTINE - INCREASE CONDENSER H2O FLOW				
12:00	10	88.5(92)	79	105	105
12:11	9.5	90(91)	83	99	96
(DISCHARGE FLORENTINE - 18 LITERS OF DISTILLATE; OPEN BOILER FIRE DOORS TO LET FIRE BURN OUT)					
12:32	4	88(88)	84.6	92	97.5
12:55	0	89(88)	78	86	87
(TURN DOWN CONDENSER WATER)					
1:14	0	86.2(84.3)	74	85	77.5
1:40	0	81.5(81.5)	71.5	64.5	66.5
1:45	TEST TERMINATED				

FIGURE 6.3: FIELD TEST NOTES (continued)

three small pieces of wood were added to the fire, just enough to maintain the rate of distillate flow. At this rate over a projected 12-14 hour distillation period the extrapolated wood use will be another 1 1/4-1 1/2 cubic meters for a total of 2 1/2 - 2 3/4 cubic meters of wood. A similar overall rate (2 3/4 - 3 cubic meters) was recorded for the performance test on Anjouan. Compared to a current rate of consumption of between 5 ands 8 cubic meters this contitutes a substantial savings. As noted above this savings can only improve once the stills are insulated and protected by adequate roofs. A consumption rate of 1 1/4- 1 3/4 cubic meters can be anticipated.

During this testing period the Team also assembled the boiler for the second Riviere installation. This boiler is intended to be connected to an existing still fitted with a new U-tube heat exchanger. A still was procured and a hole for the connection was made. Unfortunately the bottom of this still was damaged and needed repair. Further, available soldering equipment could not produce enough heat to braise the connecting flange to the existing still wall effectively. Such equipment does exist on Grande Comore but was not available during the period of the Mission. Given these two obstacles to actual installation, the Team simply sized and prepared all the necessary piping and connections and attached them to the boiler. All that remains, after the still bottom is repaired and the flange braised, is to set the still in its prearranged location, insert the U-tube and connect the hoses. The on-site personnel understand how to do this and already have a working model to use for reference.

Concurrent with the commissioning of the stills and boilers at the Riviere site the Team also installed one photovoltaic pump system and one breadbox hot water heater. The pump system performed extremely well and the PV panels were able to provide sufficient power to lift water over 6 meters (from one cistern to another) even on cloudy days. During periods when the pump was not used, the PV array successfully charged the two batteries provided by the Project Team and was being used to charge other batteries belonging to the personnel at the site.

The breadbox heater arrived in the Comoros with its top plate of glass broken beyond repair. The Project team had brought some "Tedlar" plastic film with them and used this to make a new cover. The unit was filled at 1:45 pm March 17 with 28 degrees C water. On March 18 at 2:15 PM the water temperature at the breadbox outlet was measured to be 51 degrees C. This temperature rise, while sufficient for preheating the still water, is not the highest attainable. It is anticipated that during the dry season, when there is little or no cloud cover, temperatures in excess of 60 degrees C will be achieved.

From March 14 to 19, the Team also completed the installation at Serehini. As noted earlier this site is brand new and not currently staffed. In consultation with the Government, it was decided to set up the equipment, and make the necessary connections, but not to operate the unit until this new CADER is occupied and functioning. To this end the Team had masons prepare the site so that the still could be placed at a sufficient elevation above the boiler. Once this work was finished the Team assembled the boiler, installed the still, and made the necessary connections. Before the unit becomes fully operational the Government will procure and install a standard artisinal condenser and connect it to the cistern.

The photovoltaic array was also assembled but was not placed on the site due to security considerations. Instead, it was stored at CEFADER ("Centre Federale d'Appui au Developpement Rural") the headquarters for all CADER activity. Members of the CEFADER staff are familiar with the equipment and will install it once the CADER is operational.

It is anticipated that the Riviere site will serve as a model for commissioning the Serehini site and that Adrien Riviere will be personally involved. This will ensure that the most effective mode of operation will be taught to the Serehini distillers.

The fifth and final pilot plant, at the Mikidache site at Kafouni, Grande Comore, was installed and made operational on March 20, 1984. This installation consists of one 14-panel photovoltaic array, 2 storage batteries and one pump for circulating condenser water. In consultation with the Government it was decided that the PV/pump system shipped back from Anjouan should be used for the fifth plant, rather than the breadbox heater originally envisioned. This breadbox heater will, in turn, be shipped to Anjouan for installation at the Patsy site. At the time the team left the Comoros, this breadbox was in Government storage awaiting shipment.

An operational test of the PV/pump system was made on the day of installation and the system was determined to function exactly as designed.

In summary, the disposition of the equipment shipped to the Comoros in support of this project is as follows (see Map, Figure 6.4, for locations):

A. RIVIERE SITE - MITSAMIOULI, GRANDE COMORE.
(Pilot Plants 1 and 2)

(1) Baeuerle & Morris Distillation Unit with 2 U-Tube bundles and integral condenser, having a capacity of 200 kg. flowers;
(1) Slant-Fin 21-9H Boiler;
(1) 14 panel photovoltaic array;
(1) A.Y. Macdonald Water pump;
(1) Gulf-Thermal solar hot water heater;
(1) Slant-Fin 21-5H Boiler (to be connected to existing local still when latter has been repaired);
(1) U-Tube bundle (to be installed in existing still above mentioned);
(3) Bags insulating cement

Assorted spare parts.

B. PATSY SITE - PATSY, ANJOUAN
(Pilot Plant 3)

(1) Baeuerle & Morris Distillation Unit with 1 U-Tube bundle, having 100 kg. flower capacity
(1) Slant-Fin 21-5H Boiler
(3) Bags insulating cement

C. CADER SITE - SEREHINI, GRANDE COMORE
(Pilot Plant 4)

(1) Bauerle & Morris Distillation Unit with 1 U-Tube bundle, having 100 kg. flower capacity
(1) Slant-Fin 21-5H Boiler
(1) 14 Panel photovoltaic array
(1) A.Y. Macdonald Water pump
Assorted spare parts

D. MIKIDACHE SITE - KAFOUNI, GRANDE COMORE
(Pilot Plant 5)

(1) 14 Panel photovoltaic array
(1) Water pump

E. STORAGE (MINISTRY OF PRODUCTION) - MORONI, GRANDE COMORE

(1) Gulf-Thermal solar hot-water heater

SPARE PARTS

(3) Bags insulating cement

Hoffman steam trap and air vent (Riviere)
Miscellaneous short lengths rubber hose
" " " copper pipe
" " " electrical cable
" spare valves
" electrical connectors and switches
" tubes of Dow RTV 732 Sealant
" gaskets (many) and rubber bushes
" nuts and bolts
" hose clamps

Operating Manuals have been distributed as follows:

Riviere - 1
Patsy - 1
CEFADER (Serehini) - 1
Inspector General of Rural Development - 2
UNDP Moroni - 1

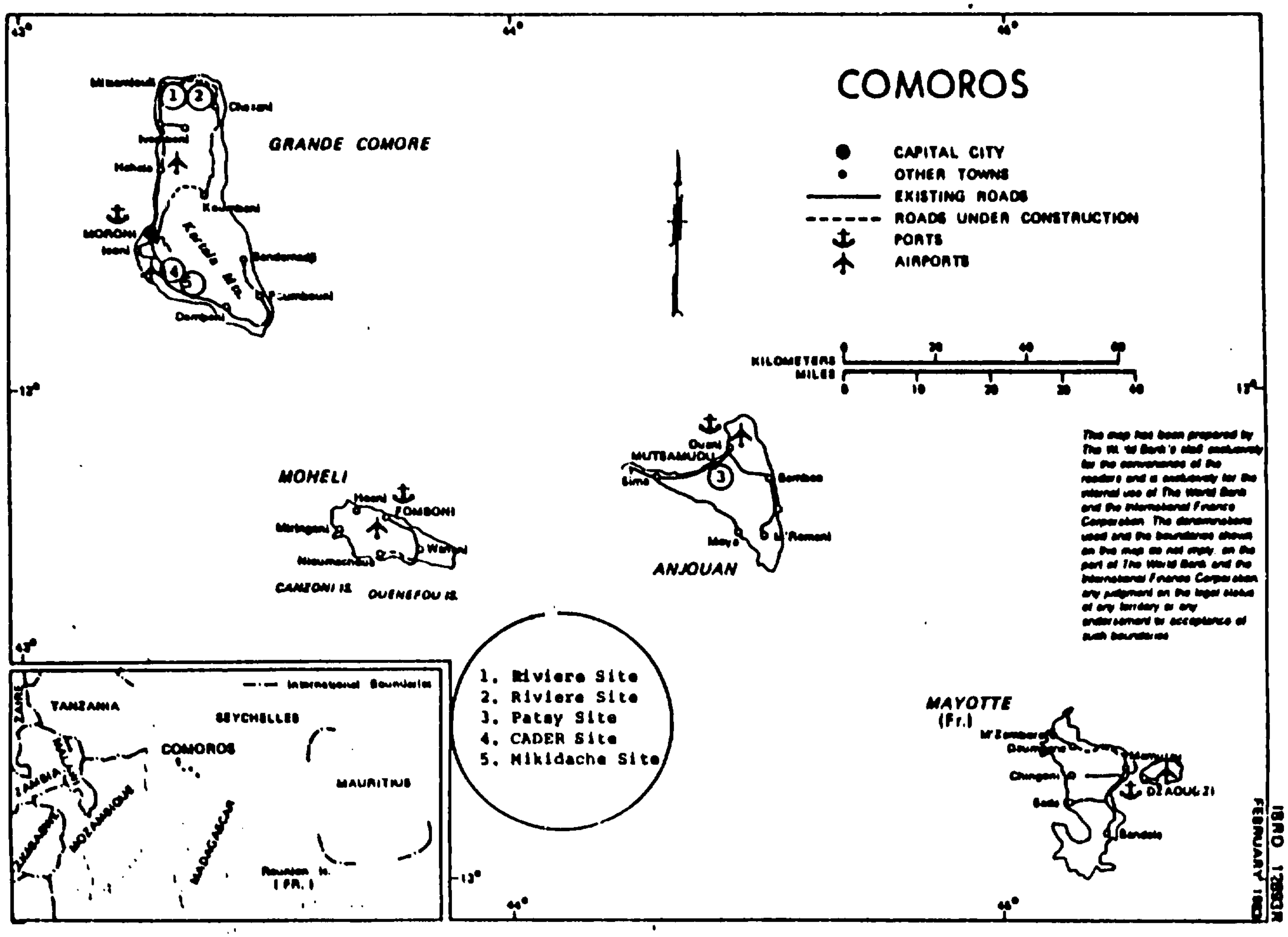


Figure 6.4: Map with Locations of Pilot Plants

7. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the performance tests conducted at the Patsy site in Anjouan and the Riviere site in Grande Comore, the pilot plants performed extremely well from an energy savings standpoint. As described in the preceding chapter, wood consumption was reduced from the 5 to 8 cubic meters used in a typical artisinal still to 2 1/4 - to 2 3/4 cubic meters. These amounts will diminish even further (to 1 1/4 - 1 3/4 cubic meters) once the units are properly protected and insulated. It is therefore clear that substantial energy savings and reductions in wood consumption are possible in the Ylang Ylang sector of the Comorian economy. This chapter discusses ways in which lessons learned from this pilot plant project can be further utilized in the Comoros. It is divided into four topic areas.

The first explains the recommendation that the demister introduced in the pilot plant stills be field tested on existing direct-fire stills. The second discusses the ways the pilot plants themselves might be expanded to a larger scale project. As noted in the preceding chapters, the chief contributor to the energy savings obtained by the pilot plants was the boiler/U-tube system of heat transfer. As a consequence, recommendations for establishing a large-scale demonstration project concentrate on the conventional fuel aspects of the pilot plants. The use of solar energy is discussed separately. While not a major source of energy savings in this type of small scale agro-industrial process, solar energy does have potential application in the country and recommendations for expanding the solar techniques used in the pilot plants to other uses in the Comoros will be discussed as the third topic of this chapter. The fourth and final topic area will discuss an alternative approach to conserving wood in the Comoros.

FIELD TESTING THE DEMISTER WITH EXISTING STILLS

Each of the three stills provided for the project was equipped with a simple wire mesh demister at the entrance to the "swan's neck" (see Chapters 3 and 4). This component was included on an experimental basis to determine if it could increase the speed with which the higher grades of oil were obtained and thereby save energy by reducing overall distillation time. This demister functioned well in Patsy, was removed at the Riviere site in Mitsamiouli and has yet to be tested in Serehini (see Chaper 6).

A series of comparative tests, over perhaps several months, are necessary to determine the actual efficacy of these demisters in the new stills and such tests will be undertaken by personnel trained by the Project Team. It is further recommended, moreover, that the Government undertake similar tests on existing, direct-fired artisinal stills. The demisters provided by the Project Team can be used or a similar form of inexpensive wire mesh can be obtained. In either case the mesh should be secured to the still top at the opening for the swan's neck, exactly as in the stills provided by the Project Team. A series of comparative tests should then be run to determine if the demister affects either the quality of the oil produced, the time of distillation, or both.

Such long-term testing was not possible for the Project Team but is highly recommended for the Government. If using the demister has no results, the stills can return to normal operation. If, however, the results are positive the Government will have a simple technique for improving quality that is inexpensive, easy to fabricate in the Comoros and adaptable to all existing stills.

ESTABLISHING A LARGE-SCALE DEMONSTRATION PROJECT

There are two basic methods for building upon the lessons learned from the pilot plants and establishing a large scale demonstration project. The first is to keep the pilot plants as presently designed and simply expand the number of them. New stills would not be required; existing stills would be adapted to the boiler/U-tube system as in Pilot Plant 2 at the Riviere site.

This approach is aided by the fact that working units now exist on the islands and could be used as models. There are certain difficulties, however. In the first place, at nearly every site the existing stills will need to be elevated in order to provide sufficient height to ensure good condensate flow from the U-tubes back to the boiler. Elevating the stills will require digging them out of their foundations and developing new suppots for them. The existing condenser will also need to be elevated sufficiently to function properly with the still. These are not major problems, but they must be taken into account if such a project is to be implemented.

With regard to the costs involved it is likely that small boilers such as the Slant/Fin 21-5H provided for the pilot plants could be purchased in bulk for $2000-2500 apiece, CIF Moroni. This is a good price for such boilers, but is still a substantial sum by Comorian standards. The U-tube bundles will cost approximately the same amount making the total cost to upgrade one still roughly $4000-5000. Assuming a Government estimated price for wood of 250-350 CFA ($0.63 - 0.88) per cubic meter and an average wood use reduction of 3 1/2 cubic meters per distillation, savings of between $2.20 (3.5x0.63) and $3.08 (3.5x 0.88) are possible each time the new system is used. Although there are no reliable statistics on the number of times an average artisinal installation actually distills in a given year, a minimum rate to make the new equipment cost-effective can be derived. Conservatively assuming a useful life for the boilers and U-tubes of 20 years, a simple payback requires $250 per year (5000/20=250). At a savings in wood consumption of $2.20-3.08 per use, the unit will need to be operational somewhere between 82(250/3.08) and 114(250/220) times per year. This does not seem an unreasonable number to expect but more research needs to be done into actual prices and numbers of distillations before this type of large scale expansion is undertaken. For example, if the money to buy these units is borrowed, the rate per year will certainly be higher in order to finance the debt. On the other hand bulk equipment prices may be lower or the price of wood higher than quoted which may offset the interest charges.

A second and more promising approach to expanding the Pilot Plants is to apply the basic <u>principles</u> involved but not to copy the existing models exactly. That is, rather than trying to obtain performance improvements in each individual artisinal still, performance improvements for groups of stills should be attempted. This will entail organizing the distillers into some form of cooperative and the degree to which this is possible within the current economic structure of the country must be investigated. If it <u>is</u> possible, substantially greater savings than are available to the individual artisinal stills are feasible.

There are two primary reasons that cooperation is more cost-effective. First, only one large boiler is used, producing economics of scale in both initial cost and operating expense. Second, the system can be designed to operate under pressure which allows a much simpler form of heat transfer mechanism, serpentine coils, to be used. An attempt was made in the original designs for the pilot plants to use such coils, but they were abandoned because of potential condensate return problems in a system operating at atmospheric pressure. Such problems do not exist in a pressurized system, however, and serpentine coils could be used in a larger scale operation. The advantage of these coils is that they are inexpensive and suitable to local fabrication in the Comoros. Although accurate costs must be determined, even if the coils cost $[illegible] per unit this would still constitute a savings of 80% over the cost of the U-tubes ($2500). It is this type of saving combined with potentially greater efficencies in a larger boiler that make large, centralized operations so advantageous.

A certain amount of study is required before any demonstration project can be undertaken. In the first place an accurate determination of the number of stills available for centralization <u>must</u> be made. The size and location of each large scale plant will be determined by the number of stills in a given area, and their locations relative to each other and to the Ylang Ylang fields. The number of stills will probably vary from 5 to 10 per plant, and the size of the boiler will vary accordingly. Accurate cost-benefit analyses will depend on the total number of stills involved, the costs of removing them from their current locations to central sites, the sizes of the boilers required, the distances the flowers must be transported, and the costs of piping and connections. The importance of an in-depth feasibility study before any work is undertaken cannot be overemphasized.

During any such study new techniques for improving performance should also be investigated. Some of the techniques mentioned in the Berreur report (see Chapter 1) such as steam recycling, accelerated distillation, hydrodiffusion or heat pumps could be explored. The Project Team did not examine these and other sophisticated tehcniques because it concentrated on improving the individual artisinal units. At the larger scale of the cooperative, however, such techniques may be effective and should be investigated.

In summary, the main conclusions and recommendations for expanding the pilot plants to a demonstration project are as follow:

1. Determine the precise number, disposition and working condition of <u>all</u> the artisinal stills in the country.

2. Determine to what extent these stills can be organized into cooperative installations and develop an organizational plan for cooperation.

3. Based on this plan and on the total number of units involved develop accurate cost estimates for transporting the existing stills to the selected central locations and for adapting them for use with large boilers (or any other techniques under consideration).

4. Conduct a techno-economic feasibility study to determine if such installations can be operated cost-effectively and, if so, how many are required and where they should be located.

This study is straightforward and can be easily accomplished if the data for the first two crucial areas is available. It is anticipated that the new Census together with an independent study by CEFADER will provide precisly this information in the near future.

This data could also be used for a feasibility study on improving individual artisinal stills by providing boilers and U-tubes for them. The exact costs of such an expansion cannot be adequately determined until the number of stills in question is known so that the number of boilers and U-tubes to be ordered can be determined. There is certainly the possiblitiy that this type of direct extension of the pilot plant project could be cost-effective, but the Team feels that the potential is far greater through some form of cooperation and recommends that this approach be investigated first.

EXPANDING THE USE OF PILOT PLANT SOLAR TECHNIQUES

Although the net contribution of the solar components to overall performance in the pilot plants was relatively minor, the photovoltaic pump system and the "breadbox" water heater both functioned extremely well and are worthy of further consideration. Because the current high costs of photovoltaics limit their use in a country like the Comoros to very remote applications where there is no other source of power available (e.g. radio signal towers), their potential for wide scale application is relatively low. They also have limited potential for local manufacture. The breadbox water heater, on the other hand, has both widespread applicability and the potential for local fabrication.

Because of their simplicity of design and operation the breadbox heaters supplied in the pilot plant project can serve as models for the manufacture of similar units in the Comoros. Galvanized metal can be welded into any of a wide range or shapes and sizes, simple wooden frames can be used and glass or plastic can serve as the cover. It was clear to the Project Team that several facilities that could undertake such work already exist in the country, and that the fabrication of such units could easily develop into a small-scale industry. The key to such development, however, is an accurate analysis of <u>demand</u>. A study must be undertaken, prior to any development in this area, to determine precisely who will use solar hot water, how much they will use and how often. Only once such information has been gathered can informed decisions be made as to the extent of the market, the most appropriate size or sizes for the water heaters, the number of heaters to be produced in a given period of time, and the size and capacity of the factory fo factories to be built. The technical capability to fabricate this type of solar heater exists within the country. Before production can commence, however, an accurate market analysis must be undertaken to determine the demand.

AN ALTERNATIVE APPROACH TO WOOD CONSERVATION IN THE COUNTRY

Based on its field experiences the Project Team recommends that the Government investigate technical improvements in domestic cookstoves as a method for reducing wood consumption in the country. Although current wood consumption in the Ylang Ylang sector is clearly wasteful and can be improved, the relative impact of this particular sector of the Comorian economy on total wood consumption remains unclear. A wide variety of techniques for improving cookstove efficiency exist throughout the world. Many contain components suitable for local manufacture in the Comoros and a project in this sector could readily form the nucleus of one or more small-scale industries. To set this process in motion, however, information is required on the types of stoves currently in use on the islands, their levels of wood consumption and their costs, if any. Against this base information a number of improvement techniques can be measured and those found most cost-effective can be implemented. Although no accurate wood consumption data is currently available for the Comoros the potential for energy savings in domestic cooking is often quite high and merits further study, especially relative to the serious deforestation problem which currently exists in the country.

COLLECTOR SUBSYSTEM

The collector subsystem is used to intercept the sunlight, and convert it to useful energy at the required temperature. Available devices for this application fall into three major classifications: tracking concentrators, non-tracking concentrators, and non-concentrating collectors.

Tracking concentrators fall into the major areas of single and two axis tracking. The two axis tracking concentrators may be of the parabolic dish or the power tower type. In either case the sun is tracked in two axes in its path across the sky. In most cases, the reflector is moved to track the sun. These collectors are useful to extremely high temperatures, the theoretical limit being 10,000 K. The primary reason for the application of this type of collector is the high temperature achievable, the penalty paid for this capability is the mechanical complexity introduced by the tracking mechanism. Practical difficulties preclude the use of this system in the Comoros. Improper operation of the system (tracking the sun with no coolant flow, for example) would immediately destroy the absorber surface. The safety problems incurred by the high energy flux density at the focal plane is another obvious restriction. Single axis tracking concentrators are most commonly of the line focussing type, this category includes trough type parabolic, some Fresnel lens collectors, and the fixed focussed mirrored concentrators, for example. A great deal of development is currently underway in the United States on this category of collectors since they are ideally suited for many process heat supply systems. These system are either oriented with their axis north-south (following the sun as it moves from east to west) or east- west (tracking the altitude changes of the sun). Upon initial investigation these appeared to be the ideal choice for the solar collector subsystem. The single axis tracker with the east-west axis must be dropped, however, due to the potential damage associated with a loss of coolant flow. The north-south axis tracker, however, is much less restricted since a loss of coolant will have only minimal effect if the sun is not followed. If, however, tracking is continued even after loss of coolant, the collector will probably be destroyed, or at least its performance will be severely degraded. Since these systems have significant durability and safety concerns associated with them, especially for this application, they are not recommended.

Non tracking concentrators are most commonly of the compound parabolic collector (CPC) type, or reflector augmented array type. CPC collectors use a line focussing collector concept but the concentration ratio is low enough, and consequently the acceptance half angle large enough, that tracking of the sun is not needed for adequate performance. When these units become widely available on the mass market they will be an ideal choice for this application. Unfortunately, they are not yet widely available and must therefore be considered unacceptable for this application. Reflector augmented arrays use one or two sheets of planar reflectors to increase the effective insolation on the conventional flat plate collector aperture. These are a particularly appropriate solution when the demand for high quality heat is seasonal. They are not the most suitable when the need for the high temperature is year round, as it is in this application.

The most common of the non-concentrating collectors is the conventional flat plate collector. This consists of a metal absorber panel with attached fluid flow passages. This is enclosed in a frame, insulated on the edges and back, and covered with one or two layers of transparent glazing material. The required operating temperatures for this application dictate that the flat plate collectors must be double glazed with low or no iron content glass (so called water white crystal). In addition, in order to limit the radiation losses from the plate the absorbing surface must be selectively coated. The appropriate coating for this application would be black chrome over bright nickel on a copper absorber. This is typical state of the art high performance flat plate collector, and is widely available. Even for this collector, the temperature limits on operation are stretching the performance limits, however. Under conditions of low insulation the performance of the collector will be negative; that is, the collector will represent a heat loss for the system. Due to the climate of the Comoros these conditions will be quite common and a system that is designed to provide 5kW thermal peak will often provide no useful energy, and if improperly operated will be a net loser. For this reason, use of a flat plate collector is not recommended.

The other type of non-concentrating collector that is commonly available is the evacuated tubular collector. These come in many configurations, the common theme is that the absorber surface is surrounded by a vacuum. The advantage of this concept is that convection and conduction losses from the absorber are cut to a munimum. There are manufacturers of these devices in the United States, Germany, Japan, and the Netherlands. The back losses of these devices are so low that adequate performance is available even on overcast days. Improper operation of the system will lead to only very small heat losses from the system, and a 5 KW system will operate between 3 and 5 KW most of the time. The primary disadvantage of this collector type is that stagnation (no flow) temperatures can be very high, in excess of 400 C.. Proper design of the distribution system can be used to ameliorate the effects of this on the system performance and reliability. With care, the system can be made to fail safe. For these reasons, the recommended collector choice for the Ylang-Ylang flower essential oil distillation system is the evacuated tubular type.

DISTRIBUTION SUBSYSTEM

The distribution subsystem is responsible for transferring the energy gained in the solar collector subsystem to the point of use. This subsystem includes the required piping, pumps, controls, and the fluid along with the numerous details that are required to ensure proper operation such as insulation, air vents, pressure and temperature relief valves, expansion tanks. etc.

A critical inital choice is that of the working fluid to be used. This fluid should ideally posess properties of high volumetric and specific heat capacity, low viscosity, low vapor pressure at the temperatures expected in the system, and in addition be environmentally safe, readily available worldwide, and low in cost. The choices to be considered are water, steam, mineral oils, ethylene glycol solutions, and special heat transfer oils.

Water is an obvious first choice and with one exception it meets all the criteria established for selection. Water's one drawback is serious however, a water system must be pressurized. Since it is impractical in a solar system to turn off the collection of heat and stagnation conditions may be expected, the system should be designed to remain intact at saturation pressures corresponding to 400 C. Not only would this require process piping that would be difficult to fabricate in the field, the pressures are not acceptable to any of the currently available collectors.

Given that high pressure piping and collectors are not available, low to moderate pressures would allow the use of steam as the heat transfer media. Unfortunately, the design of evacuated tubular collectors does not allow their use as boilers. Formation of steam would lead to vapor locking of the collector array, and to unacceptably large gas velocities in much of the collector piping.

Any of the aqueous glycol solutions may be used to elevate the boiling point of water, with the boiling point being a function of the concentration. Ethylene glycol is available world wide at moderate costs. Its only drawbacks are its production of acid solutions at elevated temperatures and some of its viscous properties. This is an acceptable choice from a technical viewpoint and may be used.

Mineral oils are widely available and have good properties for this application. The only drawbacks are the low heat capacities and the safety problems of continuous operation above the flash point. Mineral oil is a generic term, and the properties are not defined enough to be used in design calculations. From a practical viewpoint they are considered to be equivalent to the special heat transfer oils.

Special heat transfer fluids are readily available for many heat transfer applications. They are marketed under names like "Dowtherm" and "Therminol" and are available with just about any desired boiling point at moderate cost. The design considered here will use the widely available Dowtherm J heat transfer fluid. This material has a boiling point of 343 C at 1 bar pressure and hence the piping need not be pressurized. Its primary disadvantage in this application is the relatively large volumetric expansion with temperature. While this would be an advantage in a thermosyphon system, the collector design prohibits this option.

The design of the system, collector type and fluid choice, requires the use of a pump to provide coolant flow through the collectors. In addition the high efficiency collector design and the limited heat transfer area for the fluid require a relatively large pressure drop (approximately .5 Bar minimum) in the collector in order to enhance the heat transfer coefficient. While the pumping requirements would not generally be considered a design constraint, the situation in the Comoros means that a method must be provided to power the pump. The choices available for this power source are a conventionally driven generator, a small heat engine driven by the collectors, a photovoltaic array to generate power for the pump, or a small wind generator to provide power. Each of these choices must be considered in turn.

A small conventionally driven generator for the system has the advantage of lowest first cost, least technical risk, and simplicity. The only disadvantage is that we are now using expensive petroleum to help offset the burning of wood. For many nontechnical reasons this solution is considered unacceptable.

A small heat engine to power the pump driven by solar collectors is ar appealing alternative. Many such engines have been const· ıcted, either as Rankine cycles (Barber-Nichols) or as Stirling cycles (Farber et. al.). At the present time there is no such engine available on the market in the desired size range, at an acceptable cost. Design of such an engine would be straightforward, but beyond the current scope of work.

Photovoltaics have much to recommend them for this application. PV powered pumps have been used in flat plate collector arrays with quite good results. While none of these applications were quite as large as the one envisioned here, PV powered compressors have been constructed that are at least as large. In addition, with judicious design the output of the photovoltaic array, when matched with the proper motor characteristics, will eliminate any need for additional controls. In most cases, when there is enough sunlight available to power the pump there will be enough sunlight to collect useful heat for the distillation process. A small storage battery can be used to provide the initial starting pulse and to reduce transient effects. For simplicity, ease of application, and reliability, this is the preferred choice.

Small wind systems may also be used to provide the necessary pumping energy. These systems have the advantage that special pumps would not be needed. In addition, they are relatively compact and with proper selection may represent a technology that could be locally implemented in the Comoros after the completion of this project. Primary disadvantage of this approach lies in the potential poor coupling between the availability of wind and solar resources. One of the advantages, however, is that since wind energy may well be available when sunshine is not, the islanders may use the available energy for other uses.

At the time this is being written, both wind and photovoltaic sources are under investigation for the required energy source. The final choice will dictate which of the available off the shelf pumps should be chosen.

The piping itself is to be constructed of standard type k copper pipe, with a nominal diameter of 254 mm. All fittings are to be cast or forged copper or brass. All joints fashioned by soldering or brazing with 95/5 solder, with phosphorous (so called Sil-Phos). All major components are to be fitted with isolation valves and unions on all piping connections. Automatic air vents are to be fitted at all potential high points in the piping, and all runs of pipe that may be isolated will be fitted with vacuum breakers and pressure relief valves. All relief valves are to be plumbed to a storage tank, in order to avoid any release of the heat transfer oil to the environment. The pump is to be equipped with vibration isolators on both suction and discharge lines. The expansion tank shall be connected to the suction side of the pump with a not smaller than 100 mm line, and the expansion tank will be situated in such a way that the pressure on the suction side of the pump will not impair normal operation.

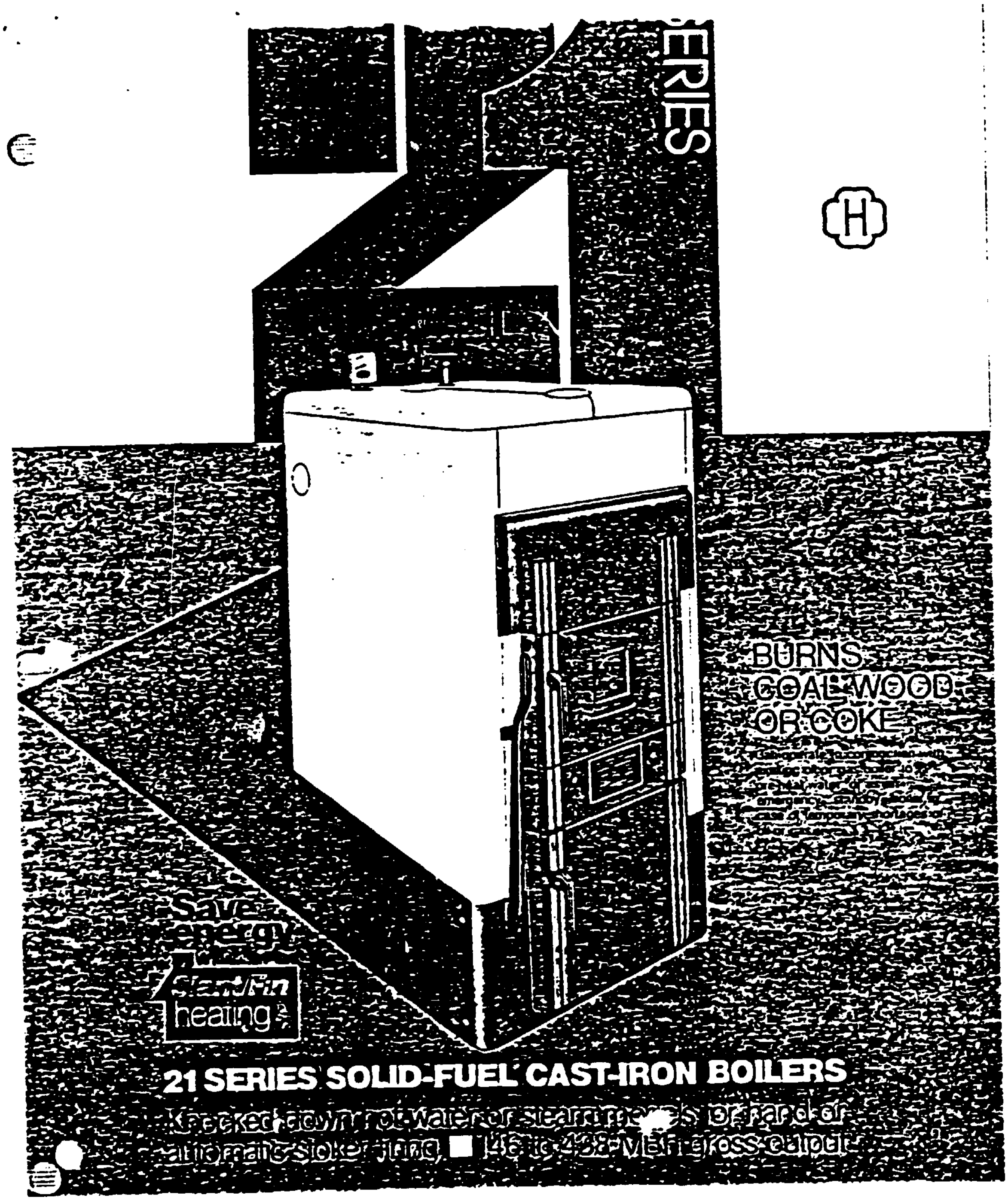
All distribution piping will be insulated with not less than 380 mm of fiberglass insulation. All insulation that is exposed to the elements will be jacketted with 1.25 mm or thicker aluminum flashing. Fittings and elbows, however, may use PVC jackets if such covers are protected with a suitable UV resistant paint.

```
10 REM     THIS PROGRAM ANALYZES THE PERFORMANCE OF
20 REM     VARIOUS ACTIVE COLLECTOR GEOMETRIES USING
30 REM     THE METHODS OF COLLARES-PEREIRA AND RABL
40 REM     AS OUTLINED IN 'SOLAR ENERGY' VOL. 23, #3,
50 REM     1979.  IT HAS BEEN UPDATED TO INCLUDE THE
60 REM     RECENT WORK OF D.L. EVANS ET.AL. AT ARIZONA
70 REM     STATE UNIVERSITY AS OF 12/81.
80 REM
90 REM     COPYRIGHT STEVEN WINTER, ASSOCIATES INC.  1982
100 REM    ALL RIGHTS RESERVED.
110 REM
120 REM    VERSION 1.0 -- TLH -3-15-82--
130 REM    STATUS; DEVELOPMENTAL, NOT FOR RELEASE
140 REM
150 REM
160 REM-------------------------------------------
170 REM    BEGIN PROGRAM
180 REM-------------------------------------------
190 RDCONV=(2*3.14159)/365
200 DIM TAMB(12),KHA(12),LCED(12),HH(12)
210 REM
220 REM   DETERMINE COLLECTOR TYPE
230 PRINT '  SELECT COLLECTOR TYPE:'
240 PRINT
250 PRINT '    [1] FLAT PLATE COLLECTOR'
260 PRINT '    [2] NON TRACKING CONCENTRATOR'
270 PRINT '    [3] NORTH-SOUTH TRACKING'
280 PRINT '    [4] EAST-WEST TRACKING'
290 PRINT '    [5] TWO AXIS TRACKING'
300 PRINT
310 INPUT '  YOUR CHOICE'; IFLAG
320   IF IFLAG<1 THEN 230; IF IFLAG>5 THEN 230
330 INPUT ' WHAT IS THE SITE LATITUDE';LAT
340 LAT=LAT*RDCONV
350 IF IFLAG>2 THEN 410
360 IF IFLAG>1 THEN 390
370 INPUT ' WHAT IS THE AZIMUTH ANGLE';AZ
380 AZ=AZ*RDCONV
390 INPUT ' WHAT IS THE TILT ANGLE';BETA
400 BETA=BETA*RDCONV
410 INPUT 'WHAT IS THE COLLECOR UA';UA
420 PRINT 'WHAT IS THE COLLECTOR MASS FLOW'
430 INPUT ' IN KG/HR';MDOT
440 PRINT 'WHAT IS THE SPECIFIC HEAT OF THE '
450 INPUT ' WORKING FLUID';CP
460 PRINT 'WHAT IS THE COLLECTOR NORMALIZED'
470 INPUT ' EFFICIENCY';NETA
480 INPUT 'WHAT IS THE COLLECTOR AREA';AREA
490 F=(MDOT*CP/UA)*(1-EXP(-UA/(MDOT*CP)))
500 PRINT 'WHAT IS THE COLLECTOR INLET'
510 INPUT ' TEMPERATURE';TCOL
520 PRINT 'WHAT IS THE PARASITIC HEAT'
530 INPUT 'LOSS';QLINE
540 INPUT 'INPUTSOLAR CONSTANT ';SC
550 REM-------------------------------------------
560 REM
570 REM    INPUT CLIMATIC VARIABLES .
580 REM
590 REM-------------------------------------------
600 PRINT ' INPUT CLIMATIC VARIABLES '
610 FOR KK=1 TO 12
620 PRINT 'FOR MONTH ',KK;
630 INPUT ' AMBIENT TEMP. ';TAMB(KK)
640 INPUT ' KH ';KHA(KK)
650 NEXT KK
```

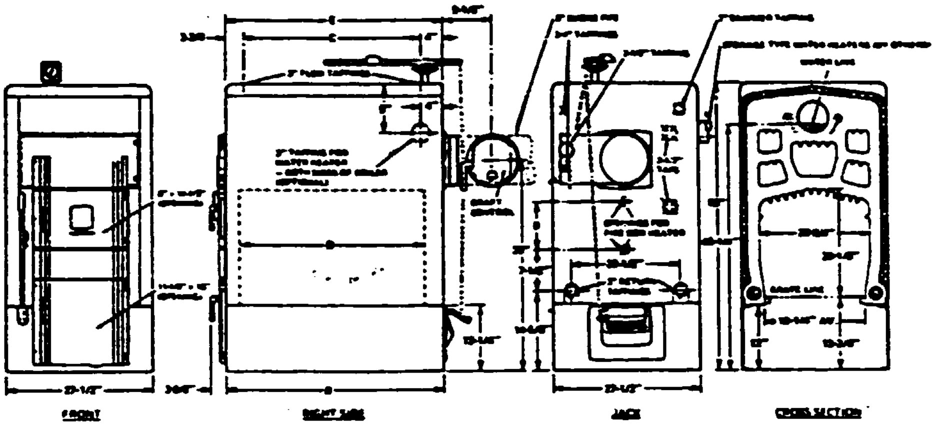
```
660 REM--------------------------------------------
670 REM
680 REM          START MONTH LOOP
690 REM
700 REM--------------------------------------------
710 FOR K=1 TO 12
720 NDAY = 15+(K-1)*30
730 DECL=23.45*RDCONV*SIN((2*3.14159)*(284+NDAY)/365)
740 TAIR=TAMB(K)
750 KH=KHA(K)
760 ZZ=-TAN(LAT)*TAN(DECL)
770 WS=ATN(ZZ/SQR(-ZZ*ZZ+1))
780 A=.409+.5016*SIN(WS-1.047)
790 B=.6609-.4767*SIN(WS-1.047)
800 D=SIN(WS)-WS*COS(WS)
810 ZZ=-TAN(LAT-BETA)*TAN(DECL)
820 WSP=-ATN(ZZ/SQR(-ZZ*ZZ+1))+1.5708
830 WC=WS
840 QUSE=0
850 HRAT=.775+.347*(WS-3.14159/2)
860 HRAT=HRAT-(.505+.261*(WS-3.14159/2))*COS(2*(KH-.9))
870 ON IFLAG GOSUB 1050,1330,1510,1670,1860
880 TC=WC*24/(2*3.14159)
890 GOSUB 2390
900 HCOL=(RH-RD*HRAT)*KH*HO
910 QLOSS=2*TC*(UA*(TCOL-TAIR)+QLINE)
920 XBAR=(QLOSS/AREA)/(NETA*HCOL)
930 GOSUB 2200
940 QNEW=AREA*F*UTIL*NETA*HO
950 IF QNEW>QUSE THEN 960 ELSE 990
960 WC=(TC-.5)*(2*3.14159)/24
970 IF TC<.25 THEN 9'0
980 GOTO 870
990 GOSUB 2510
1000 NEXT K
1010 PRINT "COMPLETE"
1020 GOTO 10
1030 REM--------------------------------------------
1040 REM
1050 REM CHOICE IS FLAT PLATE COLLECTOR
1060 PRINT "IN FLAT PLATE"
1070 REM ESTABLISH RADIATION PARAMETERS
1080 REM
1090 REM--------------------------------------------
1100 WCMINS=-WC
1110 X=COS(BETA)*SIN(LAT)-SIN(BETA)*COS(LAT)*COS(AZ)
1120 BETAO=ATN(X/SQR(-X*X+1))
1130 AZO=ATN(SIN(BETA)*SIN(AZ)/(COS(BETA)*COS(LAT)+SIN(BETA)*SIN(LAT)*C
1140 RH=((COS(BETAO)*COS(AZO)/COS(LAT)+(RHO/2)*(1-COS(BETA))))
1150 RH=RH*(A*(SIN(WCPLUS)-SIN(WCMINS)))
1160 RH=RH+(B/2)*(SIN(WCPLUS)*COS(WCPLUS)-SIN(WCMINS)*COS(WCMINS)+WCPLUS
1170 RH=RH-(COS(BETAO)*SIN(AZO)/COS(LAT))*(A*(COS(WCPLUS)-COS(WCMINS)))
1180 RH=RH-(COS(BETAO)*SIN(AZO)/COS(LAT))*((B/2)*(COS(WCPLUS)^2-COS(WCM
1190 ZS=(A*(WCPLUS-WCMINS)+B*(SIN(WCPLUS)-SIN(WCMINS)))
1200 ZO=TAN(DECL)*((SIN(BETAO)/COS(LAT))+RHO/2*(1-COS(BETA))*TAN(LAT))*Z
1210 RH=(RH+ZO)*(1/2*D)
1220 ZA=COS(BETAO)*COS(AZO)/COS(LAT)-.5*(1+COS(BETA))
1230 ZB=SIN(WCPLUS)-SIN(WCMINS)
1240 ZC=(COS(BETAO)*SIN(AZO)/COS(LAT))*(COS(WCPLUS)-COS(WCMINS))
1250 ZD=SIN(BETAO)/COS(LAT)-.5*(1+COS(BETA))*TAN(LAT)
1260 ZE=TAN(DECL)*(WCPLUS-WCMINS)*ZD
1270 RD=(1/(2*D))*(ZA*ZB-ZC+ZE)
1280 RETURN
1290 REM--------------------------------------------
1300 REM
1310 REM    END RADIATION PROCEDURE FOR FLAT PLATE
```

```
1340 PRINT 'IN NON TRACKING'
1350 REM  TRACKING CONCENTRATOR
1360 REM
1370 REM-------------------------------------------
1380 ZA=COS(LAT-BETA)/(D*COS(LAT))
1390 ZB=(A-B*COS(WSP))*SIN(WC)-A*COS(WSP)*WC
1400 ZC=(B/2)*(SIN(WC)*COS(WC)+WC)
1410 RH=ZA*(ZB+ZC)
1420 ZD=(COS(LAT-BETA)/COS(LAT)-(1/C))*SIN(WC)
1430 ZE=(COS(WS)/C-COS(LAT-BETA)*COS(WSP)/COS(LAT))*WC
1440 RD=(1/D)*(ZD+ZE)
1450 RETURN
1460 REM-------------------------------------------
1470 REM
1480 REM  END RADIATION PROCESSOR FOR NON-TRACKING
1490 REM      CONCENTRATOR
1500 REM
1510 REM
1520 PRINT 'IN NORTH SOUTH'
1530 REM   BEGIN RADIATION PROCESSOR FOR NORTH-
1540 REM   SOUTH TRACKING COLLECTOR
1550 REM
1560 REM----------------- --------------------------
1570 DEF FNG(W)=(A+B*COS(W))*SQR(COS(W)^2+TAN(DECL)^2)
1580    GOSUB 2020
1590 RH=SIMSN/(D*COS(LAT))
1600 DEF FNG(W)=(SQR(COS(W)^2+TAN(DECL)^2)-(COS(LAT)/C)*(COS(W)-COS(WS))
1610    GOSUB 2020
1611 RD=SIMSIN/(D*COS(LAT))
1620 RETURN
1630 REM-------------------------------------------
1640 REM
1650 REM   END RADIATION PROCESSOR FOR NORTH-
1660 REM   SOUTH TRACKING COLLECTOR
1670 REM
1680 PRINT 'IN EAST WEST'
1690 REM   BEGIN RADIATION PROCESSOR FOR EAST-
1700 REM   WEST TRACKING COLLECTOR
1710 REM
1720 REM-------------------------------------------
1730 DEF FNA(W)=SQR(SIN(W)^2+(COS(LAT-BETA)*COS(W)+TAN(DECL)*SIN(LAT-BET
1740 DEF FNG(W)=(A+B*COS(W))*FNA(W)
1750    GOSUB 2020
1760 RH=SIMSN/(D*COS(LAT))
1770 DEF FNG(W)=1*FNA(W)
1780    GOSUB 2020
1790 RD=SIMSN/(D*COS(LAT))-((SIN(WC)-WC*COS(WS))/(C*D))
1800 RETURN
1810 REM-------------------------------------------
1820 REM
1830 REM    END RADIATION PROCESSOR FOR EAST-
1840 REM    WEST TRACKING COLLECTOR
1850 REM
1860 REM
1870 PRINT 'IN TWO AXIS'
1880 REM BEGIN RADIATION PROCESSOR FOR TWO AXIS
1890 REM TRACKING CONCENTRATOR.
1900 REM
1910 REM-------------------------------------------
1920 RH=(A*WC+B*SIN(WC))/(D*COS(LAT)*COS(DECL))
1930 ZA=WC/(D*COS(LAT)*COS(DECL))
1940 ZB=(SIN(WC)-WC*COS(WS))/(C*D)
1950 RD=ZA-ZB
1960 RETURN
```

```
1980 REM
1990 REM END RADIATION PROCESSOR FOR TWO AXIS
2000 REM TRACKING CONCENTRATOR
2010 REM
2020 REM
2030 PRINT 'IN SIMPSON'
2040 REM    THIS SUBROUTINE SOLVE THE INTEGRAL
2050 REM    IN THE RADIATION PROCESSORS.  THE
2060 REM    INTEGRAND IS THE FUNCTION G(W), EXPRESSED
2070 REM    IN FNG(W).  THE LIMITS ARE 0 AND WC.
2080 REM    SIMPSON'S RULE IS USED WITH 6 STEPS.
2090 REM
2100 REM-----------------------------------------
2110  ZZ=WC/6
2120 ZY=4*(FNG(ZZ)+FNG(3*ZZ)+FNG(5*ZZ))
2130 ZX=2*(FNG(2*ZZ)+FNG(4*ZZ))
2140 SIMSN=(ZZ/3)*(FNG(0)+ZX+ZY+FNG(WC))
2150 RETURN
2160 REM-----------------------------------------
2170 REM
2180 REM    END OF SIMPSON'S RULE ROUTINE
2190 REM
2200 REM
2210 REM  THIS ROUTINE CALCULATES THE
2220 REM  UTILIZABILITY.
2230 REM
2240 REM-----------------------------------------
2250 R=RD/RH
2260 IF KH>.3 AND KH<.5 THEN 2320
2270 IF KH>.49 AND KH<.75 THEN 2340
2280 IF KH>.74 THEN 2360
2290 REM  KH<.3 TO LOW TO USE EFFECTIVELY
2300 UTIL=0
2310 RETURN
2320 UTIL=EXP(-XBAR+(.337-1.76*KH+.55*R)*XBAR^2)
2330 RETURN
2340 UTIL=1-XBAR+(.5-.67*KH+.25*R)^2
2350 RETURN
2360 UTIL=1-XBAR
2370 RETURN
2380 REM-----------------------------------------
2390 REM
2400 REM  THIS ROUTINE CALCULATES THE
2410 REM  EXTERESTRIAL INSOLATION ON AN
2420 REM  HORIZONTAL SURFACE.
2430 REM
2440  ZZ=COS(DECL)*COS(LAT)*SIN(WS)+WS*SIN(LAT)*SIN(DECL)
2450  ZY=1+.033*COS(NDAY*2*3.14159/365)
2460  HO=24/3.14159*SC*ZZ*ZY
2470 REM-----------------------------------------
2480 REM
2490 REM  END EXTERESTRIAL CALCULATION
2500 REM
2510 REM
2520 REM      THIS IS THE OUTPUT REPORTER
2530 REM
2540 REM-----------------------------------------
2550 PRINT 'TEMPORARY OUTPUT'
2560 PRINT
2570 PRINT 'FOR MONTH ',K
2580 PRINT 'QLOSS '; QLOSS
2590 PRINT 'QUSEFULL '; QNEW
2600 PRINT 'ON TIME ';2*TC
2610 RETURN
2620 REM
2630 110 RETURN
```

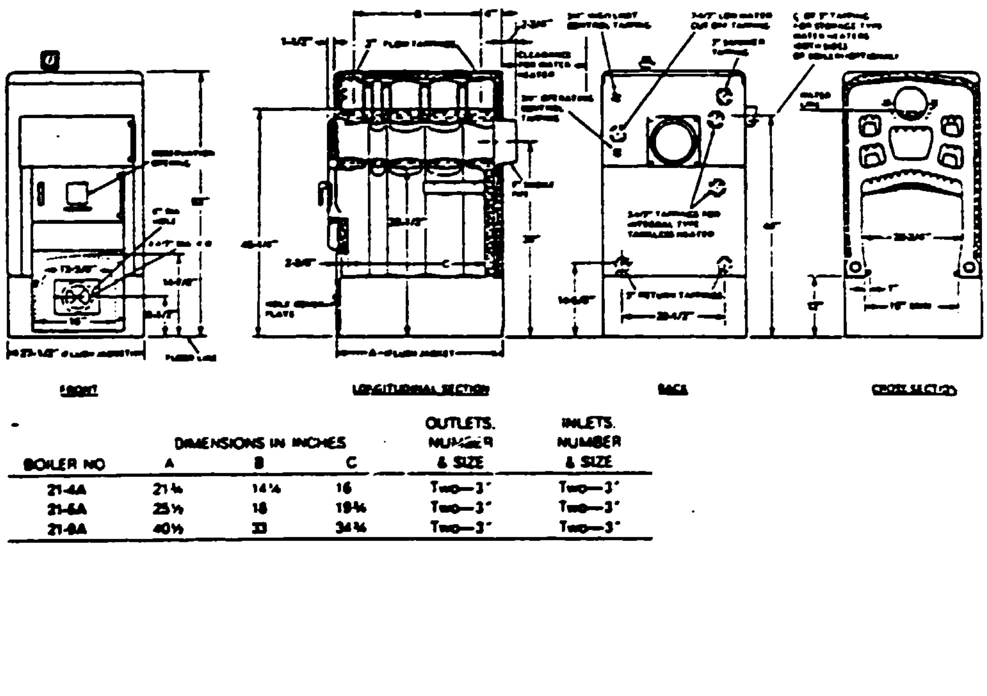

ERIES
BURNS
COAL WOOD
OR COKE
Save
energy
heating
21 SERIES SOLID-FUEL CAST-IRON BOILERS

DIMENSIONS FOR HAND FIRING MODELS



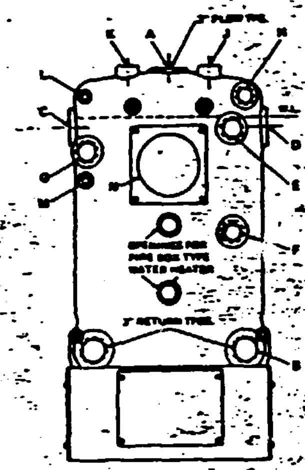
BOILER NO	B	C	D	E	OUTLETS. NUMBER & SIZE	INLETS. NUMBER & SIZE
	DIMENSIONS IN INCHES					
21-4H	21¼	14¾	16	21¼	Two—3"	Two—3"
21-5H	25½	18	19¾	25½	Two—3"	Two—3"
21-8H	40½	33	34¾	40½	Two—3"	Two—3"

DIMENSIONS FOR AUTOMATIC STOKER FIRING MODELS



BOILER NO	A	B	C	OUTLETS. NUMBER & SIZE	INLETS. NUMBER & SIZE
	DIMENSIONS IN INCHES				
21-4A	21¼	14¾	16	Two—3"	Two—3"
21-6A	25½	18	19¾	Two—3"	Two—3"
21-8A	40½	33	34¾	Two—3"	Two—3"

TAPPINGS IN BACK SECTION / ALL MODELS



LOCATION	SIZE	PURPOSE OF TAPPING: STEAM BOILER	PURPOSE OF TAPPING: WATER BOILER
A	3"	————	‡Water Heater — External Type
B	3"	Water Heater — External Type	‡Water Heater — External Type
C*	3"	‡Storage Type Water Heater	‡Storage Type Water Heater
D*	3"	‡Storage Type Water Heater	‡Storage Type Water Heater
E	2½"	‡External Type Water Heater	‡Integral Water Heater
F	2½"	‡External Type Water Heater	‡Integral Water Heater
G	2½"	Low Water Cut-Off	————
H	2"	Skimmer or Washout	Water Heater — External Type
J	1"	Steam Pressure Gauge	Combination Pressure Gauge & Thermometer Relief Valve
K	1"	Pop Safety Valve	Relief Valve
L	¾"	Optional for Pressure Limit Control	Optional for Temperature Limit Control
M†	¾"	Water Temperature Control (for Domestic Hot Water)	Water Temperature Control (for Domestic Hot Water)

NOTE: Tapping "H" is used for installation of 1¼" or larger pop safety valve or relief valve, also for pop safety valve or relief valve on hand-fired boilers. Tappings "C" or "E" may be used as upper connection for external type water heater on steam boiler. Tapping "N" is a ¼" tapping provided in the smoke hood to enable flue gas analysis, stack temperature and stack draft readings to be obtained.

*Tappings "C" and "D" available on special order only.

† Tapping "M" is recommended for installation of combination or dual controls for water boilers.

‡ Water heaters by others.

RATINGS FOR HAND FIRING MODELS

COAL, WOOD, COKE

MODEL NO.(1)	GROSS OUTPUT-MBH	NET OUTPUT MBH(2) WATER	NET OUTPUT MBH(2) STEAM	NET SQ. FT. WATER	NET SQ. FT. STEAM	GRATE AREA SQ. FT.	COVERING SURFACE UNJACKETED BOILER SQ. FT.	CHIMNEY SIZE
21-4H	184	84.7	84.7	585	355	2.18	22.9	8" x 8" x 20"
21-5H	244	108.7	108.7	725	455	2.89	25.5	8" x 8" x 25"
21-8H	438	211.1	211.1	1407	880	4.72	36.0	8" x 12" x 40"

(1) Add suffix W for water or suffix S for steam.

(2) Net ratings shown include allowances for normal piping loss and pickup load. For installations having unusual piping and pickup requirements, additional allowance should be made before selecting the size of boiler required.

RATINGS FOR AUTOMATIC STOKER FIRING MODELS

COAL

MODEL NO.(1)	GROSS OUTPUT MBH	NET OUTPUT MBH(2) WATER	NET OUTPUT MBH(2) STEAM	NET SQ. FT. WATER	NET SQ. FT. STEAM	BURNER CAPACITY LBS./HR.	CHIMNEY SIZE
21-4A	146	127.0	108.5	846	455	16	8" x 8" x 15"
21-6A	182	158.3	138.5	1055	570	20	8" x 8" x 17"
21-8A	312	271.3	234.1	1808	975	34	8" x 12" x 25"

(1) Add suffix W for water or suffix S for steam.

(2) Net ratings shown include allowances for normal piping loss and pickup load. For installations having unusual piping and pickup requirements, additional allowance should be made before selecting the size of boiler required.

SX Series™

Solar Electric Panels

Solarex Corporation presents the new standard panel for the photovoltaic industry, the SX Series™. The SX panels combine the revolutionary Semix™ semicrystalline silicon wafer material with advanced solar cell and panel production processes to offer the state of the art in photovoltaic technology. The semicrystalline silicon solar cells of the SX panels represent the first commercial departure from the single crystal silicon wafer technology borrowed for years from the semiconductor industry. With the SX Series, photovoltaics now has its own specially designed material, thus eliminating the concern over uncertain silicon wafer supply and fluctuating costs.

Each SX Series solar electric panel features 40 corrosion-resistant 10cm x 10cm semicrystalline silicon solar cells connected in series. The cells are encapsulated and are protected by a tempered glass faceplate. A sturdy architectural-grade, anodized aluminum frame provides structural support for the panel and facilitates array assembly.

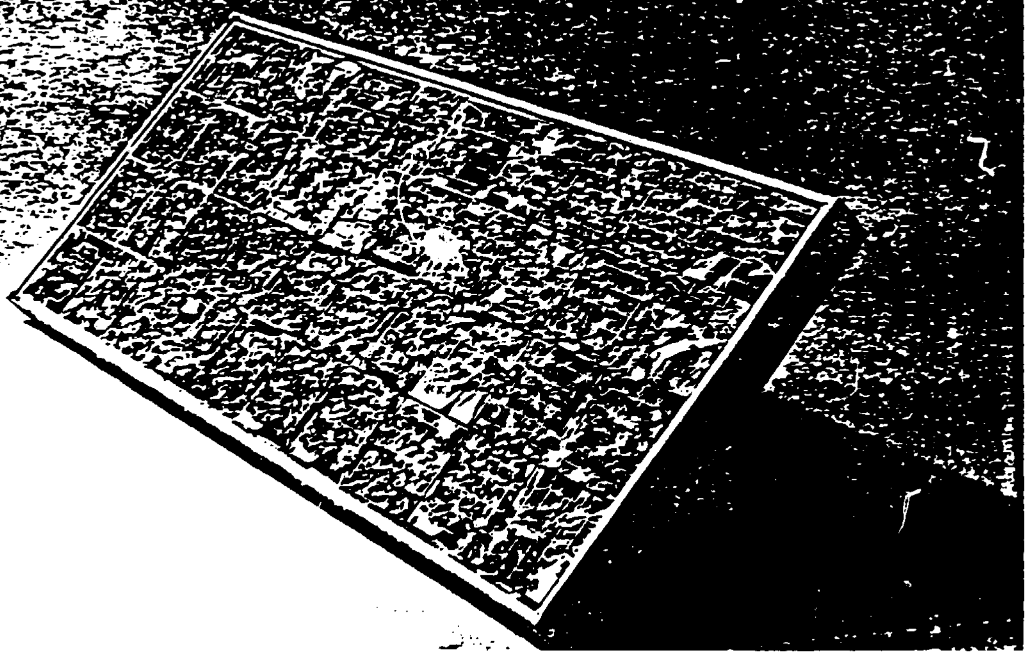
Superior Voltage Safety Margin

The 40 series connected cells of the SX panel provide superior operating characteristics in hot climates. At a cell operating temperature of 50°C, the panel's peak power point remains well above 14 volts, ensuring proper charging of a 12 volt battery or operation of a 12 volt load and sufficient voltage for proper operation of systems of higher voltage. The additional voltage also provides an allowance for system voltage losses caused by controls, cables and connectors. This voltage safety margin assures adequate system performance under a variety of design conditions.

Superior Performance When Partially Shaded

The semicrystalline silicon solar cell used in the SX Series is extremely tolerant of heat build up caused by reverse bias conditions, which can occur when individual cells or panels are partially shaded. The semicrystalline silicon solar cell is highly resistant to catastrophic local heating (hot spots) because of its semicrystalline structure, which dissipates heat broadly.*

*See the Solarex technical paper, Reverse Bias Effects in Solar Panels for a more detailed [illegible].



Electrical Characteristics

	SX-100	SX-110	SX-120
Peak power (Pp)	32	35	40
Voltage at peak power (Vpp)	17	17.25	17.5
Current at peak power (Ipp)	1.9	2.1	2.3
Short-circuit current (Isc)	2.2	2.35	2.5
Open-circuit voltage (Voc)	22	22.25	22.5

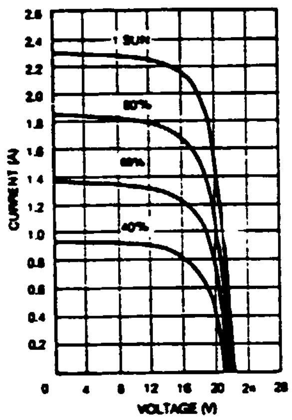
NOTES:

1. Panels are measured under full sun illumination (100mW/cm²) at 25°C ±3°C cell temperature. Minimum performance is 2 watts less than peak. The rating specification is peak watts. For a more detailed explanation, see our *Electrical Performance Measurements* bulletin.

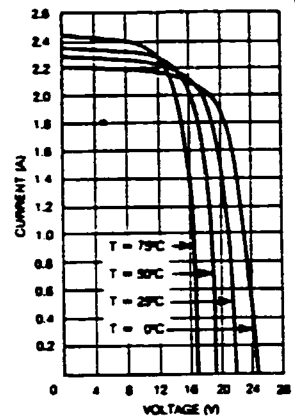
2. Electrical characteristics vary with temperature.

Voltage (Voc)	increases by decreases by	[illegible]mV/°C/cell	below above	25°C
Current (Isc)	increases by decreases by	25μA/°C/cm²	above below	25°C
Power (peak)	increases by decreases by	0.4%/°C	below above	25°C

SX-110
Performance at Various Light Intensities, T = 25°C

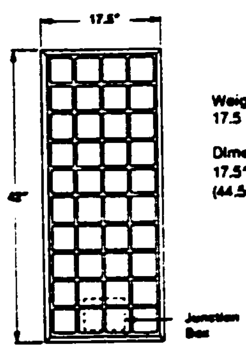


SX-110
Performance at Various Temperatures at AM1 (1kW/m²)



NOTE: These curves are representative of the performance of typical panels at the terminals, without any additional equipment such as diodes, cabling, etc. These curves are intended for reference only. Curves for the SX-100 and SX-120 panels are available from Solarex Marketing.

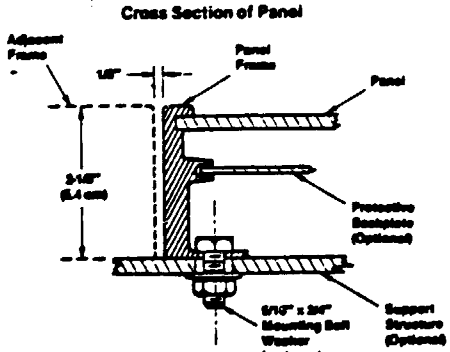
Mechanical Specifications



Weight:
17.5 lbs (7.9 kg)

Dimensions:
17.5" x 42" x 2.1"
(44.5cm) x (106.7cm) x (5.4cm)

Cross Section of Panel



Reliability and Environmental Specifications

These panels are subjected to intensive quality control during manufacture and rigorous testing before shipment. They are designed to meet or exceed the following tests with no performance degradation:

- Repetitive cycling between −40°C and 100°C.
- Prolonged exposure to 90-95% humidity at 70°C.
- Wind loading of over 160 m.p.h.

All SX Series panels are covered by the standard Solarex 5 year limited warranty.

Options and Accessories

Backplates — Anodized aluminum backplate protects the panel in harsh environments. Backplates are available either mounted inside the panel frame at the factory or as components to be mounted onto the panels during field assembly.

Diodes — In-line blocking diode prevents reverse current flow from the panel to the battery during darkness. Bypass diode is available for high voltage systems to provide alternate current path protection.

For multiple panel arrays and large power regulation, contact Solarex Marketing.

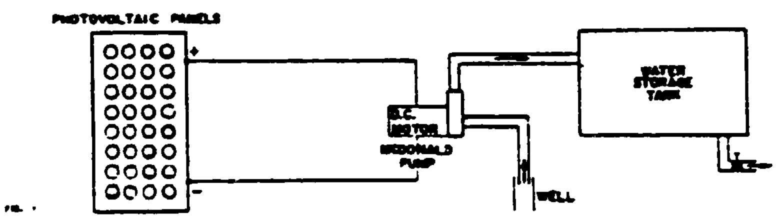
Systems and Applications

A. Y. McDonald has been active in water pumping for over a century. Engineering activity in solar-powered water pumping began in 1977 and now a number of installations are in daily service.

Photovoltaic Power - The key to direct solar generated electricity is the solar cell. Solar cells are made of a wafer of silicon or other material specially treated to change its polarity. When sunlight strikes the cell, D.C. electricity is generated. Groups of these cells are then connected and mounted in a weather-proof frame to make a solar panel. A group of panels are wired in series or parallel (an array) and provide an electrical source that will operate indefinitely at no further cost.

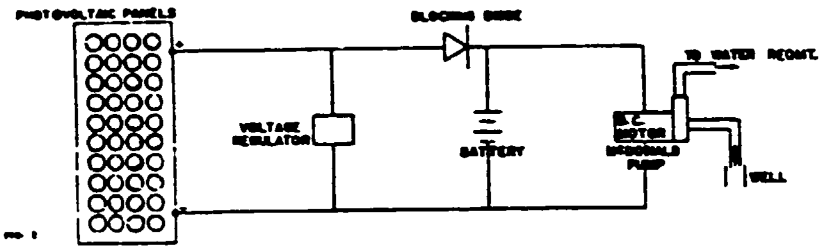
The panels' ability to produce direct current electricity is limited only by the amount of direct or diffused light from the sun. The electrical current obtained from the panel is directly proportional to the area receiving light. A photovoltaic panel can produce 100 watts or more of electricity per square meter of area covered.

Systems Design - A. Y. McDonald offers two different system configurations to optimize the match between sunlight availability and the demand for water:



The system above is based on the fact that water storage is more desirable then electrical storage. The D.C. pump motor takes its power directly from the solar panels. Water is pumped during the day and all or partially stored - for availability during cloudy periods or nighttime. This eliminates batteries and their control circuitry - reducing system cost and maintenance and improving reliability.

The second system uses rechargeable batteries to store electricity. At sunrise, the solar panels start charging the batteries and continues



charging during sunlight hours. When the battery voltage reaches a preset level, the pump system turns on. (See figure 2). The batteries maintain a stable voltage to the motor, irregardless of sun intensity, until a minimum discharge point is reached. Then the process repeats itself.

Both systems utilize a centrifugal pump. This time-proven pump, with or without jet ejector, will provide the most reliable pumping system available.

The pump with it's low starting torque requirement and direct current motor, represents the "best match" when connected directly to the photovoltaic array. Moderate water production begins in early day, increases to mid-day and tapers off toward day-end for maximum production. Centrifugals also perform well with batteries. These systems install easily, with a minimum of equipment, in shallow wells as small as 1½" pipe size and deep wells 2" diameter minimum.

Applications - A. Y. McDonald photovoltaic water pumping systems are particularly well-suited to sites where water is needed, electricity is not available (or too costly) and power needs are relatively modest;

* Furrow or Border Surface Irrigation
* Drip or Trickle Irrigation
* Low Pressure Sprinkler Irrigation
* Livestock Watering & Animal Husbandry
* Fish Hatchery Pumping & Aeration
* Remote Industrial Water Supply
* Circulation Pump Applications
* Remote Individual Home Water Supply
* Remote Village Potable Water Supply
* Greenhouse Circulation & Power

Service - A. Y. McDonald offers total water pumping system capability, including consultation and system design, system testing and documentation, complete hardware (photovoltaic power, controls, pumps, motors, tanks and irrigation and circulation equipment), user training and detail field service.

Water pumping systems using photovoltaic (P/V) solar panels require careful engineering to obtain the most practical and efficient installation possible. McDonald's staff will assist you with precise sizing of each installation if you will complete the enclosed Engineering Data Sheet and forward it to us.

Specification Data

8200 SERIES
HIGH-CAPACITY SHALLOW WELL
CENTRIFUGAL PUMP

McDonald single-stage Solar pumps are available in models 500 watt and 1300 watt (equivalent approximately to ½ HP through 1½ HP). Depths to 25 feet at sea level. See performance charts to select correct model.

Motor: The brush-type D.C. motor uses specially designed permanent magnets providing high coercive force and high residual induction. Field coils and the consequent possibility of their burn-out are completely eliminated.

Nominal speed is 3,500 RPM at design voltage. The D.C. motor can be operated at lower voltages with resulting speed reductions, with no harm to motor. Built to NEMA specifications by internationally known manufacturers to assure local service availability.

Pump: Centrifugal-type with low starting torque. Self-priming after initial prime. Designed for high capacity with moderate heads. Intended for use with cisterns, drilled, driven or dug wells and drive points as small as 1¼" dia. Simplicity makes these pumps ideal for hard-to-reach geographical locations.

Available with either dynamically balanced bronze or engineered thermoplastic impeller. Multi-volute acetal diffuser provides maximum capacity and pressure. Time proven (carbon-ceramic) seal provided as standard.

Backed by over 120 years of pump manufacturing experience, each and every McDonald pump is subjected to rigid inspection and testing at the factory to assure the highest standards of quality, dependability and performance.

Model	Watts	Volts	Impeller Material	Suction Pipe Size	Pressure Pipe Size*	Discharge Size** (NPT)	Ship Wt. (LBS)
8203050S	500	36	Plastic	1¼"NPT	1"NPT	3/4" & 1"	37
8203050SB	500	36	Brass	1¼"NPT	1"NPT	3/4" & 1"	38
8203070S	700	36	Plastic	1¼"NPT	1"NPT	3/4" & 1'	41
8203070SB	700	36	Brass	1¼"NPT	1"NPT	3/4" & 1'	42
8203090S	900	36	Plastic	1¼"NPT	1"NPT	3/4" & 1	48
8203090SB	900	36	Brass	1¼"NPT	1"NPT	3/4" & 1"	49
8208130S	1300	84	Plastic	1¼"NPT	1"NPT	3/4" & 1"	54
8208130SB	1300	84	Brass	1¼"NPT	1"NPT	3/4" & 1"	55

* 1" pressure pipe opening is plugged for single pipe operation.
** Centrifugal pumps use 1" priming opening for highest capacity discharge.

PERFORMANCE

Model No.	DC[2] Volts	Suction Lift[3]	U.S. Gal. Per Hour / D.C. Watts Required (1) — Capacities in GPH @ Discharge Pressure (PSIG) 5	10	15	20	30	Shut-off
820305DS Nom. Watts 500 (1)	36V	10'	2360 / 620	1920 / 580	1260 / 500	1200 / 490		20.5 / 330
		20'	1980 / 590	1380 / 500				15 / 330
	30V	10'	1700 / 420	980 / 350				12 / 220
		20'	1100 / 380					7 / 220
820307DS Nom. Watts 700 (1)	36V	10'	2460 / 800	2360 / 780	2000 / 700	1500 / 650		27 / 410
		20'	2280 / 770	2100 / 720	1560 / 660	920 / 580		22 / 410
	30V	10'	1870 / 500	1560 / 470	930 / 400			17 / 300
		20'	1600 / 480	1120 / 420				13 / 300
820309DS Nom. Watts 900 (1)	36V	10'	2500 / 980	2400 / 910	2200 / 880	1920 / 850	660 / 600	31 / 480
		20'	2420 / 920	2250 / 890	2000 / 870	1500 / 740		27 / 480
	30V	10'	2160 / 650	1860 / 590	1350 / 520			20 / 320
		20'	1920 / 600	1500 / 550	600 / 410			16 / 320
820813DS Nom. Watts 1300 (1)	84V	10'	2500 / 1300	2460 / 1280	2340 / 1270	2200 / 1230	1920 / 1160	39 / 650
		20'	2450 / 1280	2360 / 1270	2250 / 1250	2160 / 1210	1500 / 1050	35 / 650
	70V	10'	2370 / 870	2250 / 840	2100 / 800	1820 / 770		26 / 440
		20'	2270 / 850	2150 / 810	1880 / 790	840 / 600		22 / 440

NOTE: Performance shown is for average conditions subject to voltage input and variable speed of the permanent magnet DC motor. Performance may vary slightly due to wire size and pipe size selected in your installation.

1. Continuous operation above rated nominal (Nom.) watts is not recommended as it may shorten the life of the motor.

2. Suction lift equals distance to water from centerline of the pump.
   Feet ÷ 3.28 = meters   PSIG x 2.31 = feet   U.S. GPH x 3.78 = liters

3. 36 Volt performance anticipates use of 3-12 Volt batteries recharged by photovoltaic panels or wind generator etc. 30 Volt performance anticipates use of 2-15 Volt nominal photovoltaic panels wired in series with the balance of the array wired in parallel for proper amperage.

ProgressivTube™ SPECIFICATIONS—PT-40

Volumetric capacity:	39.84 gallons
Gross length:	88.25 inches
Gross width:	32.5 inches
Gross depth:	9.625 inches
Gross area:	19.46 FT2
Transparent frontal area:	17.4 FT2
Weight:	Dry- 240 lbs.; Wet- 559 lbs.
Flow pattern:	Series
Test pressure:	225 psi.
Design pressure:	150 psi.
Maximum Design temperature:	350°F
Normal operating temperature range:	40°F to 200°F

Absorber/Storage Tank - Four, six inch diameter type 304 stainless steel tubes, 16 GA. (.0625") welded to [illegible]" thick type 304 stainless steel headers.

Absorber Surface Coating - Selective Black Paint
a = .95
e = .52/.54

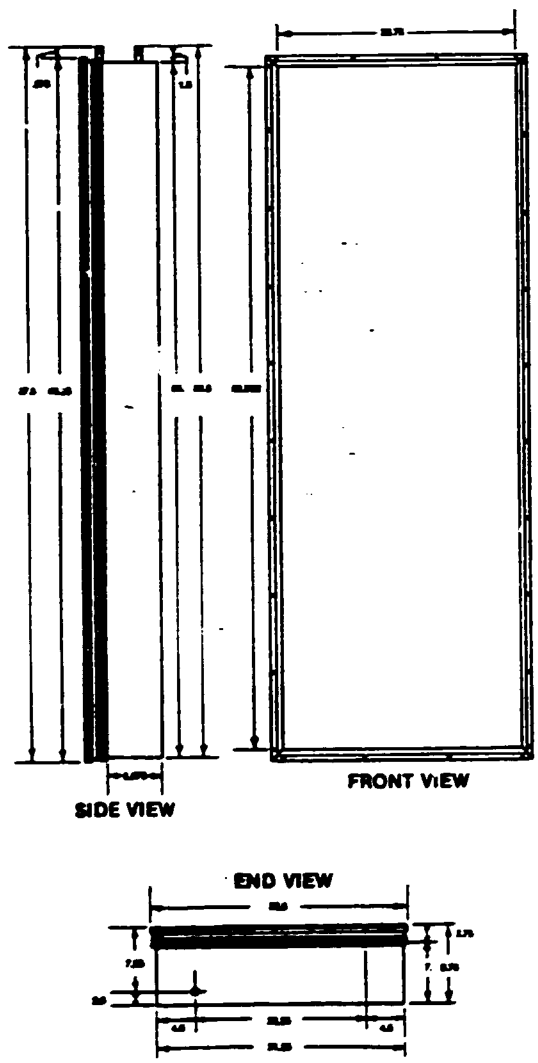
Field Connections - Two, [illegible]" schedule 40 stainless steel threaded connections, welded to header.

Case - Upper Frame: extruded aluminum glazing caps and framewall with continuous keyway for connection of mounting extrusions. Enclosure Box: .040" aluminum connected to framewall with stainless steel rivets. Bronze acrylic finish.

Insulation - Rigid polyisocyanurate board, foil faced both sides and unbonded borosilicate. R-12 minimum back and sides.

Glazing - Triple glazed for increased heat retention. Outer glazing: [illegible]" low iron tempered glass. Transmittance, 91%. Inner glazings: Two layers of Teflon FEP 100A film with a [illegible]" air space. Transmittance, 96%.

Glazing Gaskets - Outer glazing gasket: continuous channel, EPDM. Inner glazing gaskets: center, EPDM; lower, silicone.



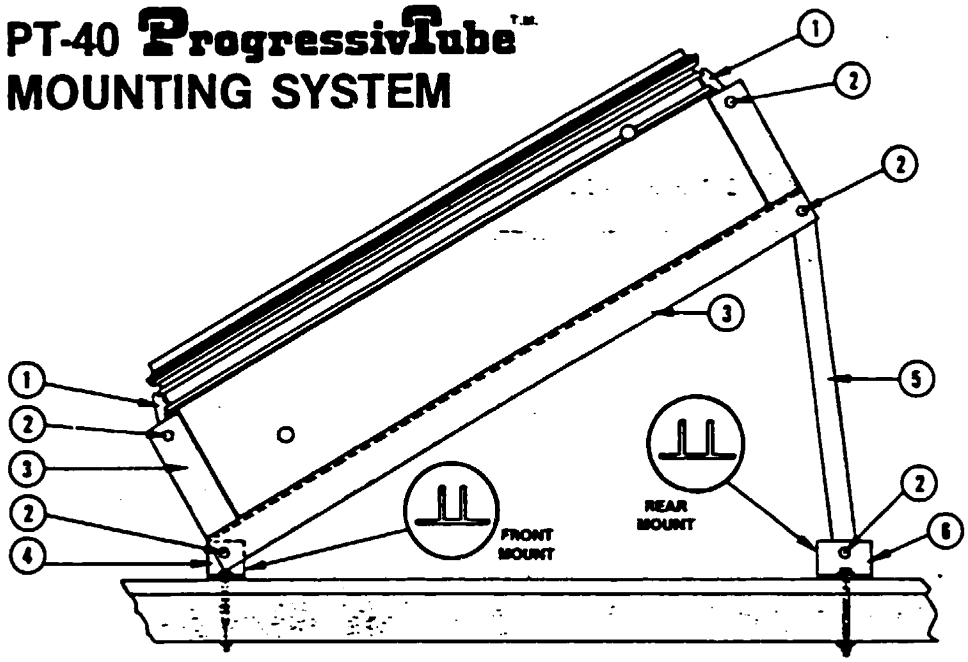
SIDE VIEW

FRONT VIEW

END VIEW

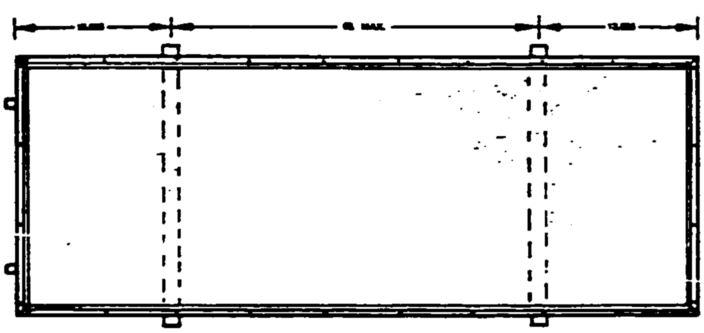
© GULF THERMAL CORP [illegible]

PT-40 ProgressivTube[T.M.] MOUNTING SYSTEM

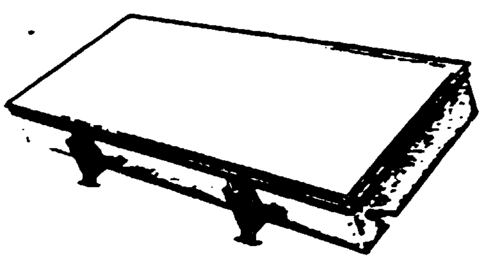


END VIEW

1. 5/16" Aluminum Hinge Mount
2. 3/8" x 2 1/2" Hex Bolt and Lock Nut
3. Cradle
4. Front Mount Base, 1" Double T
5. Strut 1 1/2" Square Tube 1/8" Wall
6. Rear Mount Base, 1½" Double T



TOP VIEW



Mounting System - Cradle is made with 2" x 1.75" x 2" x .187" aluminum channel (6061-T6) welded together, connected to upper framewall using extruded aluminum keyway connectors. Mounting base: extruded aluminum alloy 6061-T6, "Double T" drilled to accept a 3/8" diameter threaded rod. Standoffs: extruded aluminum square tube, 1/8" thick. All hardware with bronze acrylic finish. All bolts stainless steel with nylon insert lock nuts.

INSPECTION PROTOCOL: PROTOTYPE YLANG YLANG ESSENTIAL OIL DISTILLATION EQUIPMENT

Introduction

This inspection protocol reviews performance tests conducted on the prototype solar Ylang Ylang distillation plants developed for the Federal Islamic Republic of Comoros under UNIDO contract No. T81/41.

Test data for each of the three main components of the distillation plants are providead separately:

o distillation unit (still and boiler)

o photovaltaic panels

o solar water heater

Distillation Unit

The complete distillation unit was set up for testing July 7, 1983 on the premises of Baeuerle & Morris, King of Prussia, Pennsylvania.

The test arrangement was made in accordance with B&M drawing no. G-3675 and using a slant/fin boiler, model 21-9H. Since it was impossible to use flowers for a test simulation, only an evaporation test with water was made to prove the capacity of related components and to check the basic function of the system.

Data found during the test run is shown on sheet no. 1. The data obtained show that evaporation rates could be sustained over a reasonable time period. The maximum heat transfer to the distillate was 61 KW. This data checks well with the heat value measured at the same time period in the condenser cooling water.

Since the components were tested without any insulation it can be expected that the evaporation rate under practical conditions would be approximately 10 to 20 percent higher.

The condensate system worked well although the vertical distance in between the centerline of the heating coil and steam water level in the boiler was only 450 millimeters. This should be 1800 millimeters for the final operation.

All parts of the system were tight and, therefore, no adjustments were necessary.

Photovoltaic Panels
Solarex SX 110

Peak power (Pp)	36
Voltage at peak power (Vpp)	17.25
Current at peak power (lpp)	2.1
Short-circuit current (lsc)	2.35
Open-circuit voltage (Voc)	22.25

Panels are measured under full sun illumination ($1kW/m^2$) at 25 degree C ± 3°C cell temperature. Minimum performance is 2 watts less than peak. The ruling specification is peak watts. For a more detailed expanation, see our Electrical Performance Measurements bulletin.

Electrical characteristics vary with temperature.

Voltage (Voc)	increases by decreases by	2.4mV/ °C/cell	below above	25°C
Current (Isc)	increases by decreases by	25uA/ $°C/cm^2$	above below	25°C
Power (peak)	increases by decreases by	0.4%/ °C	below above	25°C

These panels are designed to meet or exceed the following conditions with no performance degradation:

- o Repetitive cycling between - 40°C and 100°C
- o Prolonged exposure to 90-95% humidity at 70°C.
- o Wind loading of over 160 m.p.h.

Solar Water Heater Gulf Thermal PT 40

This solar collector was tested by the Florida Solar Energy Center (FSEC) in accordance with prescribed methods and was found to meet the minimum standards established by FSEC. The purpose of the tests is to verify initial performance conditions and quality of construction only.

The solar collector incorporates energy collection and storage in one unit. A special test was conducted because the collector could not be tested in accordance with ASHRAE 93-97. The solar collector was filled with water and placed in its optimum orientation. Water was drawn from the storage tank three times during the day for three days. The results obtained from this test are valid only for the conditions under which the test was conducted.

Average air temperature:	26.8°C	(80.3°F)
Average inlet temperature:	27.6°C	(81.7°F)
Average outlet temperature:	45.5°C	(113.9°F)
Average daily collection:	16366 kilojoules	15522 Btu
Average daily insolation:	21406 kilojoules	1886 Btu/ft_2
Average daily efficiency:	47.3 based on transparent area of front face	

TEST PROTOCOL   DATA SHEET
SHEET 1

July 7, 1983
King of Prussia

Time	Ps	Twi	Two	ΔTw	Qw	Qw l/h	Kcal/hr	KW	Tc	Po	I"	Δr	Qd	Qd l/h	Kcal/hr	KW
			Cooling Water									Distillate				
10:35	FIRING UP BOILER WARMING UP PERIOD															
11:45	1.3	24.8	45.5	20.7	32"	1125	23287	27.1	100	1.0	638	538	816	44.1	23948	27.6
11:55	1.3	24.9	55.3	30.4	37"	973	29579	34.5	100	1.0	638	538	630	57.1	30775	35.8
12:07	1.5	24.8	50.0	25.2	32"	1100	27972	32.5	100	1.0	638	538	661	54.5	29326	34.1
12:16	1.5	24.8	55.0	29.9	30"	1180	35260	41.0	"	"	"	"	566	63.6	34228	39.8
12:32	1.5	25.0	57.2	32.2	35"	1020	32852	38.2	"	"	"	"	536	69.1	36120	42.0
12:47	1.6	25.1	48.0	22.9	16"	2180	49966	58.1	"	"	"	"	351	102.5	55212	64.2
13:20	1.5	25.1	45.9	20.8	16"	2250	46784	54.4	"	"	"	"	368	97.7	52632	61.2
13:42	1.5	25.0	46.0	20.9	18"	1980	41452	48.2	"	"	"	"	501	71.9	38700	45.0
14:25	1.4	25.1	56.1	31.0	26"	1378	42742	49.7	100	1.0	638	538	417	86.4	46526	54.1
14:30	END OF TEST															

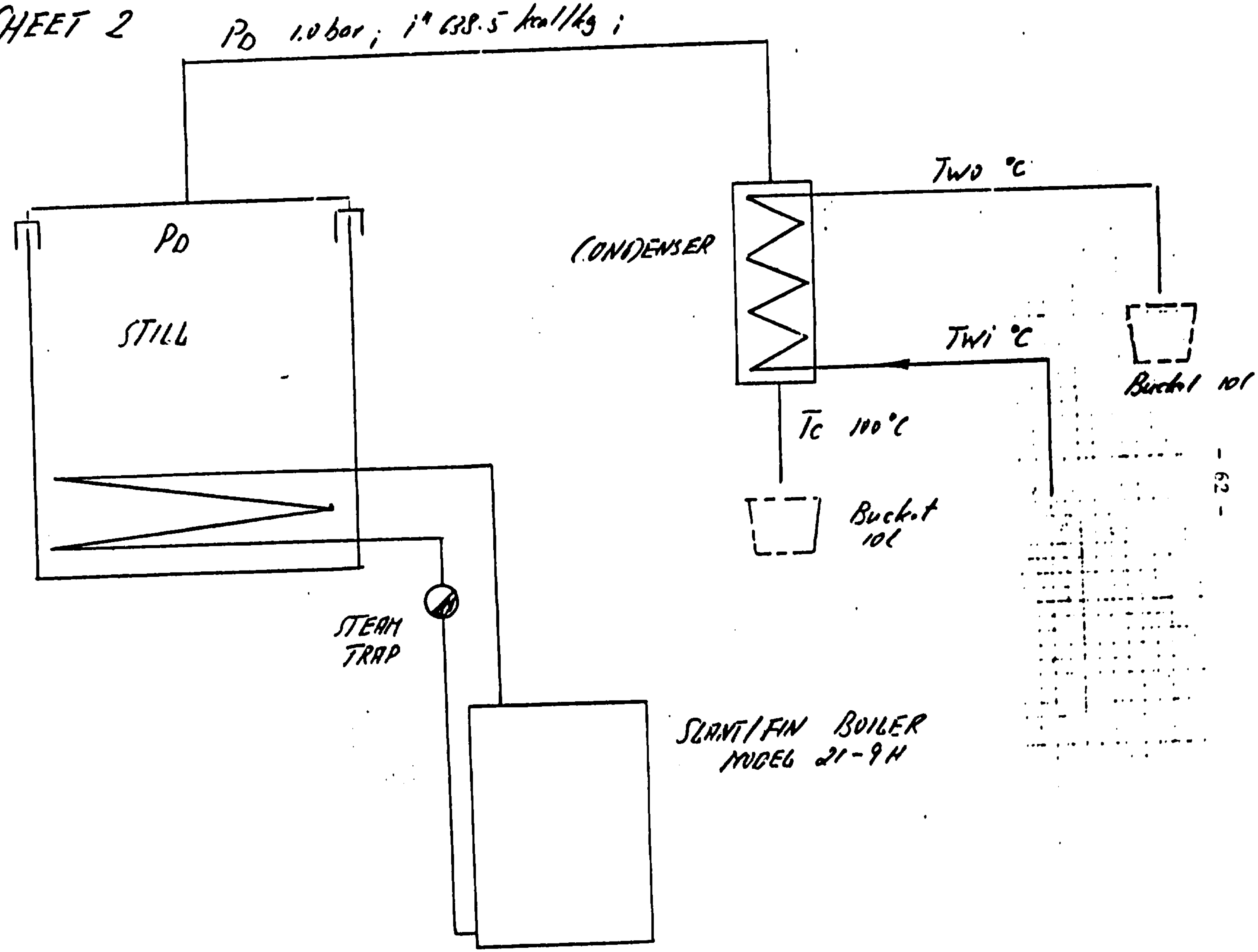
Ps bar
Twi C
Two C
ΔTw C

Qw l/h
Tc C
Po bar

HEAT REMOVED WITH COOLING WATER (ΔTw x Qw) = kcal/h; KW
LATENT HEAT IN DISTILLATE (Δr x Qd) = kcal/h ; KW

TESTPROTOCOL TESTARRANGEMENT

SHEET 2



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19 January 1981

ANNEX D

Substantive Terms of Reference

COUNTRY: Federal Islamic Republic of Comoros

PROJECT: Pilot Plant: Solar Energy Ylang-Ylang Flower Essential Oil Distillation Development

PROJECT NUMBER: US/COI/79/256

BACKGROUND INFORMATION:

a) The UNIDO Programming Mission to Comoros (30 May - 8 June 1979) has highlighted the initiation of the first phase of industrialization through concentration on industrialization of the processing of locally available materials and products mainly of agricultural origin. Ylang-Ylang essential oil is identified as one of the backbones of the export oriented agricultural/industrial production. In this connection, the mission report also stresses the need - prior to any major international assistance - for clarification of the factors which are related to the various vested interests of selected concerned groups such as planters, collectors, entrepreneurs and traders. However, in the meantime a modest scale pilot project for technological improvement of the Ylang-Ylang essential oil distillation system through alternative sources of energy suited to the needs of small units is highly desirable.

b) Ylang-Ylang flower essential oil is used in perfumes and in high quality soap industry. The present Comoros technology of extraction is rudimental and artisan based on wood heated steam. There are around 500 such small units in Comoros.

c) There is a lack of wood/forest in Comoros. In recent years, use of high quality wood as source of energy for the extraction of essential oil from the Ylang-Ylang flower has led to the almost complete deforestation of the two main islands - Grand Comoros and Anjouan.

d) The steady deterioration of the quality of essential oil produced through obsolete techniques has resulted in a sharp decline in exports.

e) Therefore, the Government is interested in the production of quality essential oil in small scale sectors through upgraded techniques and with utilization of non-conventional sources of energy.

f) In this connection, during the discussions in mid 1979 between the Minister of Production and Agro-industries of Comoros and the Director of Policy Co-ordination of UNIDO, the Minister suggested that UNIDO provide some assistance to develop a solar energy device on a demonstration basis to replace wood and fuel as a source of energy.

PURPOSE OF THE PROJECT:

a) GENERAL

To promote development and utilization of appropriate non-conventional sources of energy in Comoros, at a technologically and economically viable level within the reach of small-scale entrepreneurship of Comoros.

To help Comoros conserve wood, establish low cost simple solar distillation unit requirements, provide healthy environmental conditions, and provide an opportunity for industrialization and entrepreneurship development.

b) SPECIFICALLY

(i) To investigate the techno-economic aspects of the present system of essential oil distillation in small-scale sectors.

(ii) To establish design parameters for a solar energy operated distillation unit.

(iii) To design, fabricate prototype, test, evaluate and produce 5 improved prototypes and conduct techno-economic analysis.

(iv) To recommend ways and means of local fabrications and popularization (with imported critical components).

SPECIFIC REQUIREMENTS OF CONTRACTOR:

The subcontractor's activities will consist of the following tasks:

a) A visit of an expert to Comoros for 2 weeks to establish design parameters and a procedure to fabricate the experimental prototypes.

b) The subcontract institution in their R and D laboratory/workshop in their country will establish design parameters for a solar essential oil distillation plant. They may examine various high temperature solar collectors (see Annex I) and distillation techniques (see Annex II). They will import sufficient quantity of Ylang-Ylang flowers from Comoros under project funds for experimentation. They shall develop two types of small solar collectors - essential oil distillation plants. They may be based on the principles detailed in Annex III.

c) The sub-contracting institution after conducting experiments shall fabricate one model of each and further experiment in their laboratory/workshop.

d) They shall despatch the experimental models to Comoros, install them, operate in field conditions, conduct techno-economic analysis and improve further.

e) The sub-contracting consulting institute shall recommend to the Government ways and means of establishing a large-scale pilot demonstration project (around 50-100 solar energy - essential oil extraction plants) with some local components and detail the project proposal.

f) Important Note: The institution/sub-contractor's work is not only to develop a solar energy source but also develop an essential oil extraction system as an integrated unit which will produce high-quality oil with the most efficient/economic way suited to the small-scale farmers/entrepreneurs. Therefore, the sub-contractor should engage not only solar/mechanical engineers, but also chemical engineers and testing/evaluation should include physics/chemical/mechanical local manufacture in small-scale sectors and utilization. Some critical design parameters on actual distillation systems can be found in Appendix IV.

RESPONSIBILITIES

The contractor is expected to carry out the above tasks with home office support, their workshop/research facilities and by providing the required specialized expertise in order to arrive at the specifications and design parameters, production processes, rural demonstrations/popularization techniques for the most appropriate Ylang-Ylang flower essential oil solar distillation system.

The contractor is required to purchase the necessary equipments and components for development tests and pilot plant installations in the Comoros.

The Government of the Federal Islamic Republic of Comoros will provide:

- The required physical facilities including utilities for the establishment of the pilot plants .

- The required local personnel in terms of organizational and administrative support.

PROPOSED PROJECT WORKPLAN:

1. UNIDO initial mission to Comoros to analyze existing distillation stills from a technical point of view and secure critical data, figures, temperatures and quality process techniques. Based on above analysis, the detailed terms of reference for project implementation on a sub-contract basis will be formulated. . . February 1981

2. Contractual agreement with sub-contractor	April 1981
3. Sub-contract work	
(i) sub-contractor's short mission to Comoros	II Q 1981, IV 1982
(ii) Import of 500 kg Ylang-Ylang	III Q 1981
(iii) Design parameters	IV Q 1981
(iv) Prototype fabrication	I Q 1982
(v) Prototype testing	III Q 1982
(vi) Prototype despatch and installation in Comoros	III Q 1982
(vii) Testing and local evaluation/ improvement	IV Q 1982
(viii) Pilot demonstration project elaboration and recommendation	IV Q 1982
4. Staff intermediate and final mission:	III Q 1982 and I 19

Note: Items i, vi, vii, viii in Comoros; items ii, iii, iv, v in countr of sub-contracting institution.

REPORTS

The following reports must be produced by the contractor in English. language:

- Monthly progress report in 10 copies.
- Draft consolidated report 2 months before the end of the project with future recommendations in 15 copies.
- Final report upon completion of project in 20 copies.

LIST OF ANNEXES

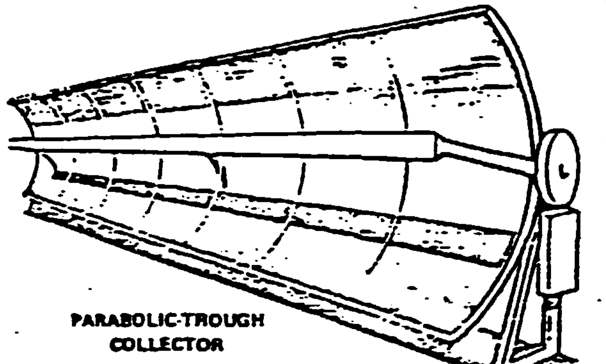
Solar High Temperature Collectors

SOLAR: hardware

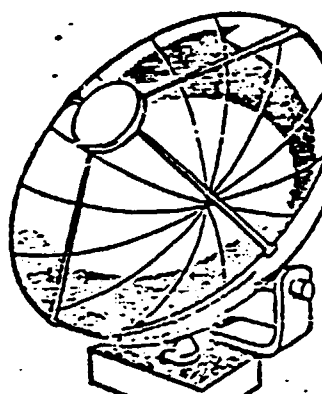
HIGH TEMPERATURE COLLECTORS

The efficiency of low and mid-temperature flat-plate collectors decreases as the absorber temperature rises (see pg. 49). There are three general types of solar collectors that can obtain high temperatures efficiently (greater than about 180°F): (1) STANDARD FLAT-PLATE COLLECTORS WITH STRUCTURAL, CHEMICAL OR ELECTRO-PLATED SELECTIVE SURFACES. Some of these are listed with the "Mid-Temperature Collectors" in the previous listing. (2) EVACUATED TUBES. These are collectors in which the absorber is contained in an evacuated tube. The vacuum serves to reduce convective heat losses, thus allowing higher temperatures. The absorber may be metal, glass tubes or fins that transfer heat to a liquid or gas, and the tubes may contain or be backed by a reflecting surface. Evacuated tubes are effective in the 180-260°F range that serves absorption cooling, finned-tube (hydronic) baseboard heating systems, process water, sterilization, etc. (3) CONCENTRATING COLLECTORS. Concentrating collectors, or simply concentrators, use curved reflecting surfaces or lenses to focus sunlight collected from a large area onto a smaller area. They may be shaped like troughs or deep dishes, parabolic, or circular (see below).

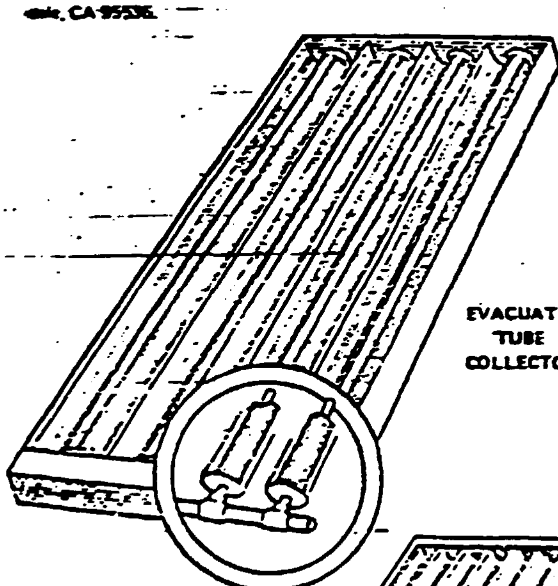
Concentrators are capable of reaching much higher temperatures (200-300°F) than flat-plate collectors. In order to attain these higher temperatures the area of sunshine collection (the reflecting surface or lens) must be greater than the area of the heat absorber (the tube or plate onto which the reflected light is concentrated). With flat-plate collectors these areas are the same. For more information on the theory and application of concentrators see: CAPTURE THE SUN: THE PARABOLIC CURVE AND ITS APPLICATION. Enterprises Unlimited, Star Route, Ferndale, CA 95536.



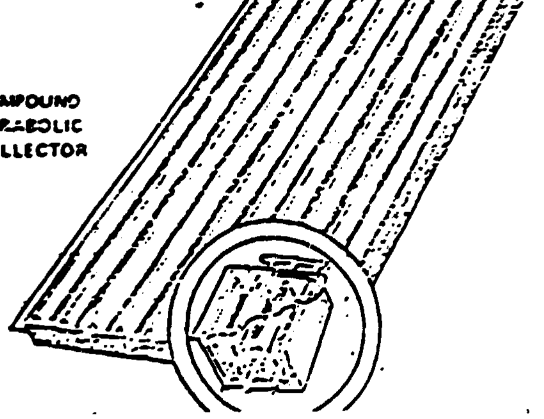
PARABOLIC-TROUGH COLLECTOR



DISC CONCENTRATOR



EVACUATED TUBE COLLECTOR



COMPOUND PARABOLIC COLLECTOR

Today commercial concentrators are being used primarily for industrial applications. For example, steam is being produced to sterilize cans in a Campbell soup cannery in Sacramento, California. Some industries are using concentrators to preheat viscous fuels for easier transport. Other industries are using concentrators for absorption cooling (air conditioning), and a few companies are selling concentrators for producing domestic hot water and operating agricultural irrigation pumps.

In general concentrators cost only slightly more than flat plates ($10-$20/ft²). Others are quite expensive. Higher costs are due to high temperature piping and tracking devices. Concentrators can only make use of the sun's direct rays and most of them must follow ("track") the sun to operate. Flat-plate collectors can collect both direct and diffuse sunlight and thus can afford to be stationary. There are a few concentrators that do not need to track.

Below is an explanation of the columns in the chart.

- Type. Single-axis tracking collectors follow the sun on one axis. No dual-axis trackers are listed. Stationary concentrators do not track the sun, but are designed to be able to concentrate its rays even at a reasonably large angle to the normal.
- Concentration ratio. This is the ratio of effective collection area to the area of the absorber that is losing heat.
- Concentrator. This is the part of the collector that focuses the collected sunlight onto the absorber surface. Many types of materials can be used for this.
- Absorber. The absorber is located at the focus of the concentrator. It absorbs the concentrated sunlight and transfers its heat to the fluid.
- Tracking controls. On the trackers, there are various ways of driving the collectors. Those listed here use a photovoltaic device to activate the steering mechanism. Obviously the stationary concentrators do not need tracking controls.
- Effective collection area. This is the area of sunshine intercepted by the concentrator (length X top width) and not the surface area of the concentrator.

Distillation Techniques

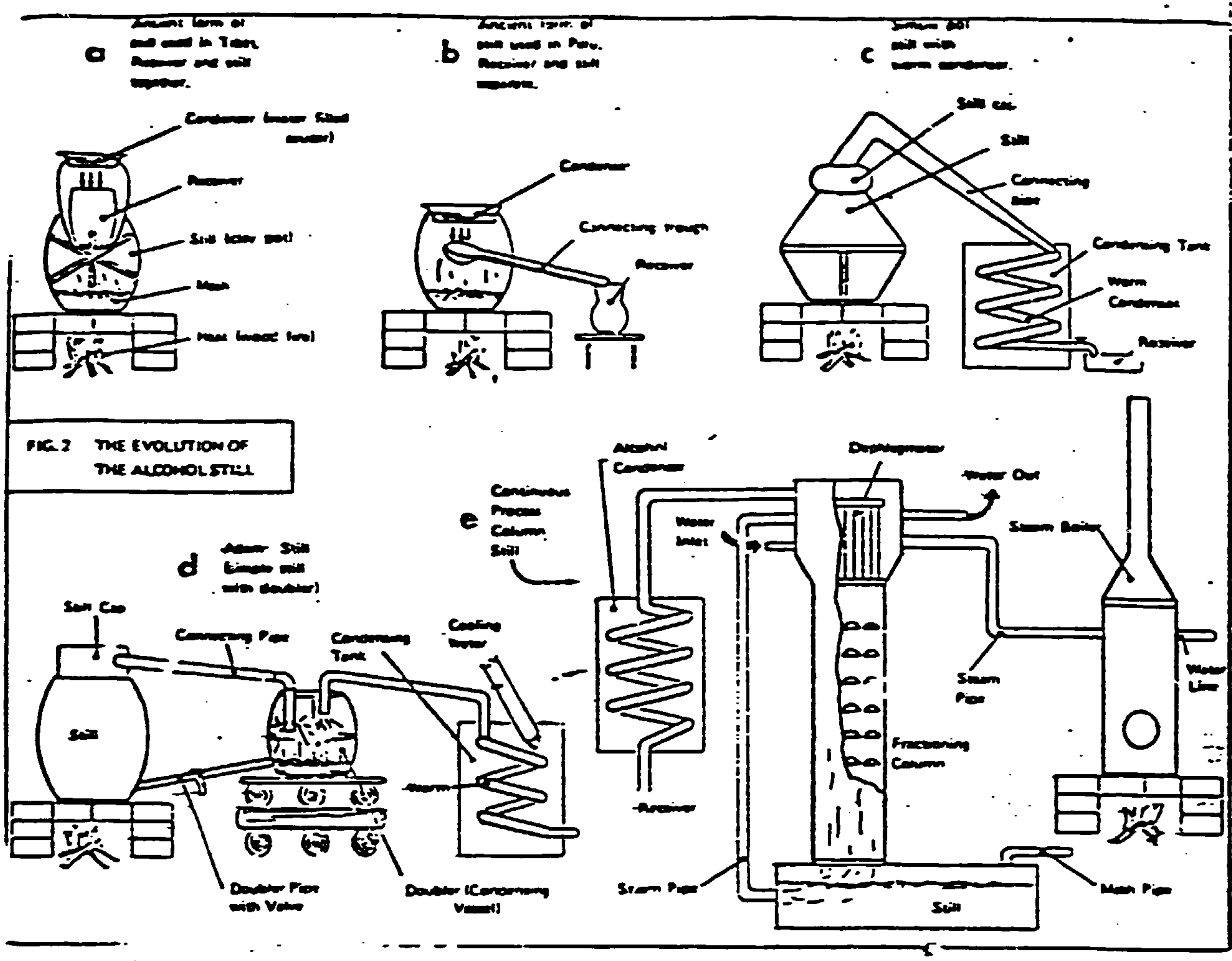


FIG. 2 THE EVOLUTION OF THE ALCOHOL STILL

a. 1801 *Adam Still:* First still to be used on an industrial scale. Used a condensing vessel (Fig. 2d). Vessel was kept at 78°C to condense as much water as possible. Extra ferment was also kept in the vessel. Thus vapors from the still were not only better dehydrated, but mixed with fresh vapors from the vessel.

b. 1819 *Acid Hydrolysis:* Discovery that wood wastes heated with sulfuric acid yielded a product that contained sugars suitable for fermentation.

c. 1820's *Continuous Still:* Allowed mash to be loaded and alcohol received without shutting still down. The savings in time and energy was revolutionary. With the simple still the weight of fuel consumed was nearly 3 times that of the alcohol produced. The continuous still reduced this to one quarter.

d. 1823 *Methyl Alcohol:* Discovery of a new alcohol produced by condensing gases from burning wood *(Destructive Distillation).*

e. 1826 *Column Still:* Alcohol distilled by blowing steam through mash spread in layers over perforated plates in a column (rectifier). The column still was the first to produce nearly pure alcohol (94-96%) on a commercial basis.

The development of the *Continuous Process Column Still* (Fig. 2e) made possible for the first time the manufacture of ethanol in large enough quantities and at low enough prices for it to be available as a fuel by the 1830's. All subsequent advances in distillation technology were essentially variations on this theme.

f. 1828 *Synthetic Ethanol:* Synthesis of ethanol from ethylene gas dissolved in sulfuric acid.

g. 1830's *Alcohol Lamps:* Ethanol mixed with turpentine, coal tar or naptha and used as a light source. Ethanol begins replacing whale oil as a popular fuel.

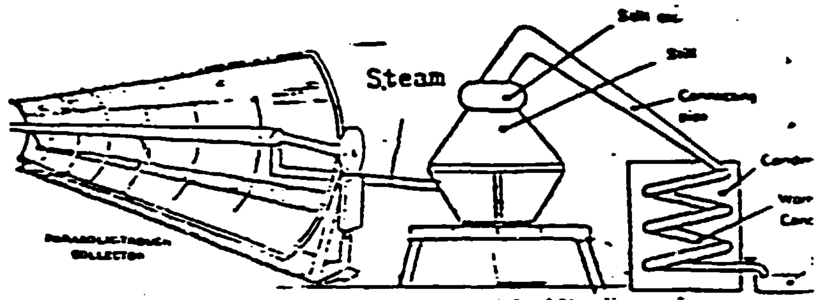
h. 1900 *Commercial Wood Alcohol:* Industrial manufacturing of ethanol using acid hydrolysis.

ANNEX III

Possible principles and configurations.
Pilot Plant: Solar Energy Ylang-Ylang Flower Essential Oil Distillation Unit

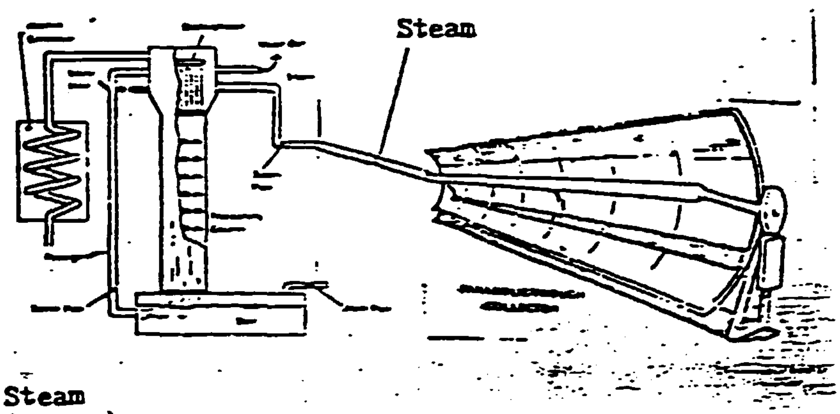
Possibility No.1

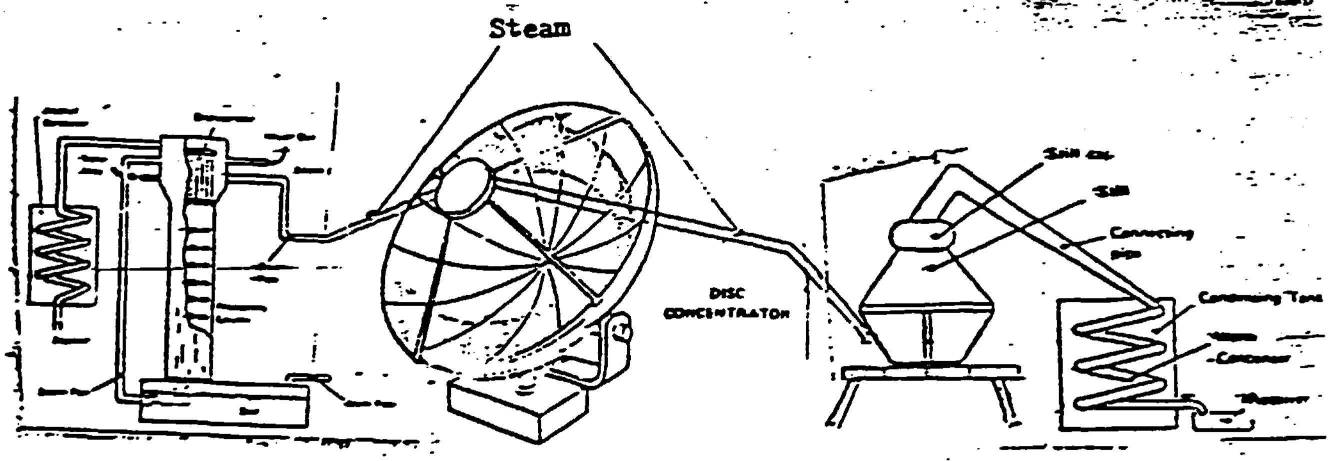
Small Parabolic Collector
- continious improved
traditional distiller



Possibility No.2

Small Parabolic Collector
column distiller





Possibility No 3

Small Dish Collector: column
distiller

Possibility No 4

Small Dish Collector: improved
traditional distiller

(Note: The above 4 possibilities are to be considered as examples only. However, it is the responsibility of the subcontractor to design and develop an appropriate small solar essential oil distillation unit/units suited to th local conditions of Comores).

ANNEX IV

Critical data on actual distillation system

Some elements about an industrial installation (unit):

Still capacity 1,800 l;

Heating by electric immersion heater 48 KW (hydro power source), ambient pressure; system not well insulated; 400 l water mixed with 180 - 200 kg flowers; flow rate condensed water/essential oil from heat exchanger 1 l/minute; separation by difference in density; condensed water recycled into still; cooling flow rate 45 l/min, $t_{in} = 20^{o}C$, $t_{out} = 35^{o}C$ (all data based on estimates).

Some elements about artisanal small-scale installation:

Still capacity 1,000 l;

Heating by wood fire, ambient pressure; 200 l water mixed with 100 kg flowers; wood consumption 5 linear meters (5 m length, 1 m height, 0.5 m width) for complete distillation; condensed water recycled into still.

Distr.
RESTREINTE
~~UNIDO/IO/R~~

19 septembre 1984

FRANCAIS

ORGANISATION DES NATIONS UNIES
POUR LE DEVELOPPEMENT INDUSTRIEL

UNITE PILOTE : MISE AU POINT D'UNE DISTILLATION SOLAIRE D'HUILE ESSENTIELLE DE FLEUR YLANG-YLANG

US/COI/79/256

REPUBLIQUE FEDERALE ISLAMIQUE DES COMORES

<u>M A N U E L</u> *

pour le fonctionnement et le maintien d'une
installation prototype pour la distillation solaire
d'huile essentielle de fleur ylang-ylang

établi pour le Gouvernement de la République fédérale islamique des Comores,
par l'Organisation des Nations Unies pour le développement industriel,

<u>d'aprés les travaux de Monsieur D. Evans, de la Société
Steven Winter Associés,
société de sous-traitance pour l'ONUDI sous le No. T81/41</u>

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* Le présent manuel n'a pas fait l'objet d'une mise au point rédactionnelle.

TABLE DES MATIERES

INTRODUCTION

Ce Manuel décrit le fonctionnement et le maintien d'une installation prototype pour la distillation de l'huile éssentielle des fleurs Ylang Ylang. Un diagramme schématique de cette installation est représenté dans l'illustration No. 1.

Dans sa méthode de distillation, l'installation est non-differente des autres cornues, petites et typiques. Un mélange de 100 a 200 kilogrammes de fleurs Ylang Ylang avec 200 a 400 litres d'eau est fait bouillir dans la cornue. La vapeur qui résulte de ce procès est passée à travers le condenseur ou elle se refroidit et se condense en huile et en eau éssentielle. Dans sa méthode de chauffage, par contre, cette installation est différente des cornues petites et usuelles. La plupart des cornues de cette grandeur sont chauffées directement par un feu ouvert, le pot soyant désigné pour que le fond soit dans le foyer, directement au dessus de la flamme. Dans cette installation prototype nouvelle, la chaleur est fournie par de la vapeur générée dans une petite chaudière, et le méchanisme du déplacement de la chaleur est un paquet de tubes en "U" qui sont installés à un côté de la cornue.

Cette représentation fourni un système à cycle fermé. La vapeur à basse pression (max 2.0 BAR) est généreé dans la chaudière à bois et fournie aux tubes en U échangeurs de chaleur dans la cornue. La condensation formée dans l'échangeur de chaleur est remise a la chaudière par un système de condensation qui consiste de purgeurs automatiques, de soupapes d'évent automatiques et d'un "Hartford Loop" pour empêcher un écoulement d'eau de la chaudière s'il y avait une fuite dans la ligne de condensation. Une pompe à main est fournie pour donner de l'eau d'alimentation de la chaudière au système quand il est sous pression.

Le chaudière qui chauffe la vapeur est désignée a brûler du bois, les écales des noix de coco, des feuilles, ou n'importe quels autres matériaux combustibles. Elle est rugueuse et très simple à opérer et à maintenir.

En plus du pot de la cornue et de la chaudière, un troisième élément majeur de cette installation prototype est le chauffage solaire et le système de pompage. Ce système utilise des paneaux photovoltaïques ("PV") pour générer l'électricité du soleil directement. Cette électricité est donc utilisée pour fournir de la chaleur à la cornue ou pour fair marcher une pompe qui fera circuler l'eau de condensation.

Chacun des trois éléments de cette installation prototype (la cornue, la chaudière, et le chauffage solaire/système à pompage) seront discutés séparément et en détail dans les sections du manuel qui suivront. L'installation complète est désignée à augmenter la qualité de l'huile éssentielle Ylang Ylang produite à un niveau non-élevé et à réduire la quantité de bois brûlé dans le procès.

LA CORNUE

LE FONCTIONNEMENT

L'élément de distillation est divisé en trois parties principales: le pot de la cornue, le condenseur, et les tubes en U échangeurs de chaleur. Chacun de ces trois éléments seront discutés séparément.

Le pot de la cornue est fait en acier inoxydable et est désigné en accordance aves les illustrations G-3675 et G-3703 inclus à la fin de ce manuel dans l'ANNEXE I. Comme dans la plupart des représentations des cornues, le haut du pot de la cornue est détachable et est scellé aux bords par de simples fermetures à eau. Pendant le fonctionnement normal, l'eau ou la vapeur peuvent occasionellement déborder a ces fermetures à eau. Ceci n'est point un problème sérieux mais pourrait indiquer que le feu est trop chaud et devrait être diminué quelque peu, ou que l'eau de condenseur est trop chaude et devrait être circulée. Le haut du pot de la cornue devrait peser fermement sur la cornue et ne doit pas être laissé à flotter sur la fermeture à eau.

Dans l'intérieur du pot de la cornue un grillage en acier sépare les tubes en U des fleurs pendant le fonctionnement. Le grillage a été fabriqué en trois sections pour qu'il puisse être enlevé pour vérification et/ou pour maintien des paquets de tubes en U. Il est aussi assez fort pour supporter le poid d'une personne pendant l'enlèvement des fleurs après que le cycle de distillation a été terminé. L'eau est enlevée en ouvrant la soupape de drainage ou d'écoulement au fond du pot. Dans l'intérieur du haut du pot de la cornue des mailles d'acier "demister" ont été installée pour améliorer l'effet fractionnant et la qualité de l'huile distillée. Ceci est détachable pour le nettoyage.

Le pot de la cornue devrait être soutenu par une fondation solide et nivelée, et, une fois installé et relié à la chaudière, ne doit pas être bougé. Les lignes de centre des tubes en U échangeur de chaleur doivent être établies à un minimum de 1800 millimetres, (6 pieds) plus haut que le niveau d'eau de la chaudière à vapeur.

Cet élément de distillation est désigné avec son propre condenseur attaché directment au pct de la cornue. L'eau dans le condenseur devrait être continuellement circulée pour éviter le surchauffement qui reduirait l'éficacité du développement du condenseur, resultant en énergie gaspillée et en huile éssentielle de mauvaise qualité.

Le haut du condenseur, comme le haut du pot de la cornue, utilise des liasions de fermetures à eau. De l'eau refroidissante est fournie par la gravité ou elle peut être pompée (voir la discussion ci-dessous - "Pompe"). Dans ce projet, l'eau refroidissante doit circuler continuellement à travers le condenseur. L'eau condensée est retournée au pot de la cornue par des tuyaux reliés directement du florentin à la cornue. L'huile éssentielle peut être écoulée du florentin à la main, ce qui se fait couramment.

Deux ensembles de paquets de tubes en U d'acier inoxydable sont utilisés pour transmettre la chaleur de la vapeur de la chaudière à de l'eau dans le pot. Chaque paquet de tubes en U est attaché au pot par une bride et peut être facilement enlevé. Les lignes de vapeur partant de la chaudiere jusqu'aux paquets de tubes en U sont 2-1/2" (63.5mm) en diamètre intérieur et sont reliés par un simple collier de boyau. Les lignes de retour de condensation sont 1-1/4" (3.18cm) en diamètre en-dedans du tuyau de cuivre et sont reliés directement avec la chaudière à vapeur. Chaque ligne de retour de condensation est équipée avec un Hoffman Series 50 (F&T) purgeur automatique (voir Annexe B) placé un peu au dessous du point auquel chaque ligne de condensation départ de chaque paquet de tubes en U. Ce modèle fonctionne en flotteur et purgeur thermostatique. Le niveau de condensation est normallement controllé par un flotteur qui donne un coulement continu jusqu'à la chaudière. L'air ou d'autres gaz non-condensables passent à travers le purgeur par une veilleuse controlée par un Thermostat qui élimine des gaz en vitesse et insure la chaleur des instruments froids instamment.

Pour l'élimination de gaz non-condensable une soupape d'évent se trouve dans le système de condensation en aval des purgeurs automatiques (Hoffman Soupape d'Air 71-C. voir Annexe B.) La propre fonction de la soupape d'évent est très importante pour le retour de la condensation à la chaudière.

LE MAINTIEN

La vérification occasionnelle et le nettoyage avec eau chaude de tout équipement cornue et condenseur et des liasions est recommandé. Pour le nettoyage des paquets de tubes en U, voir la section "Maintien de la chaudière" suivante.

Toutes les parties des purgeurs Hoffman sont accessibles sans avoir à casser les liasions entre les tuyaux. La soupape d'évent est supposée de fonctionner sans maintien.

LA CHAUDIÈRE

La chaudière dans ce systeme de distillation est un modèle désigné à brûler du bois et des sous-produits de bois à la main. Manufacturé par la Compagnie Slant/Fin, la chaudière est vendue non-assemblée et est mise ensemble dans cet emplacement. Des instructions d'assemblage pour cette chaudière sont inclues dans l'Annexe A.

LE FONCTIONNEMENT

Les Instructions générales suivantes devront être suivies pour le propre fonctionnement et maintien de la chaudière.

Gardez la chaudière à vapeur remplie d'eau j'usquà la marque fournie sur la section près du tube de niveau d'eau. Si une marque n'est pas donnée, le tube de niveau d'eau devrait être rempli à demi. Si jamais l'eau n'est pas visible sur le tube de niveau d'eau, laissez la chaudière refroidir jusqu'à ce que l'intérieur est comfortable au touché avant d'admettre de l'eau. L'EAU FROIDE DEVRAIT ÊTRE ADMISE CAUTIEUSEMENT À UNE CHAUDIÈRE QUI A ÉTÉ ALLUMÉE RÉCEMMENT.

Avant d'allumer le feu, voyez que le système est rempli d'eau. Le régulateur de pression (le contrôleur éttoufoir de courants d'air) devrait être installé et ajusté en accordance avec les instructions de montage de la chaudière dans l'Annexe A. Pour obtenir plus de chaleur, le cendrier éttoufoir de courants d'air devrait être ouvert et l'éttoufoir "check" de courants d'air fermé. (voir l'illustration no. 2). Pour produire moins de chaleur, le cendrier éttoufoir de courants d'air devrait être fermé et l'éttoufoir "check" de chaleur ouvert. (voir illustration no.3)

Enlevez les cendres tous les jours. Une accumulation de cendres dans le cendrier causera le surchauffement, la déformation et la rouillure des grilles.

Gardez le foyer remplit de combustible. Un feu profond est plus économique. Un feu maigre developera des trous, ce qui donnerait un excès d'air. Avant de secouer les grilles ou d'allumer, ouvrez l'éttoufoir boucheur et voyez que la porte du cendrier, le cendrier éttoufoir de courants d'air, l'éttoufoir "check" de courants d'air, et l'entrée secondaire d'air sont fermés. Ceci concentre le courant d'air vers la porte à feu, pour empêcher la fuite de gaz, de fumée et de poussière. (voir l'illustration no. 4)

Après avoir secoué les grilles, faites certain de les retourner à leur positions normales.

Le brûlement des ordures semble promouvoir le machefer (la fusion de cendres chaudes). Quand cette méthode de destruction ne peut être évitée, enlevez tout métal, verre et faïence, et étendez les ordures mincement sur un feu chaud pour qu'ils sèchent et se consument rapidement.

Maintenez le niveau d'eau dans la jauge de verre a la hauteur indiquée dans l'illustration no. 5, à moins que ça soit autrement indiqué sur la chaudière. Ouvrez les robinets de jauge occasionellement, quand il y a pression sur la chaudière, pour vérifier la hauteur de la ligne d'eau - (la vapeur devrait couler du robinet du haut et l'eau du robinet du bas). Pour enlever la crasse de la jauge de verre, le robinet de sûreté peut être ouvert. Les robinets de jauge devrait normalement être completement ouverts.

Le levier de la soupape de sûreté de coulement devrait être opéré occasionellement pour la verification (voir l'illustration no. 6). La soupape de sûreté de coulement devrait s'ouvrir avant que la pression indiquée sur la jauge excède quinze livres; autrement, elle devrait être réparée ou remplacée.

LE MAINTIEN

Gardez les carneaux propres. Le nettoyage fréquent des carneaux de la chaudière sauvera le combustible et prolongera la vie de la chaudière.

Quand la chaudière est hors de service, nettoyez le tuyau de fumée complètement.

Avant de réutiliser, assurez-vous de bien sceller et serrer tous ler joints avec du mastic de chaudière ou du ciment. Nettoyer soigneusement et minutieusement le foyer et n'importe quelles autres parties qui auraient pu entrer en contact avec des gaz chauds. Enlevez tout combustible et cendres des grilles et du cendrier. Ceci est extremement important puisque la rouillure et la corrosion se forment quand la chaudière ne marche pas. Huilez toutes les charnières des portes, les instruments d'orientation éttoufoir et régulateur et appliquez une fine couche de graisse aux surfaces basses de chaques portes, éttoufoirs, et leurs cadres. Pour éviter le ressuage et la rouillure de la chaudière, laissez les portes de la chaudière ouvertes.

Pour la plupart des installations c'est recommendable, quand la chaudière est hors de service, d'écouler assez d'eau de la chaudière jusqu'à ce qu'elle s'écoule entièrement pour enlever la boue et la corrosion accumulée. Les chaudières à vapeur devraient être remplies d'eau jusqu'au haut de la jauge de verre -- laissez écouler au niveau d'eau normal quand la chaudiere est mise en service. Si la chaudière est installée en place humide, c'est recommendable, pendant que la chaudière se remet hors de service, d'écouler toute eau du système pour éviter le ressuage, qui induit la rouillure et la corrosion.

Pour nettoyer le système d'eau de la chaudière, préparez une solution bouillante de sodium hydroxique (soude caustique) en proportion de 24 grammes de soude caustique par 10 litres d'eau. Débranchez complètement la chaudière de l'alambic, et remplissez avec le mélange d'eau et soude caustique, ensuite laissez marcher pour deux heures sur un feu bas et laissez écouler.

Avant de refaire marcher la chaudière, voyez que tous les joints entre les sections et autour de la base, des cadres des portes, et des cheminées sont scellés; que la base est scellée au plancher avec du ciment Portland; et que les portes et les éttoufoirs sont sécurement scellés. L'air devrait entrer la chaudière par le cendrier éttoufoir de courants d'air seulement ou par l'entrée secondaire d'air dans la porte à feu.

La cheminée devrait être vérifiée et néttoyée complètement tous les deux ans au moins. Toutes les liaisons entre les tuyaux de fumée doivent êtres scellées avec du mastic ou du ciment de chaudière. Si il y a des joints douteux et si la flame est attirée, alors il y a fuite. Les fuites dans la cheminée peut être découverte en fermant le haut et en brûlant du papier mouille, pour créer un feu à fumée épaisse.

La cheminée devrait se conformer au recommandations du manufacturier de la chaudière en ce qui concerne la hauteur et la grandeur et devrait être de construction serrée sans tournants brusques ou décalements. Le tuyau de fumée devrait être aussi court qui possible.Assurez-vous que le tuyau ne projette pas dans la cheminée au delà de la surface intérieure du carneau.

Il est recommandé que vous vérifiez votre système occasionellement en donnant une attention particulière aux points suivants.

Si L'eau dans une chaudière à vapeur semble graisseuse ou sale, l'intérieur de la chaudière devrait être nettoyé complètement en utilisant un composé de nettoyage de chaudière convenable ou d'autres moyens.

La soupape de rentrée d'air et la soupape de sûreté de coulement devrait être éxaminée et vérifiée pour juste fonctionnement avant de réutiliser la chaudière.

Pour contrôler la désincrustation de la chaudière à cause des dépots de calcium causés par une trempe à l'eau, une dose de deux cuillerées de sodium hydroxique (soude caustique) par semaine est conseillable. Préparez-vous à des écumes si il y a dose trop forte. Le PH de l'eau de la chaudiere devrait être maintenu plus haut que 8.0.

LE CHAUFFAGE SOLAIRE ET LE SYSTÈME DE POMPAGE.

Ce système est composé de deux composants principaux: un appareil de paneaux solaires électriques photovoltaïques (fabriqué par Solarex Corporation, U.S.A.), une pompe centrifuge (fabrique par A.Y. MacDonald, Inc. U.S.A.), un régulateur et deux batteries. Les paneaux photovoltaïques sont utilisés à générer de l'électricité qui peut être utilisé à fournir la chaleur directement à l'alambic par un échangeur à chaleur ou pour faire marcher la pompe. L'électricité peut aussi être réservée dans les batteries pour usage futur. Chaque composant sera discuté séparement.

LE FONCTIONNEMENT

Les Photovoltaïques

Chaque Paneau Solaire Électrique Solarex est une combinaison de séries de cellules solaires branchés et parallèles. Les cellules solaires Solarex sont des méchanismes semi-conducteurs de silicium qui convertissent la lumière directement en électricité. Quand elles sont exposées à la lumière, chaque cellule produit à peu près le même photovoltage entre ses bornes. Quand une charge est branchée entre les bornes; le courant marche.

Le montant de courant dépend sur le montant de lumière absorbée: donc, pendant des jours nuageux ou brumeux, la production de courant de l'élément est proportionnellement réduite. Le soir, il n'y pas de production du tout.

Le courant est aussi proportionnel à la superficie des cellules solaires branchés et parallèles dans l'appareil. Le système utilise des séries et des cellules branchées et parallèles pour fournir son taux de production de voltage.

Le plus petit élément dans un système est le module solaire, ou le paneau solair. Les modules sont branchées en séries et en configurations parallèles pour produire le voltage et le courant désiré. Dans ce système, trois sous-appareils sont branchés ensembles. Le premier (sous-appareil A) consiste de 4 paneaux solaires, pendant que les deux prochains (sous-appareils B & C) consistent de 5 paneaux chaque.

Les configurations méchaniques et électriques de ce système sont illustrées dans l'Annexe C. Les instructions d'assemblages sont dans l'Annexe D.

Dans cette installation prototype les paneaux photovoltaique peuvent être utilisés en trois modes distinctes. Premièrement, ils peuvent fournir de la chaleur directe à l'alambic par la bobine de résistance. Les trois sous-appareils peuvent être arrangés entre eux pour se brancher directement à la bobine (voir l'illustration 7), ou le sous-appareil A peut être arrangé pour qu'il puisse charger la batterie pendant que les sous-appareils B et C restent branchés à la bobine. (voir l'illustration no. 8). En général, la deuxième configuration est recommendée.

Dans la deuxième mode de fonctionnement, les paneaux photovoltaiques peuvent êtres utilisés pour faire marcher la pompe. Encore cette fois-ci, deux configurations sont possibles. Les trois sous-appareils peuvent être arrangés entre eux pour faire marcher la pompe directement. (voir l'illustration no.9), ou le sous-appareil A peut être arrangé pour charger la batterie pendant que les sous-appareils B et C restent branchés à la pompe (voir l'illustration no. 10). Dans la deuxième configuration la batterie devrait être arrangée pour que sa production soit aussi branchée à la pompe. De cette facon, la batterie pourra fournir de l'énergie à la pompe pour compenser le manque de production des paneaux photovoltaiques pendant des jours nuageux ou pluvieux. Pour éviter le surchauffement possible de la batterie pas les sous-appareils B et C, un isolateur est installé entre la batterie et sa prise du courant. Le surchargement par le sous-appareil A est évité par le régulateur.

Quand la batterie est proprement chargée, elle peut faire marcher la pompe seule. (voir l'illustration 11). Ce doit être dit, cependant, que les sous-appareils B et C ne générent pas assez d'energie pour faire opérer la pompe effectivement et doivent être aidés par la batterie ou le sous-appareil A.

Pour résumer, il y a trois configurations de base pour le fonctionnement de la pompe:

1. Les trois sous-appareils photovoltaîques sont branchées à la pompe (l'illustration no. 9)

2. Le sous-appareil A est relié à la batterie. Les sous-appareils B et C et la batterie sont reliés à la pompe (l'illustration 10)

3. Les paneaux photovoltaîques sont débranchés et la batterie seule est branchée à la pompe. (l'illustration no. 11).

L'information pour l'usage de la pompe paraît ci-dessous.

Le Régulateur

Le contrôle de charge pour ce système est fourni par un régulateur de séries de voltage, qui protège les batteries du surchargement. Le régulateur est calibré pour les batteries pour être utilisé dans le système et devrait fonctionner proprement quand il est branché dans le système. LE SOUS-APPAREIL "A" PHOTOVOLTAÎQUE SEUL DEVRAIT ÊTRE BRANCHÉ AU RÉGULATEUR. En faisant des branchements de fils du sous-appareil A au régulateur, faites certain que les polarités sont pareilles (+ a +, - a -), et que les branchements sont bien serrés. Notez: en activant le système, faites que les branchements à la batterie durent; en débranchant le système, débrancher les avances des fils de la batterie d'abord.

Ce régulateur de séries de voltage est désigné a un système de 24 volts. Le voltage de production peut être ajusté à 25-31 volts en utilisant un potentiomètre à vis d'entailles.

Le régulateur à été mis à une production de voltage de 28.8 volts. Ceci, est le voltage optimun pour les batteries du système. Le régulateur peut facilement être ajusté en utilisant une petite vis à entailles dans le potentiomètre à 10,000 ohm placée au haut du tableau à circuit électronique. Pour ajuster le point de règlement utilisez ce procédé suivant:

A) Faites fonctionner le système aux conditions "plein soleil" ($100 mW/cm^2$) avec l'appareil débranché, la batterie branchée, mais avec la charge débranchée.

B) Branchez un résisteur à fausse charge (250 ohm, 25 watt minimum) parallèle à la batterie. (Suggestion: branchez le résisteur aux bornes dans la boite au régulateur).

C) Débranchez les avances de la batterie à la batterie.

D) Ajustez le potentiomètre j'usqu'à ce que le voltage désiré est obtenu en mesurant l'indication de voltage sur le résisteur à fausse charge avec un voltmètre portatif.

La Batterie

Deux batteries de 12 volt, 68 ampères à cycle profond sont fournies pour chaque système photovoltaïque. Comme au résumé ci-dessus, ses batteries peuvent être utilisées, seule ou en combinaison avec les sous-appareils photovoltaïques B et C, à faire fonctionner la pompe. Elles sont spécialement utiles pendant des périodes nuageuseuses ou le soir quand la production génératrice des paneaux photovoltaïques est basse. Quand le système de distillation ne marche pas, le courant des batteries peut être utilisé pour d'autres objets, comme l'éclair.

Le dessin de la batterie permet le déchargement complet de l'appareil sans dégas et le chargement de la batterie est contrôlé automatiquement par le régulateur. Seul le sous-appareil A devrait être branché à travers le régulateur jusqu'au batteries.

La Pompe

Comme cela à été résumé ci-dessus, la pompe centrifuge peut être chargée directement des trois sous-appareils photovoltaïques, ou par de l'électricité réservée dans les batteries à cycle profond, ou par une combinaison de batterie et de sous-appareils photovoltaïques B et C.

La pompe est utilisée premièrement pour faire circuler l'eau refroidissante à travers le condenseur de l'alambic. L'eau peut soit être pompée du condenseur à une citerne puis être rejetée par la gravitée jusqu'au condenseur (l'illustration no. 12); ou un réservoir peut être utilisé pour réserver l'eau chauffée (rejetée par la gravité) sortant du condenseur. L'eau de remplacement coule dans le condenseur, (aussi par la gravité) d'une citerne ci-dessus (l'illustration no. 13). Dans cette seconde configuration, la pompe est utilisée pour pomper l'eau du réservoir j'usqu'à la citerne quand le réservoir est plein. Le pompage n'a pas besoin d'être continu. Dans la première configuration, parce qu'il n'y a pas de réservoir, l'eau doit être pompée continuellement pour assurer la propre circulation.

La pompe peut aussi être utilisée à remplir l'alambic et la chaudière quand cela est nécessaire. Elle se prime et peut-être utilisée dans des installations de puits peu profonds. Des données descriptives sont fournies dans l'Annexe E et dans les instructions sur les puits peu profonds dans l'Annexe F.

LE MAINTIEN

Les Photovoltaïques

Les paneaux solaires Solarex sont désignés à usage et fonctionnement seul et sans troubles. Les cellules solaires sont totalement encapsulées en éthyline-vinylacetate (EVA), qui est à l'épreuve des intempéries, stabilisé par l'UV, et a des qualités excellentes sous des températures de toutes étendues. Le problème de l'absorption de l'eau est circonvenu par l'usage des contactes débranchés sur les cellules solaires, faisant un élément très stable et durable.

Dans la pluart des surfaces et des applications, la pluie lavera les surfaces des paneaux, pour éviter la dégradation de la production. La crasse accumulée, qui peut être trouvée dans des places très polluées peut être corrigé en nettoyant occasionellement avec un produit léger ou de l'alcool.

Tous les ans, comme procédé de maintien préventif, tous les boulons qui fixent les paneaux et la structure de montage de l'appareil devraient être serrés pour assurer l'intégrité continue de ce système. Tous les branchements électriques dans les boîtes de jonctions et des régulateurs devraient être examinés pour la fermeté et le manque de corrosion.

Le paramètre le plus utile et facilement mesuré pour le dégagement électrique d'un paneau solaire est le courant à court circuit. S'il y a faillite ou dégradation d'une module (un paneau) individuelle dans le système, cela sera immédiatement indiqué. Le courant court circuit est en proportion avec le niveau de radiation solaire, alors une cellule typique ou un paneau typifié devraient être utilisés à déterminer les conditions de radiation solaire au temps de l'épreuve. Le procédé utilisé à dégager le système est le suivant:

1. Débranchez le système à partir du régulateur et de la charge.

2. Faites un court-circuit de la production du système avec un ampèremètre qui a assez de capacité pour suporter un courant d'à peu près 20% plus haut que le courant court-circuit du système.

3. Les mesures initielles devraient être faites à travers les points de production du système complet. Si c'est sous-normal, mettez à l'épreuve chaque paneau dans ce système comme ce sera déclaré dans le no 4 qui suit.

4. Pour identifier un paneau imparfait dans un système, abritez chaque paneau en séquence en suivant la production de courant totale dans le système. Quand un paneau qui fonctionne proprement est abrité, la chute en production totale de courant devrait être à peu près égale au courant court circuit d'un paneau. Quand un paneau imparfait est abrité, le courant tombera un petit peu, ou pas du tout.

5. L'épreuve devrait avoir lieu une journee claire à cause des grandes variations qui pourraient se passer en passant l'épreuve une journée nuageuse. Notez que le courant de chargement de la batterie n'indique pas la production de l'appareil, à cause des variations dans l'état de la charge du système de la batterie.

6. Si un paneau solaire se trouve imparfait, enlevez-le de l'appareil. Dependant du mode d'insucces, il peut être réparé sur le champ, or retourné à la manufacture.

7. En cas de dommage à la surface, de petites réparations peuvent être faites en utilisant du RTV 732 (Dow Chemical) ou un équivalent de caoutchouc silicium clair. La surface doit être complètement nettoyée en utilisant de l'alcool. Une petite goutte de RTV 732 devrait être ajoutée pour mariner pour à peu près 6 heures a température normale avant de traiter.

Le Régulateur

A) Si la batterie est branchée, débranchez-la du régulateur.
B) Branchez les avances de l'appareil au régulateur au bloc de la borne étiquetée APPAREIL.
C) Branchez une charge résistive au bloc de la borne étiquetée BATTERIE (voyez la section antérieure pour des détails).
D) Mesurez un voltage au point de la production du régulateur. Au bloc de la borne étiquetée BATTERIE, le voltage devrait être 28.8 volts à 25°C. Si la production de voltage est trop base ou près de zéro, vérifiez la polarité correcte et la continuité des avances de l'appareil. Si le voltage est trop haut, ajustez le potentiomètre à 10,000 ohms j'usqu'à ce que le voltage exigé est atteint.
E) Mesurez la chute du voltage à travers la diode SD51 (voyer le dessein schématique sur les instructions de canalisation dans l'Annexe C). Ca doit être à peu près .5 volts. Aussi vérifiez la chute de voltage sur le Emitter-Collector du transisteur de charge 2N4048 en plaçant les charges du voltmètre au bloc de la borne positive de l'appareil, et de l'étui de charge du transisteur. Le voltage devrait être à peu près 5 volts.

La Batterie

Toutes les cellules doivent être remplies d'électrolyte (de l'acide de batterie), pour toujours couvrir les plaques. Le niveau d'électrolyte doit être surmonté avec de l'eau distillée quand il en est besoin.

Notez: L'électrolyte est extrèmement nocive aux yeux et à la peau. Utilisez avec précaution.

Le branchement et le débranchement devraient être faits seulement quand les prises de courants ne marchent pas pour éviter des explosions de gaz d'hydrogène.

La Pompe

Pour éviter le dommage du puit mécanique, évitez l'opération à scellement sec. La contamination du liquide qui sera pompé avec des solides peut causer l'obstruction et du dommage d'impulsion.

Pour éviter la corrosion quand on ne l'utilise pas pendant de longues periods de temps, l'eau dans la pompe devrait être écoulée. La section électrique ne devrait pas être exposé à l'humidité, donc, l'installation au-dessus de la terre et la protection contre la pluie est recommendée.

NOTEZ: AUX CONFIGURATIONS ALTERNATIVES, UN CONDENSEUR EN EXISTENCE PEUT ÊTRE UTILISÉ AVEC UN NOUVEAU POT D'ALAMBIC ET UNE NOUVELLE CHAUDIÈRE; OU, UN POT D'ALAMBIC ET UN CONDENSEUR PEUVENT ÊTRE UTILISÉS AVEC UNE NOUVELLE CHAUDIÈRE ET UN NOUVEAU PAQUET DE TUBES EN U. DANS TOUTES LES CONFIGURATIONS, LE PROCÈS DE FONCTIONNEMENT ET DE MAINTIEN SONT COMME CELA À ÉTÉ ESQUIS DANS CE MANUEL.

UN SYSTÈME SOLAIRE ALTERNATIF QUI CHAUFFE EN AVANCE L'EAU DE L'ALAMBIC EST DÉCRIT DANS L'ANNEXE G.

ILLUSTRATION 1

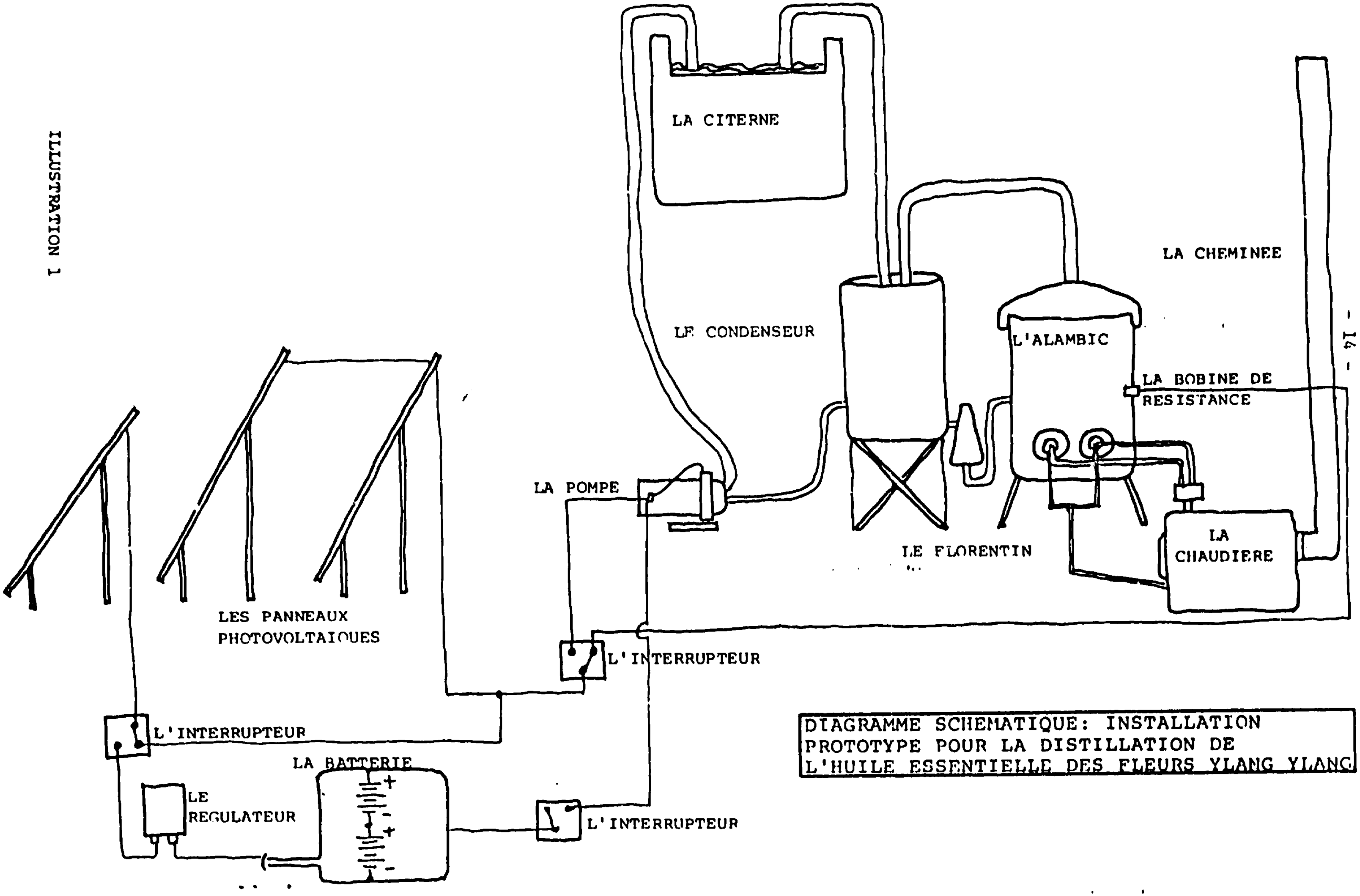


DIAGRAMME SCHEMATIQUE: INSTALLATION PROTOTYPE POUR LA DISTILLATION DE L'HUILE ESSENTIELLE DES FLEURS YLANG YLANG

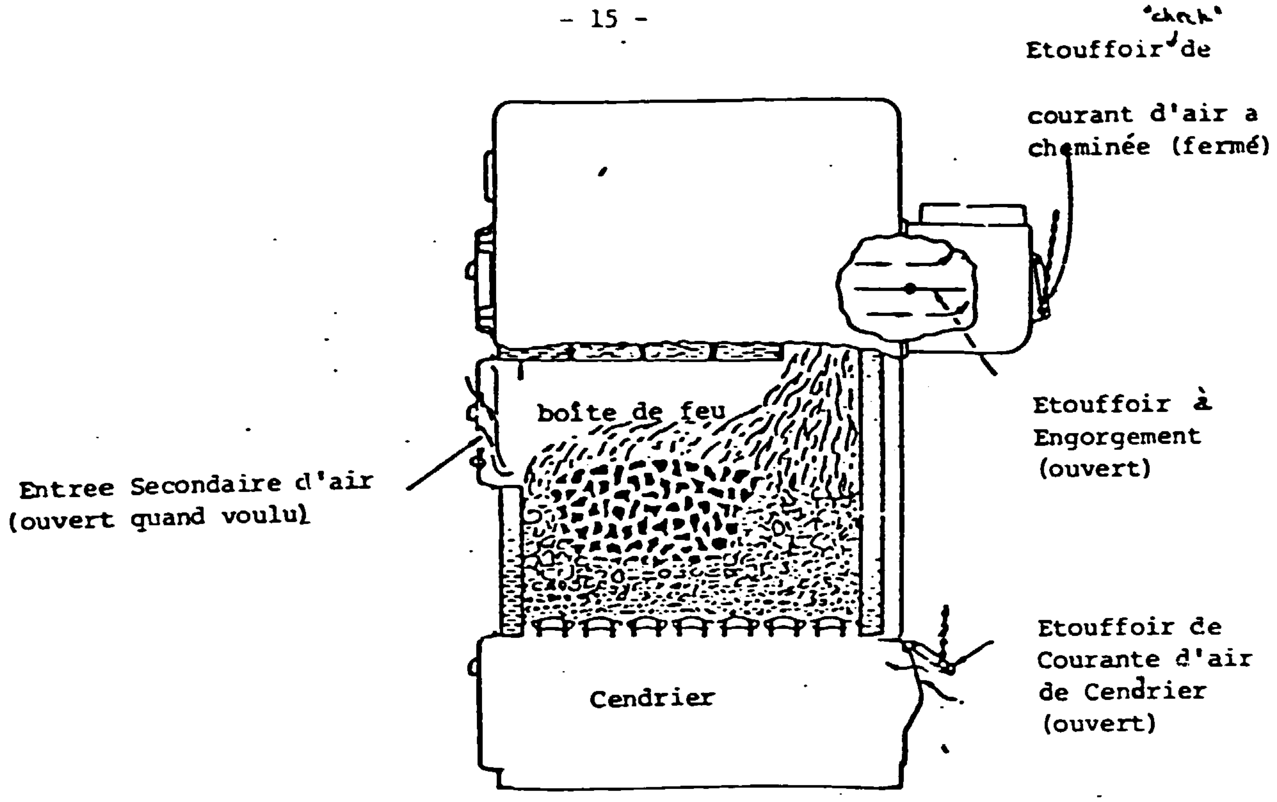


Illustration - Quand un feu chaud est désiré

ILLUSTRATION 2

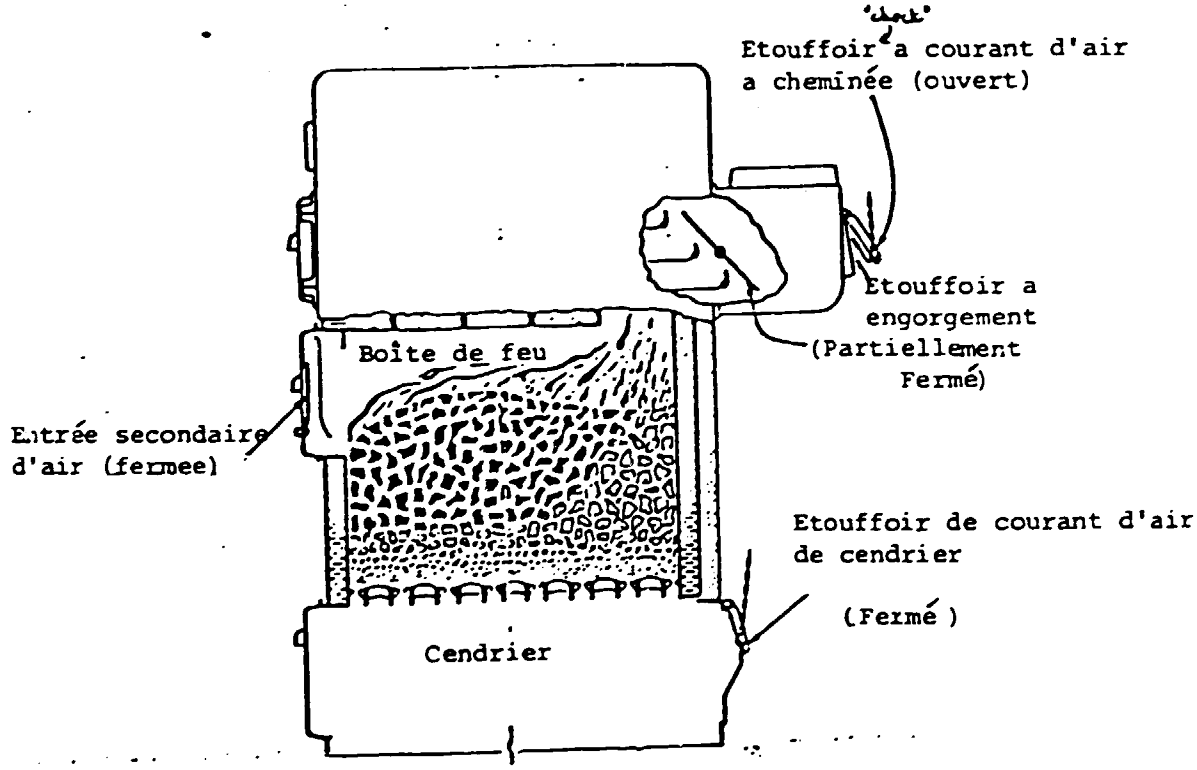


ILLUSTRATION 3

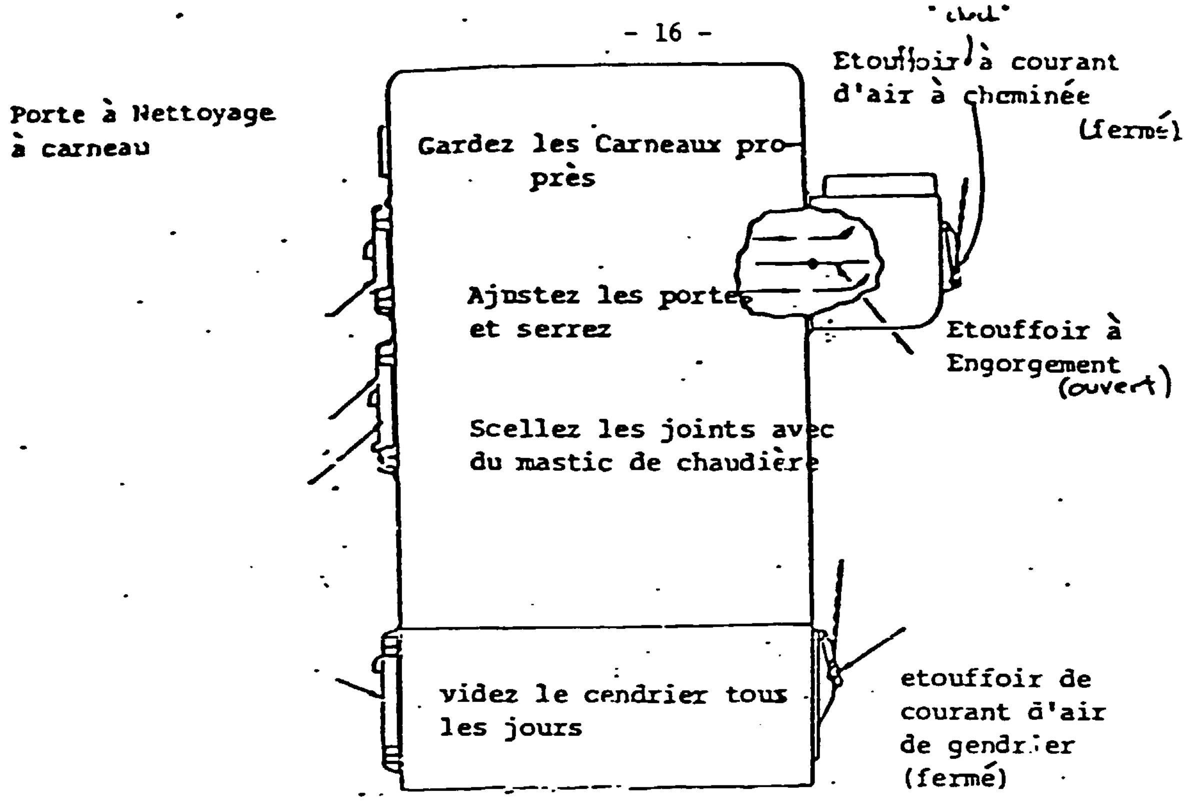


Illustration - Pour Reduire La Fumee et la poussière pendant le feu.

ILLUSTRATION 4

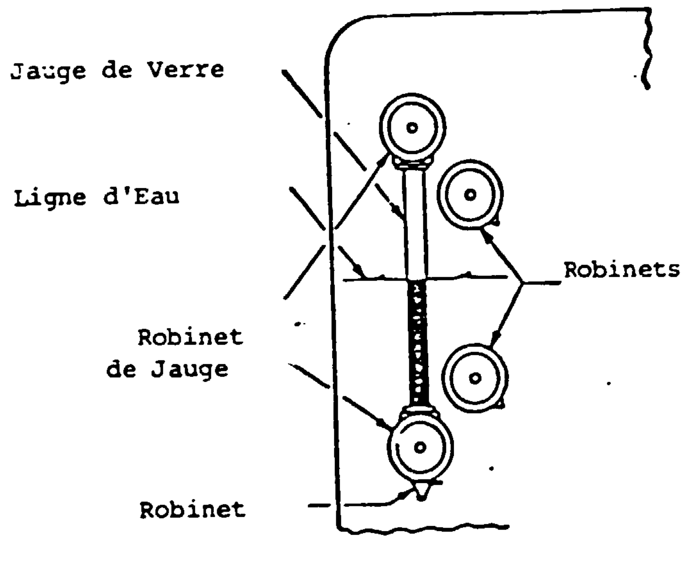


Illustration 5 - le Maintien du Niveau d'Eau Correcte dans la Chardiere a Vapeur

ILLUSTRATION 5

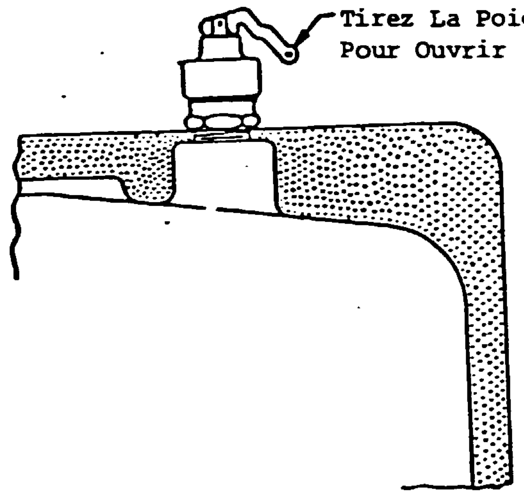


Illustration - Soupape de Surete (Vapeur)
du Soupape de Soulagement (Eau Chaude)

ILLUSTRATION 6

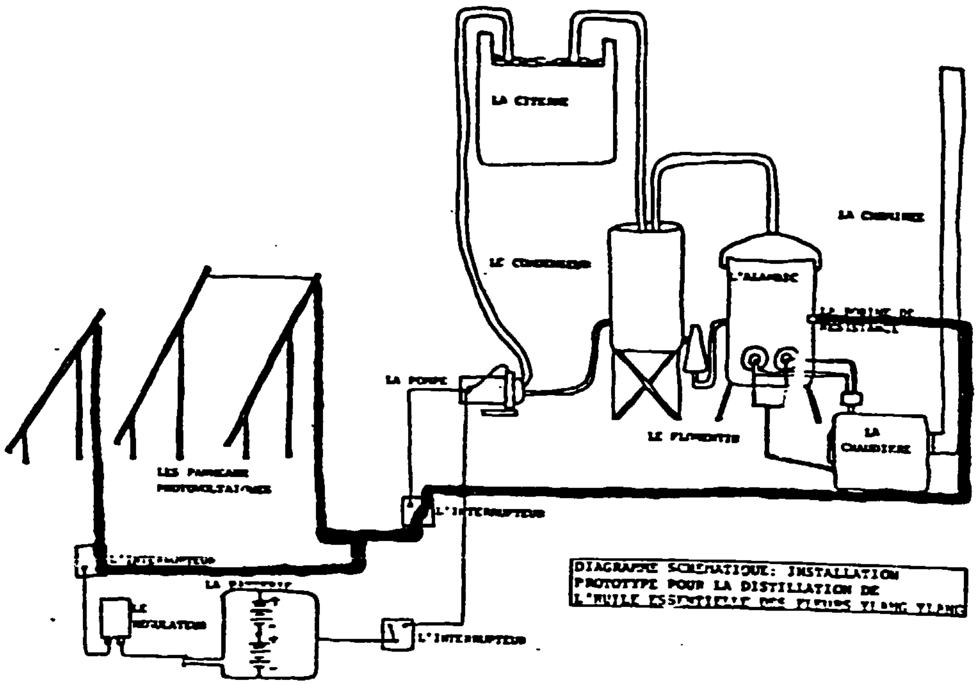


ILLUSTRATION 7

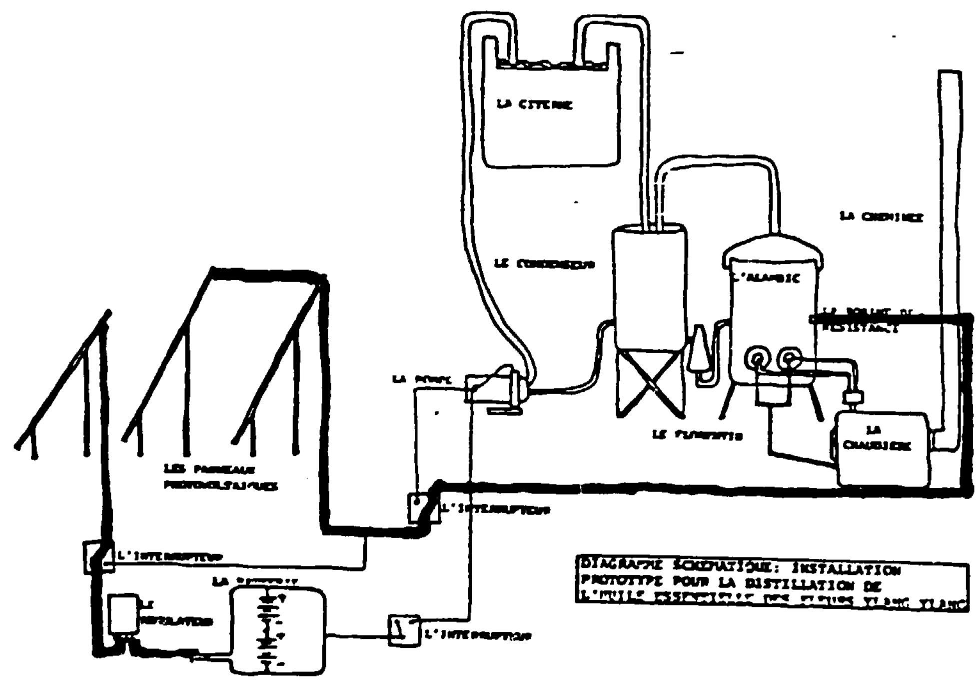


ILLUSTRATION 8

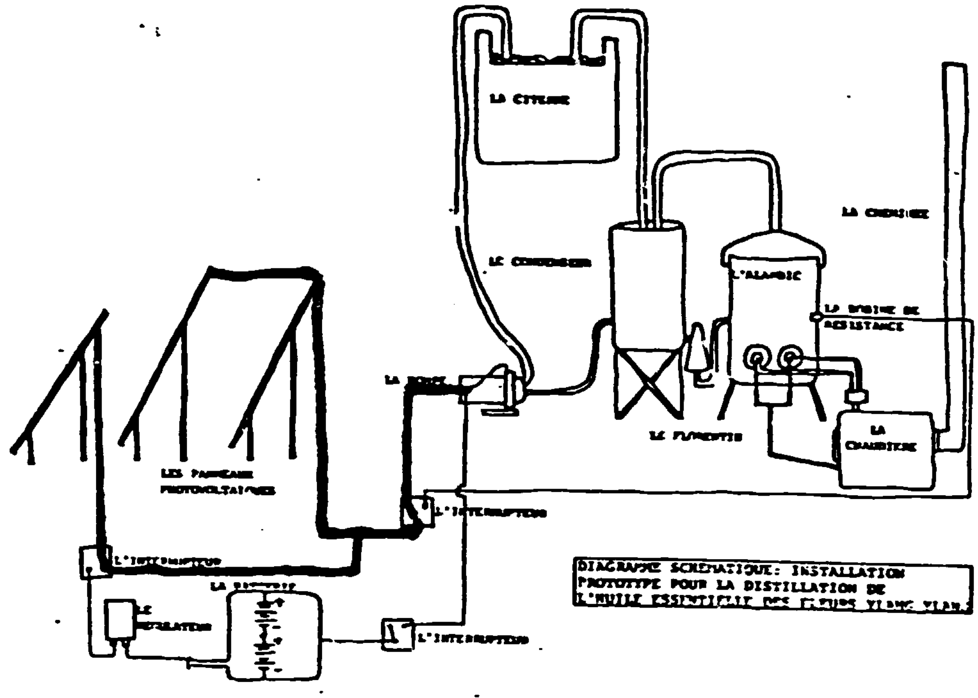


ILLUSTRATION 9

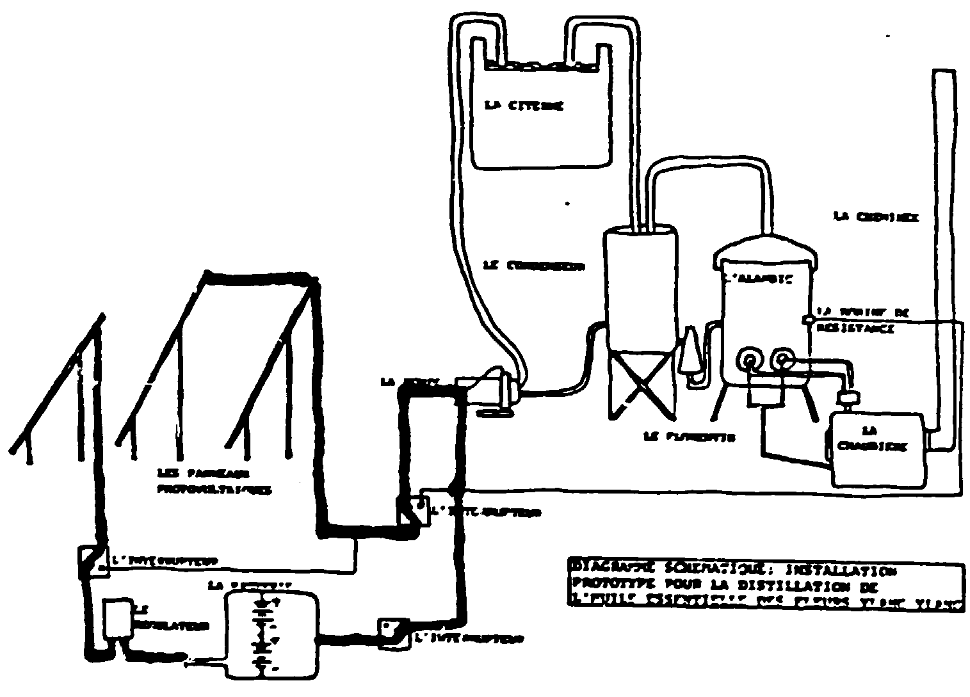


ILLUSTRATION 10

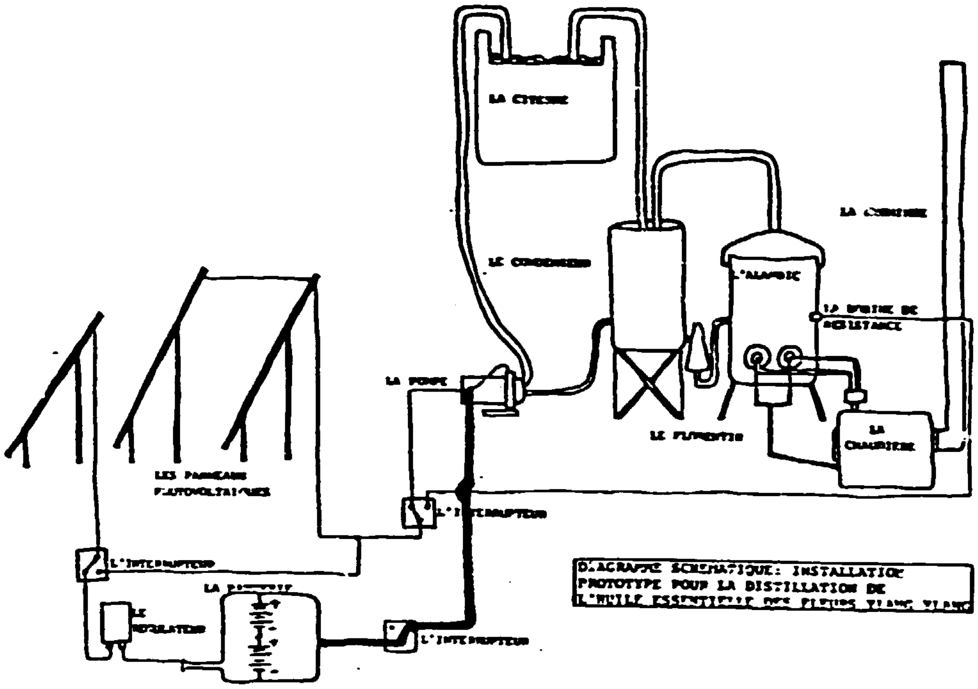


ILLUSTRATION 11

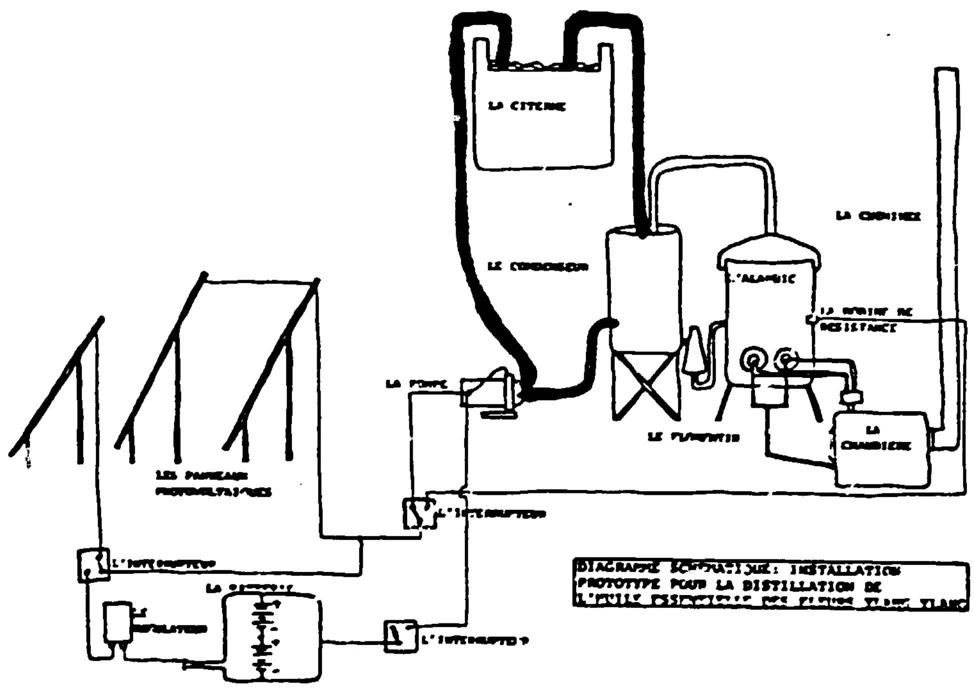


ILLUSTRATION 12

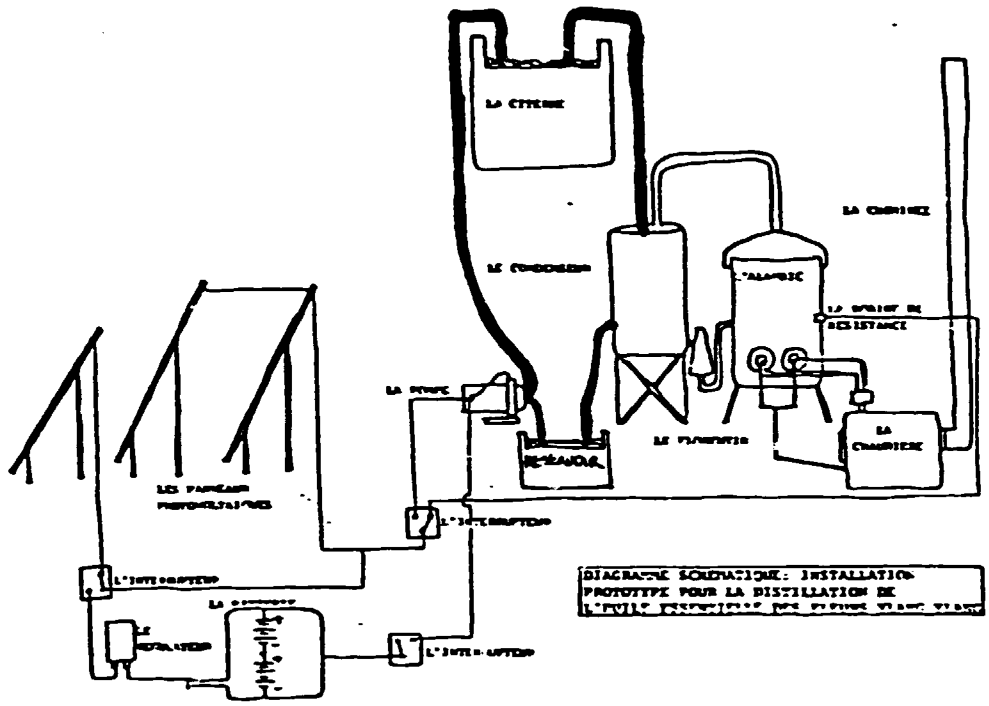


ILLUSTRATION 13

Annexe A

Directions d'assemblement
Slant/Fin "21" pour allumage a main
de Chaudière en Séries

DIRECTIONS D'ASSEMBLEMENT POUR LA CHAUDIÈRE.

1. Déballez toutes les boites et les cartons excepter ceux contenant l'enveloppe de la chaudière et vérifiez toutes les parties reçues contre les bouts de papier d'emballage.

2. Il est extrèmement important que les sections soient assemblées dans l'ordre indiqué sur la carte d'assemblement des sections de la chaudière (l'illustration no 2). Cela insurera que les ouvertures de l'enveloppe égaliseront les tapotements correspondants dans la chaudière, et permettra la meilleure opération de la chaudière.

3. Fournissez une fondation solide et nivellée pour la chaudière près de la cheminée, pour que la chaudière soit reliée à la cheminée avec un tuyau de fumée d'une grandeur élevée (9", 229 mm, de diamètre) avec aussi peu de tournants que possible. Fournissez des environs non-encombres aux côtés pour accès immédiat, et aussi au devant pour l'allumage et le nettoyage de la chaudière.

4. Assemblez les quattres paneaux de la base en utilisant des boulons à tête carrée de 3/8" x 7-1/4" (10 mm x 184 mm) avec des écrous à l'intérieur. Les paneaux des côtés devraient être attachés librements aux paneaux de base devant et de derrière. Voyez que les coins de la base sont carrés, ensuite, serrez tous les boulons.

5. Préparez les Sections d'Assemblement comme ceci. Nettoyez complètement et appliquez une couche de lubrifiant de mamelon à l'extérieur de tous les mamelons à poussoir. Nettoyez toutes les ouvertures des mamelons. Ne pas utiliser de plomb rouge ou de composé de joint de tuyau sur les mamelons à poussoir, et gardez l'huile loin de l'intérieur des sections.

6. Placez la section de devant sur la base, ensuite installez les mamelons à poussoir et montez les carrement et fermement en place en portant une planche plate sur leurs bords et en frappant la planche avec un marteau (l'illustration no 3). Faites attention que les mamelons sont droits, et que leurs bords projettent en distance égale au-dessus de la tête des ouvertures des mamelons tout autour. Ceci évitera le retroussement des mamelons, qui fera un travail dur pour rassembler les sections et pourrait causer des fuites dans les joints et des sections cassées.

7. A propos de la carte qui démontre le Propre Ordre d'Assemblement des sections de la chaudière, sélectionnez la section qui sera placée près de la section de devant, placez-la sur la base, et engagez les ourvertures des mamelons sur les mamelons à poussoir. Pour l'assemblement facile, placez d'abord la grande ouverture de mamelon sur le mamelon à poussoir de haut, ensuite, engagez les mamelons à poussoir de bas.

   Sur les chaudières nos 5 - 21, 7 - 21, et 9-21, commencez l'assemblement en mettant ensemble une Section Immédiate de 3-3/4" (95 mm) à une Section Immédiate de 7-1/2" (191 mm) à lla Section de Devant.

8. Insérez les perches à rassemblement dans les trous de chaque côtés de l'ouverture de mamelon, et placez un écrou et une rondelle plate sur chaque bout des deux perches. Insérez une des perches à rassemblement qui reste à travers chaque ouvertures de mamelon de bas, et utilisez une des grandes rondelles de fonte, une rondelle plate, et un écrou sur chaque bout des deux perches. (voir l'illustration no 4). La section de devant devrait être déplacée du paneau de base de devant pour fournir de la place pour les rondelles de fonte de devant.

9. Commencez à rassembler les sections, en les élevants également et en tournant chaque écrou un petit peu à la fois, jusqu'à ce que les sections se touchent tout autour de leurs surfaces du sol. Des fils lubrifiants de perches à rassemblement avec de la graisse et une huile forte aideront le rassemblement et évitera les fils de se dépouiller. Cela aiderait considérablement si un homme tenait un bloc de bois contre le bord de la section près du mamelon et le frappe avec un marteau pendant qu'un autre attire l'écrou (voir l'illustration no 4).

10. Placez la section de dos en position, engageant le mamelon à poussoir de haut d'abord, ensuite les mamelons à poussoir de bas. Insérez deux perches de rassemblement dans les trous de haut et deux perches dans ceux de bas, manquant les rondelles de fonte. Placez une roundelle plate et un écrou sur les bouts de chaques perches de rassemblement, et élevez la section de dos jusqu'à la chaudière en tournant chaque écrou un petit peu à la fois jusqu'à ce que la surface de sol rencontre celle de la section contigue.

11. Quand toutes les sections ont été élevées fer à fer, désserrez les écrous jusqu'à ce qu'ils soient serrés qu'au doigt.

12. En utilisant une pince a talon, centrez les sections sur la base, et voyez que les surfaces de sol sur la face de la section de devant s'alignent avec celles devant la base. Verrouillez le paneau de base de devant à la section de devant en utilisant un boulon de 3/8" x 1" et une rondelle plate insérée à travers le trou au-dessus de l'ouverture de la poignée à secousses.

13. Si une espèce de boîte de feu, chauffeuse d'eau chaude va être installée, enlevez les tissus fins jetés sur les ouvertures de la section de dos en frappant de coups secs autour des bords des tissus avec un ciseau.

14. La chaudière a été soigneusement éprouvée et vérifiée avant le chargement de la manufacture, mais c'est conseillabe d'éprouver la chaudière assemblée pour des fuites ou des dommages qui auraient pu se produire pendant le chargement. Bouchez tous les taraudages nécessaires et éprouver avec la pression de l'eau pas plus haute que psi (3164 gm/cm^2) carré. Si une examination soigneuse ne révèle pas de fuites, laissez écouler la chaudière et enlevez les bouchons des taraudages qui seront utilisés.

15. Assemblez les barreaux de grille et l'appareil de secousses à la chaudière comme ceci: laissez tomber les barreaux des grilles (avec les bras des grilles a la gauche) sur les tourillons des sections et tournez-les jusqu'à ce qu'ils tombent en place. Quand tous les sections ont été installées, tournez-les à la position normale (horizontale) et mettez le barreau de branchement de la grille sur les crochets des bras de la grille. Inclinez les barreaux de la grille à la position extrême "bascule". Insérez la poignée à secousses dans la base, ensuite basculez le bout de devant du barreau de branchement de la grille vers le milieu de la chaudière et passez le trou sur le tourillon sur la poignée de secousse. (voir l'illustration no 5). Attachez le barreau de branchement de la grille à la poignee de secousse avec une rondelle plate et large et la goupille de laiton. Mettez la porte de machefer en place derrière le paneau de base de devant.

16. En utilisant le mastic de chaudière fourni, scellez complètement toutes les ouvertures et les joints entre les sections de la chaudière et les tôleries. Scellez soigneusement les joints entre les sections de la chaudière, entre la section de devant et le paneau de base de devant, et entre le bas des sections et le derrière et les côtés des paneaux de base. (voir l'illustration no 5 et no 17). Si le plancher est inégal, remplissez les fentes entre la base et le plancher avec du ciment Portland. Un bon travail a ces points évitera la fuite de gaz et de poussière dans la salle et améliorera le contrôle du feu par le matériel de régulation de l'étouffoir automatique.

17. Attachez le loqueteau de porte et la plaque de la charnière pour la porte du cendrier au paneau de base de devant avec des boulons de 3/8" x 1" (10mm x 25mm), en utilisant une rondelle plate sous la tête du boulon qui porte en place le loqueteau de la porte (voir l'illustration no 14). Attachez la porte du cendrier au loqueteau de la porte en utilisant des broches de charnières de 1/4" x 1-1/2" (6mm x 38mm). Ajustez la porte du cendrier pour qu'elle pende droite en enfonçant la plaque de charnière de dedans ou de dehors avec un marteau, si necéssaire. Ajustez le loqueteau de la porte pour permettre que la porte s'ouvre librement et fermez-la fermement en la tapotant du haut on du bas, selon la necéssité, avec un marteau. Attachez la plaque du milieu de devant a la section de devant avec des boulons de 3/8" x 2" (10mm x 51mm), en l'alignant soigneusement avec la porte du cendrier et l'ouverture de la porte à feu. Installez et ajustez la porte à feu, avec ses plaques de charnière et ses loqueteau de porte, dans la même manière que cela à été décrit pour la porte du cendrier. Suivez le même procédé en installant et en ajustant la porte de nettoyage.

    Attachez la poignée de la serrure de secousse a la section de devant, en utilisant un boulon de 3/8" x 1" (10mm x 25mm) et une rondelle à serrure. (voir l'illustration no 5). Si la chaudière va être fournie avec une enveloppe, n'attachez pas la poignée de la serrure de secousse avant que l'envelope aie été installée.

    La cheminée devrait être attachée a la section de dos avec quattre boulons de 3/8" x 2" (10mm x 51mm).

    Attachez le cadre de la porte a courant d'air au pareau de base de dos, en utilisant des boulons et des écrous refoulés de 1/4" x 3/4" (6mm x 19mm).

18. Si la chaudière est fournie avec une enveloppe, voyez les instructions ci-dessous.

19. L'ébarbeuse dervait être installée en ce temps dans la façon suivante:

    Installez la jauge de pression de vapeur dans le tapotement à la gauche du tapotement d'écoulement dans la section du dos. Installez le robinet de jauge de verre et la jauge de verre dans les tapotements du côté droit de la section de devant. Installez la soupape de sûreté dans le tapotement de 2" (51mm) sur la face arrière du dos de la section et installez comme dans l'illustration no 15. Branchez tous les autres tapotements qui ne seront pas utilisés.

20. Installez et ajustez l'équipement d'étouffoir régulateur montré dans les illustrations no 8,9 et 10 et expliqué dans les directions ci-dessous.

21. Si le rechauffeur à eau va être installé, voyez l'illustration no 19 et 21

22. Attachez la plaque à étalonnage (dans l'enveloppe de la boîte de branchement) à la plaque de milieu du devant en utilisant les quattres épingles escucheon fournies. Voyez l'illustration no 7 pour évaluer l'emplacement de la plaque.

23. Les vues de devant et de dos des chaudières complètement assemblées sans enveloppe pour l'allumage à main sont démontrées dans les illustrations no 7 (chaudière à vapeur) et no 8 (chaudière à eau).

24. Branchez la chaudière au système de chauffage et la chaudière à eau au reservoir d'emmagasinage en utilisant des méthods approuvées (voir l'illustration no 21).

DIRECTIONS POUR L'INSTALLATION ET L'AJUSTEMENT DE L'ÉQUIPEMENT D'ÉTOUFFOIR RÉGULATEUR.

A. Installez l'étouffoir régulateur dans un tapotement de 1" à la droite du tapotement d'écoulement dans la section du dos (un tuyau à mamelon de 1" x 2" (25mm x 51mm) est fourni pour ceci avec une espèce d'étouffoir régulateur de vapeur). Le pivot devrait être près de l'arrière de la chaudière (voir l'illustration no 10).

B. Insérez le barreau régulateur pour que l'encoche dans le barreau est au bord de la pièce d'appui, ensuite serrez la vis pour garder en place le barreau.

C. Installez le contrôleur à courant d'air Barochek sur le tuyau de fumee (en coupant un trou dans le tuyau de fumée, en attachant un col sur le trou, en plaçant un Barochek dans le col, et en liant des chaines) en accordance avec les directions comprises avec ce contrôleur. Barocheck peut être installé où sur un tuyau de fumée vertical (voir l'illustration no 9) ou un tuyau de fumée horizontal (voir l'illustration no 8 et 10), comme désiré.

D. Placez du poids sur le barreau régulateur. Ceci causera le bout de derrière du barreau à s'élever, entrainant le balancier, causant que la porte de courant d'air ne s'ouvre pas à au moins 3" (76mm) racourciez la chaine "A" assez pour obtenir ce total d'ouverture (W=3")(W=76mm).

E. Ajustez la position du poids sur le barreau du régulateur pour maintenir la température d'eau désirée ou la pression de la vapeur dans la chaudière. Pour obtenir plus de chaleur, placez le poids au loin de l'étouffoir régulateur -- pour produire moins de chaleur, placez le poids vers l'étouffoir régulateur.

L'INSTALLATION DE L'ENVELOPPE ET L'ISOLEMENT.

Si la chaudière est fournie avec une enveloppe, n'installez pas l'ébarbeuse de la chaudière, l'équipment d'étouffoir régulateur ou le réchauffeur d'eau avant que l'enveloppe aie été installé.

Notez: Attachez l'emblème de l'enveloppe (emplacée dans l'enveloppe dans la boîte à branchement) au paneau du haut de devant.

L'enveloppe a été désignée pour qu'elle n'ait pas besoin d'être installée qu'après les tuyaux d'écoulement et de renvoi au système de chauffage, et aussi le tuyau de fumée à la cheminée, ont été branchés à la chaudière. Le dommage fait à l'émail cuit et fini de l'enveloppe (à cause de la chute des outils, ou le renversement de l'huile, le plâtre, etc.) peut être évité en ne pas emballant et ne pas installant l'enveloppe avant que les branchements précites ont été completés.

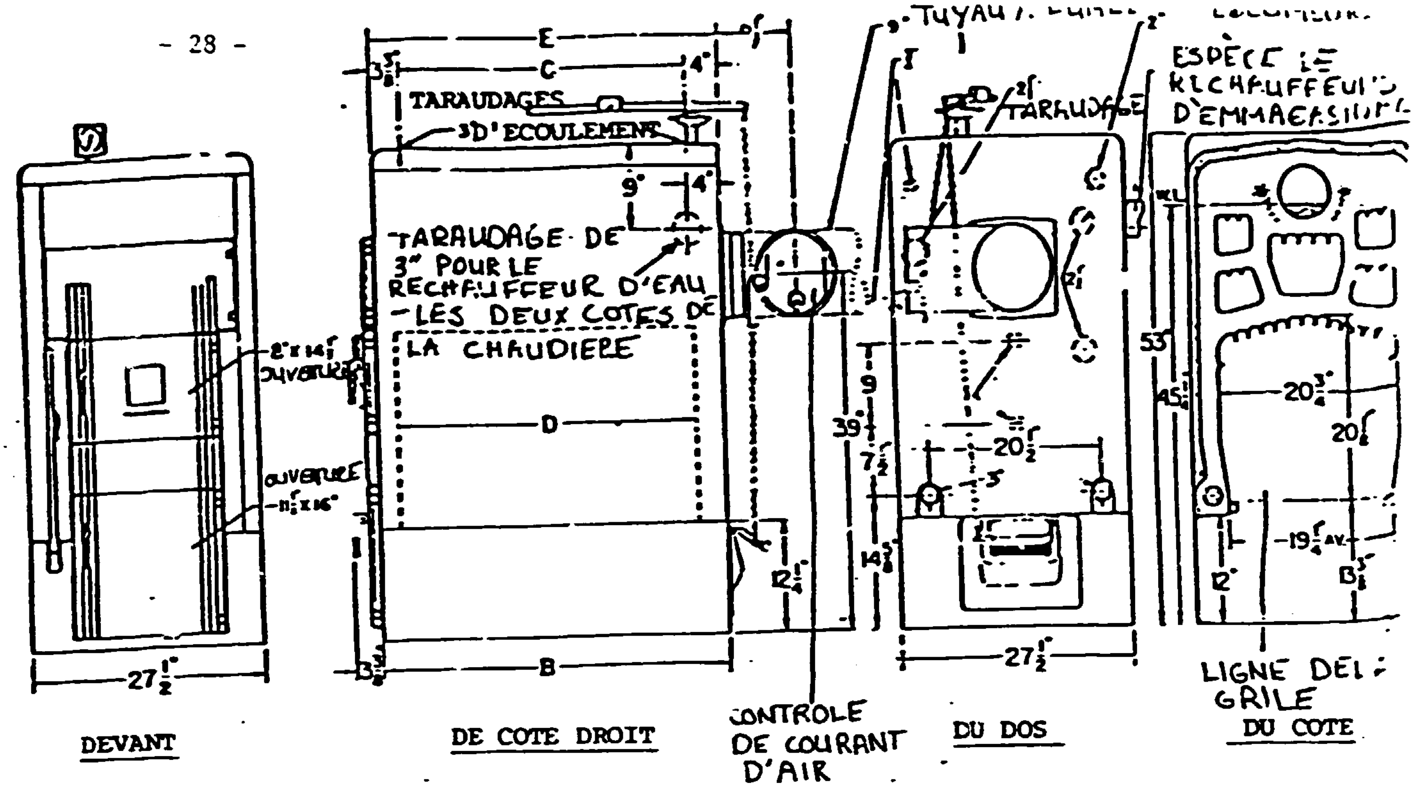


ILLUSTRATION 1 - ILLUSTRATIONS ET DIMENSIONS DE LA CHAUDIERE ASSEMBLEE DE LA SEPIE 21 SLANT/FIN POUR L'ALLUMAGE A MAIN (ESPECE H)

Section D'Assemblement

Boiler No. 4-21	2F	28P	2B			
Boiler No. 5-21	2F	24P	28P	2B		
Boiler No. 6-21	2F	28P	28P	2B		
Boiler No. 7-21	2F	24P	28P	28U	2B	
Boiler No. 8-21	2F	28P	28P	28U	2B	
Boiler No. 9-21	2F	24P	28P	28P	28U	2B

Explication des symboles pour identifier les sections

2F - Section du Devant-Taraude
24P- Section Intermediaire-Simple
28P- Section Intermediaire-Simple
28U- Section du Poit de Sortie-Simple
28 - Section du Dos-Taraude

Illustration 2 - Table D-Assemblement Des Sections De La Chaudiere

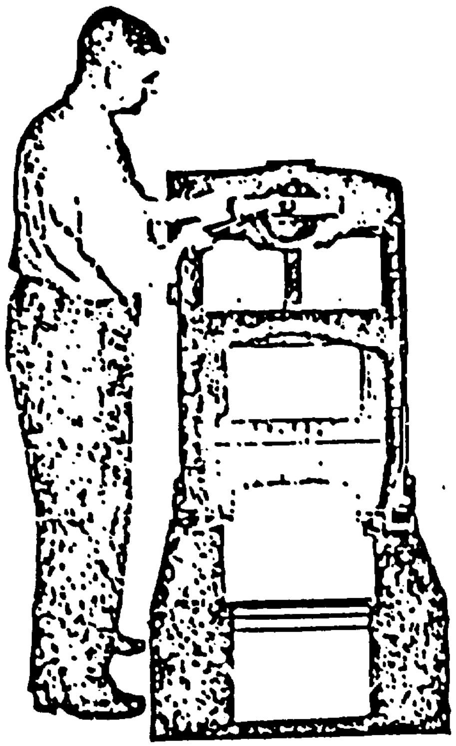


Illustration 3 - Pour Installer Les Mamelons A Poussoir

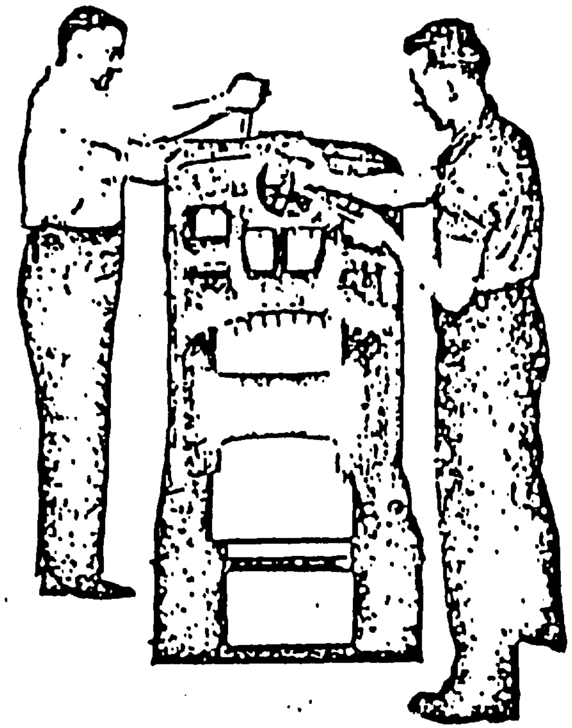


Illustration 4 - Continuation De La Section D'Assemblement, Montrant L'Usage Des Rondelles De Fonte

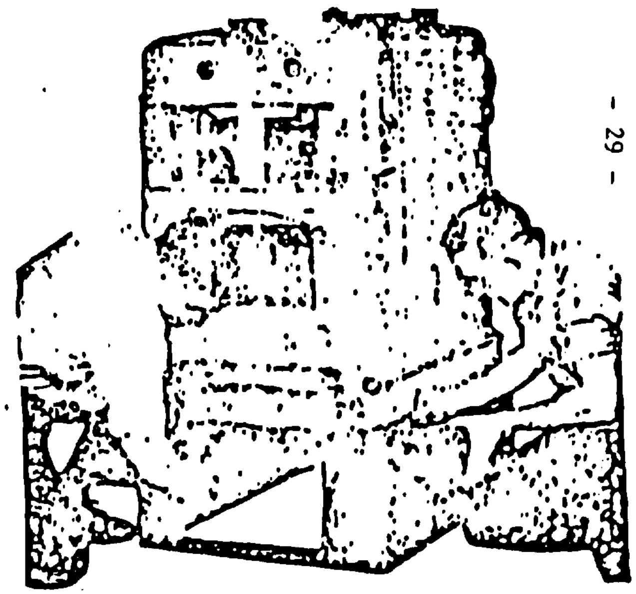


Illustration 5 - Installation Du Barrea De Branchement De La Grille Et Le Sceau Des Joints Avec Du Mastic Chaudiere.

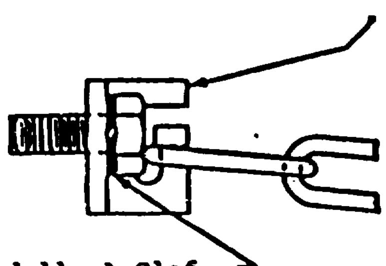


Illustration 6 - Metnode D'Attachement De La Poignee A Secousses A Clef.

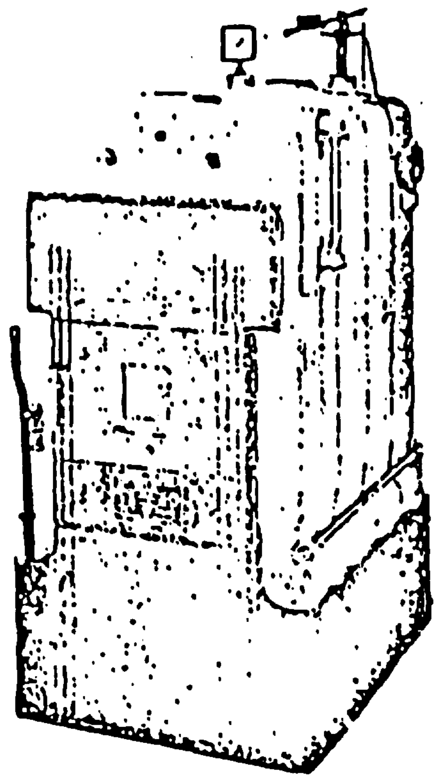


Illustration 7 - Vue De Devant De La Chaudiere Vapeur Sans Enveloppe. (Espece H).

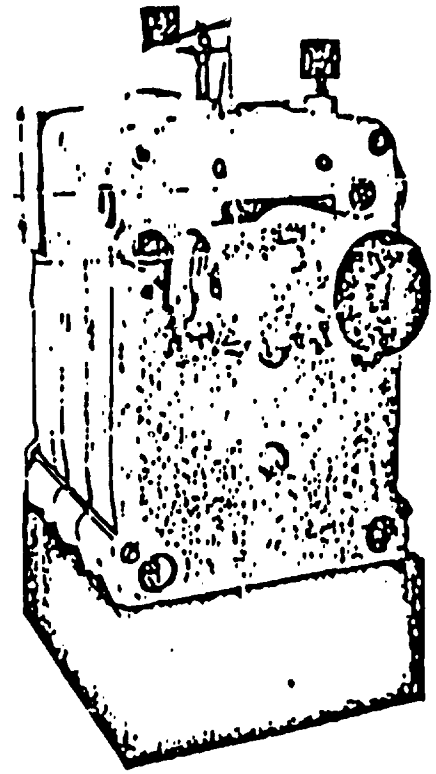


Illustration 8 - Vue De Derriere De La Chaudiere A Eau Sans Enveloppe. (Espece H)

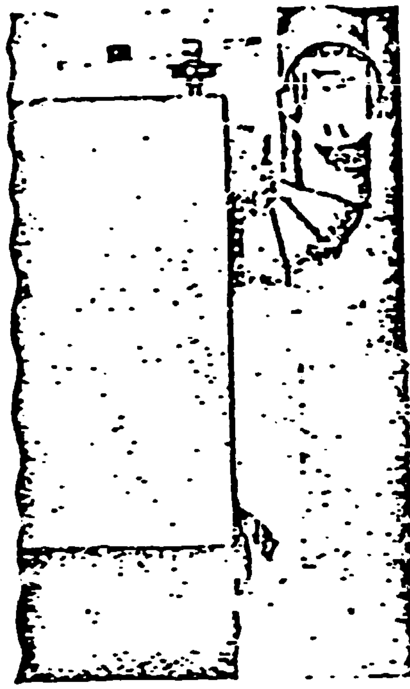


Illustration 9 - Controle De Courant D'Air Barocher Installee Sur Un Tuyau De Fumee Vertical.

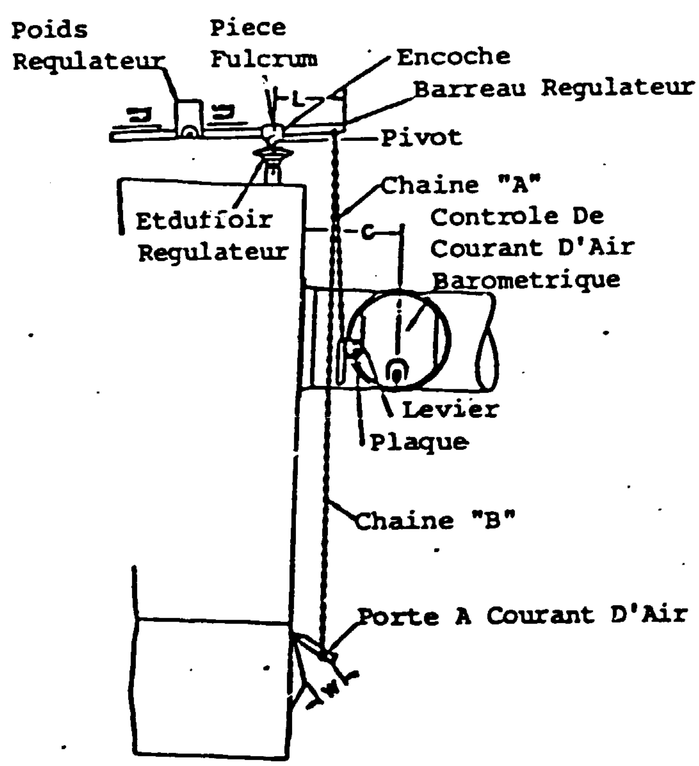


Illustration 10 - Assemblement Des Parties De L'Equipement D'Etouffoir Regulateur (Installement Barocher Sur Le Tuyau De Fumee Horizontal.)

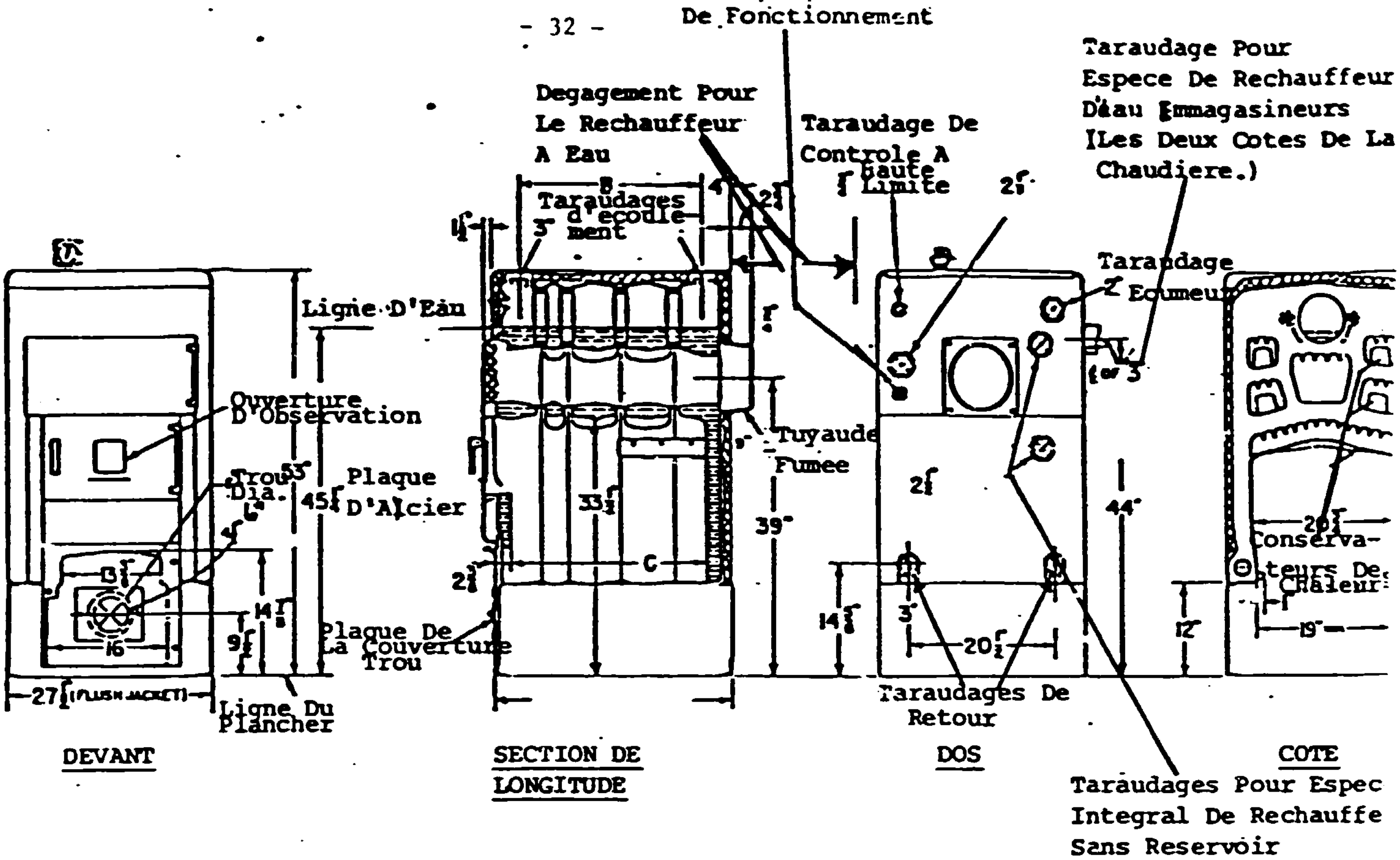


Illustration 11- Illustrations Et Dimensions De La Chaudiere Assemblee De La Series 21 Slant/Fin Pour Allumage Automatique (Espece A).

Section D'Assemblement

Boiler No. 4-21	2F	28P	2B			
Boiler No. 5-21	2F	24P	28P	2B		
Boiler No. 6-21	2F	28P	28P	2B		
Boiler No. 7-21	2F	24P	28P	28U	2B	
Boiler No. 8-21	2F	28P	28P	28U	2B	
Boiler No. 9-21	2F	24P	28P	28P	28U	2B

Explication Des Symboles Pour Identifier Les Section

2F - Section Du Devant-Taraude
24P - Section Intermediaire-Simple
28P - Section Intermediaire-Simple
28U - Section Intermediaire-Simple
2B - Section Du Dos-Taraude

Illustration 12 - Table D'Assemblement Des Sections De La Chaudiere

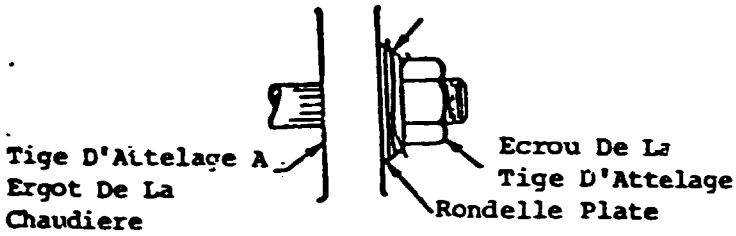


Illustration 13 - Methode D'Installation
D'Eau D'Expansion

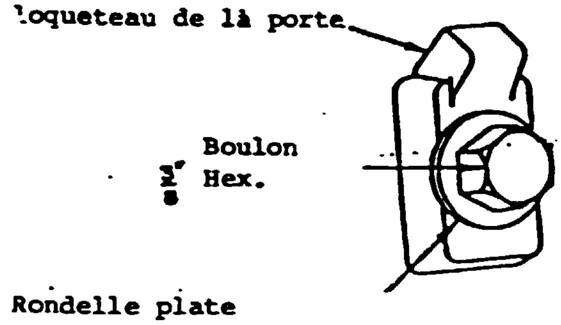


Illustration no. 14 - Methode D'Attache De Loqueteau, De La Porte.

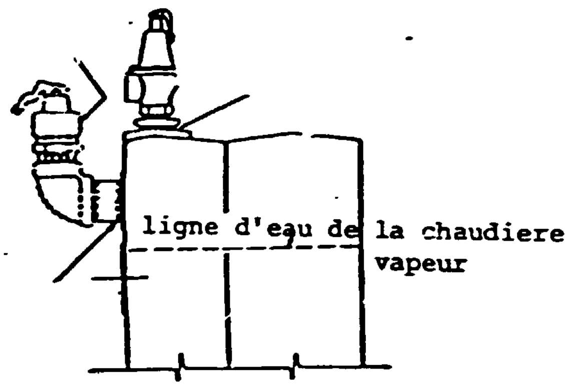


Illustration No.15 - Methode de l'installation de la soupape de surete ou de la soupape de soulagement. (Sur toutes les chaudieres Allumees a main, indtallez une soupape de surete ou une soupape de soulagement dans le taraudage H.)

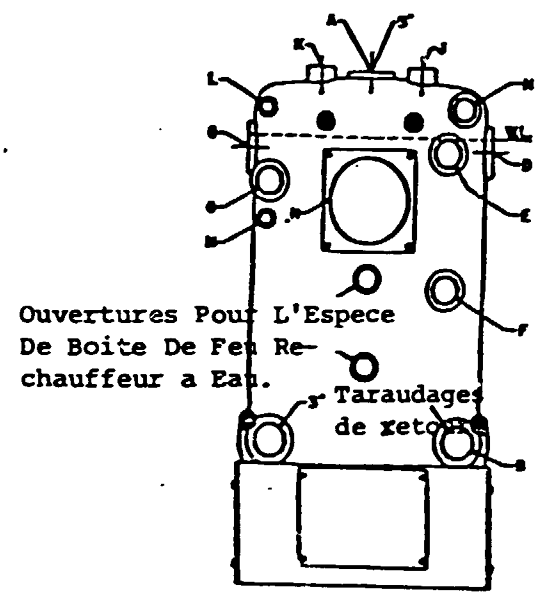


Illustration 16
Taraudages Dans La Sections Au Dos

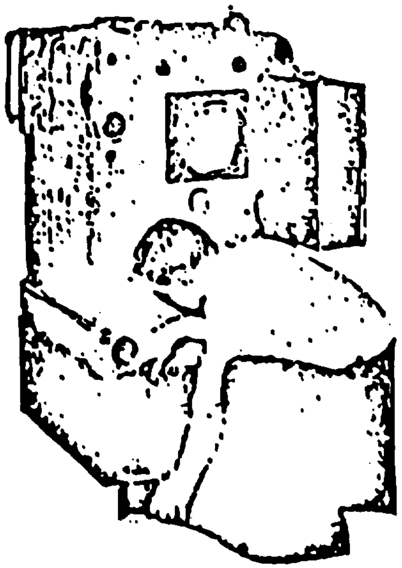


Illustration No. 17 - Vue De derriere De La Chaudiere a Vapeur Sans Enveloppe Avec Rechauffeur D'Eau Integral

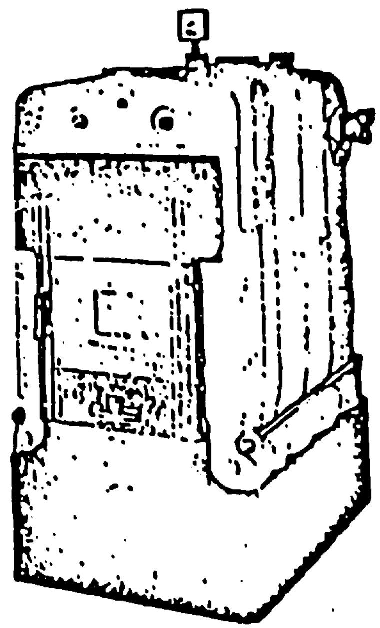


Illustration No. 18 - Vue Du Devant De La Chaudiere A Eau

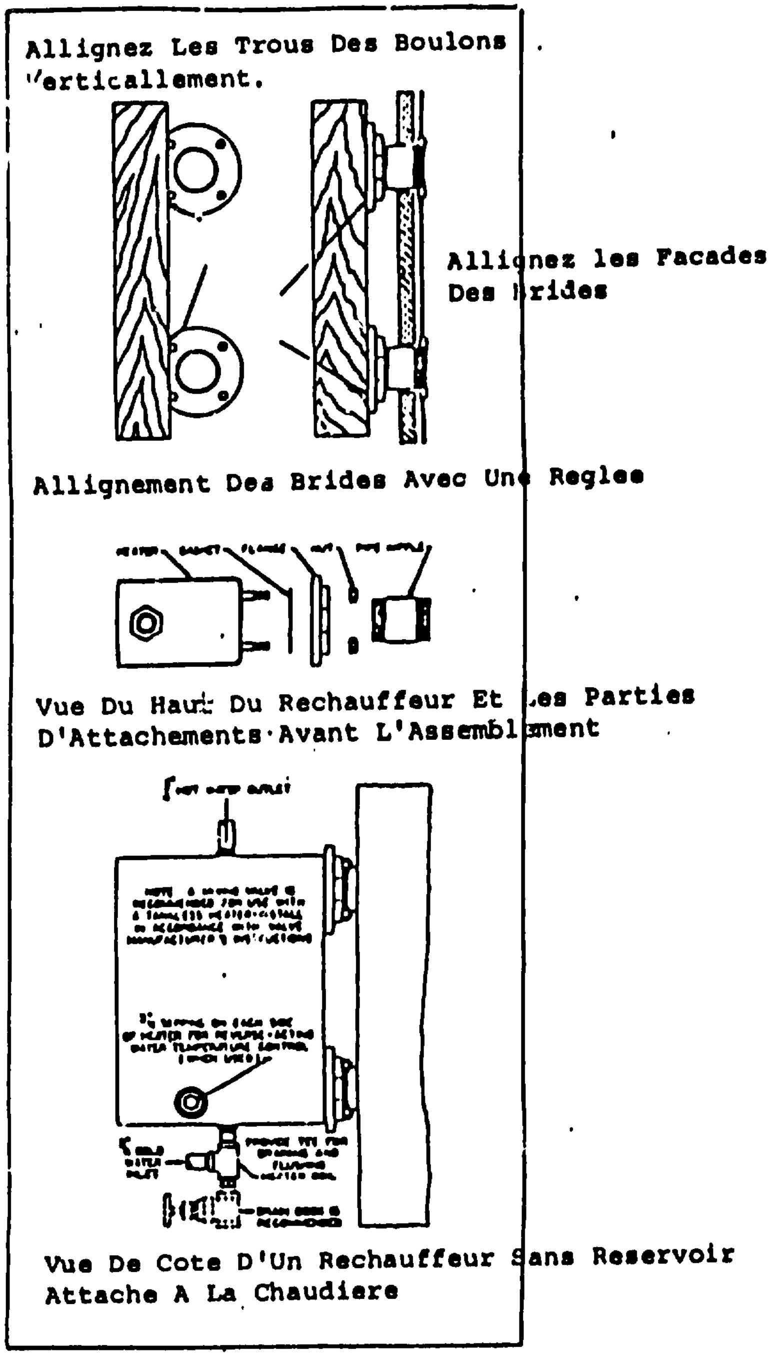


Illustration No. 19 - Methode D'Installation Des Rechauffeurs D'Eau Sans Reservoir Et

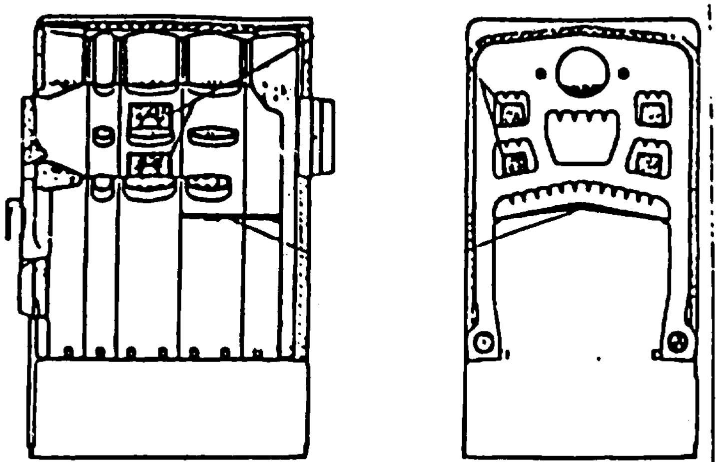


Illustration 20 - Methode D'Installation Des Conservateurs De Chaleur - (boites de feu et - de carreaux) espece A Chaudieres Pour Allumage D'Huile Ou De Gaz

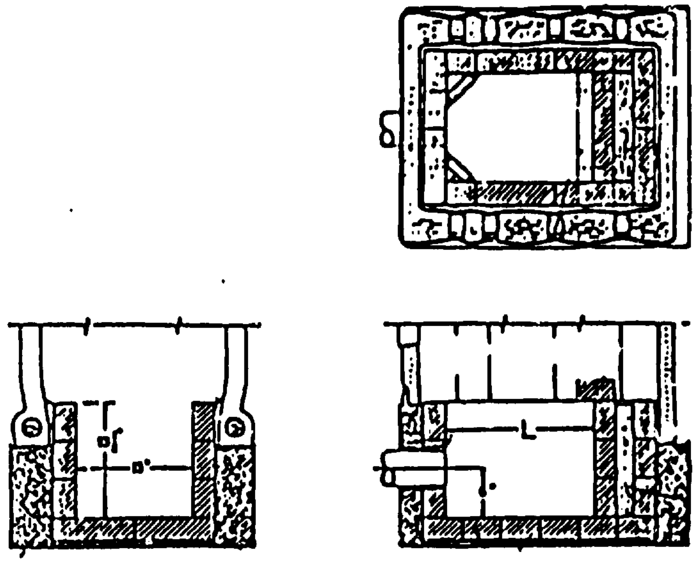


Illustration No. 22 - Methode Recommendee D'Installation D[illegible] Combustible De Brique De Feu Pour L'Allumage D'Huile.

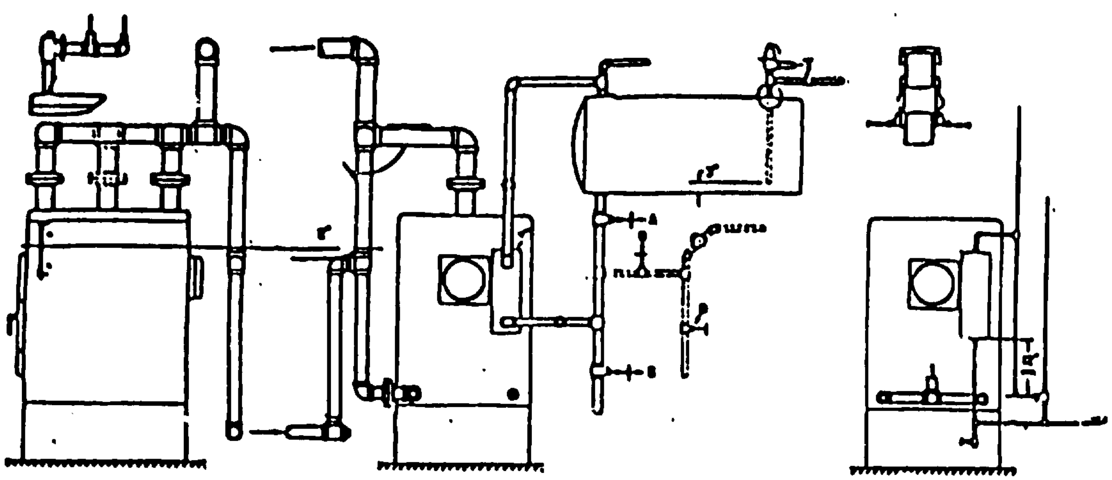


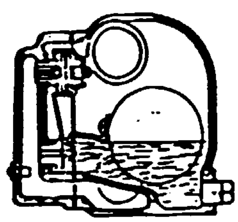
Illustration 21 - Tete De Vapeur Recommendee Et Le Branchement De Retour
[illegible] Et Tuyaudage Pour Espace Emmagasineuse

Annexe B
Les Purgeurs à Platteurs Hoffman

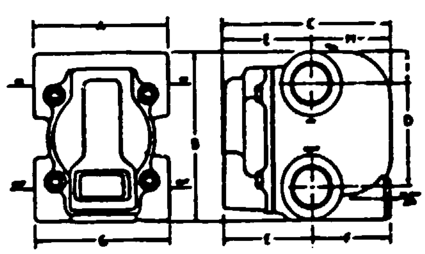
Les purgeurs à flotteurs thermostatique de la série Hoffman 50 sont utilisés avec l'équipement à vapeur pour relâcher la condensation et l'air librement mais ils se ferment pour éviter de relâcher la vapeur.

La condensation remplit le corps du purgeur premièrement à un niveau prédéterminé qui est suffisant pour sceller l'ouverture de la soupape, qui est gardé fermée par la tige de la soupape. Pendant que le niveau de condensation s'élève, le flotteur s'élèvera causant l'entrée de la soupape à s'ouvrir. La condensation sera déchargée à travers la sortie du purgeur. La montée et la tombée du niveau de condensation cause un déchargement continu de condensation, ce qui est typique aux purgeurs R+T. L'air qui entre par le purgeur est déchargée à travers la soupape thermostatique. L'ouverture et la fermeture de l'entrée du thermostat dépend sur la termpérature autour de l'élément thermostatique.

La soupape d'air 71-C. Une espèce de trou d'évent flotteur avec port non-règlable. Cela décharge l'air, scelle contre la fuite d'eau et de vapeur. Le type siphonal télescopique. Une jambe droite NPT de 3/4" (19mm). La pression opérative jusqu'a 11 psi(773 gm/cm^2). La pression maximume 15 psi (1055 gm/cm^2).



DIMENSIONS:

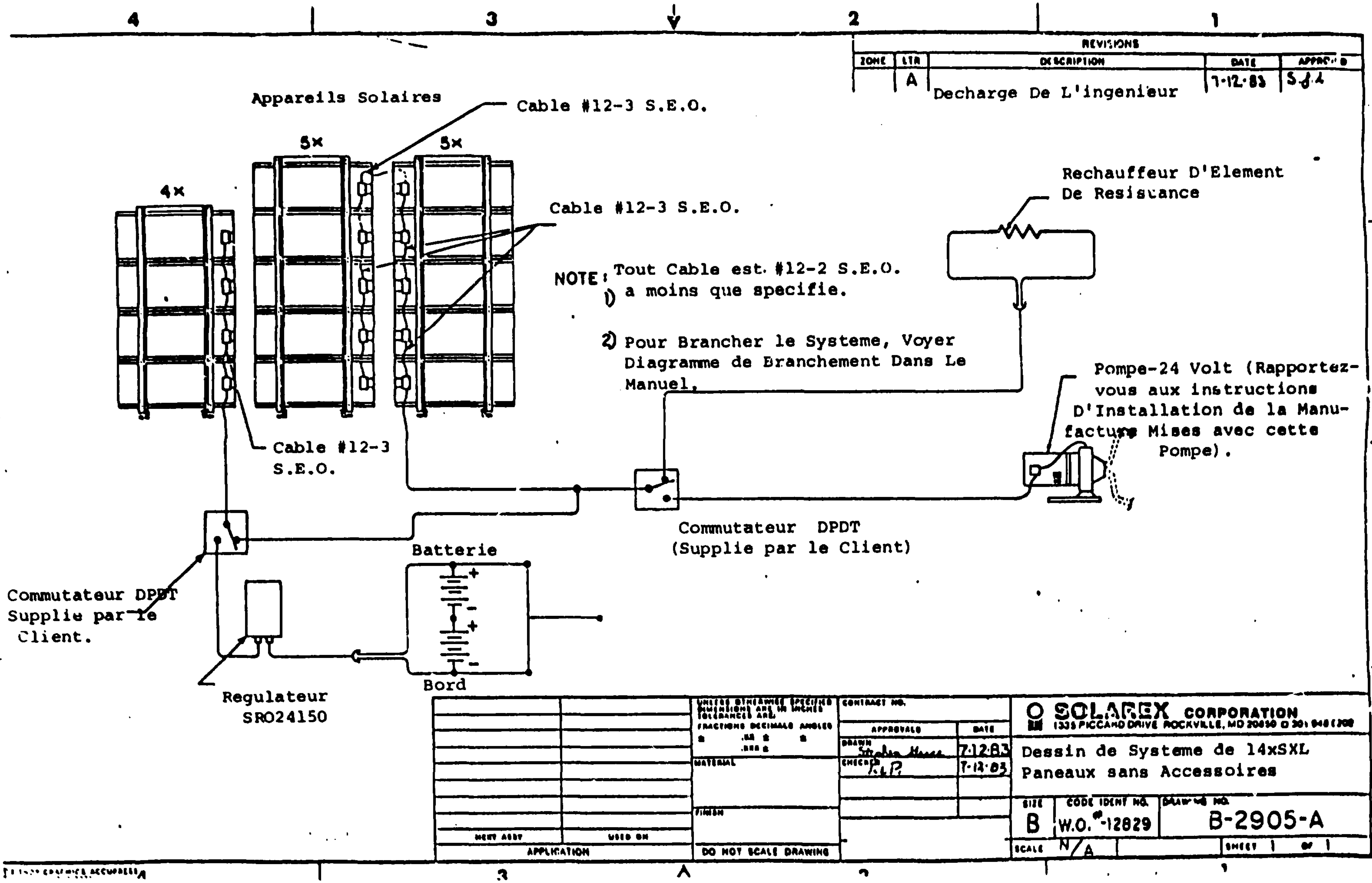


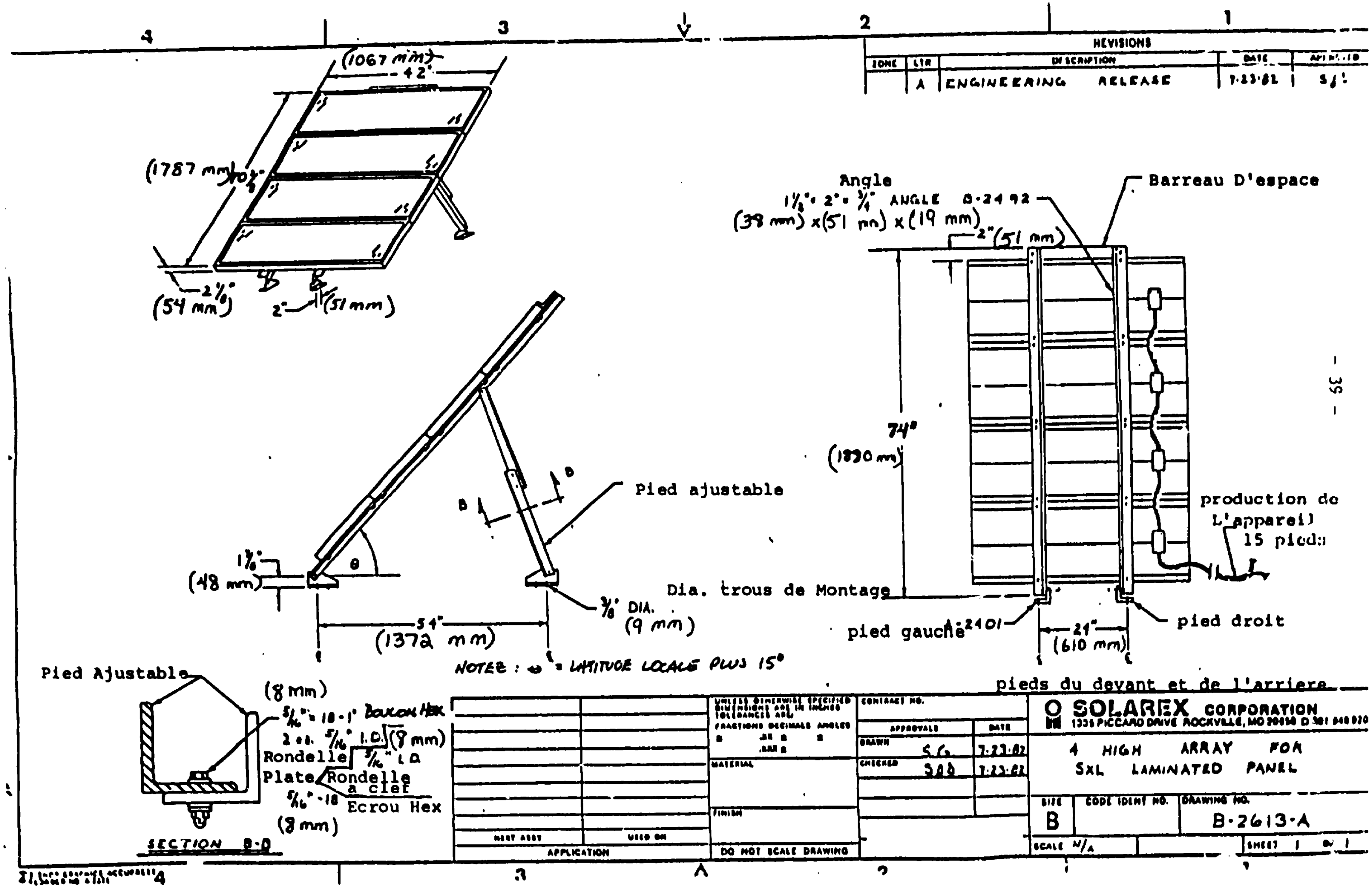
LOW, MEDIUM and HIGH PRESSURE TYPES and NUMBERS		DIMENSIONS Due to variation in casting, gasket thickness, clearance dimensions may vary as much as 1/16"								
Float & Thermostatic	Float	A	B	C	D	E	F	G	H	I
53FT-54FT-540FT 541FT-542FT	53-54-540 541-542	4⅛	5	5¼	3⅛	2¾	2⅜	4⅛	2½	15/16
mm =		(105)	(127)	(133)	(79)	(70)	(60)	(105)	(64)	(24)

ANNEXE C

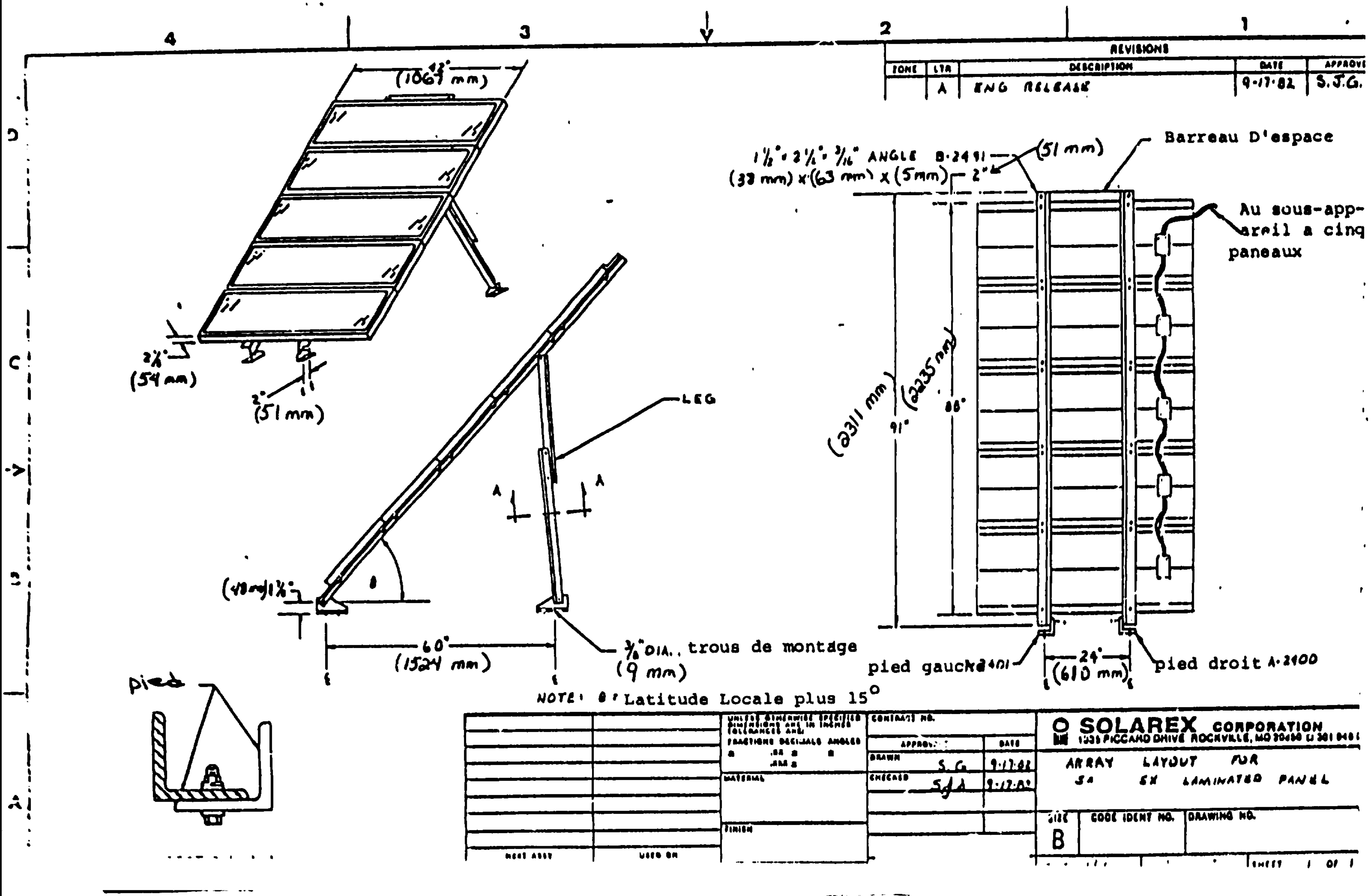
DESSEINS MÉCANIQUES ET ÉLECTRIQUES POUR
LE SYSTÈME PHOTOVOLTAÏQUE

Notez: Tous les mesures peuvent être converties en millimètres en multipliant par 25.40.

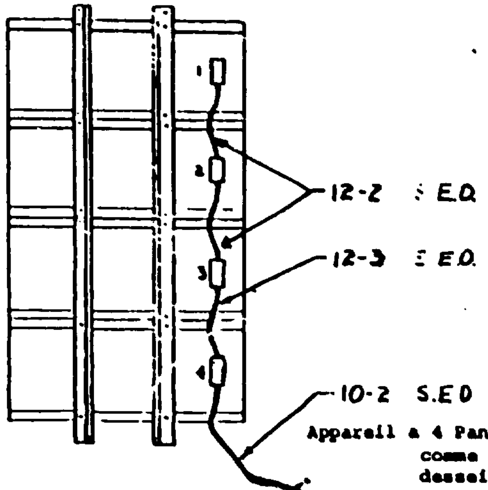

4
3
2
1
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
A
Decharge De L'ingenieur
7-12-83
D
C
B
A
Appareils Solaires
Cable #12-3 S.E.O.
4×
5×
5×
Cable #12-3 S.E.O.
Rechauffeur D'Element De Resistance
NOTE: 1) Tout Cable est #12-2 S.E.O. a moins que specifie.
2) Pour Brancher le Systeme, Voyer Diagramme de Branchement Dans Le Manuel.
Pompe-24 Volt (Rapportez-vous aux instructions D'Installation de la Manufacture Mises avec cette Pompe).
Cable #12-3 S.E.O.
Commutateur DPDT (Supplie par le Client)
Batterie
Commutateur DPDT Supplie par le Client.
Bord
Regulateur SR024150
CONTRACT NO.
APPROVALS
DATE
DRAWN
7-12-83
CHECKED
7-12-83
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
SOLAREX CORPORATION
Dessin de Systeme de 14xSXL Paneaux sans Accessoires
SIZE
B
CODE IDENT NO.
W.O.#-12829
DRAWING NO.
B-2905-A
SCALE
N/A
SHEET 1 OF 1

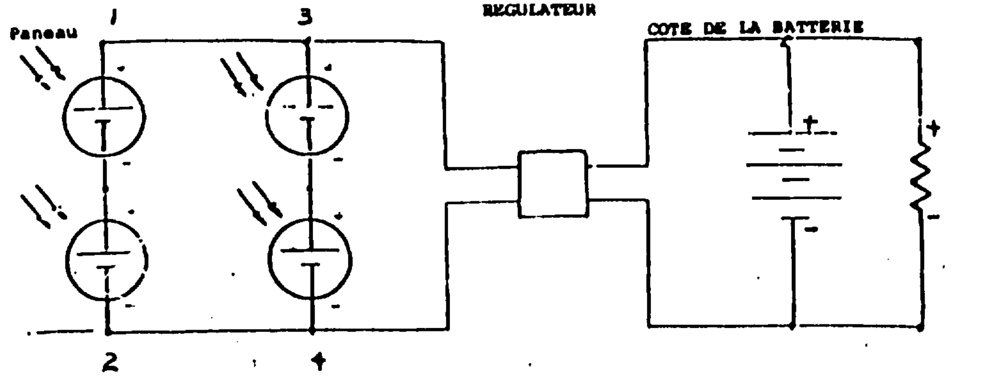


REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | ENGINEERING RELEASE | 7-23-82 | SJ
(1067 mm) 42"
(1787 mm) 70 3/8"
2 1/8" (54 mm)
2" (51 mm)
Angle
1 1/2" x 2" x 3/4" ANGLE B-2492
(38 mm) x (51 mm) x (19 mm)
2" (51 mm)
Barreau D'espace
74" (1880 mm)
production de L'appareil 15 pieds
Dia. trous de Montage
pied gauche A-2401
pied droit
21" (610 mm)
Pied ajustable
B
B
θ
1 7/8" (48 mm)
3/8" DIA. (9 mm)
54" (1372 mm)
NOTE : θ = LATITUDE LOCALE PLUS 15°
pieds du devant et de l'arriere
Pied Ajustable
(8 mm)
5/16" x 18 x 1" Boulon Hex
2 ea. 5/16" I.D. (8 mm) Rondelle Plate
5/16" I.D. Rondelle a clef
5/16" -18 Ecrou Hex (8 mm)
SECTION B-B
DO NOT SCALE DRAWING
APPLICATION
NEXT ASSY
USED ON
SOLAREX CORPORATION
1335 PICCARD DRIVE ROCKVILLE, MD 20850
DRAWN S.G. 7-23-82
CHECKED 7-23-82
4 HIGH ARRAY FOR SXL LAMINATED PANEL
SIZE B
DRAWING NO. B-2613-A
SCALE N/A
SHEET 1 OF 1



REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | ENG RELEASE | 9-17-82 | S.J.G.
42" (1067 mm)
2⅛" (54 mm)
2" (51 mm)
LEG
A A
(48 mm) 1⅞"
θ
60" (1524 mm)
⅜" DIA. trous de montage (9 mm)
NOTE: θ: Latitude Locale plus 15°
Pied
1½" x 2½" x 3/16" ANGLE B-2491
(38 mm) x (63 mm) x (5mm)
2" (51 mm)
Barreau D'espace
Au sous-appareil a cinq paneaux
91" (2311 mm)
88" (2235 mm)
pied gauche A-2401
24" (610 mm)
pied droit A-2400
NEXT ASSY
USED ON
MATERIAL
FINISH
CONTRACT NO.
APPROVALS
DATE
DRAWN S.G. 9-17-82
CHECKED SJG 9-17-82
SOLAREX CORPORATION
1335 PICCARD DRIVE ROCKVILLE, MD 20850
ARRAY LAYOUT FOR 54 SX LAMINATED PANEL
SIZE B
CODE IDENT NO.
DRAWING NO.
SHEET 1 OF 1





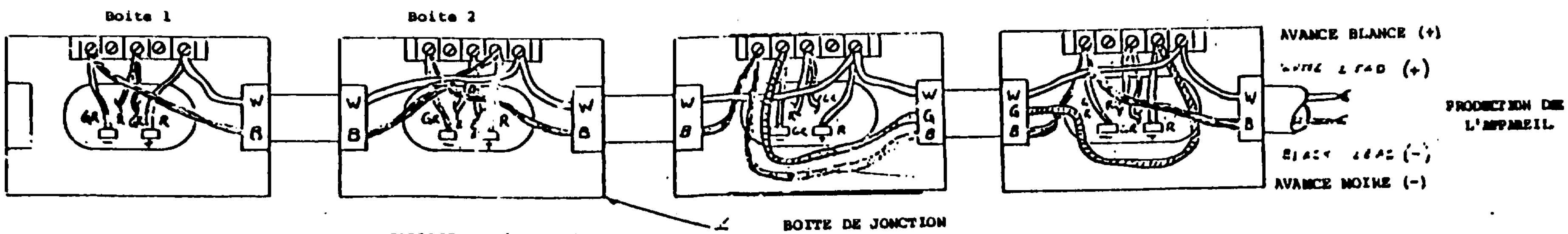
SYSTEME DE CABLAGE

Apparell a 4 Paneaux - Branchez les boites comme cela est demontre dans le dessein.

Apparell a 10 Paneaux - Branchez le boites 1-4, comme cela est demontre dans ce dessein. Branchez les boites 5,7 et 9 comme cela est demontre dans la boite 3. Branchez les boites 6,8 et 10 comme dans la boite 4.

LE CABLAGE VU DE DERRIERE

systeme scematique



CABLAGE DE L'APPAREIL

CODE DE COULEUR DE BRANCHEMENT

NOIRE	BLACK - B(-)
vert	GREEN - G
blanc	WHITE - W(+)
gris	GREY - GR(-)
ROUGE	RED - R(+)

REVISIONS

A ENG. RELEASE

CONTRACT NO.

APPROVALS DATE

DRAWN 4-12-7?

CHECKED

FRACTIONS DECIMALS ANGLES

MATERIAL

FINISH

NEXT ASSY USED ON

APPLICATION

CORPORATION
1335 PICCARD DRIVE ROCKVILLE, MD 20850

CODE IDENT NO. 12594

DRAWING NO. B-2870-A

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
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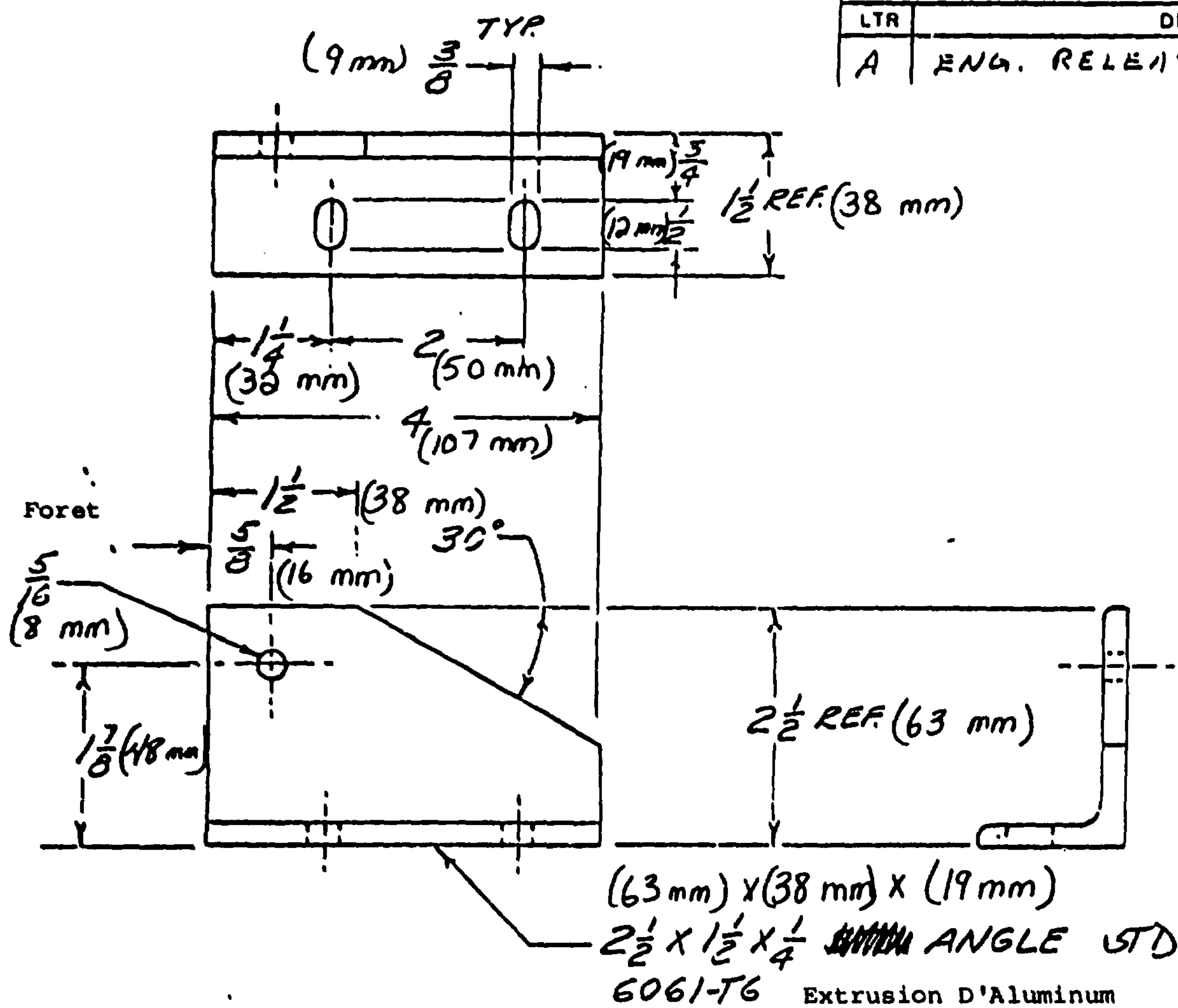


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:	CONTRACT NO.	
FRACTIONS ±.031, DECIMALS .XX ± .XXX ±, ANGLES ± 5°	APPROVALS	DATE
	DRAWN BILL WEAVER	2-6-82
MATERIAL NOTE	CHECKED [illegible]	3-15-82
FINISH CLEAR ANODIZE		
DO NOT SCALE DRAWING		

USED ON

APPLICATION

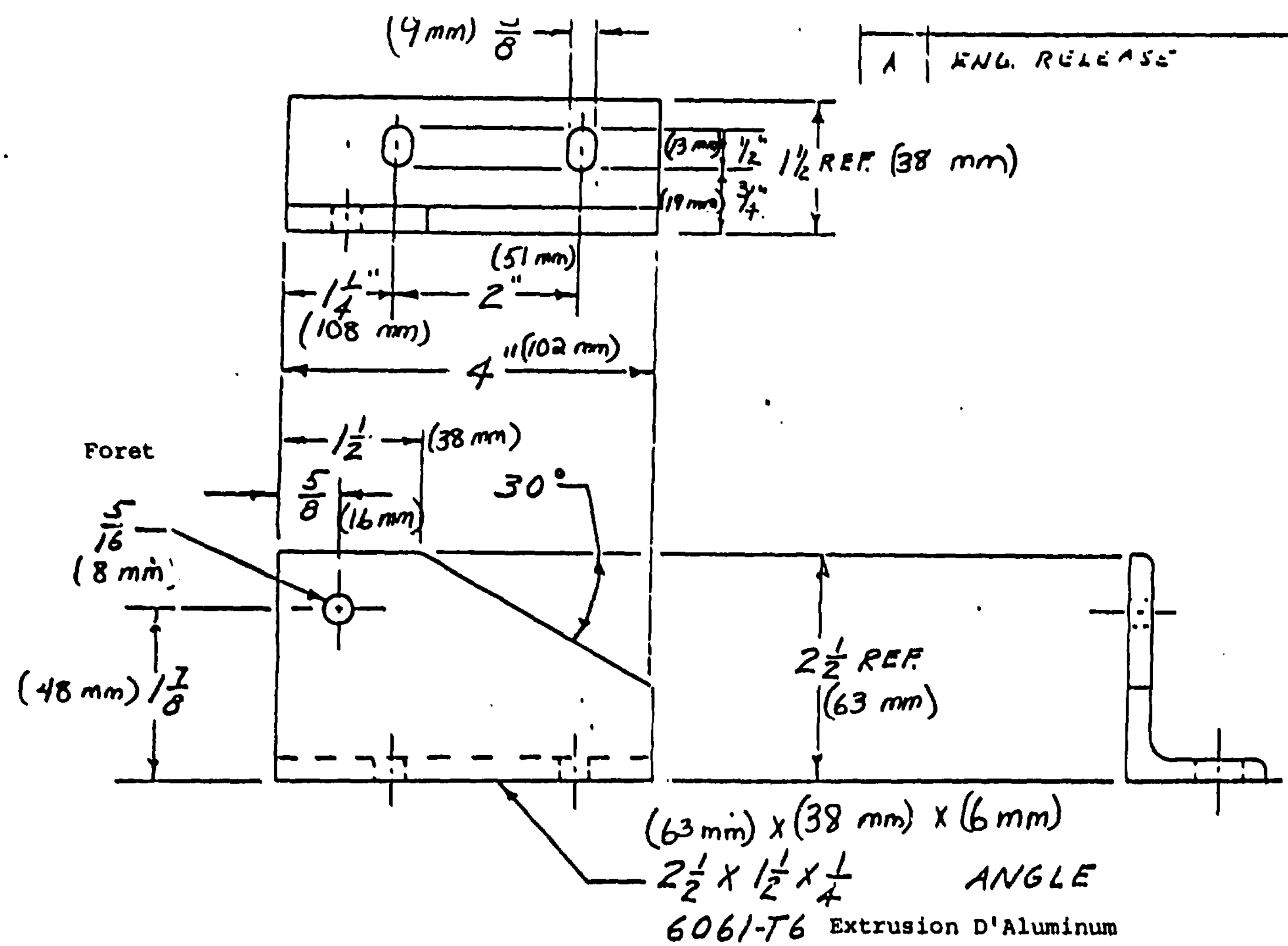
SOLAREX CORPORATION
1335 PICCARD DRIVE ROCKVILLE, MD 20850 ☐ 301 948 0202

Pied Seul, Gauche

SIZE	CODE IDENT NO.	DRAWING NO.
A		A-2401-A

SCALE 1/2 = 1 SHEET 1 OF 1

A	ENG. RELEASE	4-5-82	S. [illegible]

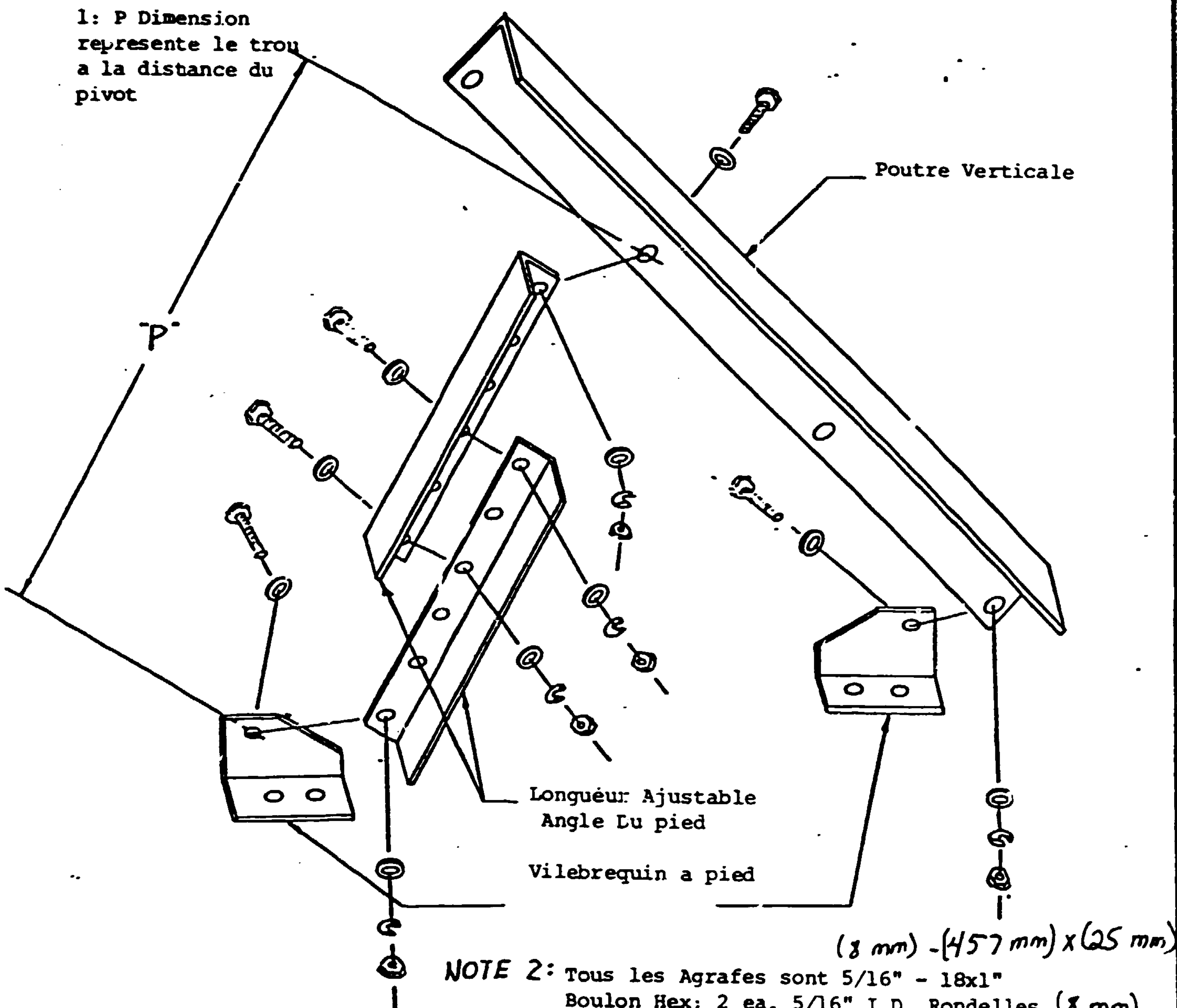


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±	CONTRACT NO.	**SOLAREX CORPORATION** 1335 PICCARD DRIVE ROCKVILLE, MD 20850 ☐ 301 948
	APPROVALS / DATE	
	DRAWN S. G. 3-32-82	Pied Seul, Droit
MATERIAL NOTE	CHECKED S.J.G 4-5-82	
FINISH CLEAR ANODIZE		SIZE A / CODE IDENT NO. / DRAWING NO. A-2400-A
APPLICATION / USED ON / DO NOT SCALE DRAWING		SCALE N/A / SHEET 1 OF 1

APPLY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
		A	ENG. RELEASE	8-3-82	S.J.D.

DIMENSION

1: P Dimension represente le trou a la distance du pivot



(8 mm) -(457 mm) x (25 mm)

NOTE 2: Tous les Agrafes sont 5/16" - 18x1" Boulon Hex; 2 ea. 5/16" I.D. Rondelles (8 mm) Plates; 5/16" I.D. Rondelle clef; et (8 mm) 5/16"-18 ecrou Hex (8 mm) - (457 mm)

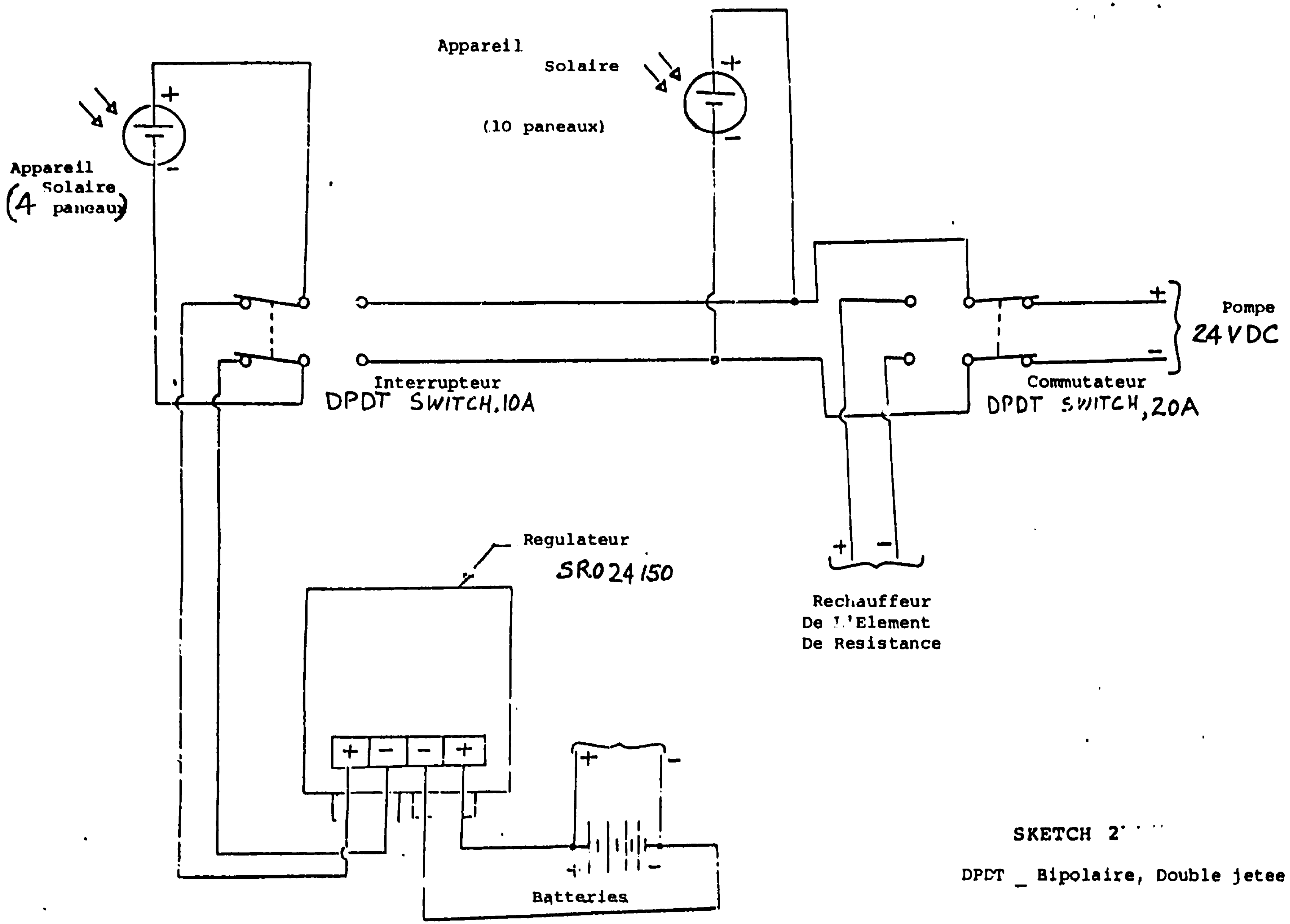
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± ± .XXX ±	CONTRACT NO.	
	APPROVALS	DATE
	DRAWN S.G	7-21-82
MATERIAL	CHECKED S.J.D.	8-3-82
FINISH		C-8
DO NOT SCALE DRAWING		

SOLAREX CORPORATION
1335 PICCARD DRIVE ROCKVILLE, MD 20850 □ 301 948 0202

Assemblement de Support de Fontes pour la fonte a angle

SIZE	CODE IDENT NO.	DRAWING NO.
A		A-2610-A
SCALE N/A		SHEET 1 OF 1

LINE CORP. REORDER NO. A 5990



SKETCH 2

DPDT _ Bipolaire, Double jetee

Annexe D
Système d'assemblage photovoltaïque.

1. Enlevez les paneaux et la quincaillerie de leur récipient d'embarquation. Maniez les paneaux solaires soigneusement pendant l'assemblement et le montage. Des coups au devant et au dos des surfaces des paneaux pourraient faire dommage aux éléments.

2. Avec le text suivant, rapportez-vous précisement aux desseins et aux esquisses pour assurer le bon assemblage et cablâge du système.

3. Les procédés d'assemblement mécaniques et leur suite décrits ci-dessous sont pour le sous-appareils à 4 paneaux A, et sont identiques pour les sous-appareils à 5 paneaux B et C aussi.

4. Premièrement, serrez tous les boulons à main seulement; quand l'assemblement est complet, les boulons devraient être serrés par une clef.

5. Une seule grandeur de boulon est éxigée pour l'assemblement L'assemblement de boulon complet comprend 2 rondelles plates, 1 rondelle à clef fondue, et 1 écrou. Les seules exceptions sont les assemblements de boulon qui assurent les paneaux aux poutres appuyées verticales; ceux-ci comprennent qu'une rondelle plate.

6. Commencez l'assemblement en plaçant quattre paneaux, le côté de verre et les longs côtés contigus à une surface propre et rembourrée. Placez deux poutres appuyées verticales (B-2492)(B-2491 pour 5 paneaux) contre les dos des paneaux, les angles ouverts vers l'extérieur des paneaux. Allignez les trous dans les poutres avec les trous dans les cadres des paneaux.

7. En utilisant quattre assemblements de boulons, assurez chaque paneaux aux poutres. Les boulons devraient être insérés d'abord dans les trous dans les cadres (du dedans) et ensuite dans les poutres.

8. Avec deux assemblements de boulons, attachez la barre d'espace aux poutres au haut de la structure - les angles ouverts vers les devants des paneaux.

9. Attachez un vilebrequin à pieds au bas de chaque poutres verticales - les angles ouverts vers l'extérieur.

10. En utilisant deux assemblements de boulons pour chaque, verrouillez les sections du pied à deux pièces (A-2402) (A2495 pour 5 paneaux) ensembles.

11. Attachez les pieds assemblés avec un assemblement de boulons chaque aux poutres appuyées verticales au dos de la structure. Utilisez le trou de boulon emplacé à peu près un tiers du chemin sur la poutre.

12. Attachez un vilebrequin à pieds au dessous de chaque pieds.

13. Enlevez les tampons à vis (excepté celui de haut) de chaque bout de chaque boîte de jonction de paneau (j-box) emplacée sur l'arrière des paneaux. Vissez les branchements Efcor dans les trous vides. Insérez des espèces de sections de cable 12-2 our 12-3 (comme indiqué sur les desseins) à travers les brancheurs et dans les boîtes de jonction. Rapportez-vous précisement au(x) diagramme(s) de câblage pour propre utilisation des cables et le propre câblage des boîtes des séries électriques de 4 et 10 paneaux. Un espèce de cable de production 12-2 de 15' (460 cm) a été fourni. Les deux unités de cinq paneaux seront branchés électriquement et auront aussi un cable de production de 15' (460 cm). Serrez les Efcors et remplacez les couvercles.

14. Quand vous assemblez l'appareil dans l'hémisphere sud, il devrait faire face au nord. Généralement, il derrait être monté à un angle qui est de 10° a 15° plus haut que la latitude locale. La structure de montage devrait être fermement attachée à une estrade sure ou à une autre surface par des trous de boulons dans les pieds.

15. A cause du cadre de métal, la grandeur, et l'emplacement exposé des appareils solaires, de propres précautions devraient être prises par l'installeur quand les appareils sont montés aux places ou il y a des éclairs. Ces précautions devraient suivres les procédés typiques de protection contre l'éclair. Tous les régulateurs de voltage Solarex sont équipés avec des aresteurs de surtension qui protègent leurs circuits contre des voltages causés par l'éclair, ou d'autres sources, mais pas contre un coup d'éclair direct.

Annexe E

DONNÉES DE SPÉCIFICATION

Série 8200
Puits peu profond à grande capacité
Pompe centrifuge

Le Moteur:

Une espèce de balai à moteur D.C. utilise des aiments permanents spécialement désignés fournissent une haute force coercitive et une induction résiduelle haute. Des bobines de champ et la possibilité conséquente de leurs fusions sont complètement éliminées.

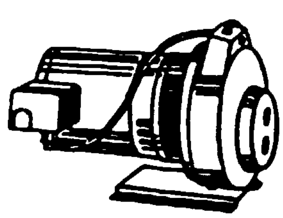
La vitesse nominale est 3,500 RPM au voltage voulu. Le moteur D.C. peut être utilisé à de voltages plus bas, ce qui résulte en réductions de vitesse, sans mal au moteur. Construit aux spécifications NEMA par des manufacturiers internationaux et connus pour assurer la disponibilité de service local.

La Pompe:

Une espèce centrifuge avec un couple bas. Elle se prime après la prime initielle. Désignée pour grande capacité avec des hauteurs modérées. Projetée pour usage avec des citernes, des puits percés, instantanés ou creusés et les points instantanés aussi petits que 1-1/4" (32mm) de diamètre. La simplicité fait que les pompes sont idéales pour des emplacements géographiques difficiles à atteindre.

Disponible avec le bronze balancé et dynamique ou avec une roue mobile thermoplastique de l'ingénieur. Un diffuseur acétal plusieurs volutes fournit la capacité et la pression maximum. Un sceau standard éprouvé par le temps (carbone-céramique) est fourni.

Supporté par plus de 120 ans d'expérience en manufactures de pompes, chaque pompe McDonald est soumise à une éxamination et une épreuve rigide à la manufacture pour assurer les plus hauts niveaux de qualité, de sûreté et d'accomplissement.



8200 SERIES

Modèle	Watts	Volts	Matériel de la roue mobile
8203090SB	900	36	laiton

Grandeur du tuyau de pression*	Grandeur du déchangement**
1" NPT (25mm)	3/4" + 1" (19mm + 25mm)

Grandeur du tuyau de succion	Poids de chargement
1 1/4" NPT (32mm)	49 livres (22.2 kg)

* L'ouverture du tuyau de pression est 1" 25mm) et est bouchée pour le fonctionnement d'un seul tuyau.

** Les pompes centrifuges utilisent une ouverture de 1" (25mm) de prime pour le plus grand déchargement.

Annexe F
DONNÉES DE L'INGENIEUR

Installation d'un puit non-profond
Instructions

Un système à puit peu profond ne devrait pas être installé où il y plus de 25 pieds du niveau de la mer de succion totale. L'élévation de la succion doit être réduite à la vitesse d'à peu près 1 pieds (30cm) par 1000 pieds (300 m) à l'élévation. L'élévation de la succion totale se compose de la distance verticale du niveau d'eau quand le pompage passe à la pompe et les pertes causées par le frottement dans la ligne du tuyau. Le volume d'eau délivré diminue avec une élévation augmentée de succion.

Les puits creusés, percés et sondés peuvent employer un arrangement comme dans l'illustration no. 1. Les puits instantanés et les points d'ensablement emploient la configuration dans l'illustration no. 2.

1(a) Installez une soupape de pied sous la ligne de succion et placez la 5 à 10 pieds (150-300 cm) sous le niveau bas, ce qui est le niveau d'eau quand l'unité pompe sa capacité mesurée. Elle devrait être assez loin du fond du puit pour éviter de pomper du sable et de la boue. (ill. no.1)

(b) Dans l'installation de puits intantanés, installez une soupape à retenue avec détente sur le tuyau vertical au moins cinq pieds plus haut que le point du puit, ou installez une soupape à retenue horizontale dans la ligne de succion près de la pompe. (ill. no.2)

2 Vérifiez la soupape de pied, voyez qu'elle est proprement mise et qu'il n'y ait pas d'obstacle qui l'éviterait d'ouvrir ou de se refermer. Une soupape de pied avec une fuite causerait le cyclage excessif (le moteur qui commence et s'arrête).

3 Premièrement, baissez la longueur du tuyau de succion, avec la soupape de pieds attachée dans le puit, ensuite remplissez le tuyau avec de l'eau propre. Si l'eau se retire, c'est qu'il y a une fuite. Si il n'y a pas de fuite, rassemblez les section(s) du tuyau qui restent et vérifiez contre les fuites.

4 Installez le sceau du puit au haut du puit et serrez bien les boulons du sceau (ill. no. 1).

5 Installez un dé au haut du tuyau de succion, avec un bouchon.

dans l'ouverture du haut, et branchez par une union du fil femelle dans la pompe même.

6. Branchez le déchargement de la po..pe à l'usage à eau.

7. Après que les tuyautages ont été complètés et le moteur est bien branché, enlevez le bouchon primeur sur la pompe et remplissez la avec de l'eau. Laissez assez de temps pour que l'air dans le système s'échappe, and remplissez la pompe avant de remplacer le bouchon primeur si nécessaire. Commencez le moteur et l'unité devrait marcher. Si non, il peut être nécéssaire de re-primer (le moteur devrait tourner dans le sens des aiguilles d'une montre regardant le côté opposé de la roue mobile.)

8. Quand l'unité a atteint le plus haut point de pression, et s'est arrêté automatiquement, vérifiez tous les tuyautages de succion et de déchargement pour des fuites, parce qu'ils seront sous pression.

9. Quand la pompe sera utilisée comme système simplement centrifuge (à grande capacité), le taraudage NPT de 1" (25mm) sous le taraudage de succion NPT de 1 1/4" (32mm) doit être bouché. Il est aussi recommendé que le haut de l'ouverture du bouchon primeur de 1" (25mm) soit utilisé en sortie de déchargement (l'ouverture du côté de déchargement NPT de 3/4" (19mm) doit donc être bouchée.).

Notez: Il est recommendable de placer la pompe aussi près de la tête du puit (source d'eau) que possible. Le tuyautage de succion et de déchargement devrait être gardé aussi large que cela serait pratique pour diminuer les pertes de frottement, surtout sur les installations centrifuges simples, ex. un tuyau de succion de 2" (51mm), 1 1/2" (32mm) ou plus de déchargement dépendant sur la longueur du tuyautage.

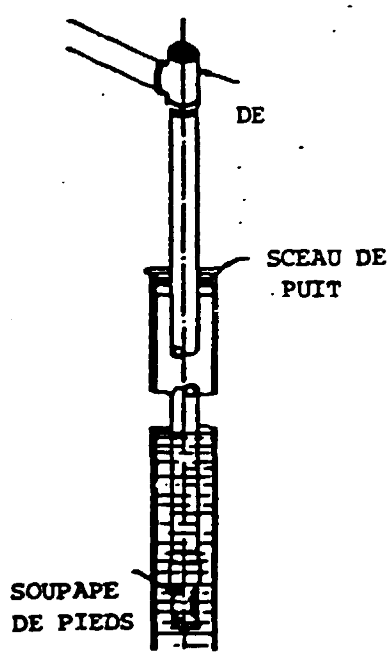


Figure 1

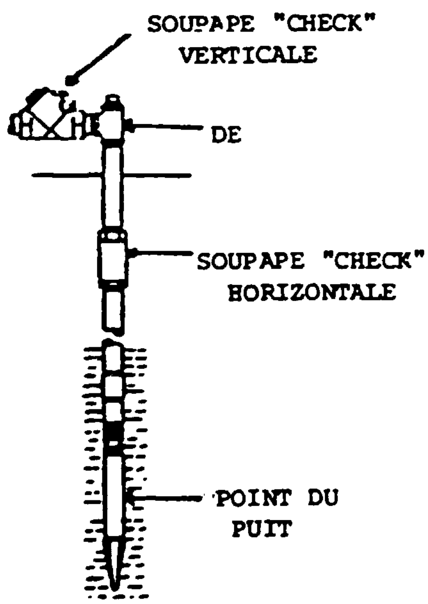


Figure 2

Annexe G

Cet annexe décrit l'usage de réchauffeur solaire d'eau (Modele PT 40, fabriqué par Gulf Thermal Corporation, Sarasota, Florida, USA). pour chauffer à l'avance l'eau utilisée dans le pot de l'alambic. Un diagramme schématique d'une installation typique se trouve dans l'illustration no.1.

Les réchauffeurs solaires absorbent l'énergie du soleil et l'utilise pour chauffer de l'eau. Ils marchent mieux quand leur surface de verre est exposée au soleil directement pour autant de temps que possible. Ils ne fonctionnent pas pendant des periodes longues de pluie ou de nuage ou le soir.

Le réchauffeur d'eau solaire PT - 40 de Gulf Thermal fonctionne au principe simple "batch". Le réchauffeur est complètement rempli par l'ouverture A (voyez l'ill. no.2) avec de l'eau d'une citerne ou d'une autre source. Ceci est accompli en ouvrant la soupape AA dans la ligne du boyau de provision et en fermant la soupape BB dans la ligne de déchargement. Aussitôt que le réchauffeur est rempli d'eau, la soupape AA devrait être fermée pour éviter que l'eau, une fois qu'elle à été chauffée, s'écoule vers le boyau de provision d'eau.

Pendant la journée, le soleil, passant à travers le devant de verre du réchauffeur, chauffe les quattre tubes d'acier inoxydable qui contiennent l'eau et qui forment le réchauffeur lui-meme. A la fin d'une journée normale ensoleillée, cette eau sera chaude (40 à 70 °C). Pour préserver cette chaleur jusqu'au prochain matin quand l'eau est utilisée à remplir l'alambic, l'unité est désigné avec deux couches de film sous la façade de verre pour augmenter la capacité isolatrice. Si cette isolation est insuffisante, la façade de verre peut être couverte la nuit avec un tissu qui retient la sortie de la chaleur. Ce tissu doit être à l'épreuve du temps, surtout contre la pluie et le vent.

Le matin, avant de refaire marcher le procès de distillation, la soupape BB devrait être ouverte pour que l'eau chaude dans le réchauffeur solaire puisse couler dans l'alambic. Si l'eau du réchauffeur ne remplit pas l'alambic complètement, plus d'eau fraiche peut être admise a l'alambic avant que les fleurs sont placées dedans. Le réchauffement d'eau de l'alambic à l'avance dans cete manière réduit la quantité d'énergie éxigée pour faire bouillir le mélange de fleur et d'eau, et cela peut aboutir à un procès total de distillerie plus éfficace, et à la qualité d'huile éssentielle plus haute.

Apres que le réchauffer solaire à été vidé dans l'alambic, la soupape BB devrait être fermée, la soupape AA ouverte et la réchauffeur remplit d'eau fraîche pour que le procès de

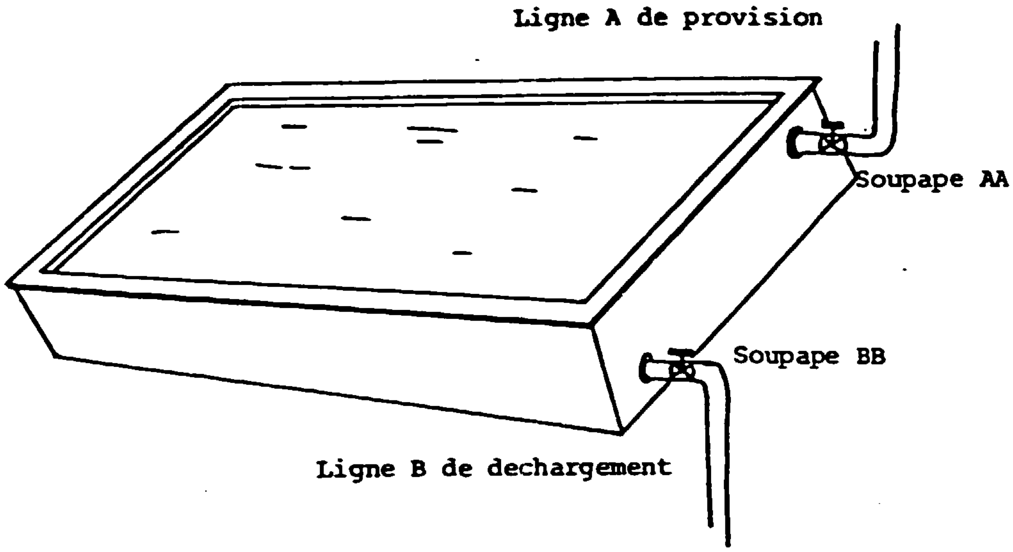


ILLUSTRATION 1 - DIAGRAMME SCHEMATIQUE

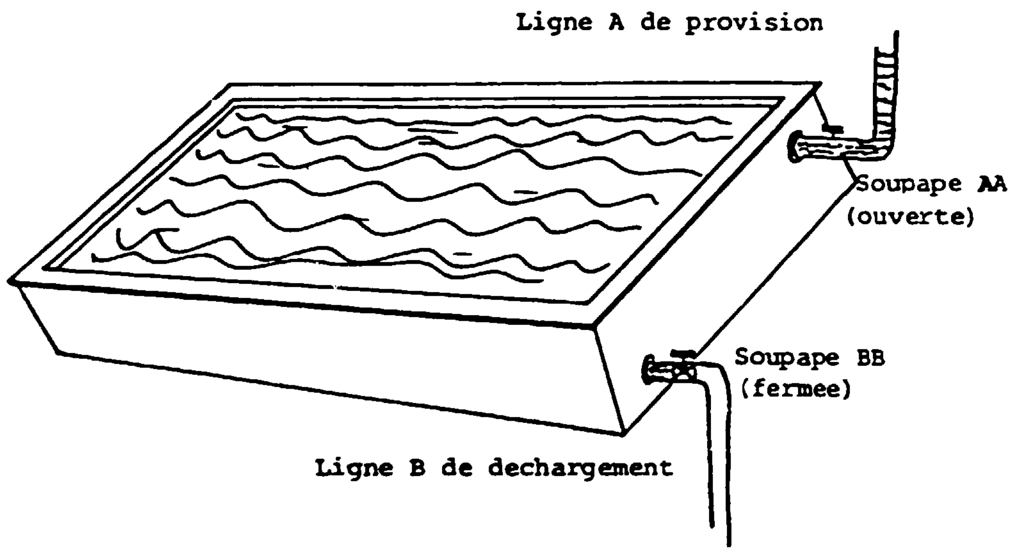


ILLUSTRATION 2 - LE REMPLISSAGE DU RECHAUFFEUR chauffage puisse recommencer. Si une espèce de couverture à isolement à été placée sur la façade de verre pendant la nuit, elle devrait être enlevée pour que la lumière du soleil passe librement à travers le verre et réchauffe l'eau dans les tubes d'acier inoxydable.

Pour résumer, les points suivants devraient être suivis pour des espèces de fonctionnement "batch":

1. Ouvrez la soupape AA, gardant ferme la soupape BB, et remplissez d'eau le rechauffeur, à peu près 150 litres.

2. Fermez la soupape AA et laissez le réchauffeur dans le soleil toute la journee.

3. A la fin de la journée, si désiré, couvrez le verre avec une espèce de tissu isolateur pour éviter la perte de chaleur.

4. La prochaine journee, enlevez la couverture d'isolation, ouvrez la soupape BB et videz l'eau du réchauffeur dans l'alambic.

5. Fermez la soupape BB, ouvrez la soupape AA, remplissez le rechauffeur d'eau fraiche et répéter le procés.

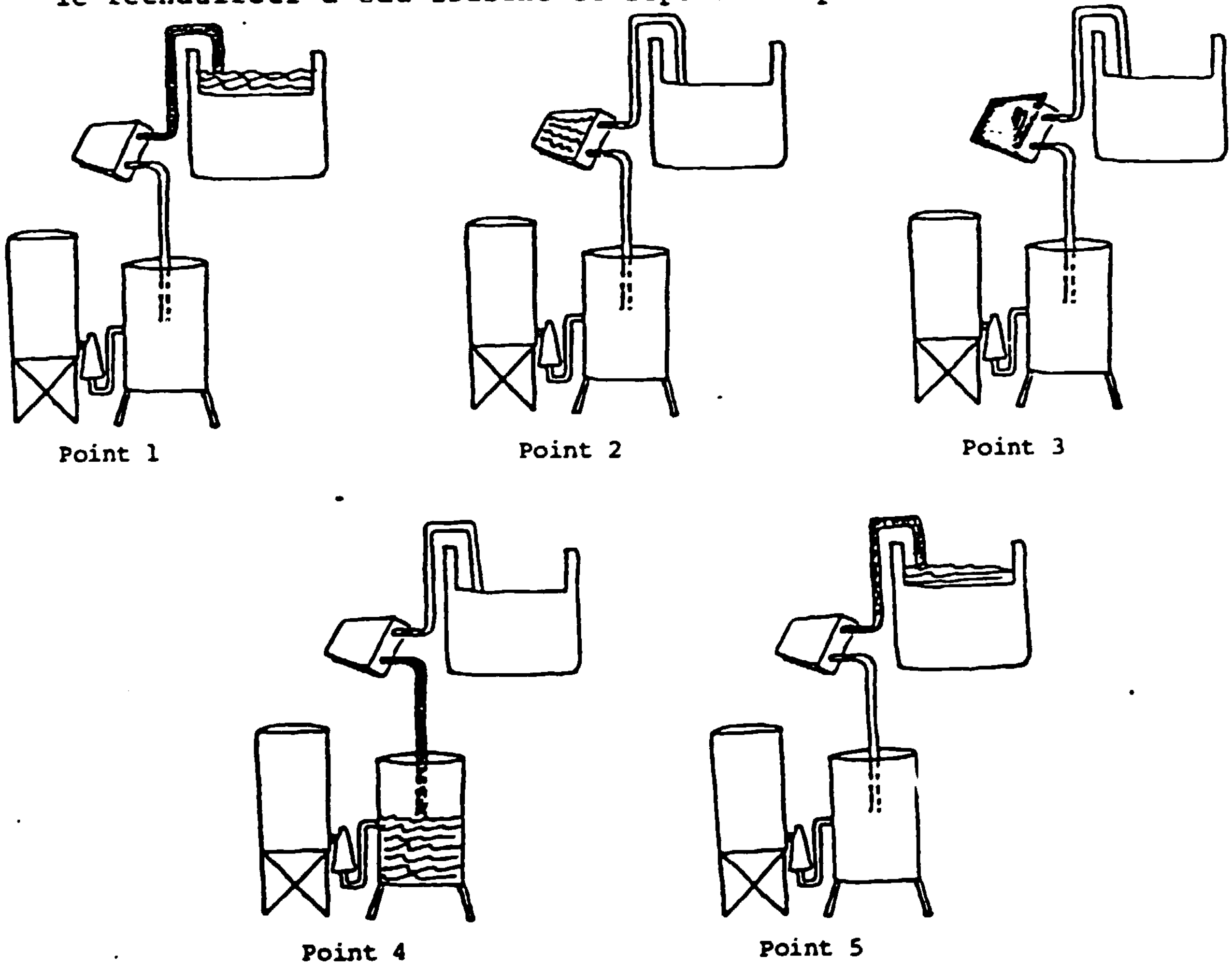


ILLUSTRATION 3

Le réchauffeur solaire devrait être installé pour qu'il reçoive la quantité maximum de soleil direct tous les jours. Il devrait donc être incliné au nord de 10-15°.

Pendant les périodes quand l'unité de distillation ne fonctionne pas, le réchauffeur solaire peut être utiliser dans d'autres façons, comme le chauffage d'eau pour de raisons domestiques. Dans ces situations, un système "batch", modifié d'un écoulement continu à demi peut être utilisé. Dans cette façon le réchauffeur solaire est rempli en ouvrant la soupape AA pendant que la soupape BB rest fermee. Aussitot que le rechauffeur est plein d'eau, la soupape AA est aussi fermée et le réchauffeur reste au soleil jusqu'à ce que l'eau en dedans a atteint la température désirée. (Le temps que cela prend à atteindre la température correcte sera déterminé par la chance.). Aussitôt que la température est assez haute, la soupape BB est ouverte et l'eau chaude peut s'écouler et peut être utilisée directement ou emmagasinée. Aussitôt que le réchauffeur est vide, la soupape BB est fermée, la soupape AA ouverte et le procès est répété autant que désiré, dépendant des conditions et des nécéssités locales.

Le Maintien

Le réchauffeur d'eau solaire PT 40 est presque sans besoin de le maintenir. Les boyaux et les branchements devraient être vérifiés quelquefois pour l'usure et le verre devrait être nettoyer s'il devient très sale, quoique la pluie normale devrait éviter ceci. Le soin devrait être prit pour que le réchauffeur ne soit par laisser tombé ou heurté par un objet lourd. Il est designé pour une longue vie en dehors, mais il est aussi susceptible au dommage s'il n'est pas soigneusement apporté pendant l'installation et le fonctionnement.

ANNEXE H
ADDRESSES DES MANUF[illegible]URIERS DE L'EQUIPEME[illegible]

- La Chaudiere
  Slant/Fin Corporation
  100 Forest Drive
  Greenvale, New York 11548
  U.S.A.

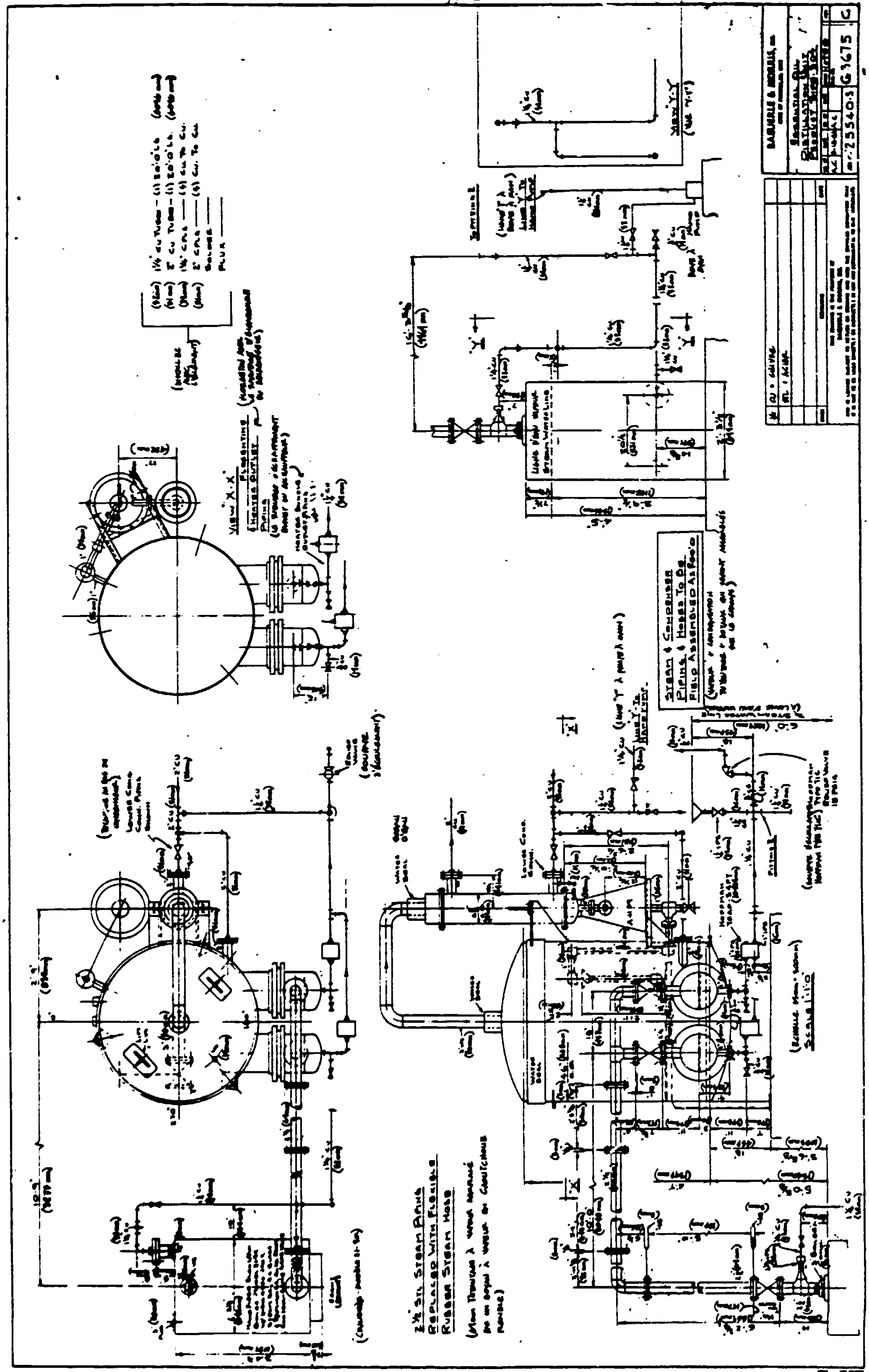
- L'Alambic
  Baeuerle & Morris, Inc.
  282 S. Gulph Road
  King of Prussia, Pennsylvania 19406
  U.S.A.

- La Pompe
  A.Y. McDonald Mfg. Co.
  P.O. Box 508
  Dubuque, Iowa 52001
  U.S.A.

- Le Systeme Photovoltaique
  Solarex Corporation
  1335 Piccard Drive
  Rockville, Maryland 20850
  U.S.A.

- Le Rechauffeur Solaire D'Eau
  Gulf Thermal Corporation
  P.O. Box 1273
  Sarasota, Florida
  U.S.A.

- Purgeur Automatique
  Hoffman Speciality ITT
  1700 West 10th Street
  Indianapolis, Indiana 46222
  U.S.A.


VIEW X-X
VIEW Y-Y
STEAM & CONDENSER PIPING & HOSES TO BE FIELD ASSEMBLED AS REQ'D
2½" STL STEAM PIPING REPLACED WITH FLEXIBLE RUBBER STEAM HOSE
BABCOCK & WILCOX
25540-3
G3675