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Technical Report

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PORTABLE TOPPING PLANT,

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

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U. S. Naval Civil Engineering Laboratory.
Technical Report R-031.
PORTABLE TOPPING PLANT.
by M. C. Lorenz. 55p. illus. 29 October 1959.
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Results of a program for developing and testing a portable topping plant capable of rapid erection and immediate production of satisfactory fuels from crude oils where locally available. The Mark II has been found successful and practical.

- I. Topping plants.
- I. Lorenz, M. C.
- II. Y-F015-99-013.

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PORTABLE TOPPING PLANT

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(10) by

M. C. Lorenz

U. S. NAVAL CIVIL ENGINEERING
LABORATORY
Port Hueneme, California

OBJECT OF PROJECT

To conduct engineering tests and evaluations of prototypes of general equipment resulting from research and development projects.

OBJECT OF TASK

To develop and test a portable topping plant capable of rapid erection and immediate production of satisfactory fuels from crude oils where locally available to Naval occupation and construction forces.

OBJECT OF REPORT

To present the results of a long-term development program on a portable topping plant (Mark II).

ABSTRACT

The need for a portable petroleum refinery or topping plant to supply fuel for equipment at advanced bases is discussed. The development of two prototype units for the production of gasoline, kerosene and diesel oil is outlined. The details of the testing, modifications, and retesting of the Mark II prototype at two different locations in Montana are discussed. Testing was accomplished under a variety of weather conditions including sub-zero temperatures. Several different crude oils were used, yielding products in varying proportions. Portability of the unit was proved by dismantling and moving 400 miles by truck in the middle of winter. The plant can be erected and producing fuel within 48 hours. The feasibility of Seabee operation was determined by having Seabees participate. Operation of the plant was improved by modifications to simplify the components, increase durability and reliability, and improve products. Suggestions are made for a short additional program which should result in a prototype which can be recommended for stock in the Navy supply system. Consideration of an asphalt unit to use the waste residual oil for the manufacture of asphalt for paving and roofing is recommended.

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PHILOSOPHY OF NEED

The philosophy behind the development of a portable oil refinery stems from the following factors:

1. Crude oil is available in many parts of the world where military action might take place in the future.
2. Aerial bombardment can wipe out refining plants and tank farms, but in order to destroy an oil well a charge of explosive must be introduced into the well itself. This is difficult, if not impossible, to do from the air.
3. Petroleum or petroleum products comprised over one-half of the total tonnage, including food, clothing, machinery, munitions and personnel, that was shipped overseas in World War II.
4. Refined products which must be shipped by tanker are difficult to deliver to a military area because of the vulnerability of tankers to enemy submarine action.

These factors combine to make the creation of a portable refinery, which can be easily transported and quickly assembled in a military area, an important logistics consideration.

In order to simplify the construction and operation of the plant, as well as to reduce the hazard inherent in a refinery, it was decided that a simple fractionation or topping plant would best serve the purpose. Such a plant does not have the extremes of temperature and pressure which exist in a cracking plant. Although the quality of products is somewhat lower than could be obtained from a cracking plant, it is considered adequate to operate construction equipment and similar types of gasoline and diesel engines. No aviation gasoline would be produced. Jet fuels could be made by blending products. Thus, a portable topping plant would be a means of producing from local crudes satisfactory fuels for construction forces, thereby reducing the logistic load during the emergency construction period. Such a topping plant would offer immediate fuel production possibilities for:

1. The temporary resupply of occupation-force equipment from crude oil fields taken from the enemy.
2. The temporary or permanent resupply of local equipment engaged in exploitation of reserve fields.
3. The emergency replacement of permanent refineries damaged by combat or local hazards.

It was contemplated that the design be portable and of unitized construction in order to speed the assembly of the plant and to render it capable of easy shipment by surface or air-borne methods. The capacity of the plant would be sufficient to produce approximately 3,600 net tons, per month (800 bbl per day) of usable products from asphaltic crudes. This production, which could be increased as required by multiples of the proposed plant, is clearly of a magnitude to vitally affect logistics in the supply of overseas bases over long ocean routes. The proposed plant or multiples thereof therefore:

1. Would eliminate or reduce the number of tankers required to support a base.
2. Would reduce the load on tankers and on the transportation, storage, and handling of crudes in supporting major refineries from which the base would otherwise have to be supplied. The total tonnage required to support a division would be decreased up to one-third (representing the fuels required by the ground forces).
3. Would reduce the number of tankers lost by sinkings or damage from the hazards encountered over long ocean routes.
4. Would reduce the number of personnel as well as handling, storage, and protective facilities required to support long overseas supply lines.
5. Would assure emergency supply of fuels should supply lines be disrupted or local tank farms be destroyed.

6. By its portability and flexibility, such a topping plant would assure immediate on-the-spot fuel production for initial or occupying forces, and rapid reassembly at advanced points for forces progressing through crude fields.

The above economies assume vital importance when considered in relation to military situations which might develop; such as:

1. The occupation and development of known crude fields in arctic regions where forces would otherwise be almost entirely dependent for fuel on the delivery of a one-year supply during a very short summer shipping season. The possibility of damage to this long-period supply and the difficulty of replacement in the event of loss require provision for emergency production of fuel.
2. The progressive occupation of the successive crude oil fields within an enemy sphere where long overseas and long overland supply routes would otherwise be required for fuel delivery.
3. The loss of the Mediterranean Sea Route for supporting forces dependent upon it, which otherwise would necessitate resorting to long and hazardous Pacific routes.

To supplement the above, the Navy has contemplated preparing shallow, medium, and deep-well drilling components. Also contemplated is a training program for the recruitment of personnel experienced in drilling, refinery operation, pipeline work, tank farm work, and associated required skills.

TEST UNITS

Cleaver-Brooks Mark I Unit

To meet the objectives of this program, the Bureau of Yards and Docks negotiated with the Cleaver-Brooks Company of Milwaukee, Wisconsin, for the design and fabrication of a portable topping plant which would have a

capacity of 400 gallons per hour (228 barrels per day). This plant had a contract price of \$62,485, and a specified delivery date of 26 June 1948. The plant (Figure 1) was received on 22 November 1948 and was tested in the spring of 1949 by the Advance Base Proving Ground, Port Hueneme. The plant produced usable products, although it could not produce specification products because of the limiting factors of design. In several major items the plant failed to meet specifications. Its total height was 28 feet, 2 inches, whereas 15 feet was desirable. It was 10 feet wide, 13 feet long. The fractionating tower contained 14 bubble trays. After the test program was completed and the results were analyzed, it was decided that although the plant produced usable products it did not meet the requirements of the Bureau of Yards and Docks, so the project was closed out and a more realistic list of requirements was prepared for the Mark II unit. Subsequently, the Cleaver-Brooks unit was considered for use in Alaska by the Alaska contractors on a BAREX expedition. Investigation showed that the unit was in too poor condition to rehabilitate, so the plant was declared surplus, salvageable items removed, and the rest scrapped.

Lummus Mark II Unit

Specifications. The revised specifications provided for a larger plant to have a capacity of 1,000 barrels of oil per day throughput. This plant was to be designed for KUWAIT crude oil and would have a capacity for fractionating, condensing and cooling the following maximum quantities of products:

Gasoline	275 barrels per stream day
Kerosene	150 " " " "
Diesel Oil	187 " " " "
Residues	545 " " " "

These quantities were determined to be the amount necessary for a single plant to furnish the daily fuel requirements of a Naval Construction Battalion. Four such plants would be capable of supplying the fuel needs of a Marine Combat Division. Fuels produced by the plant would not be specification fuels, but they would be adequate for emergency purposes; it was expected that they could be used continually in equipment for three to six months without deleterious effect on the equipment. It was expected that the plant would weigh not over 70 tons exclusive of the crude-oil supply system and water supply. It was to be capable of being erected in the field and ready for the production of fuels within 48 hours with water and crude-oil supplies available.

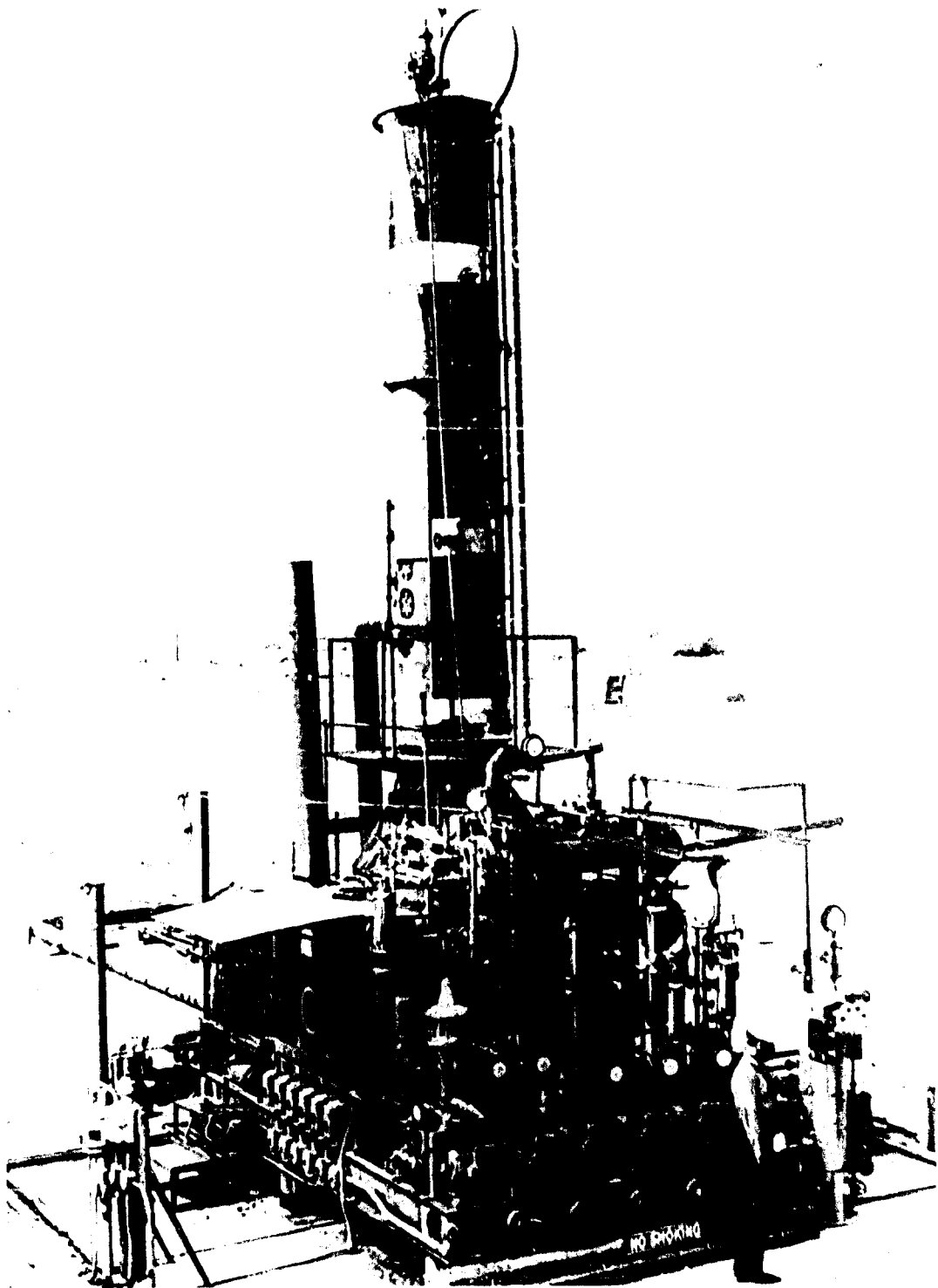


Figure 1. Original Mark I topping plant at Port Hueneme.

Feasibility Study. The first step of the Mark II project involved a feasibility study, which was negotiated with the Lummus Company of New York. This contract, dated 27 June 1950, provided for an engineering study and the development of complete specifications for a portable topping unit of 1,000 barrels per day capacity. The cost of this contract was \$18,000. The study was completed and the conclusion was that such a plant as was proposed was entirely feasible.

Design and Specifications Contract. After the completion of the feasibility study, negotiations were conducted with the Lummus Company for detailed engineering work required to fabricate the portable topping plant. This included detailed equipment specifications, working drawings for fabrication, and designs and requisitions for the procurement of the necessary materials. This portion of the work, referred to as the design phase, was performed under a contract dated 30 November 1950 at a cost of \$32,000. When the design phase was completed and the complete working drawings were available, they were submitted to a consulting engineer, Mr. Earl Gard, of Los Angeles, for review and comment. As Mr. Gard had previously been retained on the Mark I project for the test phase of that project, he was familiar with the requirements of the project. His conclusion was that the plans for the Mark II unit were complete and acceptable and should result in a satisfactory unit. (See Appendix A for details of design.)

Fabrication Contract. The Bureau of Yards and Docks then took bids for the fabrication of the topping plant. The low bidder was the Lummus Company, for a total cost of \$112,500. A contract dated 21 June 1951 was entered into with the Lummus Company calling for the fabrication of the Mark II plant within the shortest reasonable time. The plant (Figures 2 — 4) was completed and shipped by rail to the U. S. Naval Civil Engineering Laboratory at Port Hueneme, where it was received on 21 December 1952. The plant was damaged in transit by a collision with a low bridge on the railroad, and repairs were made after it was received in Port Hueneme.

TESTS AND MODIFICATIONS

Because of the large amount of crude oil which would be required for the testing period, it was not considered feasible to test the plant at the Construction Center. It was thought desirable to have the plant tested by experienced refinery personnel and preferably in an operating refinery to take advantage of the facilities, personnel, and supply and marketing arrangements available there.

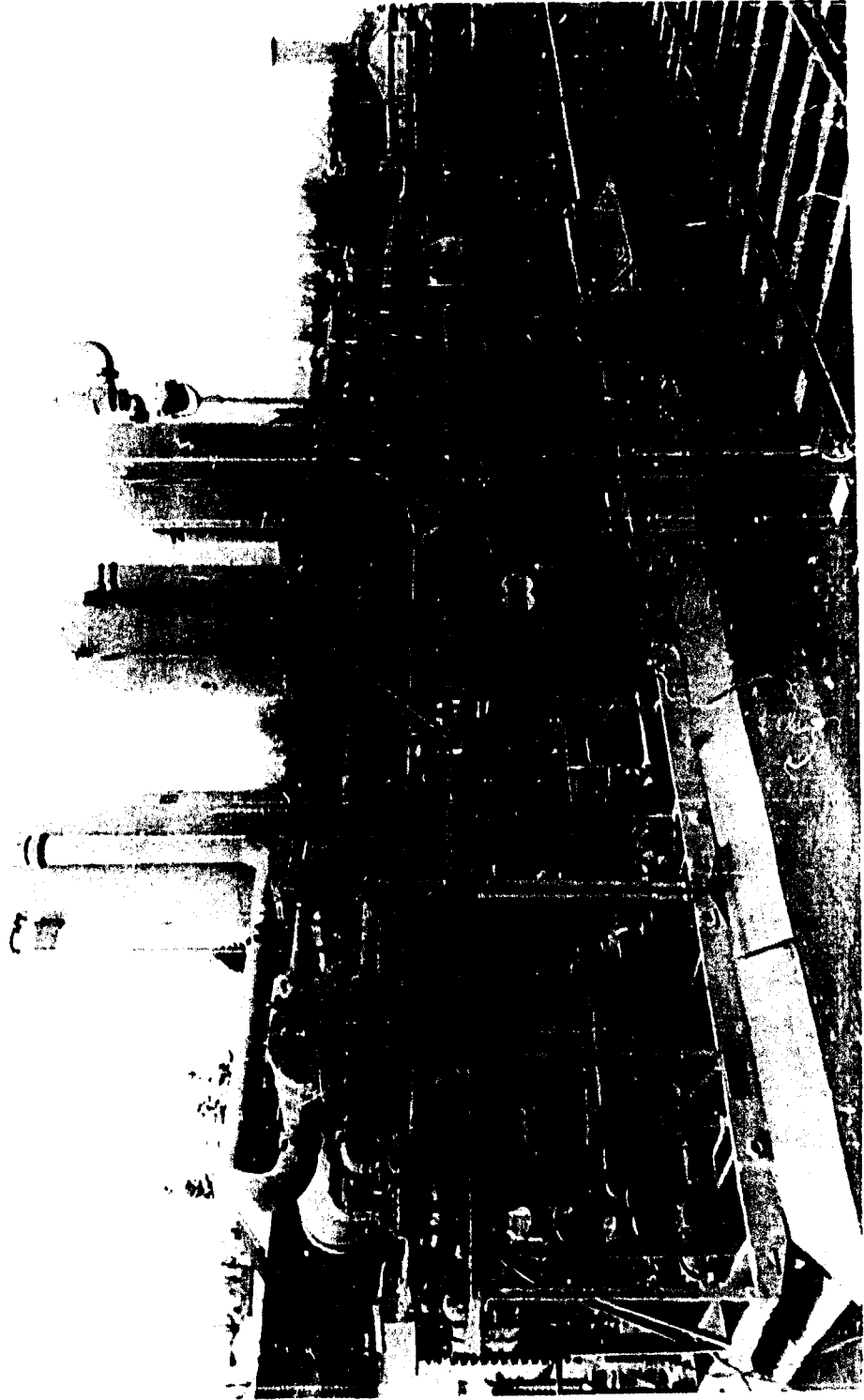


Figure 2. Operating side of refining section of Mark II topping plant.

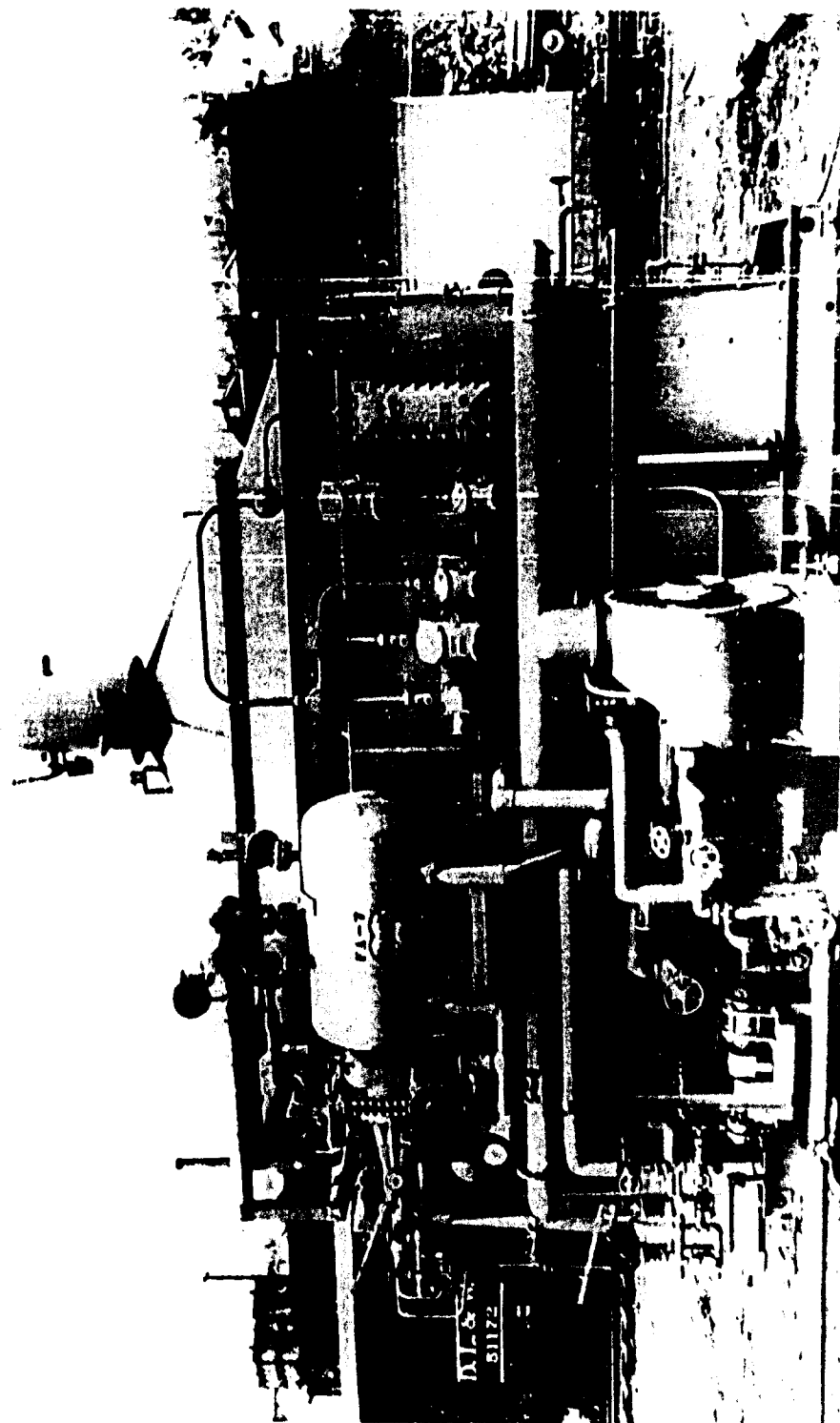


Figure 3. Operating side of heater of original Mark I topping plant.

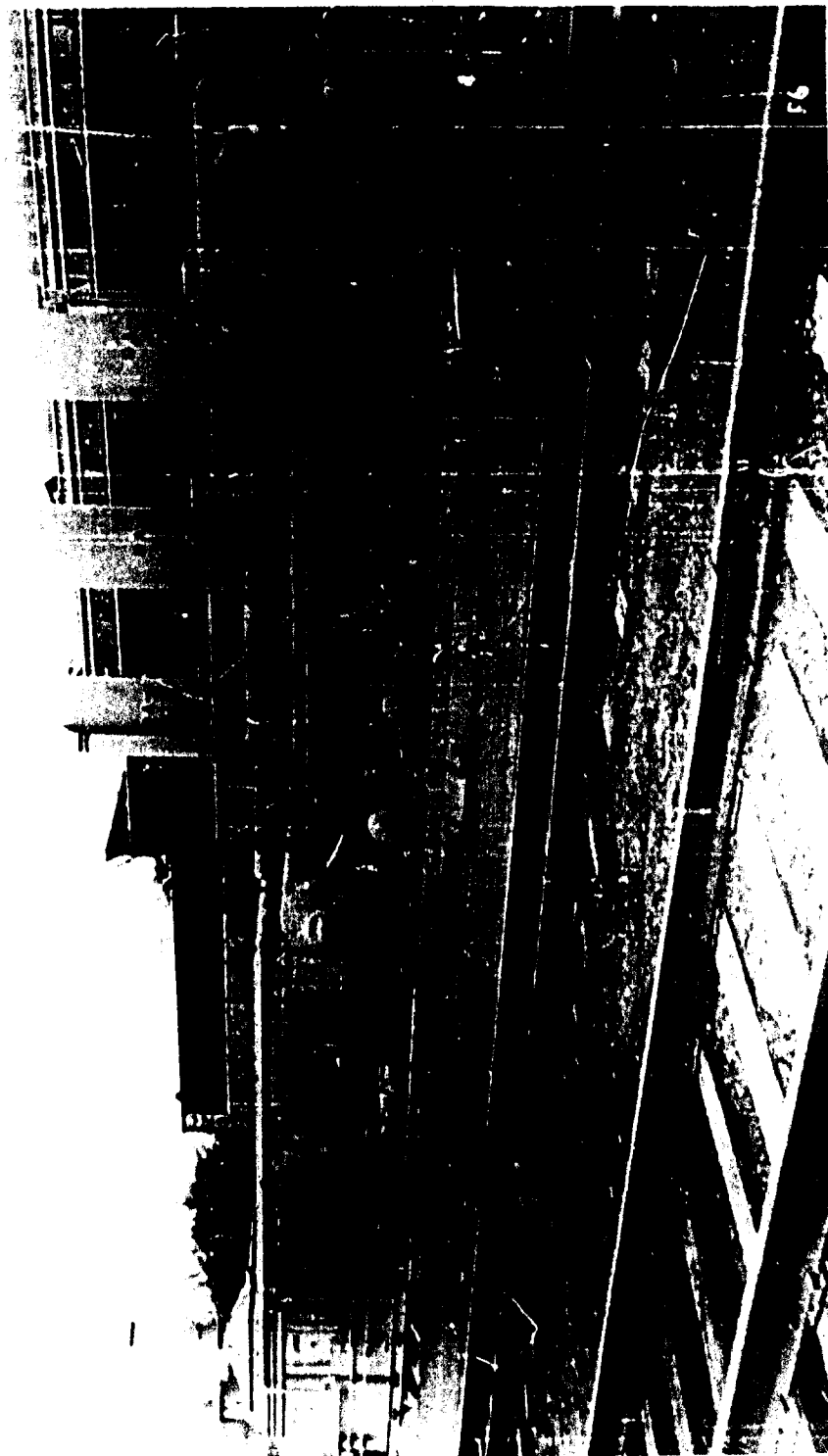


Figure 4. Topping plant heater and refinery assembly (rear view).

In an effort to locate the plant as near Port Hueneme as possible, every independent refiner in Southern California and about six major refiners were contacted to determine their interest in the testing of the plant. At this time, crude oil was extremely scarce in California. This was due to the normal growth of the State and the incidence of the Korean War which was under way at that time and which required a large amount of petroleum products to be shipped from California refineries. Because of the existing shortage of crude oil, very few refineries in Southern California were interested in even discussing the testing of the plant. At the suggestion of consultant Gard, an attempt was made to obtain navy oil from Elk Hills to be sold to the potential contractors, but this was not possible because of the controls and regulations placed on the sale of this oil. The few refineries which were interested in the testing of the Lummus Plant proposed contracts involving such high payments that they were impractical. Because crude oil was in greater supply east of the Rocky Mountains, it was determined that the testing of the plant should be done in either Texas or one of the North Central States.

About this time a letter of inquiry was received from the Modern Oil Company of Shelby, Montana, a small refiner operating a 1500-barrel-per-day plant in that location. Because of their favorable proposal and the value of testing in a northern climate with rigorous winters, a contract was executed with the Modern Oil Company which provided for 60 days of tests.

Shelby Operations

After repairs were made to the plant in Port Hueneme, it was shipped by rail to Shelby, Montana, where the Modern Oil Company unloaded the plant and erected it on their property. Because of the necessity of grading the site, burying the pipe, erecting bolted steel tankage, and similar operations requiring considerable time, the total erection period extended to approximately four months.

Technical engineering assistance was provided by contract with the Ralph M. Parson's Company of Los Angeles, who assisted Laboratory engineers in establishing test procedures and analyzing and evaluating the results.

Crude Oil Used and Products Produced. The Modern Oil Company used two different crude oils to determine the characteristics of the topping plant. A lighter gravity crude oil than that used as the basis for design was used to test the functioning of the unit in the light distillate section and heater sections because such a crude has a higher percentage of distillate products, particularly in the gasoline-kerosene range. The crude oil secured by the Modern Oil

Company for the purpose of testing the light fraction sections of the plant was a 40.2-degree API gravity paraffin-base crude oil from the East Poplar Field in Eastern Montana. A heavier gravity crude oil to test the heavy ends section of the plant was represented by a 21.5-degree API gravity mixed base crude oil from the Chinook Field in North Central Montana. The yield of these crudes included:

	East Poplar Crude 40.2-Gravity	Chinook Crude 21.5-Gravity
Gasoline	32.20%	13.57%
Kerosene	19.30	11.56
Gas Oil	7.80	4.92
Residuum	40.10	68.95
Waste	1.00	1.00

Test runs on both crudes consisted of operating the unit at various flow rates. Generally, a minimum flow rate, an average flow rate, and a maximum flow rate was determined. In testing the light distillate sections, a 36-hour test run was carried out at the design product flow rate of the lightest distillate fraction using the lighter gravity crude oil. The general procedure followed was to set a predetermined rate based on design stream flows, adjust the operating temperatures and reflux ratios to produce specification products and hold the plant at these conditions for several hours. After it was determined from plant-site laboratory analysis and observation of plant data that these conditions could be maintained, the plant was operated for a minimum period of 24 hours. During the test period, the temperatures, pressures and flows of processed liquids, cooling water, and steam were recorded by the operating personnel and analyses of all products were carried out at 4-hour intervals in the plant laboratory. Composite stream samples were saved and submitted to a commercial laboratory for check analyses at the conclusion of each test. Appendix B shows typical test results and records.

No product specifications, other than estimates, were set forth in the design criteria of the portable topping unit except the broad statement that the products obtained should be acceptable for emergency use in military vehicles and equipment. In the Shelby tests, product specifications required to be met were set at those of straight-run distillates acceptable in the marketing area of the Modern Oil Company, and at all times operations were conducted so as to produce products acceptable to their product blending or sales commitments.

Modifications. During the Shelby operations many modifications and improvements were made to the plant. Most of the difficulties encountered were centered in the furnace, or heater, section of the plant. Due to difficulty of combustion, non-uniformity of heat produced, and inadequate control of the fire, the six Maxim (compressed-air atomization) burners furnished with the unit were replaced by two Iron Fireman (mechanical atomization) burners. This substitution permitted the removal of the large air blower used as a compressor to assist in fuel oil atomization. This, in turn, simplified the design of the furnace, minimized maintenance requirements and permitted the furnace to be enlarged to give more efficient combustion area.

It was also found that the stack area was not sufficiently large to provide the proper draft. It was determined that this situation could be improved in one of three different ways: (a) by a stack of larger diameter and cross section, (b) by a higher stack to secure more natural draft, or (c) by a forced draft involving a fan or blower in the stack. The cheapest method was tried, that of lengthening the stack using the same diameter to create a greater natural draft (Figure 5). This was subsequently changed in later tests at Lodge Grass, when the stack was greatly enlarged in diameter and shortened to a more practical height, resulting in better operation (Figure 6).

A fire was experienced in the vicinity of the oil burners on the outside of the furnace as a result of a leaking fuel hose and a flashback from an oil burner, resulting in the destruction of a flexible fuel line and other damage. This fire pointed out the poor design of the base of the furnace and of the tower bases, which collected inflammable drippings. This fault was corrected by providing drainage to minimize this hazard. The fire also demonstrated that flexible rubber hoses should not be used as fuel-oil lines leading to the oil burners. It also pointed out that the only steam available for fighting fires was that created by the steam tubes within the heater section itself. In the case of a fire in or around the heater, the burners would be shut off to prevent further damage. This would stop the formation of steam within the steam tubes, which in turn would prevent fighting the fire with steam. As a safety measure, therefore, it was decided to remove the steam tubes from the heater and provide steam for process use, as well as for fire protection, by installing a separate steam generator, which was subsequently done at Lodge Grass.

Several minor fabrication deficiencies appeared during the Shelby operations. These included minor piping inadequacies, check valves installed in reverse position, gauge glasses in an exposed condition subject

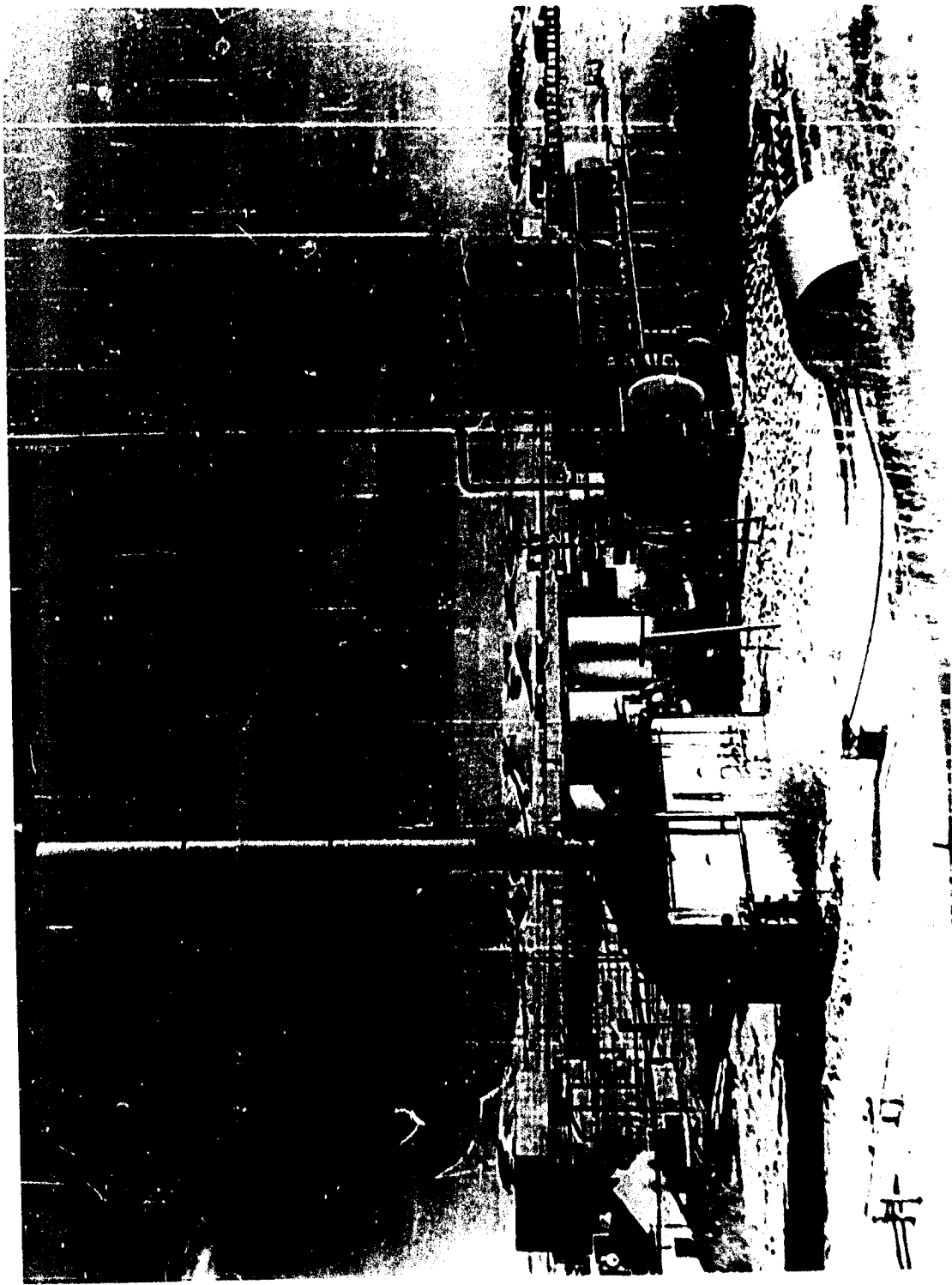


Figure 5. Mark II topping plant at Shelby location with first heater modifications (lengthened stack and new oil burners).

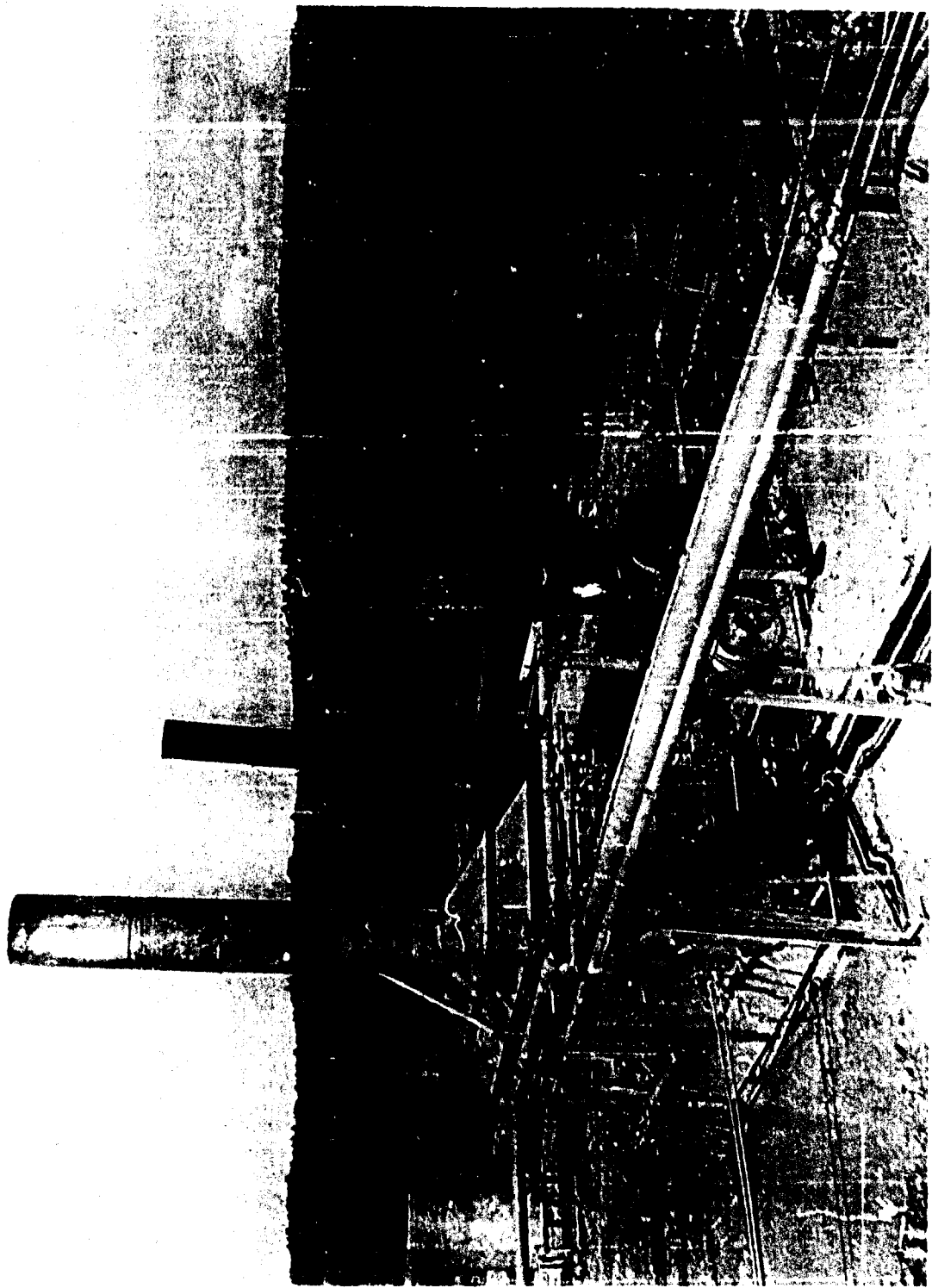


Figure 6. Modified heater with larger stack. (Lodje Grass).

to easy breakage, and so forth. The major fabrication error was discovered in the Number One tower, in which it was found that the stainless steel downcomer leading from the bubble trays was not welded to the sides of the tower. As a result, this downcomer warped and gave some difficulty in operation. This fault was corrected by opening the tower, welding as required, and resealing the tower. No similar trouble was experienced with the other two towers.

Move to Lodge Grass

Subsequent to the testing period in Shelby, the contractor went into bankruptcy and it was decided to move the topping plant to a new location for additional tests. A contract was negotiated with the Petroleum Products Refining and Producing Company of Abilene, Texas, which owned a small producing field (the Soap Creek Field) in Southeastern Montana, south of Hardin near Lodge Grass. (This company was subsequently taken over by the Texas Calgary Company of Abilene, Texas, which assumed the responsibility for completing the contract.)

During the winter of 1955-56, the topping plant was dismantled, moved by truck from Shelby to Lodge Grass, and re-erected at that location. During this move there was approximately 10 inches of snow on the ground and the temperature was constantly below zero. All of the loading and unloading was done with ordinary oil-field equipment, winch trucks, gin poles. The crews used for the dismantling, loading, and hauling were experienced and proved the easy portability of the plant. The hauling distance of approximately 400 miles was made without incident or damage, and was an important and successful operation. (Figures 7 and 8.)

Lodge Grass Operations

As no refinery existed at Lodge Grass prior to installing the Mark II plant, it was necessary to build everything from "scratch." The site was graded, a water well was drilled, access roads were built, a tank farm was constructed, loading and unloading facilities were developed, a water cooling tower was built, and power lines were brought in. Although the quantity of work done in this regard resembled that at an advanced base, the quality was for considerably more permanence and consequently the cost and time of development was not comparable to that of a military installation. Figure 9 shows a general view at the Lodge Grass location.

Crude Oil Used and Products Produced. The crude oil from the Soap Creek field was a very heavy viscous asphalt-base 19.5-gravity oil which contained only about 7 percent gasoline. The gasoline was of low quality and of value primarily for blending purposes or as a solvent for cut-back asphalts or road oils.

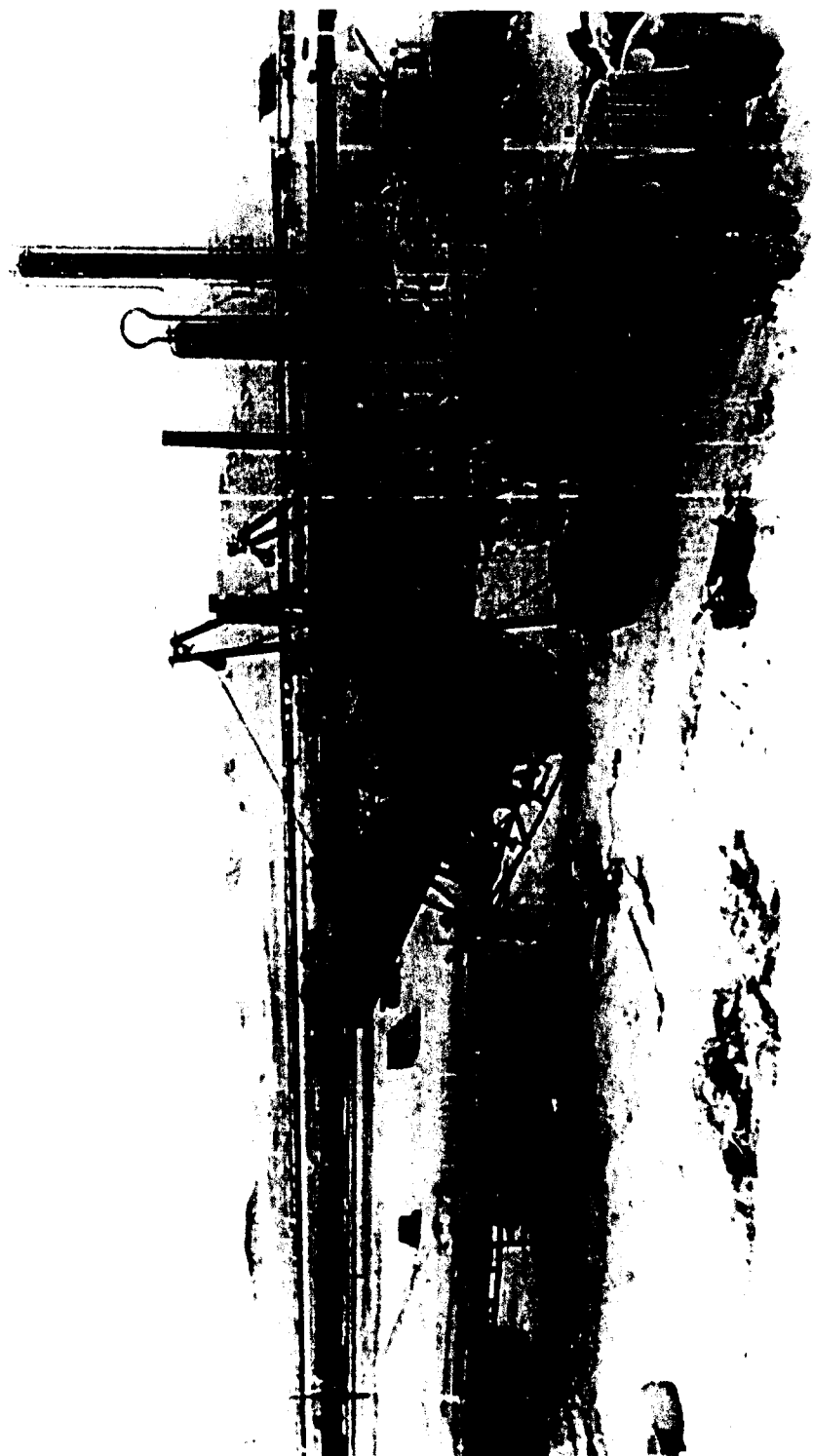


Figure 7. Loading a tower section for truck shipment* from Shelby to Lodge Grass.

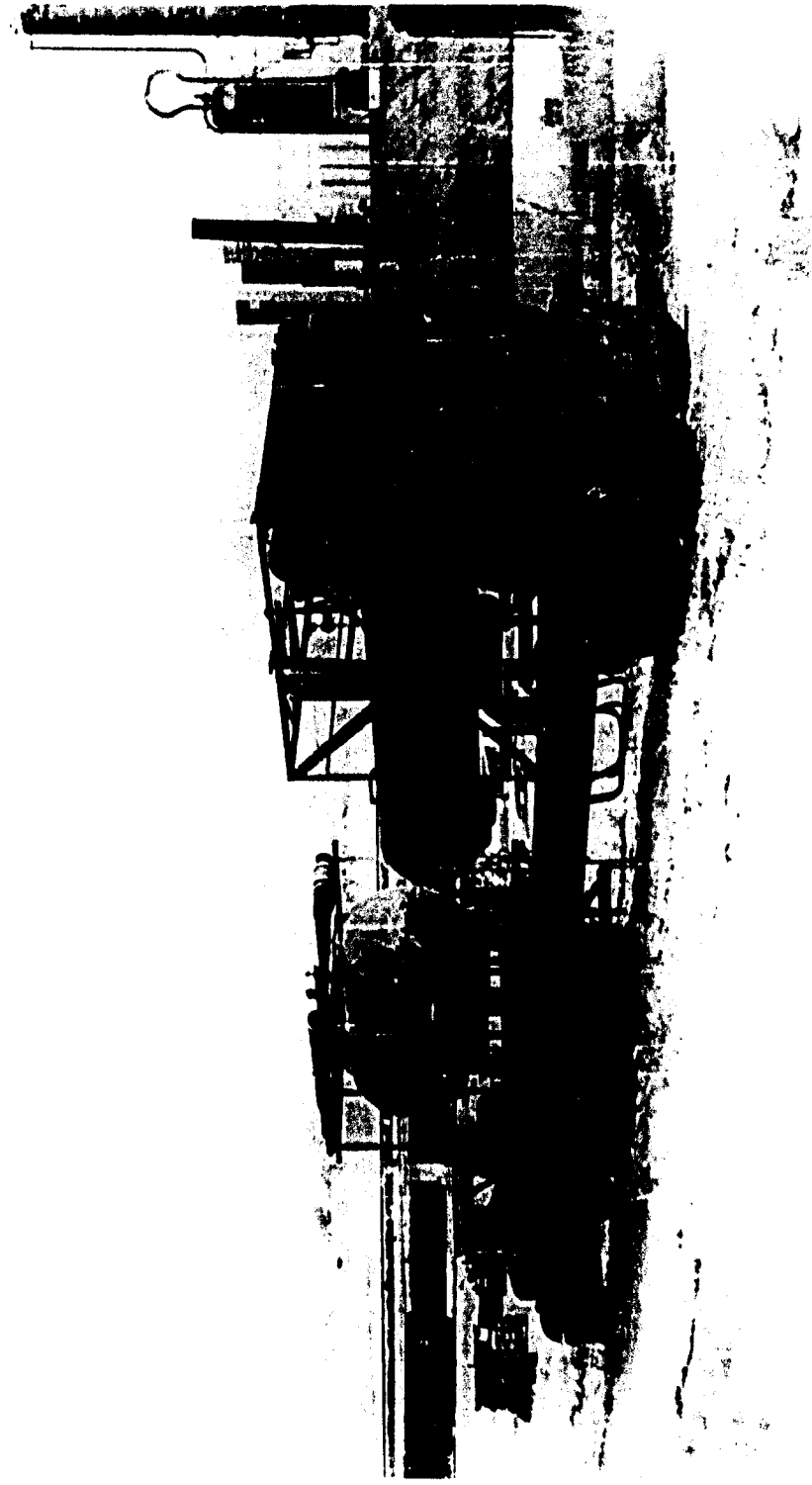


Figure 8. Tower section and crude settler section on truck for shipment from Shelby to Lodge Grass.

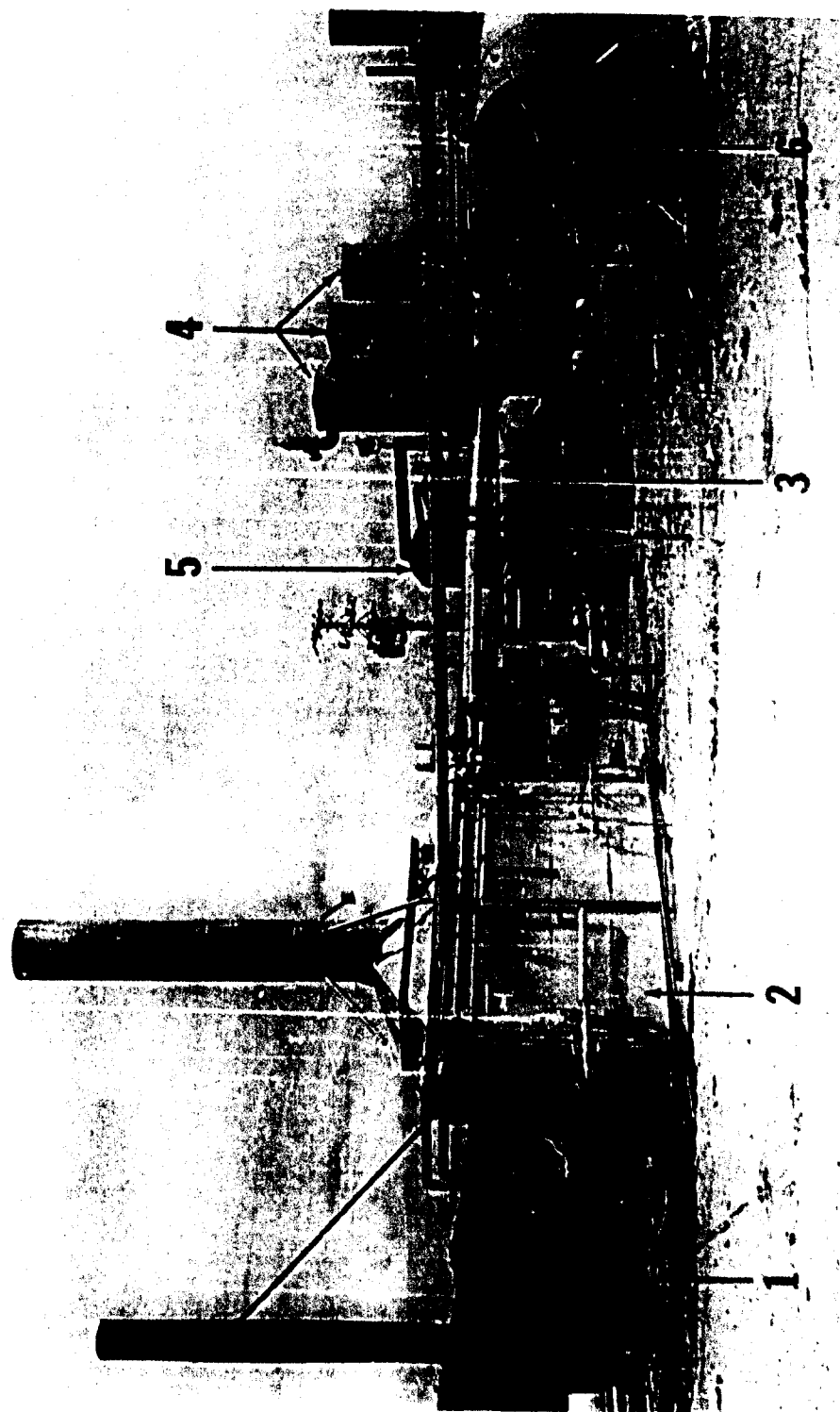


Figure 9. General view at Lodge Grass. Left to right, (1) black boiler for asphalt production, (2) heater, (3) crude settler, (4) fractionating towers, (5) vacuum tower for asphalt production, (6) separator steam generator for fire protection and process steam.

The yield of this crude included:

Gasoline	7.05%
Kerosene	12.13
Gas Oil	8.89
Residuum	71.18
Waste	0.75

As the residuum was used as feed stock for asphalt production, it is apparent that asphalt was by far the most important product.

Other characteristics of the crude oil and the products will be found in Appendix B in the test reports dated 1956.

Modifications. The high viscosity of the Soap Creek crude led to trouble in the crude oil feed (centrifugal) pump. This pump had difficulty in maintaining the flow into the plant and overheated easily because of the load put on the electric motor. The centrifugal pump was replaced with a Moyno pump (Figure 10), which for this service had greater capacity and required less power. No further trouble was experienced in this section of the plant.

The contractor suggested that automatic controls for the plant, with motorized valves and other control equipment, would simplify the operation of the plant and improve the product. Accordingly, an automatic control system (Figure 11) was installed and proved to be very desirable. Controller records are shown in Appendix B.

The heavy crude used at this location required a greater heater capacity and additional oil tubes were installed in the furnace, which approximately doubled the heat-exchange capacity of the furnace. Because of the limited capacity of the heat exchangers and coolers on the diesel oil product line, this product was not cooled sufficiently and the product pumps ran hot. Additional heat exchangers for cooling were added which corrected the situation.

Seabee Operation

To determine the possibility and practicality of having the topping plant operated by Seabees, two enlisted men were sent to the site for one month. They were given instructions in the operation and maintenance of the plant as well as in sampling techniques and laboratory test operations. This experience indicated that Seabees could be trained within 30 days for routine operations,

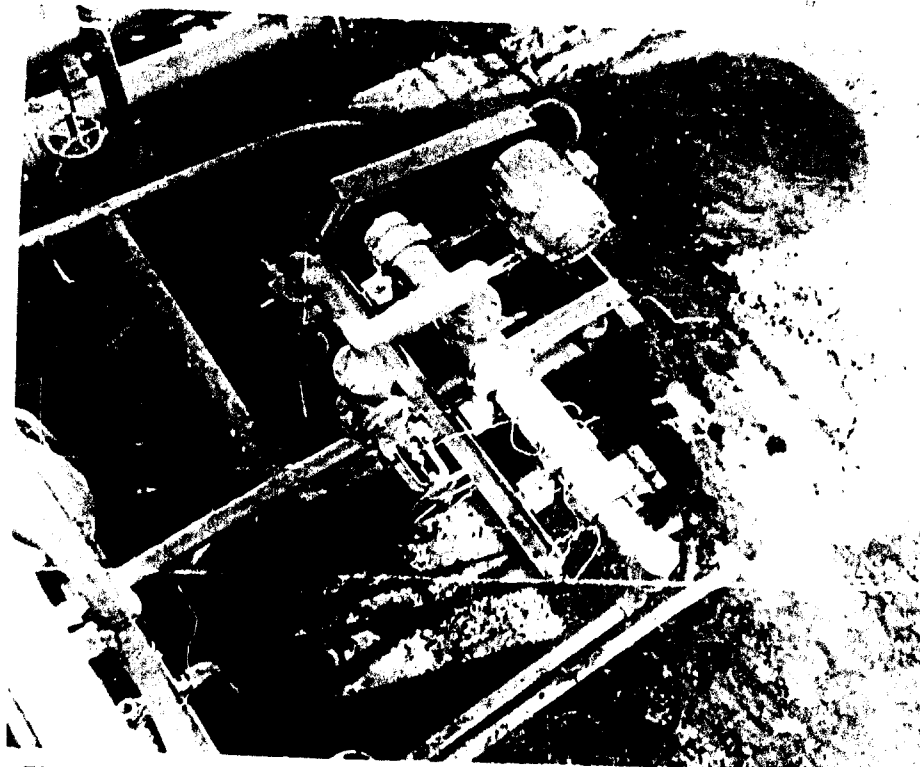


Figure 10. View from above of Moyno pump, replacing centrifugal crude oil feed pump.

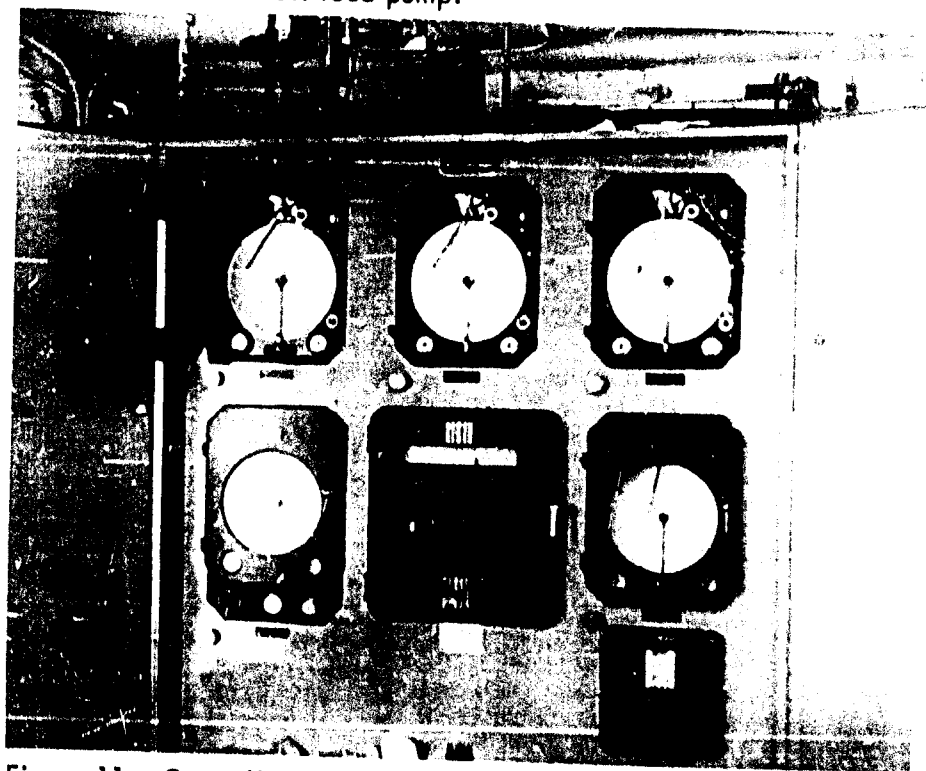


Figure 11. Controller-recorder panel added at Lodge Grass for automatic operation of topping plant.

but should have an experienced supervisor to take care of the unusual conditions and emergencies which might arise. Suggested operating personnel for a military operation are listed in Appendix C.

EVALUATION

In most respects, the Lummus Mark II unit satisfactorily met all specification requirements. With the exception of the modifications to the heater section, most modifications and improvements indicated would be minor. In general, the unit is reliable, would have sufficient durability for its anticipated combat life, and is quite rugged, although some improvement could be made in details of structural framework.

The portability of the unit, as evidenced by the ease with which it was shipped by rail (Figure 12) and truck and also the ease with which it was erected and dismantled, indicates that it meets all the portability requirements. No measure of its air-transportability was made except an appraisal of its physical dimensions and weight, which indicates that it would meet these requirements also.

It is estimated that the plant (exclusive of tankage) can be erected and producing within 48 hours.

Most of the trouble encountered in this unit was in the furnace, or heater, section. There was a need to improve the combustion characteristics of the furnace and, with the change of oil burners, this was made possible by the elimination of the blowers on the outside of the furnace. This change permitted a widening of the furnace and an expansion of the internal combustion area. Combustion characteristics were also improved by the enlargement of the stack area. The removal of the steam tubes provided sufficient room for additional oil-heater tubes, which increased the capacity of the entire plant. Minor modifications include the relocation of some of the component items to provide for a maximum width of usable combustion area. A steam snuffing system for fire protection was added. It is considered that the furnace should be completely redesigned to incorporate all of the modifications made as well as a few other desirable changes, including premolded refractory material which would not be as fragile as fire brick, consideration of alternate burners, and oil heating tube analysis for size and surface area.

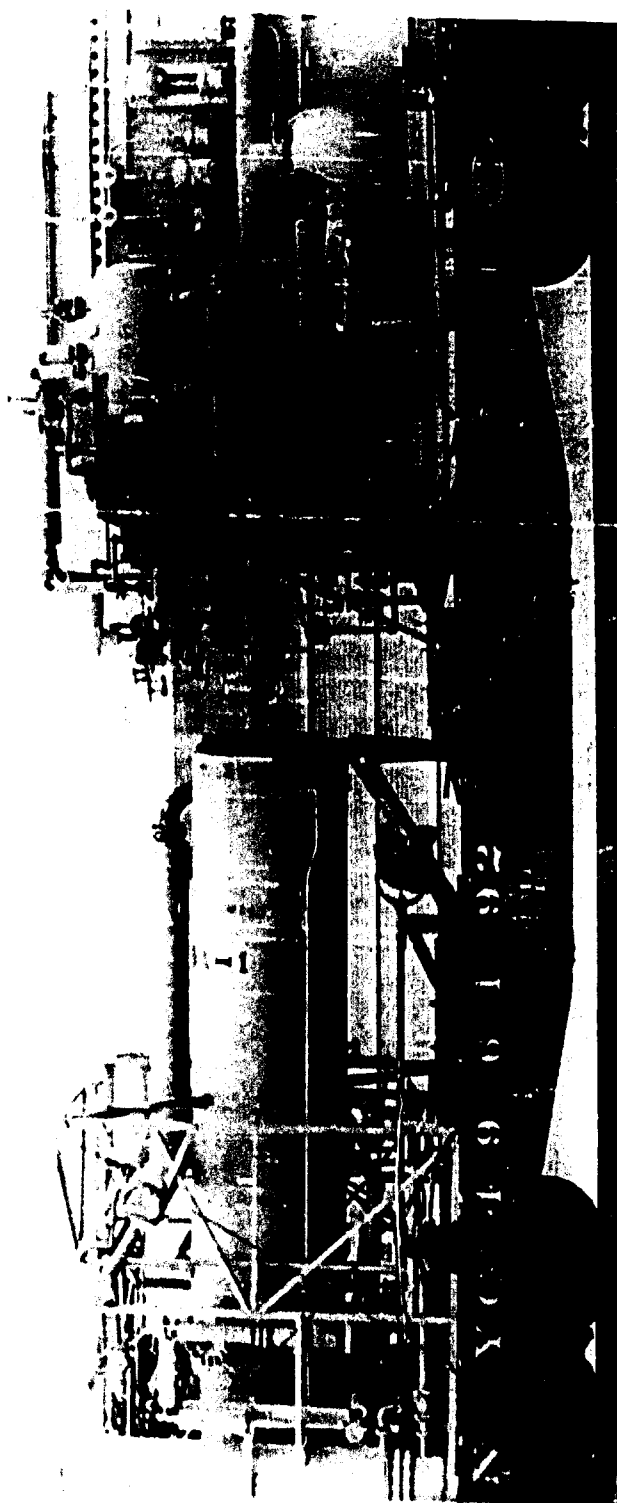


Figure 12. Method of loading heater and one tower section for rail shipment (Mark II topping plant).

With the exception of the fabrication deficiency in the towers mentioned on page 12, the components seemed to be satisfactory and gave a minimum of difficulty. The quality of the products produced and the flexibility with which products could be changed according to need seemed to meet all requirements. Some modifications are indicated in the heat exchangers, coolers, and product condensers in order to give them a greater capacity and a longer life. It is suggested that heat exchangers of a uniform size and capacity be designed so that additional units may be added according to the requirements of various crude oils.

It is apparent that the yard facilities required will depend upon the location and particular situation which exists at every individual installation of the topping plant. Tankage requirements will depend upon the source of the crude oil, the method of transporting the crude oil from the wells to the plant site, the kind or quantity of storage required for both crude and finished products, the characteristics of the crude itself, safety considerations, and other factors. In general, tankage (Figure 13) will be required for crude-oil storage, for products storage, and for operating use ("slop" tanks). Rubber "pillow" tanks (Figure 14) are the quickest to install but are the most expensive. They require only a smooth foundation, and being connected with the portable pipelines, manifolds and hoses supplied with the tanks and they are ready for use. Standard bolted steel tanks cost approximately one-third as much as rubber tanks but require much more time for installation. In addition, some difficulty may be encountered if bolted steel tanks are erected in cold weather because of the inability of the gasket material to seal the tanks.

Other yard facilities required include pipelines to and from unloading facilities for crude oil, loading facilities for finished products (Figure 15), pipelines connecting the tank farm to the topping plant, a water cooling tower and pipelines connecting it to the plant, portable electric generators, portable steam generators with pipelines, laboratory facilities (Figure 16) for control tests to control production, and a building to house personnel during inclement weather. Most of these facilities are standard stock items for which representative designs and quantities are specified in Appendix D.

Only a few pieces of standard laboratory equipment are necessary for control tests for the production of fuel. These tests are simple and routine in nature, can be explained by an operating manual, and are capable of being performed by relatively untrained Seabees.

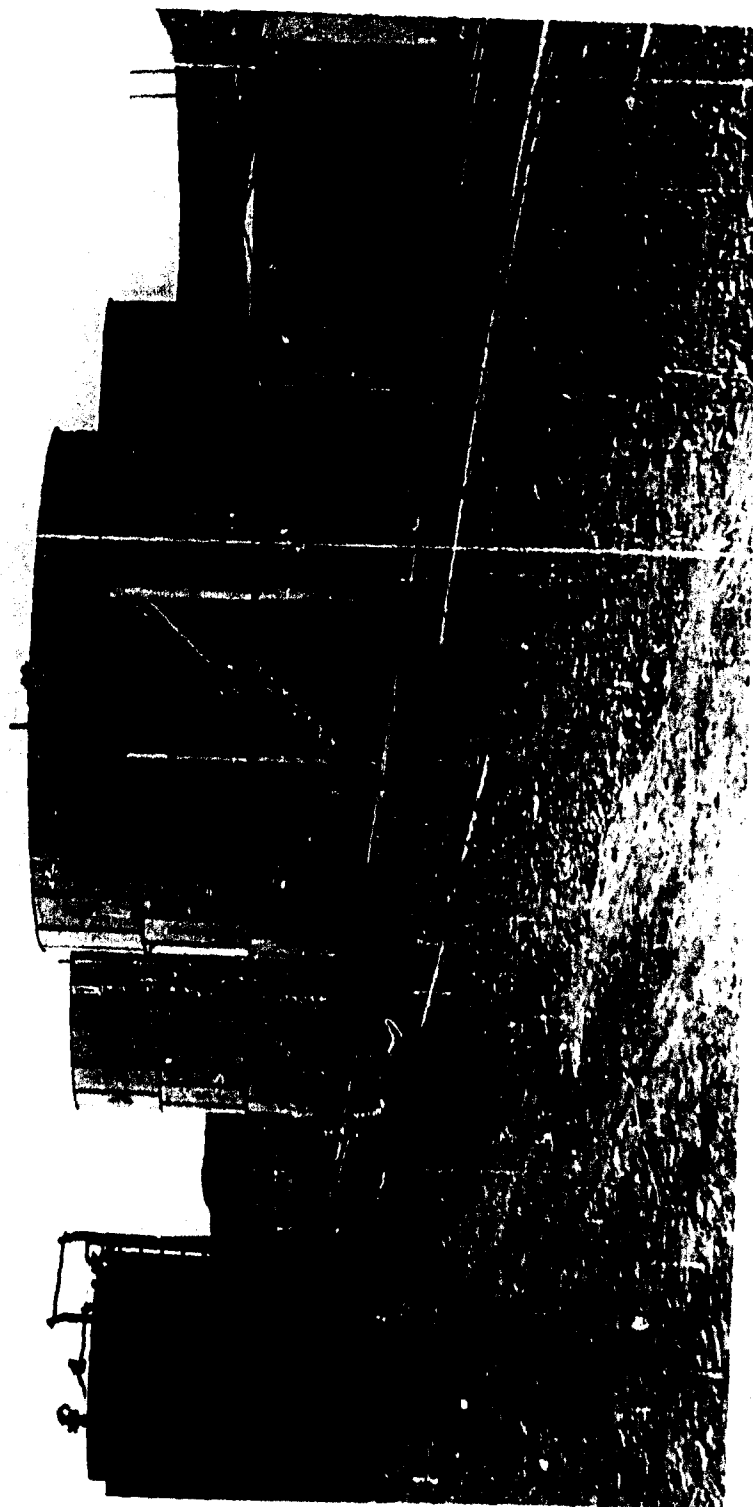


Figure 13. Part of tank farm at Shelby.



Figure 14. Two rubber "pillow" tanks (10,000 gal capacity), one empty and one partially filled.



Figure 15. Truck loading facilities for refined products at Lodge Grass.

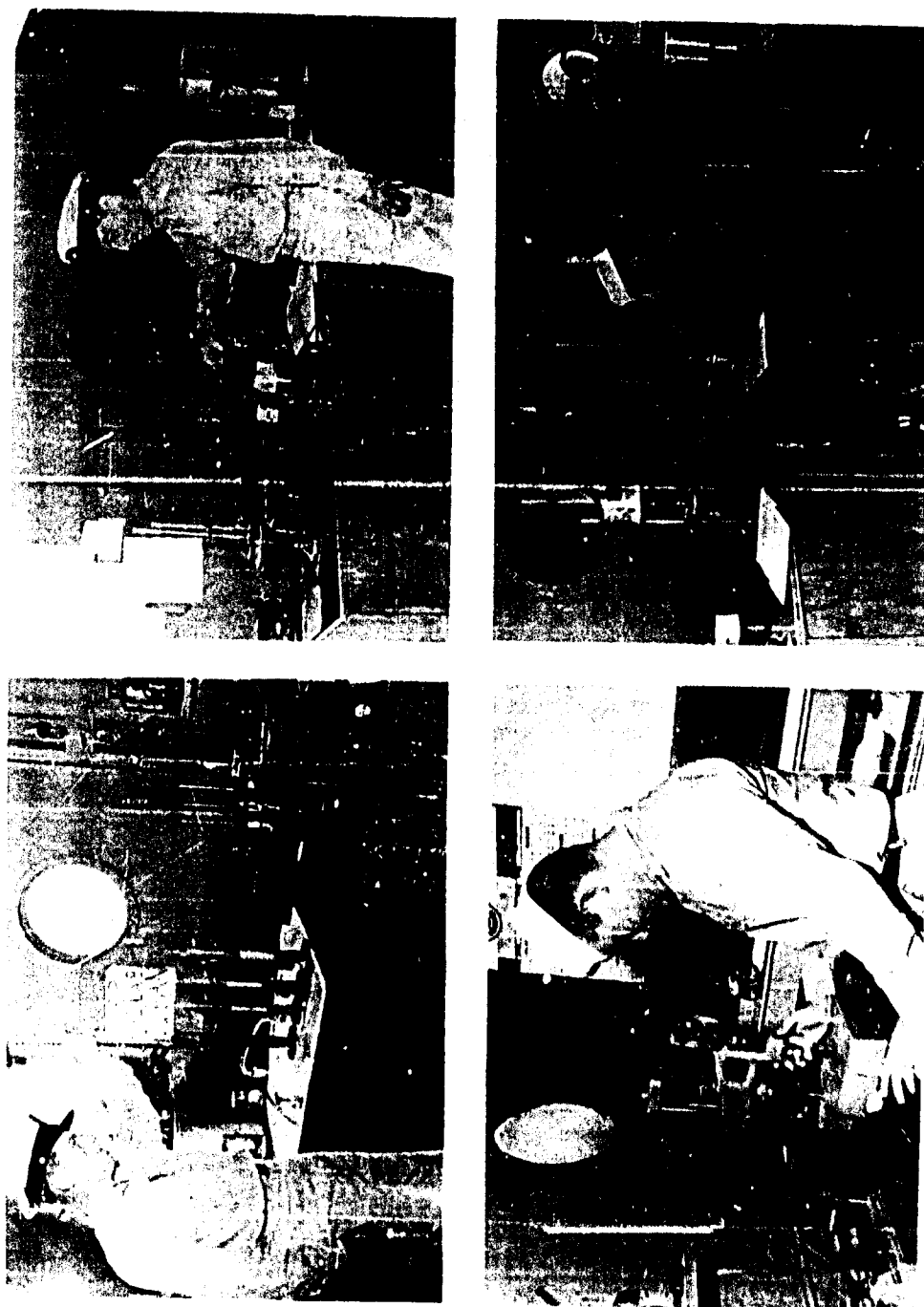


Figure 16. Views of laboratory at Lodge Grass.

An operating manual should be prepared at the time the fabrication plans are completed, written in nontechnical language for Seabee understanding. Besides manuals for the operation, repair, and maintenance of the plant itself, there should be special manuals for bolted steel tank erection, operation and care of portable electric generators, a laboratory manual for control tests, and other special manuals for particular equipment as required. The manuals should give the maintenance requirements of the plant and its various components.

It is anticipated that an operating crew for the plant would consist of one experienced operator and one apprentice assistant for each shift. In addition, there should be a mechanic, an electrician, and a welder available for call at any time should an emergency arise. One laboratory technician should be available during the daylight shift to record the operating results of the night shifts and to complete tests of all samples taken during the preceding 24-hour period. (See Appendix C.)

On the basis of actual operational tests, it is estimated that a crew of Seabees can be trained to operate the plant, exclusive of emergency requirements, within 30 days. One skilled technician, who understands the plant and who is qualified to take care of any emergency, should be sent with every topping plant put into use. This man should supervise the unloading and erection of the plant, as well as the initial firing up and placing of the plant on stream. No current military rating provides for this particular skill, so a limited number of personnel may have to be secured from the petroleum industry when needed.

A feasibility study has been completed to determine the practicality of a proposed asphalt unit to be operated in conjunction with the topping plant. Such a unit is feasible and the estimated cost in 1957 was \$12,000 for design and \$41,000 for fabrication. Such a unit would make use of the otherwise waste product of residual oil and would furnish a substantial part of all asphaltic requirements for paving, roofing, and waterproofing purposes. The unit would have a capacity of 600 barrels per day of residual oil to be processed as crude stock. As the products of the asphalt unit would meet a significant need at advanced bases, such a unit could double the military value of the plant.

CONCLUSIONS

The Lummus Topping Plant, Mark II, is an excellent compromise between maximum capacity and maximum portability. Its throughput (1,000 barrels per day) is sufficient so that it will, in many cases, serve the entire needs of the

installation being considered. For larger requirements, batteries of this unit may be used. The quality of products is excellent and fully satisfactory for emergency uses. With the exception of the heater, the basic design of the unit is satisfactory. It is considered desirable to completely redesign the heater to take advantage of the extra width available and to incorporate the various modifications (improved draft, improved burners, redesigned oil heating tubes, etc.) found necessary to improve combustion characteristics. With the substitution of the Moyno crude feed pump and various other relatively minor modifications, it is considered that this unit is very reliable. Its durability is adequate for the purpose intended.

RECOMMENDATIONS

1. That the fabrication drawings of the entire plant be revised to incorporate the findings of the testing program, and particularly that the heater be completely redesigned to improve its combustion characteristics by taking advantage of the extra width now available. (Information for revision of plans is available from the "as-modified" drawings maintained at NCEL.)
2. That complete purchase requisitions be prepared for the bills of materials required for such purchase items as the water cooling tower, laboratory, and office building.
3. That plans for various yard facilities, including typical tank farms, water cooling facilities, loading and unloading facilities, and laboratory be completed for future use.
4. That the Bureau of Yards and Docks bring the Topping Plant to the attention of OCDM for potential civilian use in the event of a disaster which may cripple or destroy the refining facilities of the United States.
5. That a topping plant following the design of the Lummus Mark II be modified according to NCEL recommendations and tested, and following successful test be adopted for military use.
6. That an asphalt unit, to be operated in conjunction with the topping plant, be designed, fabricated, and tested for the production of asphalt for paving, roofing, and waterproofing purposes. Such a unit could double the military value of the topping plant and make use of an otherwise waste product (residual oil).

BIBLIOGRAPHY

1. Technical Note N-199, "Evaluation of Lummus Topping Plant Mark II," by R. B. McIntosh, U. S. Naval Civil Engineering Laboratory, Port Hueneme, California, 11 October 1954.
2. Report, "Test and Evaluation of a Portable Topping Unit," by the Ralph M. Parson Company, 28 January 1954.
3. "First Portable Oil Refinery," by M. C. Lorenz and R. F. Berger, International Oilman Magazine, September 1957.

APPENDIX A

DESIGN

Without going into unwarranted detail, the following Flow Sheet (Figure 17), and the Plot Plan and General Arrangement (Figure 18), indicate the general design.

Some major modifications have been made, including a separate source of process steam (removed from the heater to a separate steam generator) and a greatly increased heat-exchange capacity (nearly doubled) in the heater for heating crude oil.

Complete specifications and working drawings for all fabrication details are in the files of the Naval Civil Engineering Laboratory at Port Hueneme, California. These drawings have not been revised to show the "as-modified" condition; they show the original design only. Corrected drawings are available, however, to revise the original drawings.

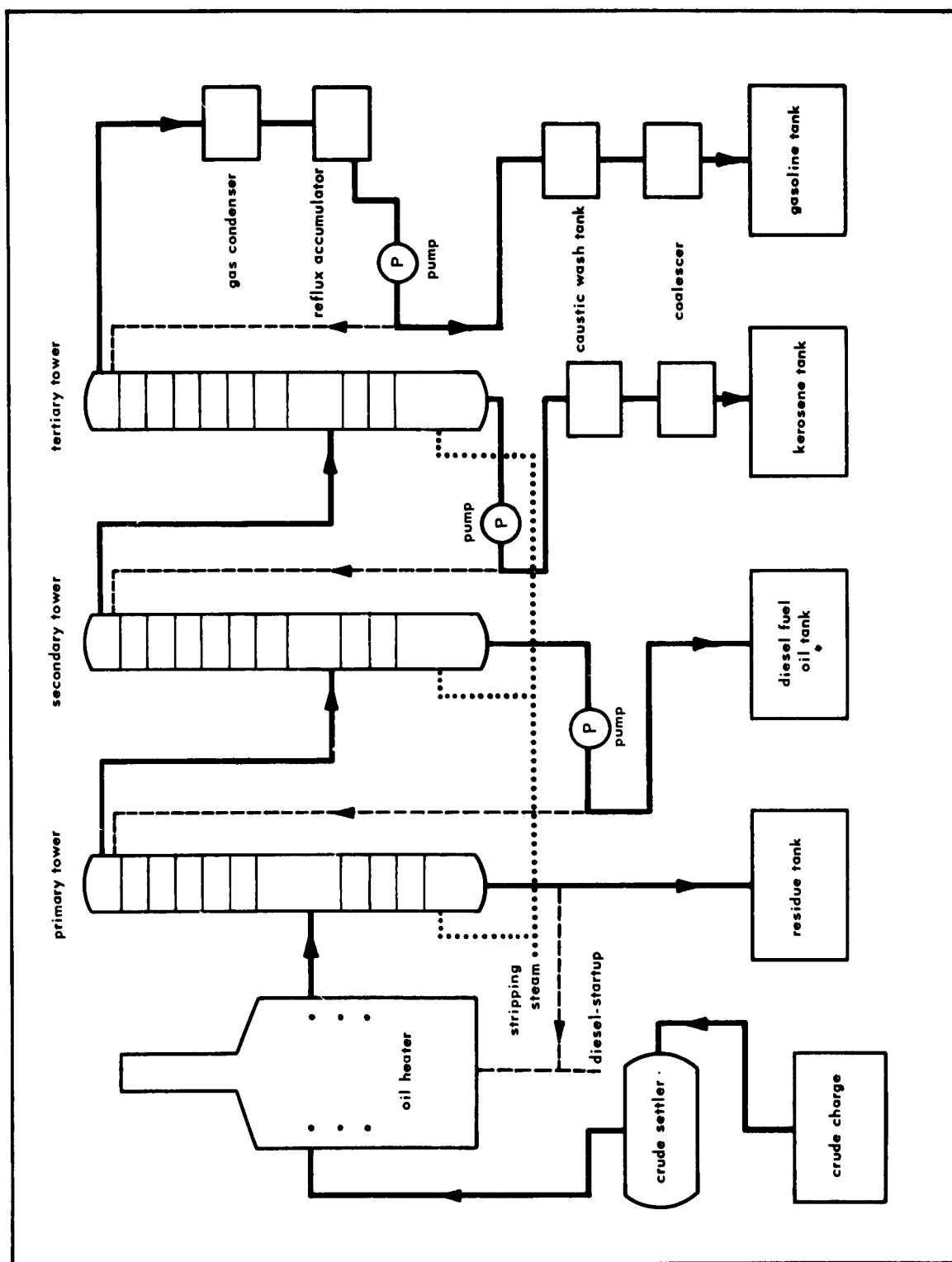
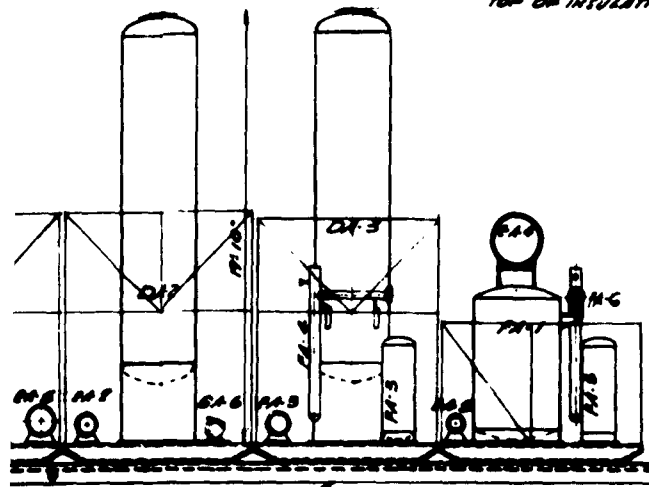
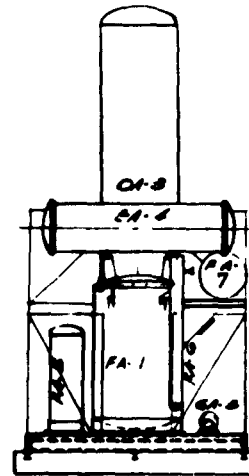
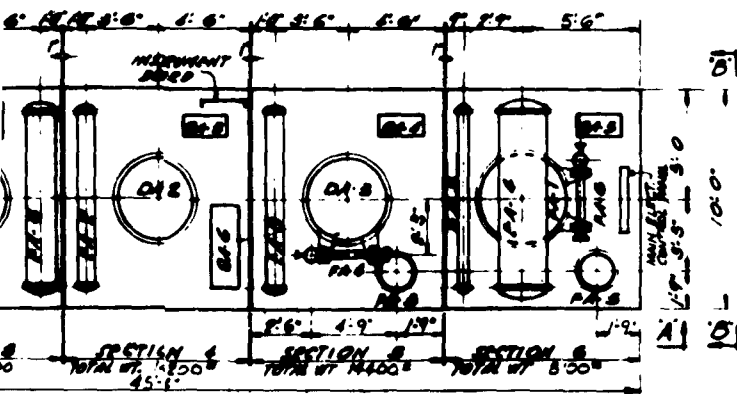


Figure 17. Flow Sheet.

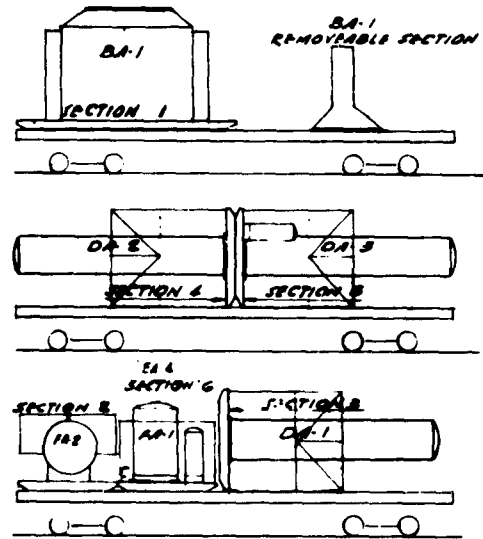
TOP OF INSULATION ON TOWERS 7

FOUNDATION BY CUSTOMER
ELEVATION A-A

ELEVATION B-B



PLAN



PLATFORM LOADING ARRANGEMENT

18. Plot plan and general arrangement.

2

APPENDIX B

TEST RESULTS AND RECORDS

The data contained herein include the results of a commercial laboratory inspection of the crude oil processed and of the products produced. They show that the fractionating sections of the unit are capable of making satisfactory product separations.

The test reports dated 1953 (Tables I through IV) are for the Shelby operations and reflect adverse firing conditions experienced throughout the runs due to the heavy residue being used for fuel and due to manual adjustment of burners to hold close product fractionations.

The test reports dated 1956 (Tables V and VI) are for the Lodge Grass operations after automatic controls had been installed on the plant. The circular charts (Figures 19 through 22) show the close control of temperatures at key points provided by the automatic controls.

Table 1. Badger Distillation, 40 Gravity Crude, Shelby.

CABLE ADDRESS "SAYBOLTOIL"
ALL CODES USED - SPECIFY

TELEPHONE - TERMINAL 4-5307

INSPECTION OF BULK CARGOES,
PETROLEUM AND OTHER LIQUIDS.
LICENSED WEIGHERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
SPECIALISTS IN TANK CALIBRATING

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DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

CERTIFICATE OF ANALYSIS

SAMPLE OF **CRUDE OIL**

November 6, 1953

FROM Submitted by The Ralph M. Parsons Company - from Modern Oil Company,
Shelby, Montana.

FOR Analyses

U. S. Navy No. C.B.C. 91632-54

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CRUDE

Gravity, API @ 60°F. 40.2
B.S. & W. 0.2%

Badger Type Distillation

	<u>Gasoline</u>	<u>Kerosene</u>	<u>Diesel</u>	<u>Residue</u>
Yield, %	32.2	19.3	7.8	40.1
Gravity, API @ 60°F.	61.1	41.3	35.3	25.3
Viscosity, Saybolt Univ. @ 100°F. -	-	-	40.6 secs.	-
Viscosity, Saybolt Furol @ 122°F. -	-	-	-	20.2 secs.
DISTILLATION:				
Initial Boiling Point	113°F.	410°F.	530°F.	636°F.
5% Recovered	160°F.	417°F.	540°F.	660°F.
10% "	178°F.	420°F.	545°F.	670°F.
20% "	202°F.	426°F.	550°F.	687°F.
30% "	232°F.	432°F.	555°F.	
40% "	242°F.	439°F.	558°F.	
50% "	258°F.	446°F.	561°F.	
60% "	276°F.	456°F.	565°F.	
70% "	294°F.	466°F.	570°F.	
80% "	312°F.	478°F.	578°F.	
90% "	331°F.	495°F.	592°F.	
95% "	347°F.	513°F.	610°F.	
End Point	374°F.	536°F.	630°F.	
Recovery	98.0%	98.0%	99.0%	

Crude Marked:

From 9/12/53 - 1800 hrs.

To 9/13/53 - 1800 hrs.

Sample from full tank.

E. W. SAYBOLT & CO.

R. Schaefer

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Table II. Analyses of Products, 40 Gravity Crude, Shelby.

CABLE ADDRESS "SAYBOLTOIL"
ALL CODES USED - SPECIFY

TELEPHONE - TERMINAL 4-5307

INSPECTION OF BULK CARGOES,
PETROLEUM AND OTHER LIQUIDS,
LICENSED WEIGHERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
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DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

CERTIFICATE OF ANALYSIS

SAMPLE OF **AS SHOWN BELOW**

November 4, 1953

FROM **Submitted by The Ralph M. Parsons Company - from Modern Oil Company,
Shelby, Montana.**

FOR **Analyses**

U. S. Navy No. C.B.C. 91632-54

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<u>Plant Samples</u>	<u>Gasoline</u>	<u>Kerosene</u>	<u>Diesel</u>	<u>Residuum</u>
Gravity, API @ 60°F.	60.4	42.0	35.5	24.5
Color, Saybolt	+30	+30	+5	~
Flash, P.M.C.	-	154°F.	240°F.	375°F.
Reid Vapor Pressure @ 100°F.	3.8 lbs.	-	-	~
B.S. & W.	-	-	-	Trace
Viscosity, Saybolt Univ. @ 100°F.	-	-	40.7 secs.	~
Viscosity, Saybolt Furol @ 122°F.	-	-	-	26.6 secs.
Octane, Research (Clear)	46	-	-	~
<u>DISTILLATION:</u>				
Initial Boiling Point	122°F.	374°F.	472°F.	638°F.
5% Recovered	165°F.	398°F.	520°F.	677°F.
10% "	183°F.	410°F.	540°F.	686°F.
20% "	207°F.	420°F.	550°F.	
30% "	227°F.	428°F.	558°F.	
40% "	244°F.	436°F.	564°F.	
50% "	262°F.	443°F.	570°F.	
60% "	278°F.	452°F.	577°F.	
70% "	297°F.	462°F.	585°F.	
80% "	317°F.	475°F.	593°F.	
90% "	339°F.	490°F.	605°F.	
95% "	352°F.	505°F.	617°F.	
End Point	374°F.	516°F.	632°F.	
Recovery	98.0%	98.5%	99.0%	
Bottoms	1.0%	-	-	
Loss	1.0%	-	-	

All samples marked:

From 9/12/53 - 1800 hrs.

To 9/13/53 - 1800 hrs.

Sampled every 4 hours.

E. W. SAYBOLT & CO.

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Table III. Badger Distillation, 21 Gravity Crude, Shelby.

CABLE ADDRESS "BAYBOLT OIL"
ALL CODES USED - SPECIFY

TELEPHONE - TERMINAL 4-5207

INSPECTION OF BULK CARGOES,
PETROLEUM AND OTHER LIQUIDS.
LICENSED WEIGHTERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
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DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

CERTIFICATE OF ANALYSIS

SAMPLE OF CRUDE OIL, Marked: 21 Gravity Crude

December 4, 1953

FROM Submitted by The Ralph M. Parsons Company - from Modern Oil Company,
Shelby, Montana.

FOR Analyses

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Gravity, API @ 60°F. 21.5
B.S. & W. 1.0%

BADGER TYPE DISTILLATION

	<u>Gasoline</u>	<u>Kerosene</u>	<u>Gas Oil</u>	<u>Residuum</u>
Yield % Dry Crude	13.57	11.56	4.92	68.95
Gravity, API @ 60°F.	60.2	38.7	32.1	13.1
Viscosity, Saybolt Univ. @ 100°F. -	-	-	40.6 secs.	-
Viscosity, Saybolt Furol @ 122°F. -	-	-	-	462 secs.
<u>DISTILLATION:</u>				
Initial Boiling Point	123°F.	416°F.	528°F.	612°F.
5%	171°F.	431°F.	537°F.	633°F.
10%	190°F.	436°F.	540°F.	643°F.
20%	215°F.	442°F.	545°F.	653°F.
30%	236°F.	448°F.	550°F.	-
40%	256°F.	455°F.	555°F.	-
50%	275°F.	462°F.	560°F.	-
60%	293°F.	471°F.	567°F.	-
70%	310°F.	480°F.	574°F.	-
80%	326°F.	491°F.	585°F.	-
90%	345°F.	508°F.	609°F.	-
95%	360°F.	525°F.	-	-
End Point	378°F.	542°F.	617°F.	-
Recovery	98.0%	98.5%	99.0%	-

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Table IV. Analyses of Products, 21 Gravity Crude Shelby.

MAIL ADDRESS "BAYBOLT" -
ALL CODES USED - SPECIFY

TELEPHONE - TERMINAL 4-5507

INSPECTION OF BULK BARRELS,
PETROLEUM AND OTHER LIQUIDS.
LICENSED WEIGHERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
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DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

CERTIFICATE OF ANALYSIS

SAMPLE OF **CRUDE OIL**

December 26, 1953

FROM Submitted by The Ralph M. Parsons Company from Modern Oil Company, Shelby,
Montana.

FOR Analyses

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Second set of Plant samples that arrived with a 21.5 Gravity Crude, December, 1953.

	<u>Gasoline</u>	<u>Kerosene</u>	<u>Diesel</u>	<u>Residue</u>
Gravity, API @ 60°F.	61.5	43.8	34.9	13.1
Color	+30, Saybolt	+30, Saybolt	1 Lt., MPA	-
Flash, PMCC	-	140°F.	216°F.	305°F.
Weld Vapor Pressure @ 100°F.	3.6 lbs.	-	-	-
B.S. & W.	-	-	-	0.7%
Viscosity, Saybolt Univ. @ 100°F.	-	-	37.3 secs.	-
Viscosity, Saybolt Furol @ 122°F.	-	-	-	460.5 secs.
Research Octane No. - Clear	(46.4) 46	-	-	-
<u>DISTILLATION:</u>				
Initial Boiling Point	124°F.	347°F.	443°F.	550°F.
5%	172°F.	372°F.	483°F.	600°F.
10%	188°F.	381°F.	493°F.	628°F.
20%	209°F.	390°F.	503°F.	656°F.
30%	227°F.	397°F.	513°F.	-
40%	244°F.	403°F.	521°F.	-
50%	259°F.	410°F.	531°F.	-
60%	274°F.	416°F.	540°F.	-
70%	287°F.	425°F.	550°F.	-
80%	307°F.	435°F.	565°F.	-
90%	326°F.	450°F.	586°F.	-
95%	341°F.	465°F.	604°F.	-
End Point	369°F.	481°F.	626°F.	-
Recovery	98.0%	98.0%	99.0%	-
Residue	1.0%	1.0%	-	-
Loss	1.0%	1.0%	-	-

E. W. BAYBOLT & CO.

R. Schaefer

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Table V. Badger Distillation, 19 Gravity Crude, Shelby.

39

CABLE ADDRESS "SAYBOLTOIL"
ALL CODES USED — SPECIFY

TELEPHONE - TERMINAL 4-5207

INSPECTION OF BULK CARGOES,
PETROLEUM AND OTHER LIQUIDS.
LICENSED WEIGHERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
SPECIALISTS IN TANK CALIBRATING

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DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

(31-L) 1417

CERTIFICATE OF ANALYSIS

September 20, 1956

SAMPLE OF **CRUDE OIL**

FROM Submitted by Ralph W. Parsons Company, Soap Creek, Montana

FOR Analysis

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Marked: Soap Creek Crude Oil

ANALYSIS OF CRUDE
Gravity, API @ 60°F. 19.5
B.S. & W. 0.1

BADGER TYPE DISTILLATION

	<u>GASOLINE</u>	<u>KEROSENE</u>	<u>GAS OIL</u>	<u>RESIDUAL</u>
% Yield	7.05%	12.13%	8.89%	71.18%
Gravity, API @ 60°F.	58.5	39.2	31.4	12.5
Color Saybolt	+22	+15	-	-
Color A.S.T.M.	-	-	1 Lt.	-
Reid Vapor Pressure @ 100°F.	3.0 lbm.	-	-	-
Research Octane	48.0 (48)	-	-	-
Flash, P.M.C.	-	154°F.	250°F.	380°F.
Viscosity, Saybolt Univ. @ 100°F.	-	-	40.8 sec.	-
Viscosity, Saybolt Furel @ 122°F.	-	-	-	620 sec.
<u>DISTILLATION:</u>				
Initial Boiling Point	125°F.	366°F.	510°F.	595°F.
3% Recovery	179°F.	391°F.	519°F.	630°F.
10% "	199°F.	401°F.	529°F.	642°F.
20% "	224°F.	415°F.	534°F.	650°F.
30% "	243°F.	427°F.	541°F.	-
40% "	260°F.	439°F.	548°F.	-
50% "	272°F.	450°F.	555°F.	-
60% "	287°F.	461°F.	563°F.	-
70% "	300°F.	473°F.	572°F.	-
80% "	317°F.	488°F.	584°F.	-
91% "	340°F.	509°F.	605°F.	-
95% "	358°F.	530°F.	-	-
End Point	380°F.	556°F.	620°F.	-
Recovery	98.0	98.0	98.0	-

E. W. SAYBOLT & CO.

R. L. Schaefer

DEPUTY INSPECTOR OF PETROLEUM
APPROVED BY NEW YORK PRODUCE EXCHANGE

MEMBERS OF A. S. T. M., P. I., S. A. E.

Table VI. Analyses of Products, 19 Gravity Crude, Soap Creek.

CABLE ADDRESS "SAYBOLTOIL"
ALL CODES USED — SPECIFY
TELEPHONE - TERMINAL 4-5207

INSPECTION OF BULK CARPAGES,
PETROLEUM AND OTHER LIQUIDS.
LICENSED WEIGHERS AND SAMPLERS
OF VEGETABLE OILS, WAXES
AND FATS.
SPECIALISTS IN TANK CALIBRATING

E. W. SAYBOLT & CO.
CHAS. M. SMYTHE—JOSE. M. MCCABE MEMBERS
OF THE FIRM APPROVED AND LICENSED
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SEATTLE, WASH.

(11-1) 1417

DEPENDABLE INSPECTION SERVICE AT ALL PORTS ON THE ATLANTIC, GULF AND PACIFIC COASTS

CERTIFICATE OF ANALYSIS

September 20, 1936

SAMPLE OF

OIL

FROM

Submitted by Ralph W. Parsons Company, Soap Creek, Montana

FOR

Analysis

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Marked:	GASOLINE	KEROSENE	DIESEL	GAS OIL (Tank)	GAS OIL (Stream)
Gravity, API @ 60°F.	58.2	37.4	28.2	21.8	24.4
Color Saybolt	+5	-	-	-	-
Color A.S.T.M.	-	1	1 1/2	(Darker Than 8)	5 Lt.
Reid Vapor Pressure	2.0 Lbs.	-	-	-	-
Research Octane	51.0 (51)	-	-	-	-
Octane No.	-	-	50.1 (50)	-	-
Flash, Mies	-	162°F.	216°F.	214°F.	230°F.
B. S. & W.	-	-	#11	0.2	Trace
Viscosity, Saybolt Universal @ 100°F.	-	-	51.7	178.3	145.3
DISTILLATION:				***	***
Initial Boiling Point	173°F.	358°F.	447°F.	470°F.	412°F.
5% Recovery	206°F.	395°F.	558°F.	570°F.	588°F.
10% "	215°F.	405°F.	576°F.	620°F.	633°F.
20% "	225°F.	421°F.	592°F.	670°F.	675°F.
30% "	235°F.	438°F.	605°F.	698°F.	701°F.
40% "	245°F.	459°F.	613°F.	723°F.	725°F.
50% "	255°F.	477°F.	622°F.	740°F.	745°F.
60% "	266°F.	494°F.	631°F.	765°F.	777°F.
70% "	279°F.	512°F.	640°F.	802°F.	805°F.
80% "	294°F.	530°F.	652°F.	824°F.	824°F.
90% "	324°F.	553°F.	669°F.	870°F.	885°F.
95% "	377°F.	571°F.	685°F.	-	-
End Point	441°F.	585°F.	698°F.	-	-
Recovery	98.0	98.0	98.5	-	-

*** Gas Oil Tank and Gas Oil Stream distillations run under vacuum and temperatures reported at Atmospheric pressure. Distillations run only to 90% recovered.

E. W. SAYBOLT & CO.



DEPUTY INSPECTOR OF PETROLEUM
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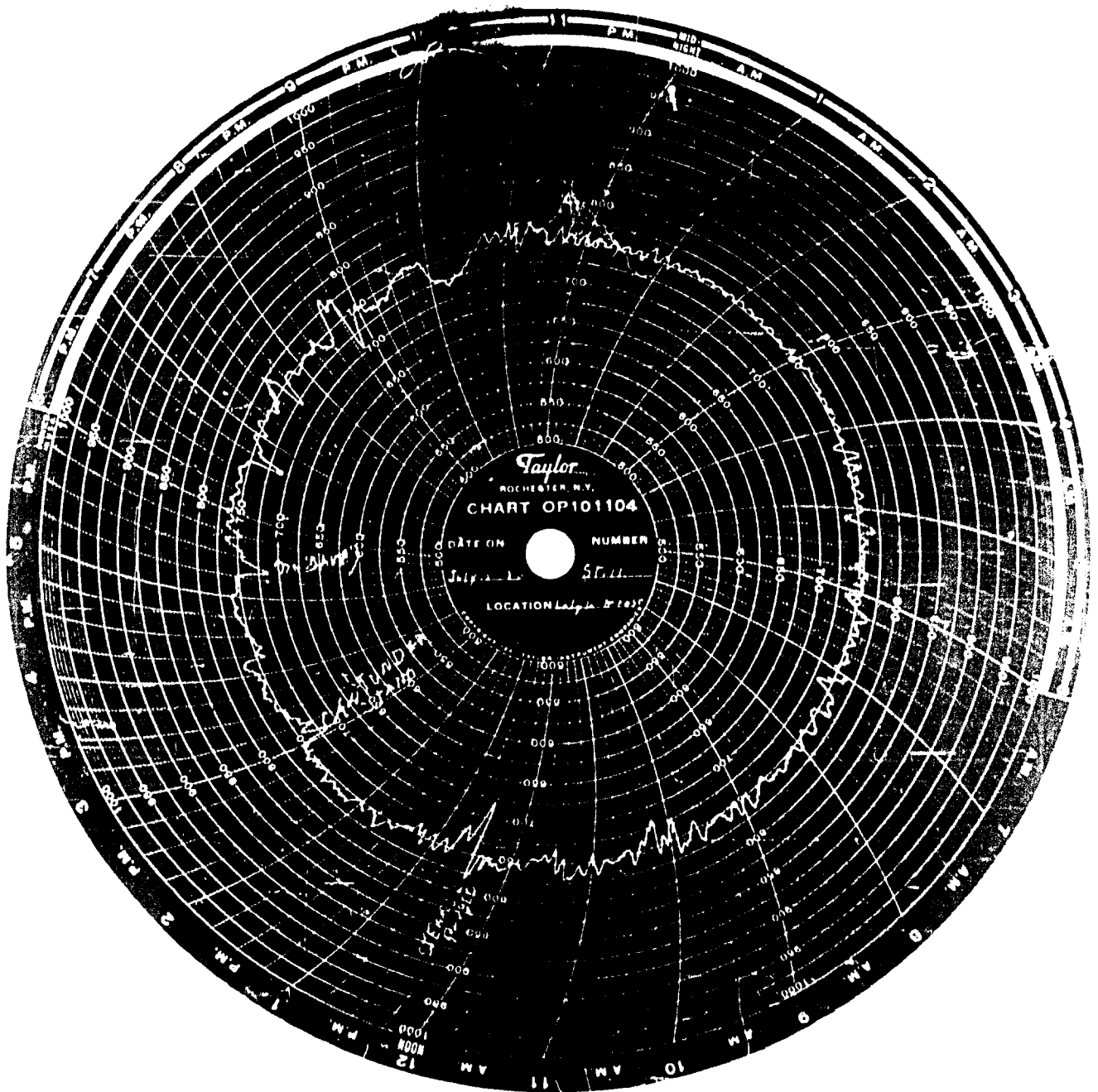


Figure 19. Temperature chart on still with automatic controls.

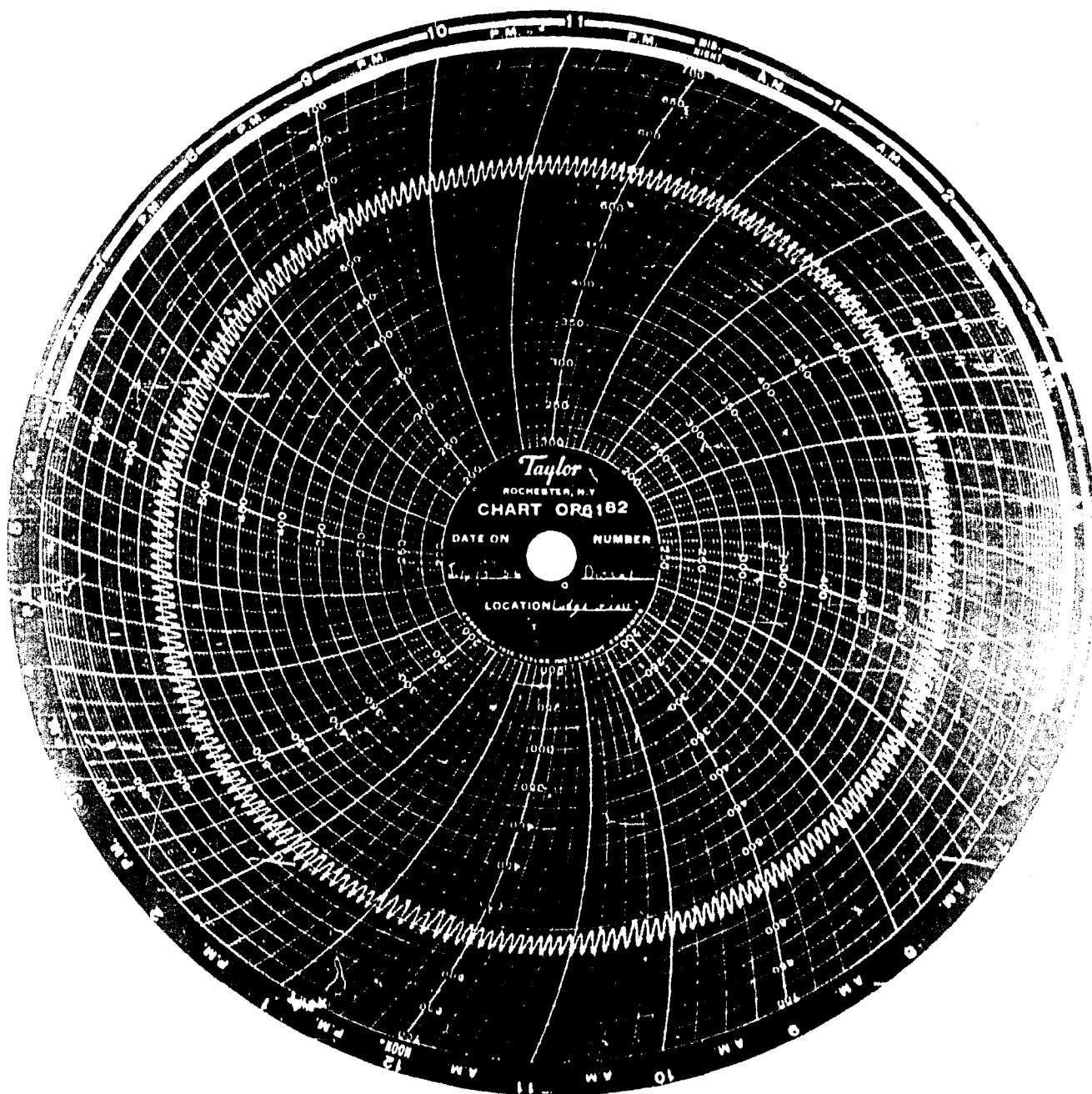


Figure 20. Temperature chart on diesel tower with automatic controls.

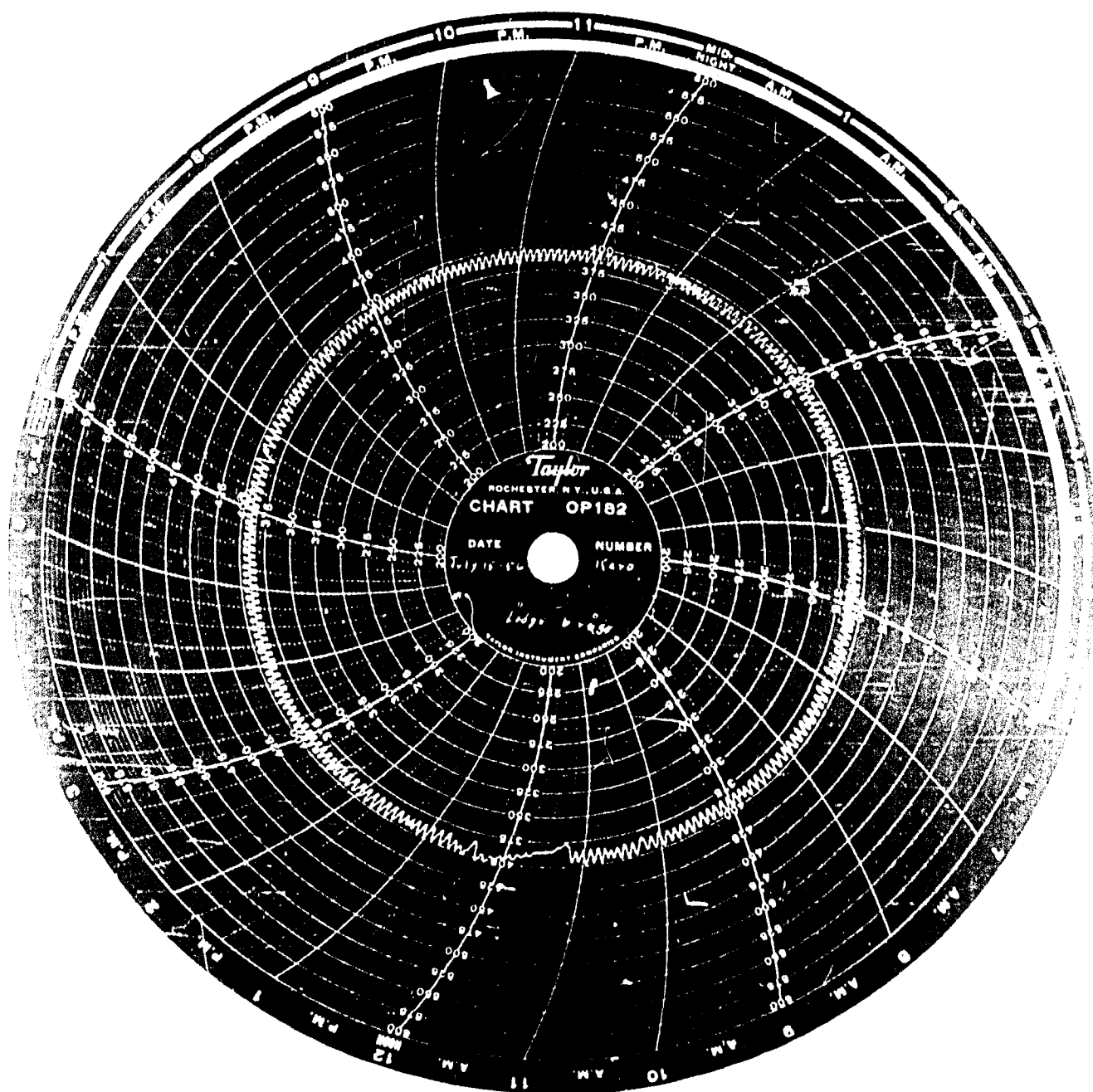


Figure 21. Temperature chart on kerosene tower with automatic controls.

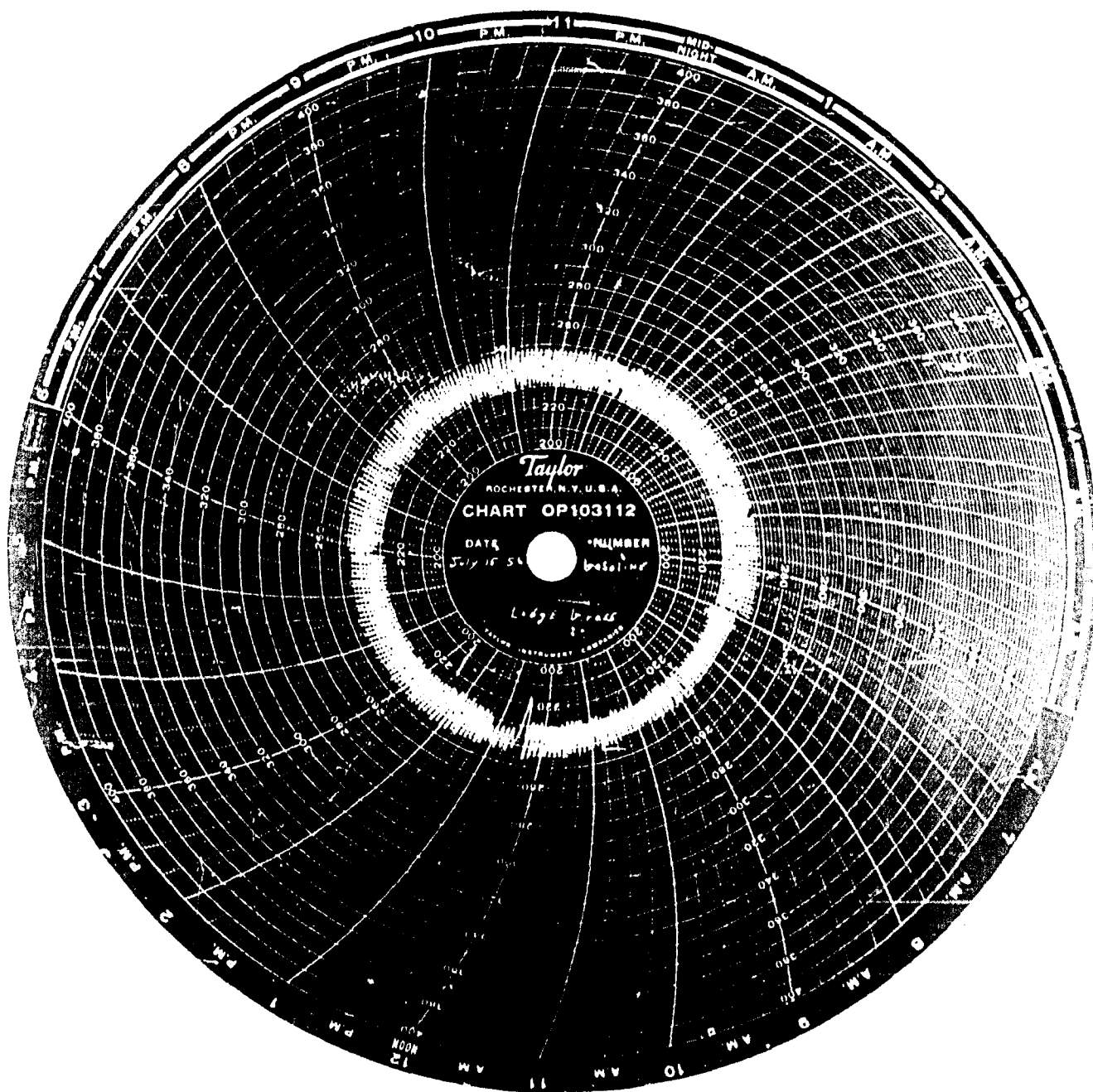


Figure 22. Temperature chart on gasoline condenser with automatic control.

APPENDIX C

OPERATING PERSONNEL

The following is a suggested staffing of officer and enlisted personnel for military operation of the topping plant. (Personnel requirements are for continuous operation 24 hours per day 7 days per week).

- | | |
|---|--------|
| 1. Lieutenant CEC Designator 5100 Billet Code 4922
(Officer in Charge) | 1 each |
| 2. Chief Petty Officer UTC (UT-6177) Assistant to
Officer in Charge and Supervisor of Operations | 1 each |
| 3. Petty Officer UT1 (UT-6177) (Operator) | 4 each |
| 4. Helper General UTCN (UT-6177) | 4 each |
| 5. Laboratory Technician BT1 (ESX-9648) | 1 each |

It is possible that plant maintenance could be performed by other military elements located in the area. However, if the plant should be located in an isolated area the following additional personnel would be required to perform maintenance work:

- | | |
|--|--------|
| 1. Petty Officer UT2 (Steamfitter) | 1 each |
| 2. Petty Officer CEG2 (Power and Lighting) | 1 each |
| 3. Petty Officer CMD2 (Diesel Mechanic) | 1 each |
| 4. Petty Officer SWS2 (Steel Worker) | 1 each |

APPENDIX D

UNFINISHED WORK -- COMPLETION ESTIMATES

A number of items will have to be completed, furnished, or designed before the topping plant can be considered to be ready for emergency use. These items are described briefly below with recommended action and estimated cost.

1. Complete the drawings and specifications on the topping plant, incorporating all changes, modifications and recommendations as a result of the testing and evaluation program. Plant to include all necessary automatic controls, recorders and related equipment required to set up the plant. Estimated cost, \$22,000.
2. Design a field-type laboratory testing kit with necessary specifications for control-testing of all petroleum products produced by the plant (including asphalt). Total estimated cost, \$500.
3. Prepare an operating manual to cover the operation of the complete topping plant including associated facilities. Total estimated cost, \$5000.
4. Design a temporary tank farm (Figures 23 and 24) for crude and petroleum products, using rubber tanks (Figures 14 and 25), hose, etc., for rapid installation. Total estimated cost, \$1000.
5. Design a semi-permanent tank farm for crude and petroleum products using bolted steel tanks, steel pipe, regular valves, etc. Total estimated cost, \$1500.
6. Design a semi-permanent tank farm similar to (5) but for asphalt products. Total estimated cost, \$600.
7. Design a knocked-down cooling tower that can be easily shipped and erected. Total estimated cost, \$2000.
8. Prepare a bill of material and specifications as required on consumable items and spare parts required to operate the plant for 90 days, giving stock numbers where available. Total estimated cost, \$2000.
9. Prepare purchase requisitions for bills of materials for all purchased items such as the water cooling tower, laboratory, and office building. Total estimated cost, \$1000.

10. Design a master plan which describes and locates all of the above into a working installation. Include in the plan all necessary buildings, generators, water facilities, pumps and pipelines, electrical equipment, tank farms, etc., plus a bill of material listing everything required to support items (1) through (7) above. Total estimated cost, \$1500.

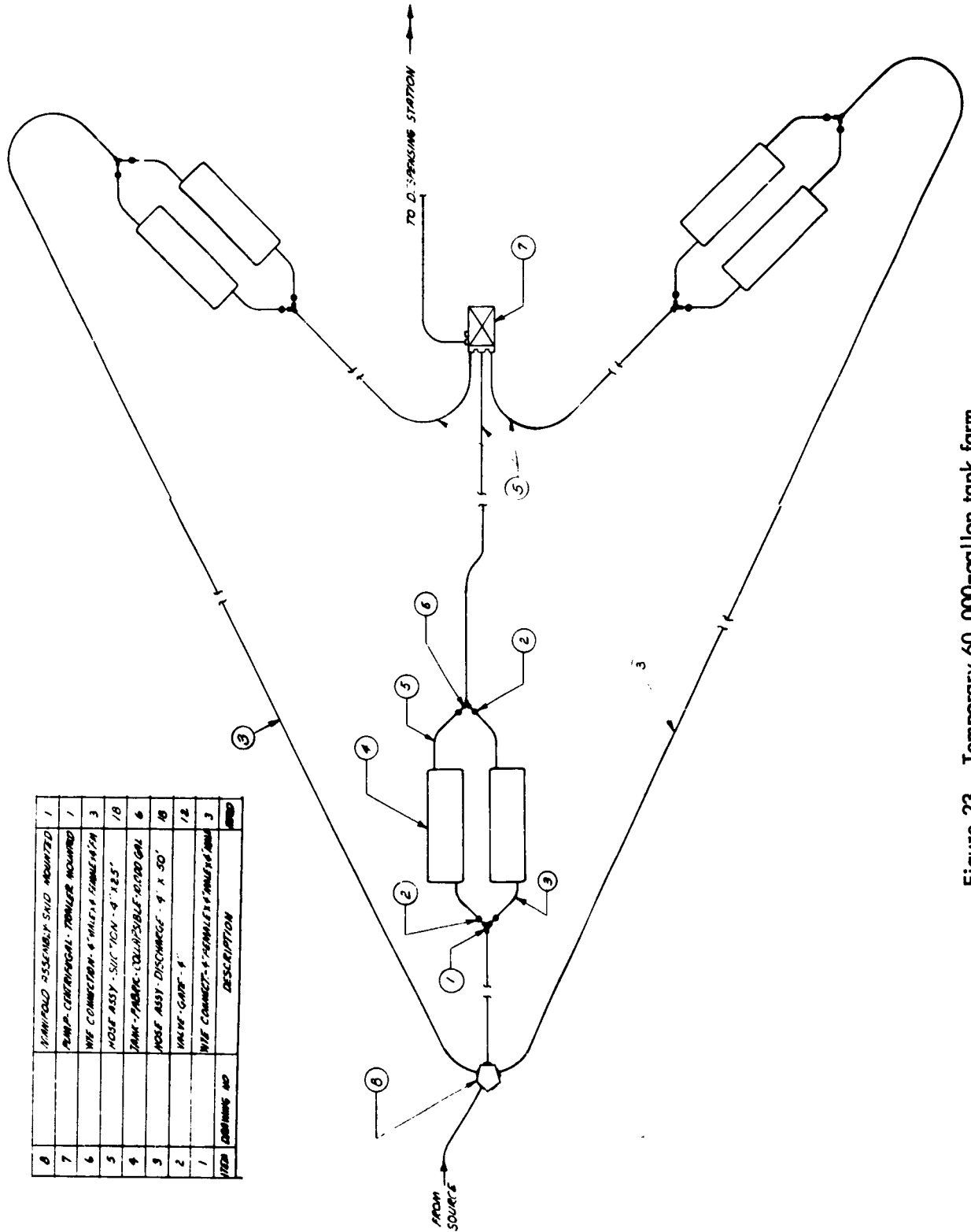
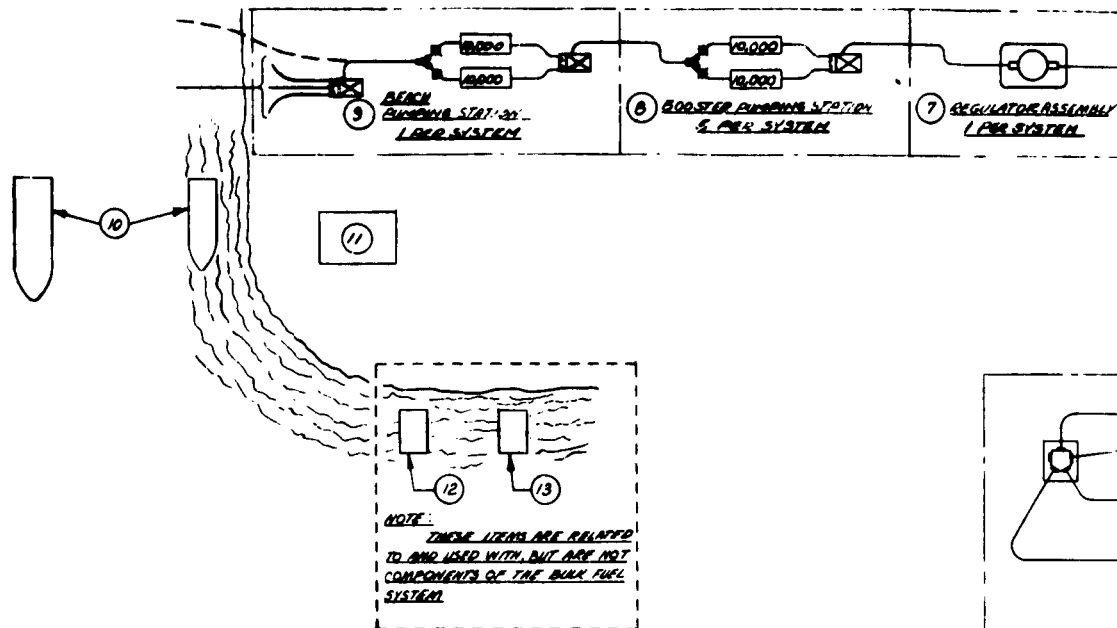
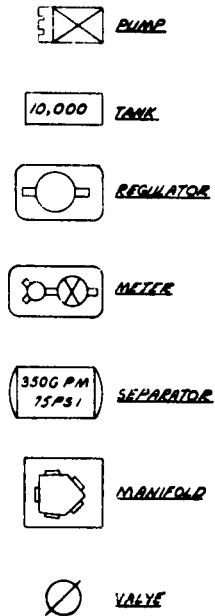


Figure 23. Temporary 60,000-gallon tank farm.

LEGEND



13		AUXILIARY ASSY -	
12		AUXILIARY ASSY	2*
11		GENERAL REPAIR KIT	1
10		ADAPTER ASSY - FUEL SHIP	2
9		PUMPING STATION - BEACH UNLOADING	1
8		PUMPING STATION - BOOSTER	5
7		REGULATOR ASSEMBLY	1
6		HOSE ASSEMBLY - DISCHARGE - 6" X 50'	300
5		DRUM UNLOADING ASSEMBLY	1
4		MANIFOLD ASSEMBLY	2*
3		CONDUIT - ROAD - 8" X 10'	12
2		TANK FARM - 9551 - 60,000 GALLON	5
1		FUEL DISPENSING ASSEMBLY	2
ITEM	DRAWING NO	DESCRIPTION	QTY

Figure 24. Temporary 300,000-gallon tank farm.



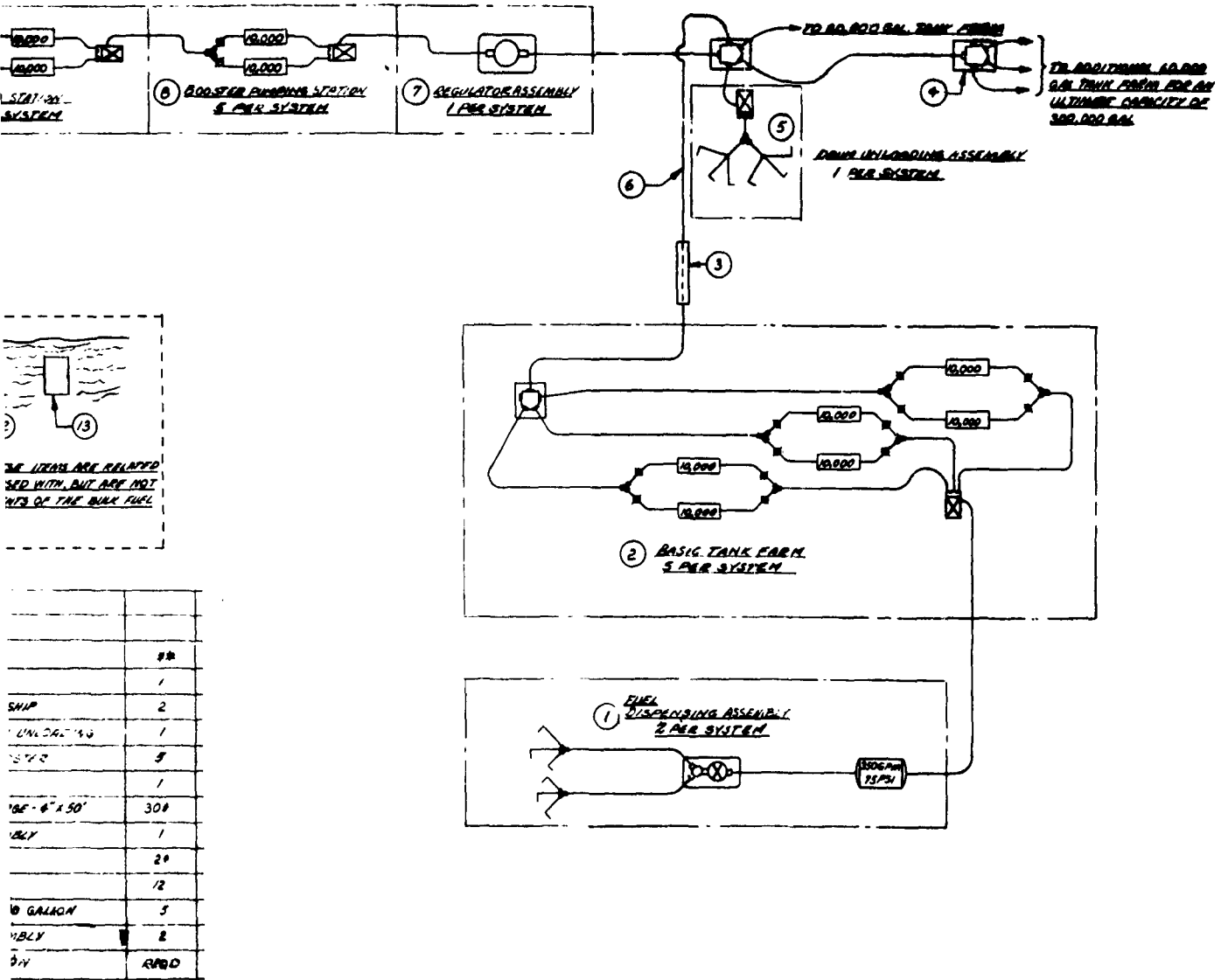


Figure 24. Temporary 300,000-gallon tank farm.

2

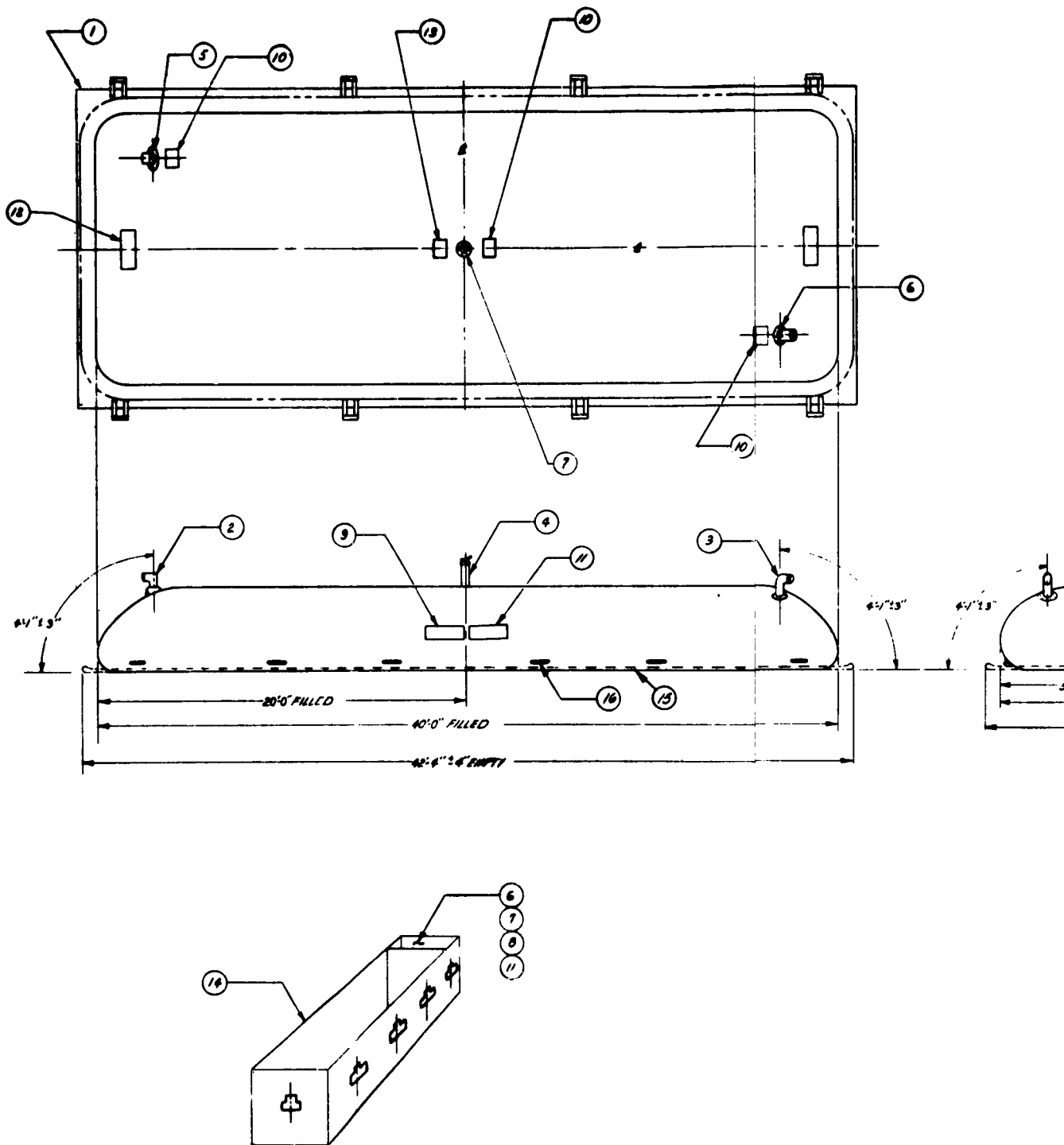
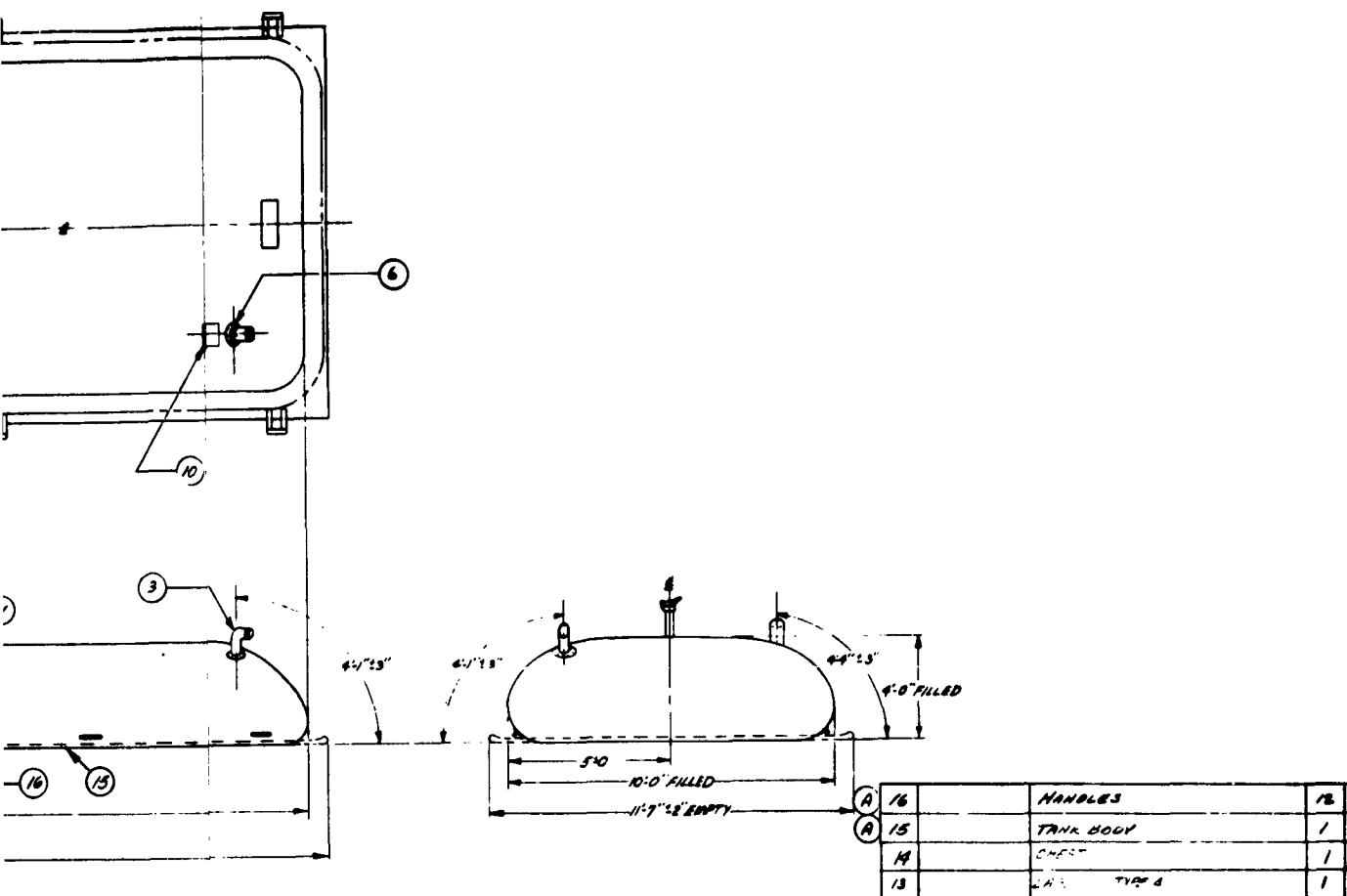


Figure 25. Plans for 10,000-gallon fabric collapsible tank.





12	LABEL TYPE 6	2
11	LABEL TYPE 5	1
10	LABEL TYPE 3	3
9	LABEL TYPE 2	1
8	REPAIR KIT	1
7	TANK FITTING - CIRCULAR	1
6	TANK FITTING - CIRCULAR	1
5	TANK FITTING - OVAL	1
4	VENT ASSEMBLY	1
3	FILLER OR DISCHARGE ASSEMBLY	1
2	FILLER OR DISCHARGE ASSEMBLY	1
1	GROUND CLOTH	1
ITEM	DESCRIPTION	QUANTITY

25. Plans for 10,000-gallon fabric collapsible tank.

2

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