WAR DEPARTMENT TECHNICAL MANUAL **TM 5-350**

MILITARY PIPE-LINE SYSTEMS

WAR DEPARTMENT · 15 NOVEMBER 1943

WAR DEPARTMENT TECHNICAL MANUAL

TM 5-350

MILITARY PIPE-LINE SYSTEMS

THIS MANUAL SUPERSEDES TM 5-350 (TENTATIVE), 1 MAY 1943

War Department • 15 November 1943

United States Government Printing Office

Washington : 1943

WAR DEPARTMENT,
WASHINGTON 25, D. C., 25 October 1943.

TM 5–350, Military Pipe-line Systems, is published for the information and guidance of all concerned.

[A. G. 300.7 (31 Aug 43).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:
B and H (3).
(For explanation of symbols see FM 21–6.)

MILITARY PIPE-LINE SYSTEMS • TM 5-350

CONTENTS

This manual supersedes TM 5–350 (Tentative), 1 May 1943.

CHAPTER 1
INTRODUCTION

1. GENERAL. This manual describes equipment, layout and planning, construction, operation, maintenance, and operating personnel organization for the portable pipe-line system designed for military use. Transmission capacities, using lightweight 4- and 6-inch pipe, are 200 and 400 barrels per hour, respectively. Associated pumping and control equipment has been designed for these capacities and for operation at 200 pounds per square inch.

2. USES FOR PIPE-LINE SYSTEM. **a.** Pipe-line systems were designed to provide a means for transmitting, distributing, and storing bulk liquids in theaters of operations, and pipe-line equipment is considered to embrace all that is necessary for carrying out such operations.

b. Pipe lines will ordinarily be used to make bulk deliveries of gasoline or water from terminals to distribution points. More specifically, they can be used for—

(1) Transmission of liquids over terrain too rugged for other means of transportation.

(2) Relief of congestion where road capacity is limited and traffic is heavy.

(3) Rapid transmission of liquids over long distances.

(4) Transmission of liquids over short distances where conditions arising from enemy action make other means of transportation impracticable.

c. Military pipe lines may also be used to ship crude petroleum from producing fields to shipping terminals or refineries.

d. Tests to determine a procedure for constructing and laying ship-to-shore submarine pipe lines are planned. Upon completion of such tests a supplementary manual outlining a recommended procedure will be issued.

CHAPTER 2
DESCRIPTION OF MILITARY PIPE-LINE EQUIPMENT

3. STORAGE.

a. Storage Tanks. Storage at terminals or loading locations normally will be in bolted steel tanks, with capacities ranging from 100 to 10,000 barrels (42 U. S. gallons equal 1 barrel). These tanks are to be supplied in accordance with American Petroleum Institute specifications, as modified for military use. (See app. I.) Bolted tanks will be shipped "knocked down" with bolts, gaskets, and fittings for erection. Pressure and vacuum release valves are supplied with all sizes of tanks.

b. Storage Barges. For temporary or semi-permanent storage at the source, there are several types of standard approved Army and Navy tank barges. These barges range in size from small ones of 21-foot beam and 43-foot length, 4-foot draft and capacity of 350 barrels, to large self-propelled barges of 43-foot beam and 107-foot length, 4-foot draft and capacity of 1,750 barrels. Discharge equipment is not a part of the barge and must be furnished as extra equipment.

c. Collapsible Containers. Collapsible containers have been developed for the storage of petroleum products, including high octane or aromatic gasoline. These cells or bags are constructed of synthetic rubber impregnated fabric, supported in suitable containers of duck or plywood panels.

(1) The cells are made for both stationary and portable service, in capacities ranging from 7½ to 3,000 gallons, and are designed for use where transportation space and time of erection are controlling factors. Figures 1 and 2 show a 3,000-gallon cell of the type used for stationary storage; figures 3 and 4 show a 2,700-gallon cell of the type used for bulk transportation by rail. There is a 750-gallon tank, similar to that shown in figure 4, which is used for bulk transportation by truck (2½-ton 6 by 6, cargo).

(2) Three men can assemble a 3,000-gallon tank in 30 minutes, but a 2,700-gallon tank for stationary storage requires about 4 hours.

(3) Complete assembly instruction is furnished with each cell. In handling collapsible containers, care must be exercised that the treated fabric is not damaged by dragging it along the ground, walking upon it, or refolding it about tools and fastenings.

4. PIPE, COUPLINGS, AND FITTINGS, INCLUDING REPAIR ACCESSORIES.

a. Pipe. Lightweight pipe of the spiral or longitudinal weld types is commonly used. The 4- and 6-inch standard sizes of pipe are made of 14- and 12-gage steel, respectively. (See app. I.) For heavy wall pipe, standard American Petroleum Institute specifications have been adopted for both 4- and 6-inch sizes. All pipe is grooved on each end to accommodate Victaulic type couplings, and is supplied in standard lengths of 20 feet. The lightweight pipe is reinforced at the grooved ends.

b. Couplings. Victaulic type flexible pipe couplings (fig. 5) are utilized for military pipe lines. They allow for some degree of angular deflection and contraction or expansion. Such couplings are composed of a malleable iron housing in two or more parts (held together by two or more track neck bolts), which mechanically engage and lock adjacent grooved or shouldered pipe ends in a positive couple. A single, continuous, hollow-moulded, composition, sealing gasket, C-shaped in cross-section, is so installed that internal pressure or vacuum serves to increase the tightness of the seal. All of the standard types of fittings, such as elbows, reducers, tees, and crosses, may be obtained at equipment pools, with grooves for use with Victaulic type couplings.

c. Gate Valves. Commercial type gate valves of either flange, screw, or weld design are available, installed in joints of pipe fabricated to 20-foot total over-all length (fig. 6). (See app. I.)

d. Check Valves. Commercial type check valves are installed in joints fabricated into 20-foot lengths for installation at any point in

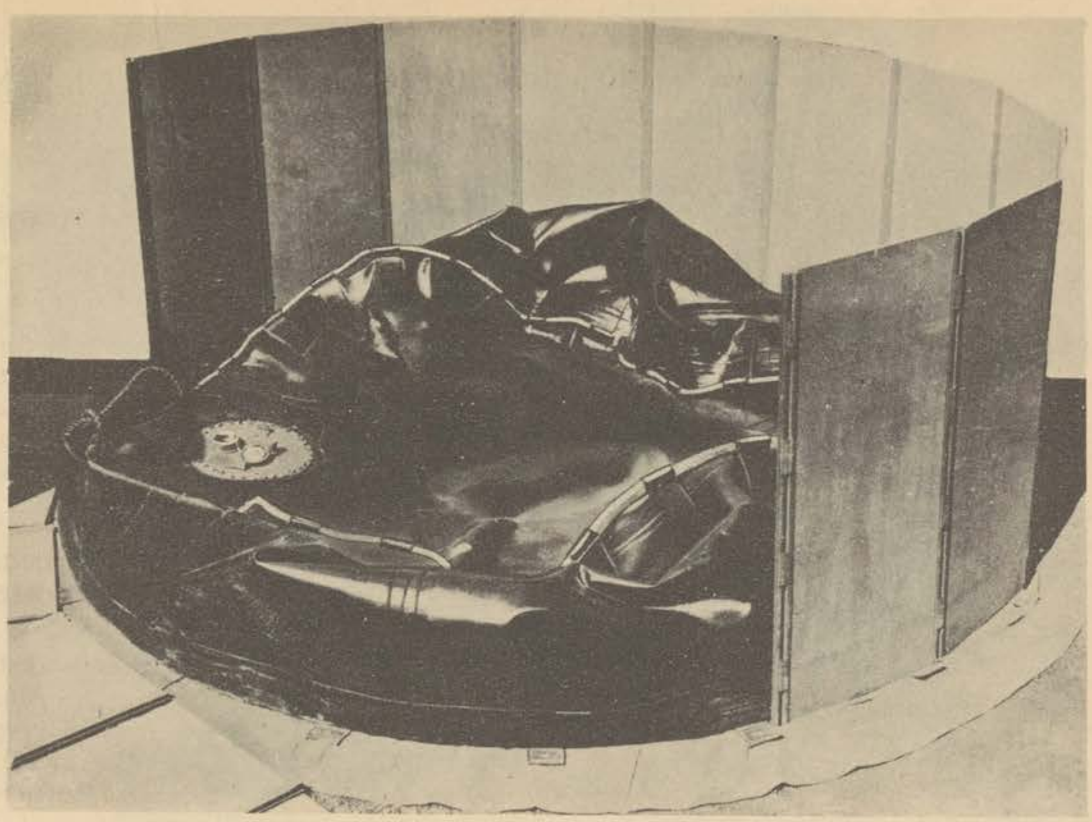


Figure 1. Stationary collapsible container, partially assembled.

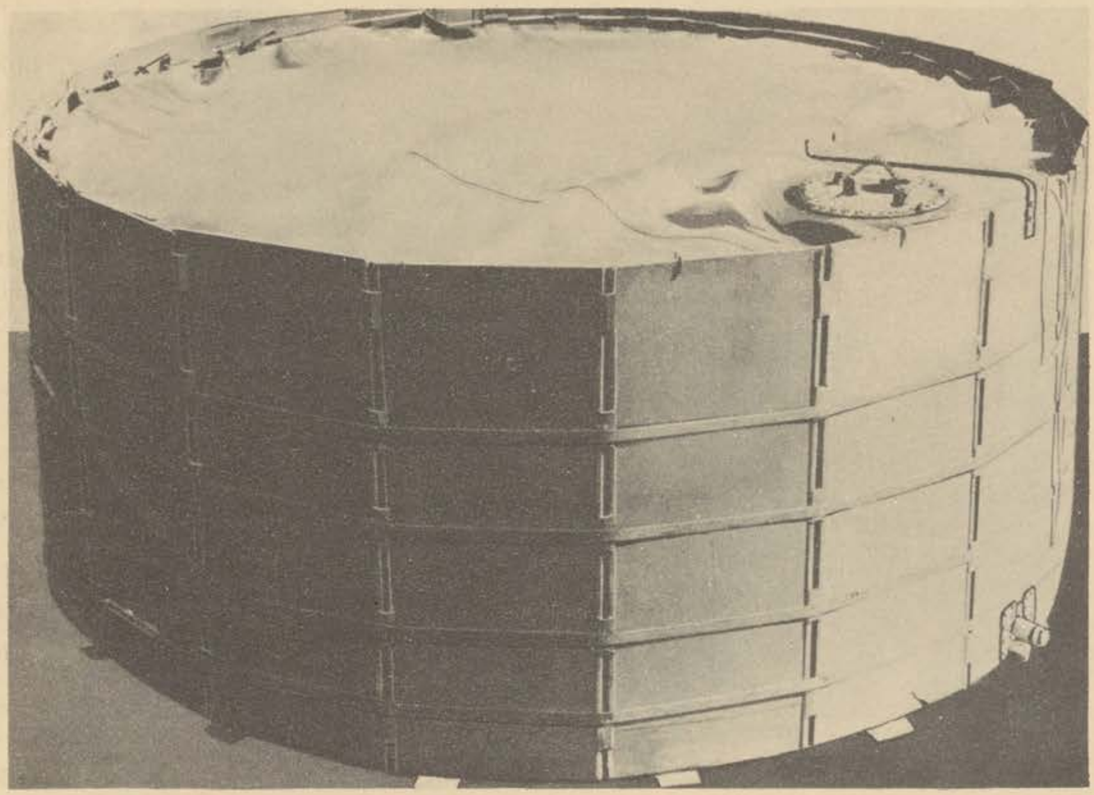


Figure 2. Stationary collapsible container, capacity 3,000 gallons.

Figure 3. Transport collapsible container, partially assembled.

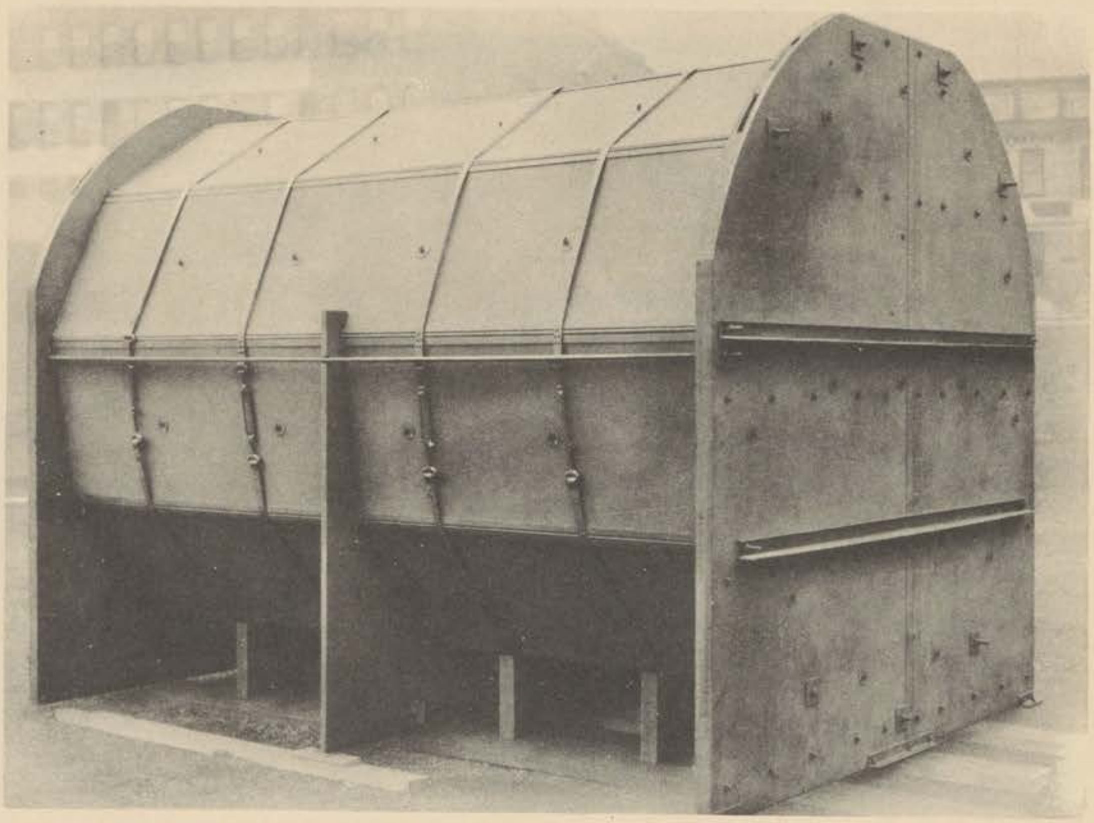


Figure 4. Transport collapsible container, capacity 2,700 gallons.

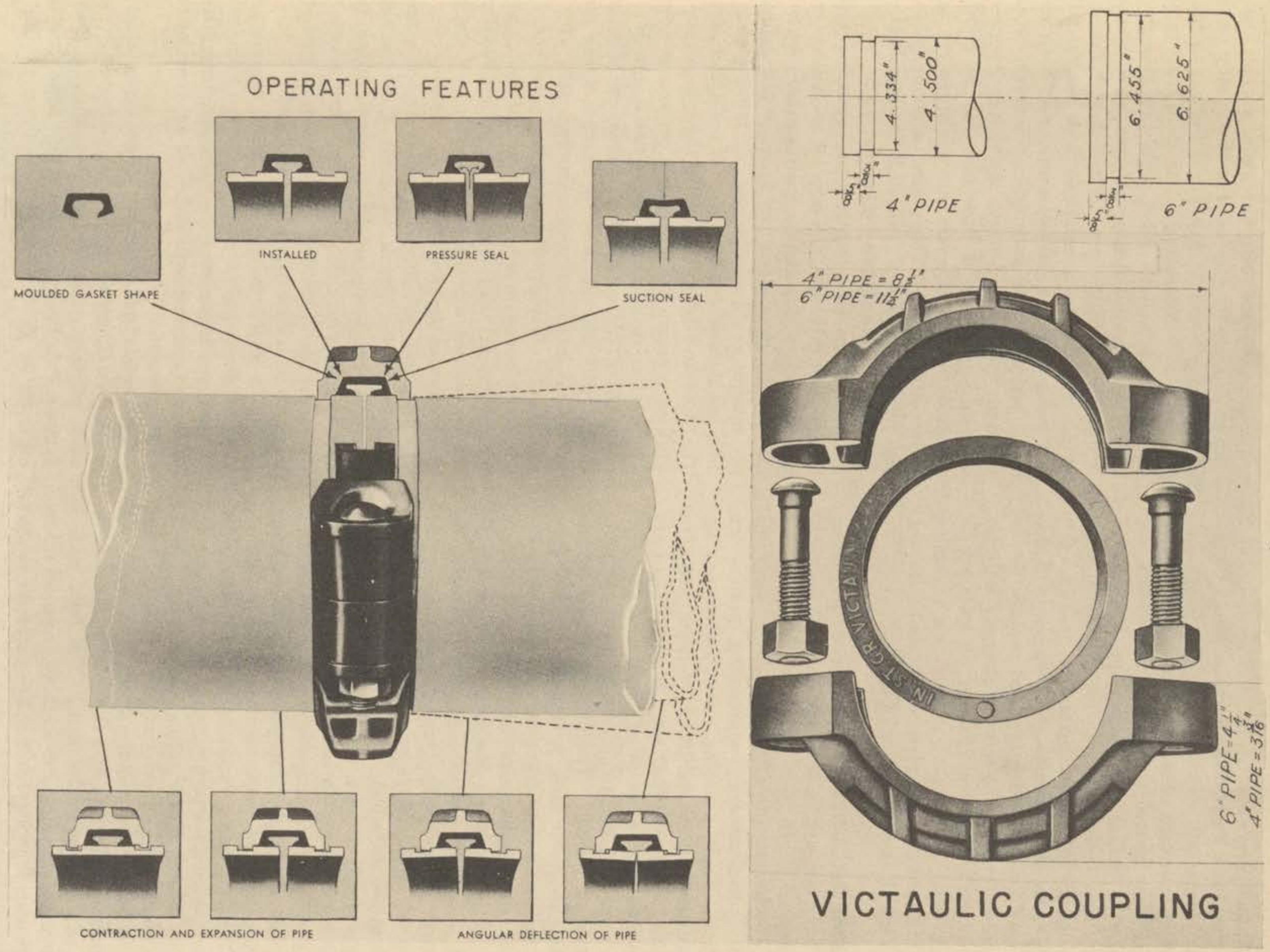


Figure 5. Victaulic coupling.

the line. There are two types now in use, both combination check-gate valves, the nonreversible (fig. 7), and reversible (fig. 8).

e. Pressure Reducing Regulators. Diaphragm-actuated, spring-loaded regulators are furnished to reduce pressure, such as on downhill lines. These pressure reduction regulators are installed in 20-foot sections of pipe, the ends of which have been grooved for Victaulic type couplings (fig. 9). (See app. I.)

f. Repair Accessories. Entire joints of this pipe may be replaced easily and rapidly, hence equipment for repairing minor leaks only is necessary. Such equipment consists of split repair clamps (figs. 10 and 11), saddle repair clamps (fig. 12), and Dresser type split clamps for use over Victaulic type couplings (fig. 13).

5. PUMPING UNITS. Two types of pumps have been adopted as standard for military pipe-line service.

a. Reciprocating Pumps. Two sizes of positive displacement reciprocating pumps are standard. Small pumping stations are made up in five sections to facilitate transport and to simplify installation (fig. 14). These sections are pump and engine mounted on a common skid base, sand trap, discharge header, main-line pipe, and suction header. The main-line pipe section is interchangeable with a standard 20-foot pipe joint and is fitted with connections leading to the suction and discharge of the pump. The sand trap section connects the pump suction to the main line. The discharge header connects the discharge of the pump through the suction and discharge relief valves and the discharge gate valve to the main line. Each pumping station is complete with all pipe, valves, and controls, and is ready for field installation and operation. Large size positive displacement pumping stations are equipped with engine and pump on separate skids and are, therefore, made up of six sections (fig. 15).

(1) The small-size reciprocating pumping unit has a Gaso duplex piston pump, 4½-inch bore by 6-inch stroke, double-acting, driven by V-belt. This pump has a capacity of 200 barrels per hour or 140 gallons per minute at 90 revolutions per minute, and operates at a differential pressure of 200 pounds per square inch. The fluid end is constructed to withstand working pressures up to 750 pounds per square inch. The pump is powered with a six-cylinder Buda, model K–428, 4⅜-inch bore by 4¾-inch stroke, spark ignition, water-cooled, industrial, gasoline engine. This engine is rated at 96 horsepower under continuous load, which is approximately double the horsepower required to operate the pump under normal load. Gasoline supply for the engine will normally come from the main line, if gasoline is being pumped, by means of a double valve line from the top of the sand trap to a 45-gallon supply tank located under the engine hood, and from there to the engine by gravity flow. For other types of service the engine is equipped with an electric fuel pump so that a gasoline supply may be taken from can, drum, or underground storage, when required. A synchro-start, ignition-interrupter, overspeed governor is provided (fig. 16 shows schematic wiring diagram for synchro-start ignition interrupter). The engine is connected to the pump through a twin-disk, hand-operated clutch (figs. 18 and 19). (See app. I.)

(2) Each large size reciprocating pumping unit has a V-belt driven, 4-inch bore by 10-inch stroke, Gaso double acting duplex piston pump, with a capacity of 200 barrels per hour or 140 gallons per minute at 70 revolutions per minute and a differential pressure of 400 pounds per square inch. The fluid end of the pump is built to stand a working pressure of 750 pounds per square inch. The engine on the large pump unit is a Buda model JL–877, four-cylinder, four-cycle, gasoline engine, with 6½-inch bore by 7⅛-inch stroke and 877 cubic inches displacement (fig. 20). It is capable of delivering 100 percent more power than the rated horsepower requirement of the pump, when equipped with 4-inch liners. Specifications for accessories are the same as for the engine used to power the small units.

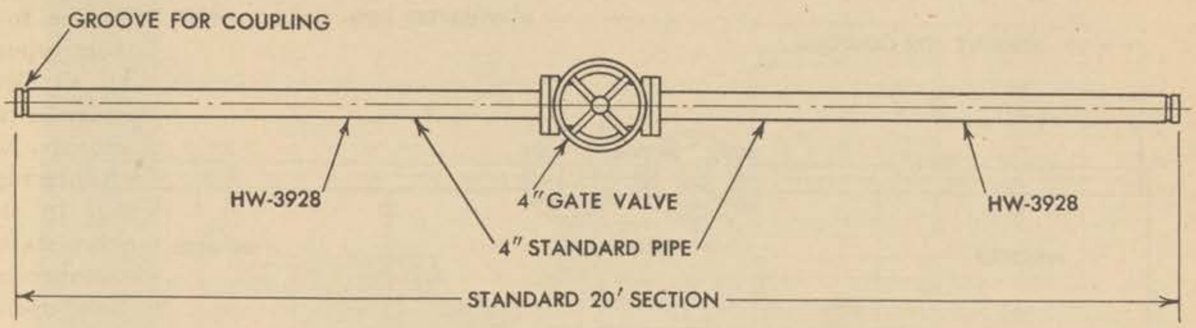
(3) The small pumping unit is mounted on a skid, fabricated from 6-inch H-beams and channels, which is sufficiently strong to permit lifting the unit on and off a truck or trailer. In the case of the larger unit, this skid base is made in two sections, to be bolted together in the field.

(4) For a further description of the two sizes of positive displacement pumps and their respective engines, see Manufacturers Parts and Instruction Manual, furnished with each unit as a part of the tool equipment.

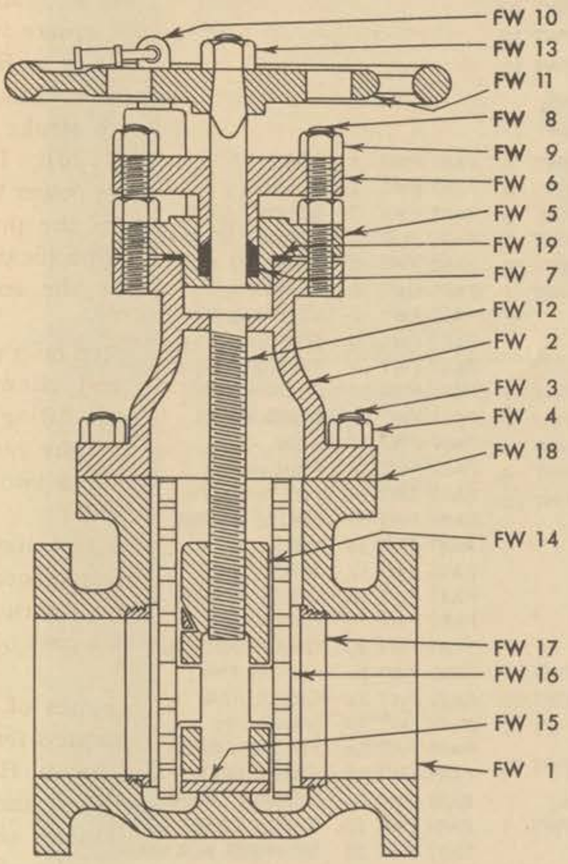
b. Centrifugal Pumps. Two types of centrifugal pumping units have been adopted for use with military pipe-line systems; one, a Byron Jackson Pup Pump for use on pipe lines, and the other an A. D. Cook deep-well pump for use in pumping from underground storage tanks. Specifications of the pup unit are as follows:

(1) The pump consists of a two-stage close-coupled

GATE VALVE



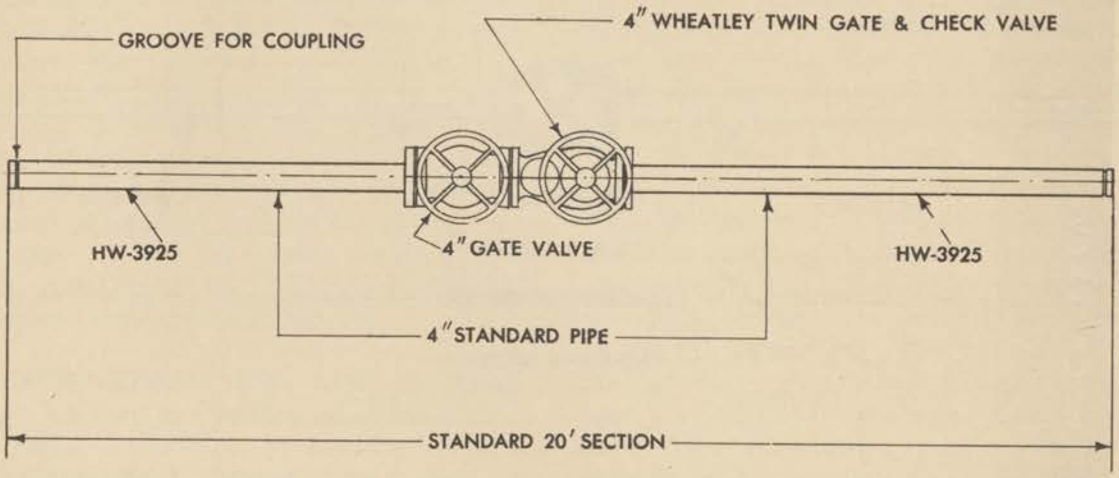
VALVE PIPE SECTION

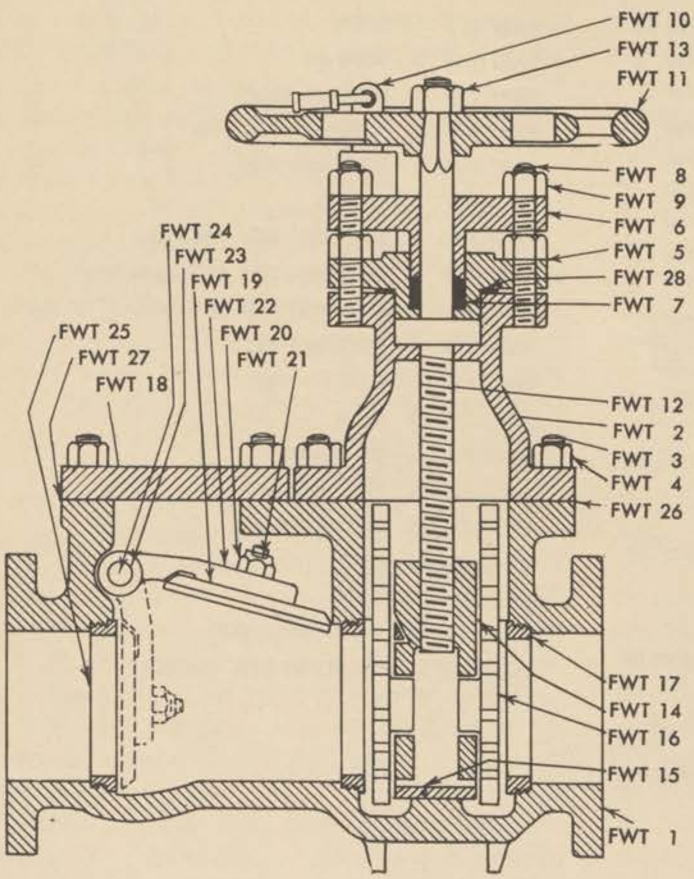


PART FW 1 BODY
PART FW 2 BONNET
PART FW 3 BONNET STUD
PART FW 4 BONNET STUD NUT
PART FW 5 STUFFING BOX
PART FW 6 GLAND
PART FW 7 STUFFING BOX PACKING
PART FW 8 STUFFING BOX & GLAND STUD
PART FW 9 STUFFING BOX & GLAND STUD NUT
PART FW 10 LOCKING PIN
PART FW 11 HAND WHEEL
PART FW 12 STEM
PART FW 13 STEM NUT
PART FW 14 NUT WEDGE
PART FW 15 LOOSE WEDGE
PART FW 16 DISC
PART FW 17 SEAT
PART FW 18 BONNET GASKET
PART FW 19 STUFFING BOX GASKET

Figure 6. Gate valve.

CHECK & GATE VALVE PIPE SECTION





PART FWT 1	BODY
PART FWT 2	BONNET
PART FWT 3	BONNET STUD
PART FWT 4	BONNET STUD NUT
PART FWT 5	STUFFING BOX
PART FWT 6	GLAND
PART FWT 7	STUFFING BOX PACKING
PART FWT 8	STUFFING BOX, GLAND STUD
PART FWT 9	STUFFING BOX, GLAND NUT
PART FWT 10	LOCKING PIN
PART FWT 11	HAND WHEEL
PART FWT 12	STEM
PART FWT 13	STEM NUT
PART FWT 14	NUT WEDGE
PART FWT 15	LOOSE WEDGE
PART FWT 16	DISC
PART FWT 17	SEAT
PART FWT 18	CHECK COVER
PART FWT 19	CHECK DISC
PART FWT 20	CHECK DISC NUT
PART FWT 21	COTTER PIN
PART FWT 22	CHECK ARM
PART FWT 23	HINGE PIN
PART FWT 24	PIN HOLE PLUG
PART FWT 25	CHECK SEAT
PART FWT 26	BONNET GASKET
PART FWT 27	CHECK COVER GASKET
PART FWT 28	STUFFING BOX GASKET

Figure 7. Check and gate valve pipe section.

DOUBLE GATE AND REVERSIBLE CHECK VALVE

SYNTHETIC SEAL ON CHECK IS OPTIONAL

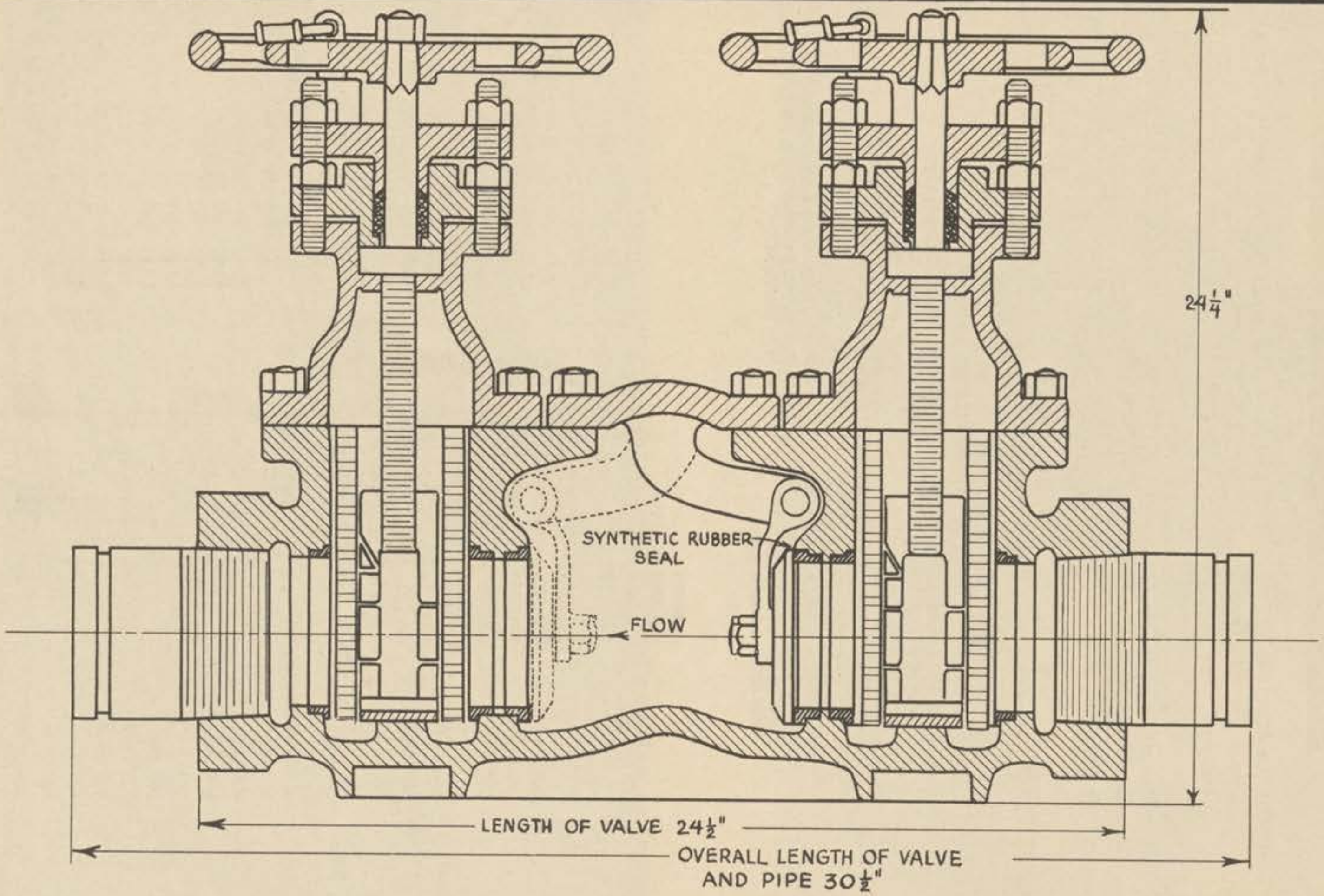
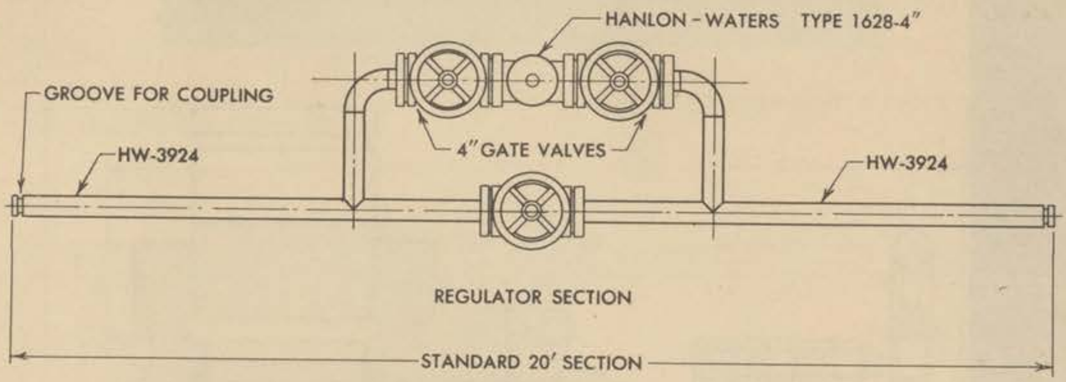


Figure 8. Double gate and reversible check valve.

4″ PRESSURE REDUCING STATION



PARTS LIST

HW-107	SPRING CAP
HW-139-A	BODY GASKETS
HW-142-B	SPRING
HW-1909	SPRING
HW-2037	VALVE STEM BUSHING
HW-2765	ADJUSTING SCREW
HW-2820	UPPER SEAT RING
HW-2821	LOWER SEAT RING
HW-2899	SPRING SEAT
HW-3776	UPPER DISC
HW-3778	LOWER DISC
HW-3905	DIAPHRAGM PLATE
HW-3908	UPPER BACK-UP PLATE
HW-3909	UPPER PLUG GUIDE
HW-3910	LOWER PLUG GUIDE
HW-3911	DIAPHRAGM
HW-3933	VALVE STEM
A-791	BOTTOM PLATE
A-792	LOWER DIAPHRAGM CASING
A-793	UPPER DIAPHRAGM & SPRING CASE
A-797	VALVE BODY

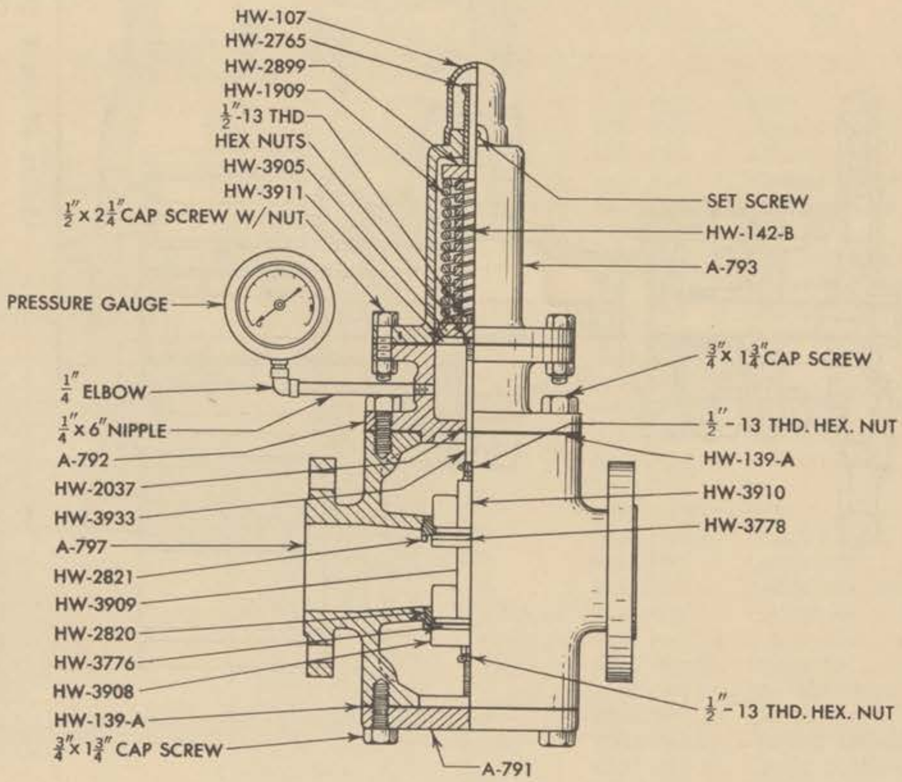


Figure 9. Regulator and regulator section for downhill installations.

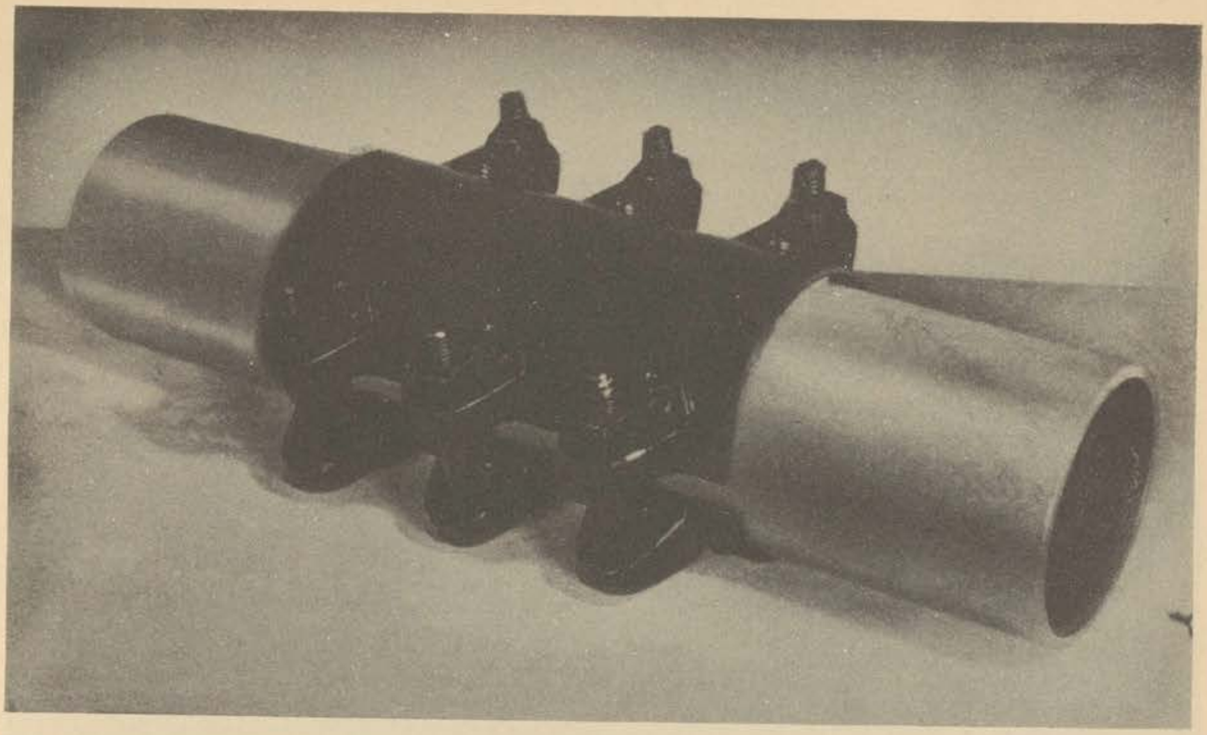


Figure 10. Split repair clamp made up of two half-shells.

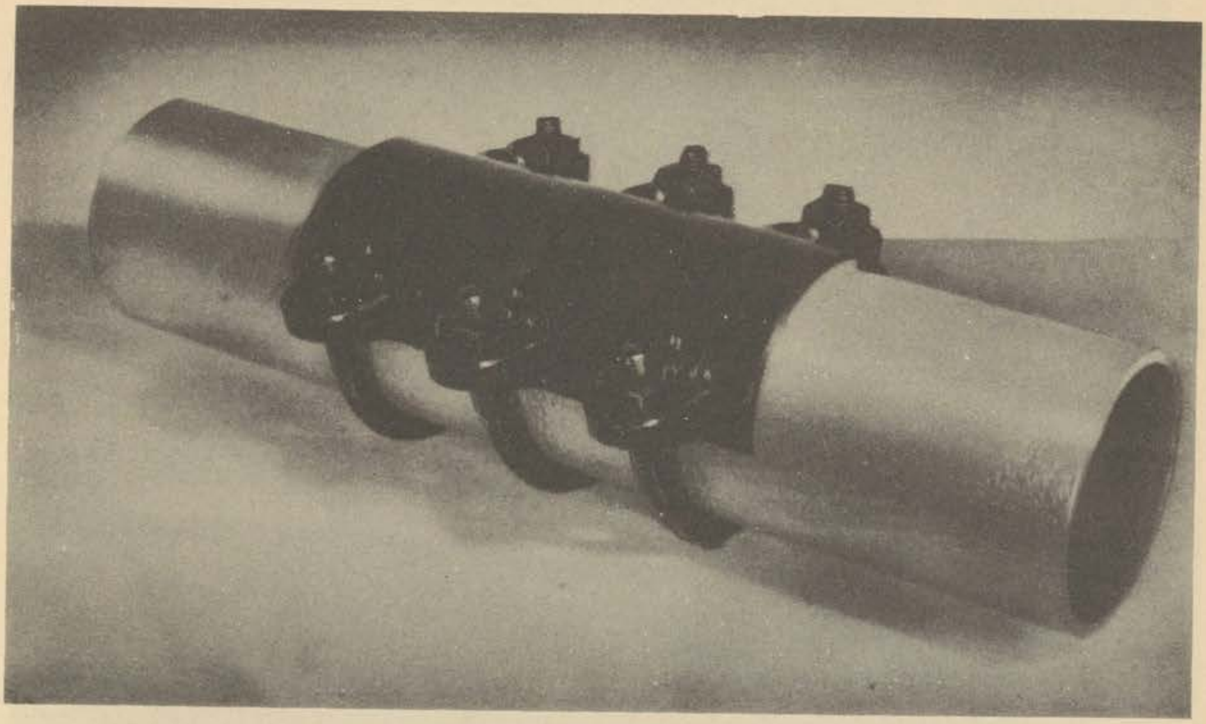


Figure 11. Half-shell of split repair clamp used with stirrup bolts.

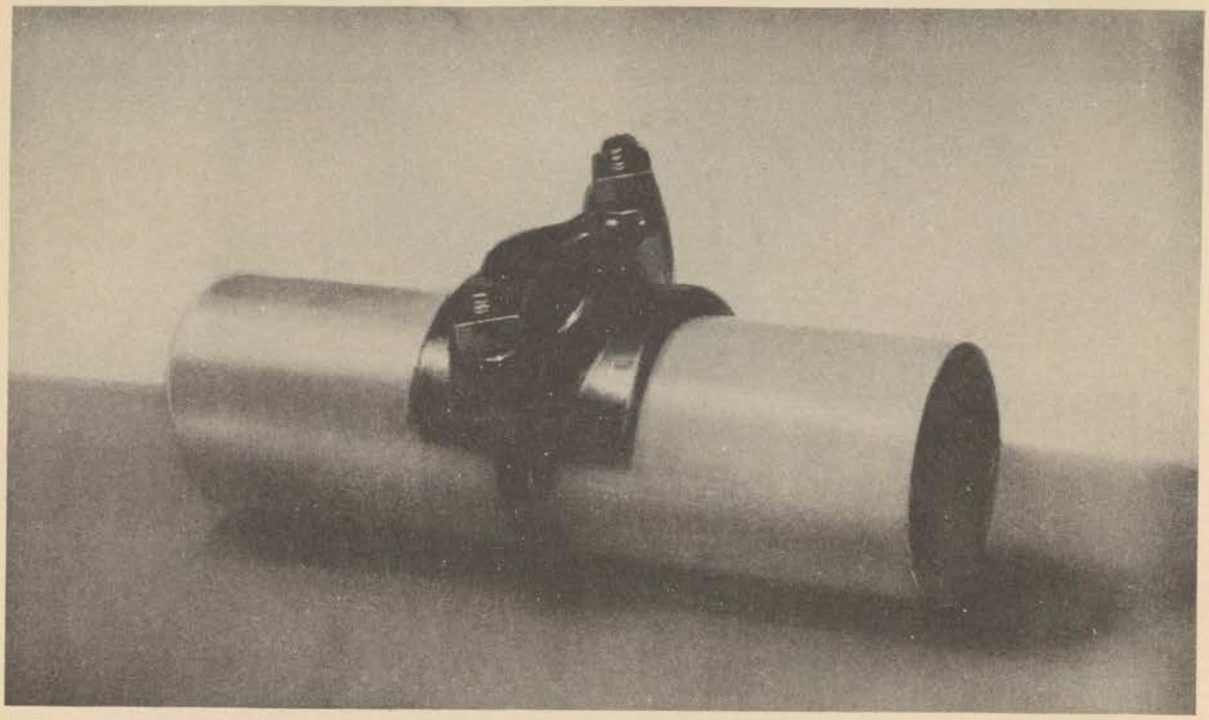


Figure 12. Saddle repair clamp.

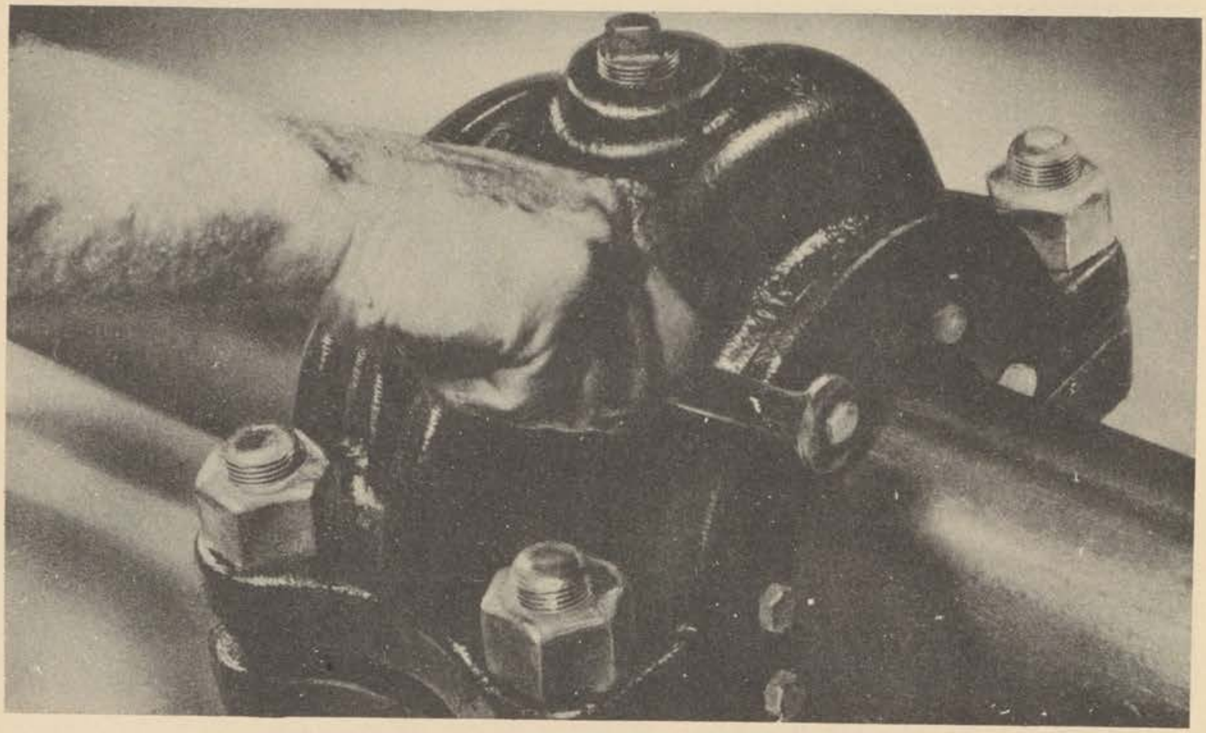


Figure 13. Dresser type split clamp for use over Victaulic type couplings.

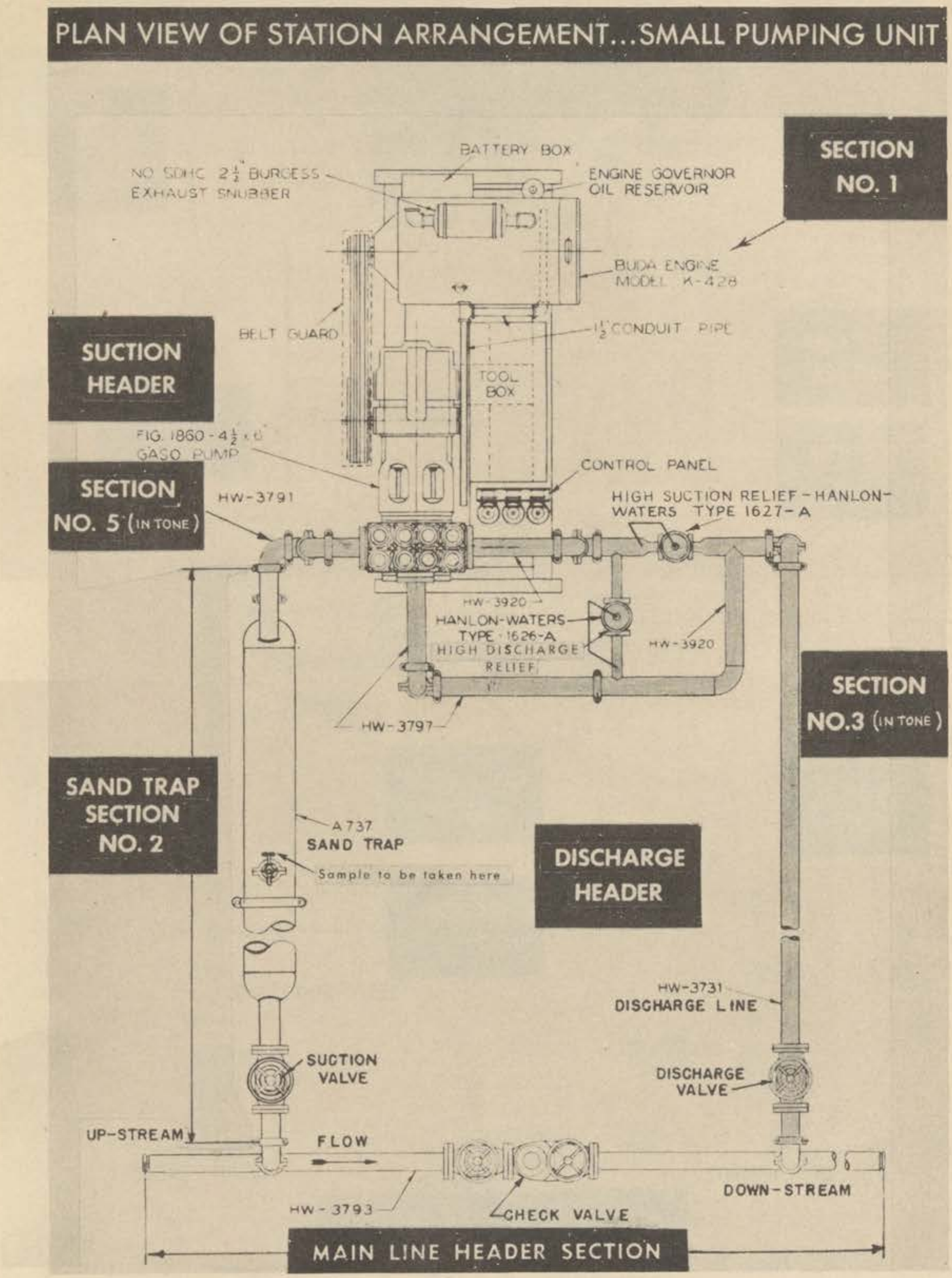


Figure 14. Plan view of small reciprocating pump station arrangement.

PLAN VIEW OF STATION ARRANGEMENT.. LARGE PUMPING UNIT

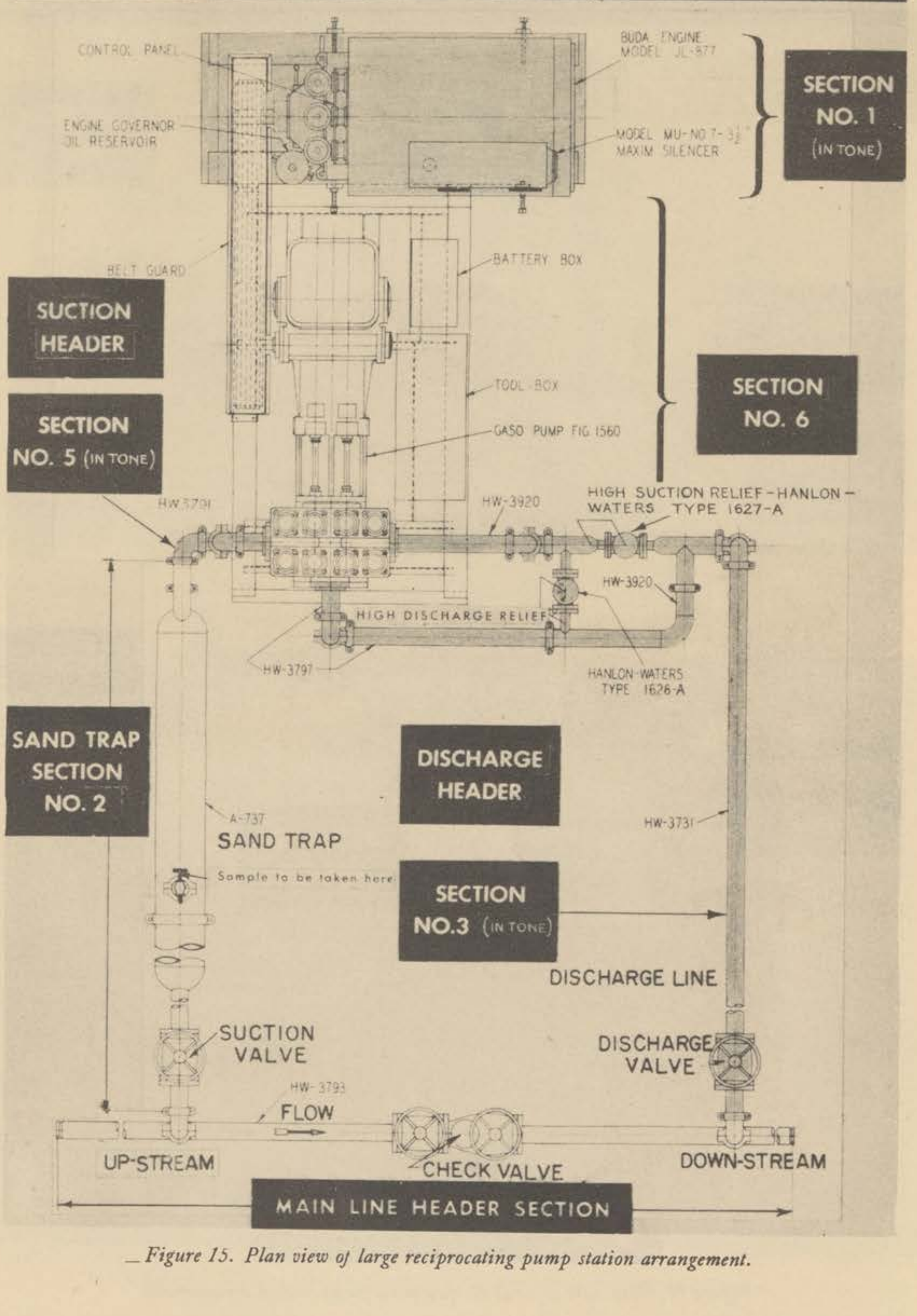


Figure 15. Plan view of large reciprocating pump station arrangement.

WIRING DIAGRAM SYNCHRO-START IGNITION INTERRUPTER

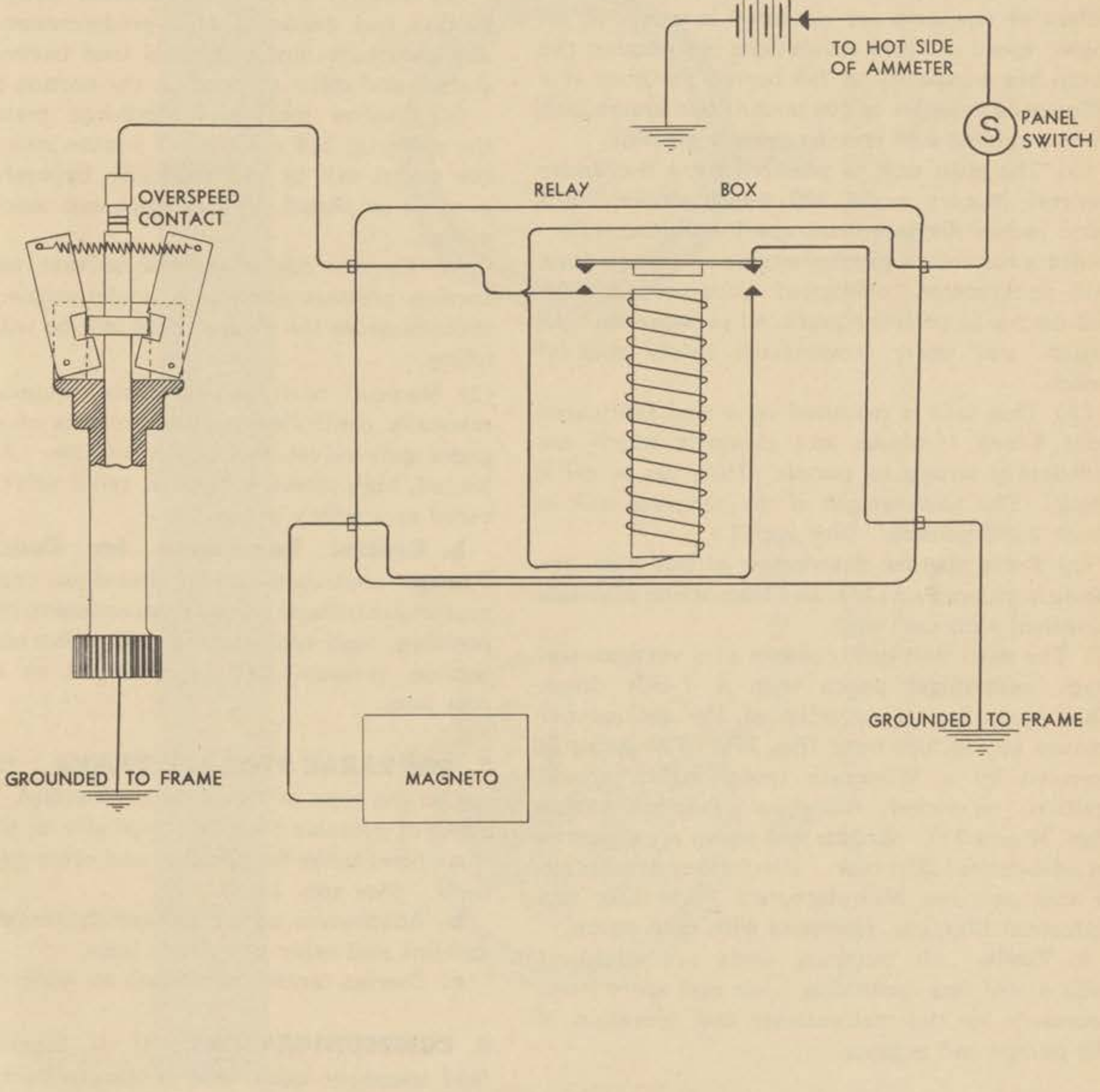


Figure 16. Wiring diagram, synchro-start ignition interrupter.

centrifugal pump connected to a gear speed increaser built integrally with the pump (figs. 21 and 22). Connection to the engine is by means of a flexible coupling. The pump has two suction nozzles beneath and two discharge nozzles above, of the 4-inch Victaulic type, all of which are on the same side of the pump. Connecting pipe is supplied so that the two stages may be run either in series or in parallel (figs. 23 and 24). All pump parts are designed for a maximum working pressure of 700 pounds per square inch so that two units can be safely run in series. When the two impellers of one unit are operated in series at an engine speed of 1,950 revolutions per minute, the pump has a capacity of 200 barrels per hour at a differential pressure of 200 pounds per square inch when pumping 0.68 specific gravity gasoline.

(*a*) The *pup* unit is powered by a 6-cylinder General Motors model 270, 4-inch stroke, 269.5 cubic inches displacement, spark-ignition, water-cooled, automotive, gasoline engine. It is equipped with tachometer, overspeed governor, suction and discharge pressure gages, oil pressure shut-off switch, and water temperature safety shut-off switch.

(*b*) This unit is mounted on a skid fabricated from 8-inch H-beams and channels which are sufficiently strong to permit lifting on or off a truck. The total weight of the complete unit is about 2,000 pounds. (See app. I.)

(c) For a further description of this unit, see Manufacturers Parts List and Instruction Manuals furnished with each unit.

(2) The deep well unit consists of a vertical, six-stage, centrifugal pump with a V-belt drive. This pump has a capacity of 150 gallons per minute at 150-foot head (fig. 25). The pump is powered by a Wisconsin model AHH, spark-ignition, air-cooled, industrial, gasoline engine (figs. 26 and 27). Engine and pump are mounted on a fabricated skid base. For further description of this unit see Manufacturers Parts List and Industrial Manuals, furnished with each pump.

c. Tools. All pumping units are equipped with a tool box containing tools and spare parts necessary for the maintenance and operation of the pumps and engines.

6. CONTROL EQUIPMENT. This equipment may be either automatic or manual.

a. Control Equipment for Reciprocating pumps.

(1) Automatic control equipment supplied is manufactured by Hanlon-Waters, Inc., and is the conventional diaphragm-actuated, spring-loaded type used in conjunction with hydraulic engine speed governors. This control equipment is mounted on the engine-control panel and is an integral part of the pumping unit. It is capable of performing the following functions automatically:

(*a*) Control pumping rate so that the liquid received is pumped at a rate to maintain a predetermined suction pressure.

(*b*) Control pressure differential between the suction and discharge at a predetermined limit, and distribute any additional load between that station and other stations on the suction side.

(c) Control maximum discharge pressure of the pump at 650 pounds per square inch so that the pump will be automatically bypassed when a valve is closed on the discharge side of the pump.

(*d*) Control engine throttle so that when the suction pressure exceeds a predetermined maximum pressure the engine speed will be reduced to idling.

(2) *Manual controls*. Control equipment for manually controlled stations consists of pressure gages, gate valves, and engine throttle. A spring-loaded, high-pressure, bypass, relief valve is provided as a safety device.

b. Control Equipment for Centrifugal Pump. Automatic safety shut-down controls to protect centrifugal pumps from excessive discharge pressure, high temperature, and abnormally low suction pressure will be provided on military pipe lines.

7. PORTABLE STORAGE TANKS. Depending on the type of liquid to be handled, various types of portable tanks are available as follows:

a. Steel tanks for gasoline and other petroleum fuels. (See app. I.)

b. Adaptation of the collapsible container for gasoline and other petroleum fuels.

c. Canvas tanks can be used for water storage.

8. COMMUNICATIONS. U. S. Signal Corps field telephone equipment is standard for service with military pipe lines. Field radio and messengers may be also used. Field Manuals should be consulted for details on operation, installation, and maintenance of these types of communication systems.

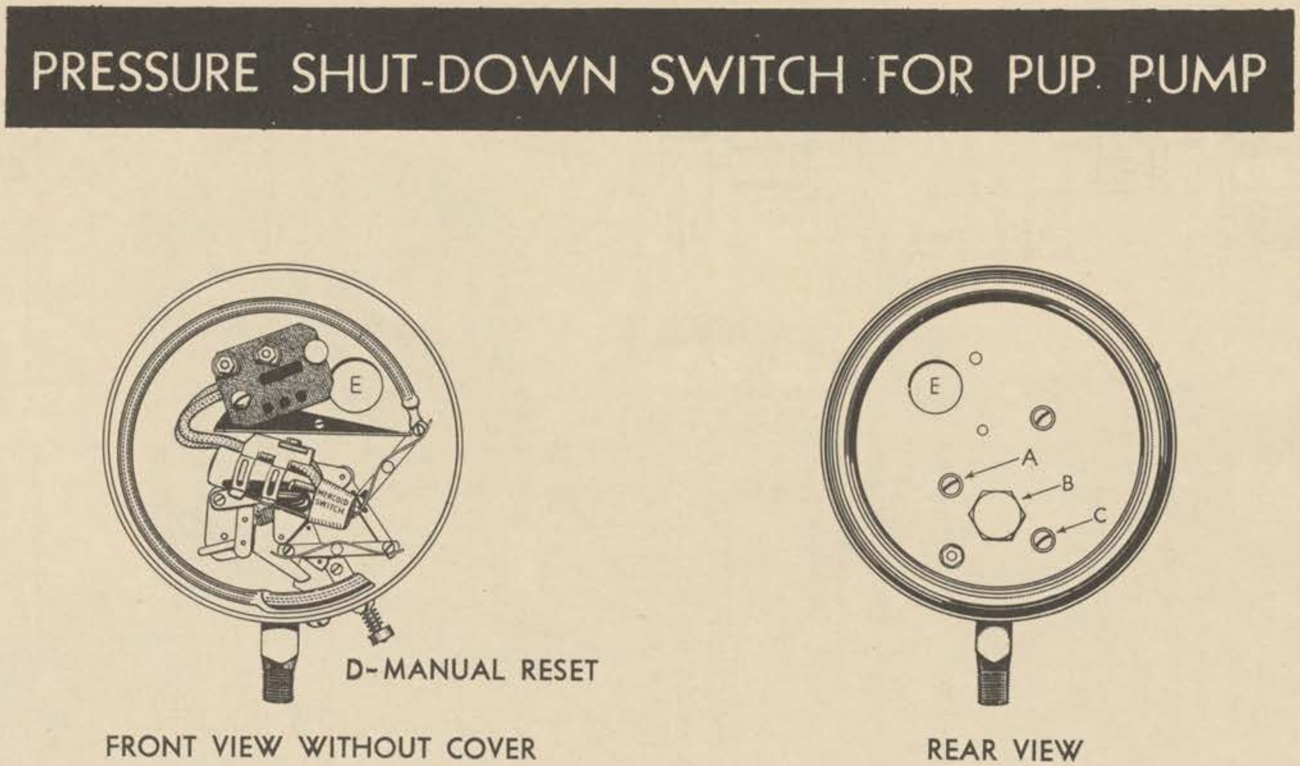


Figure 17. Pressure shut-down switch for Pup Pump.

DIMENSION DRAWING SMALL PUMPING UNIT

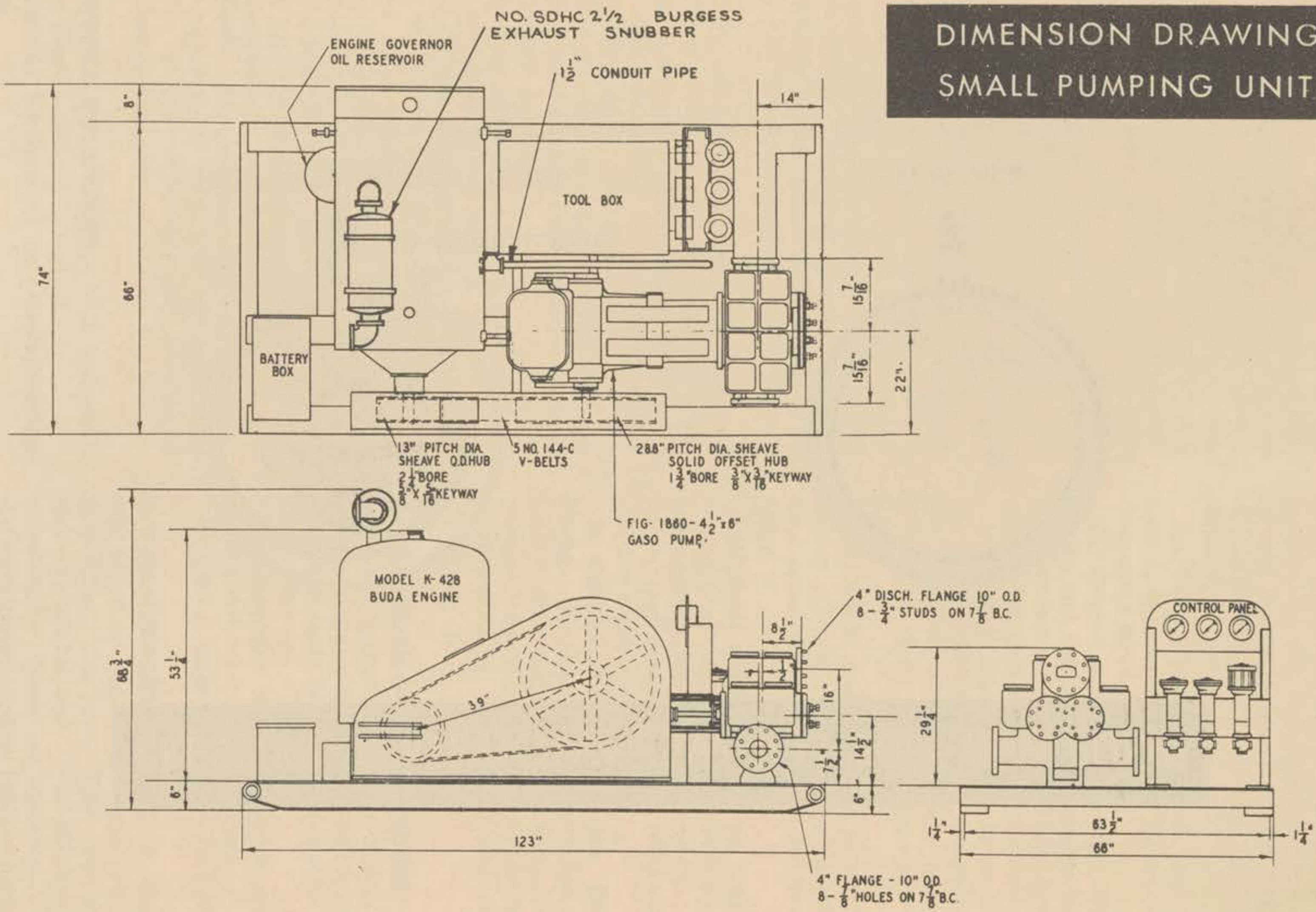


Figure 18. Dimension drawing of small reciprocating pump unit.

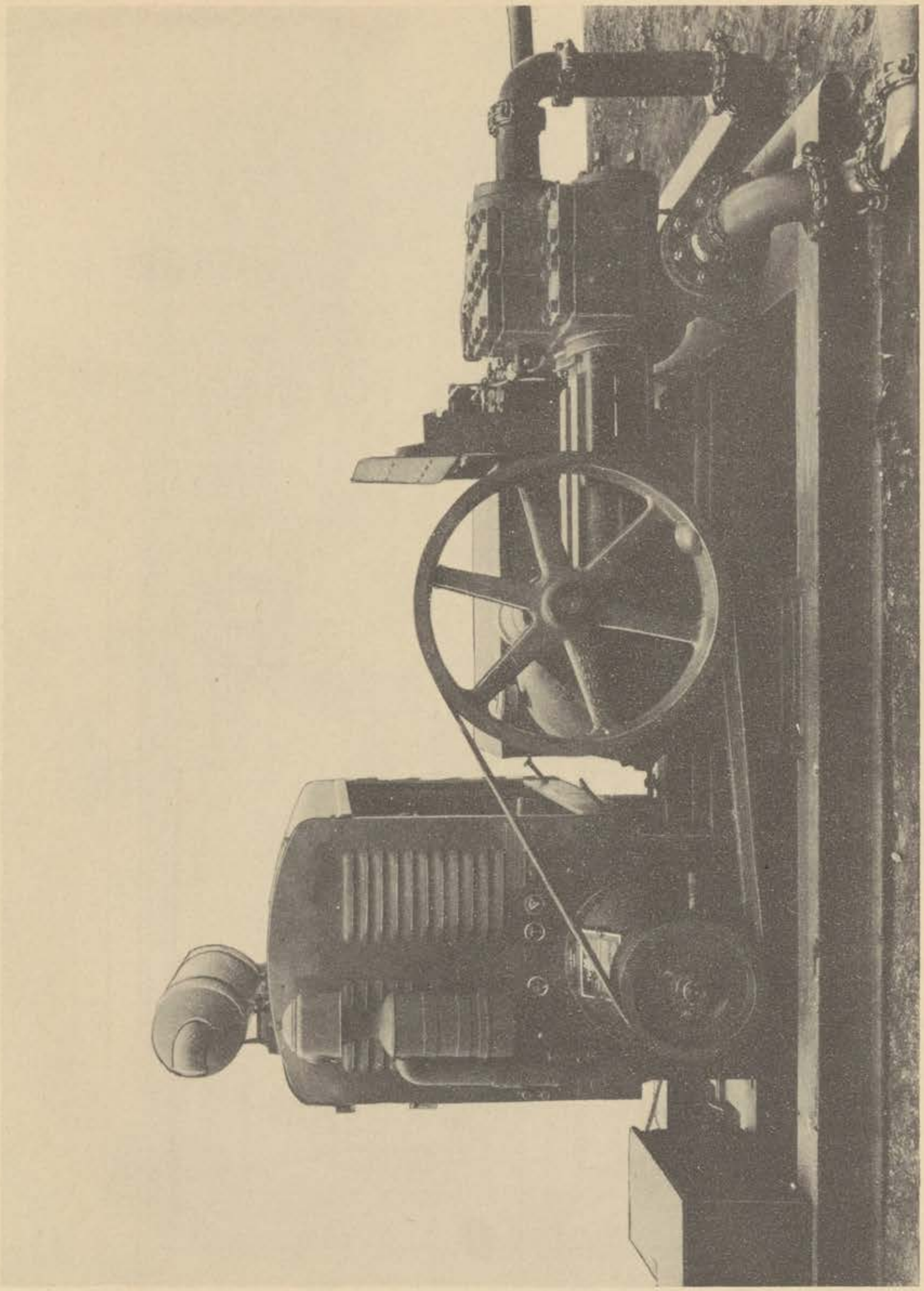


Figure 19. View of small reciprocating pump unit.

DIMENSION DRAWING . . . LARGE PUMPING UNIT

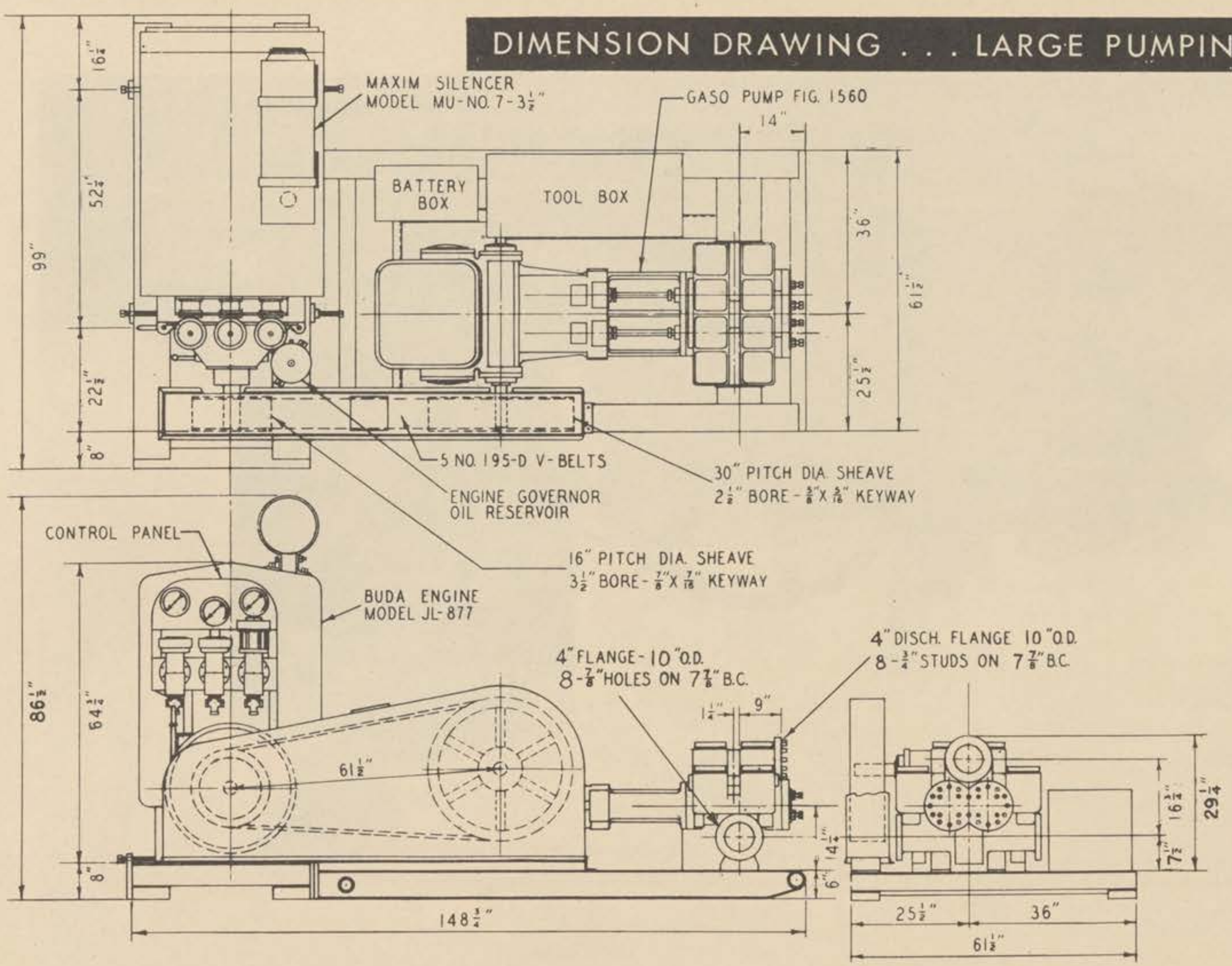


Figure 20. Dimension drawing of large reciprocating pump unit.

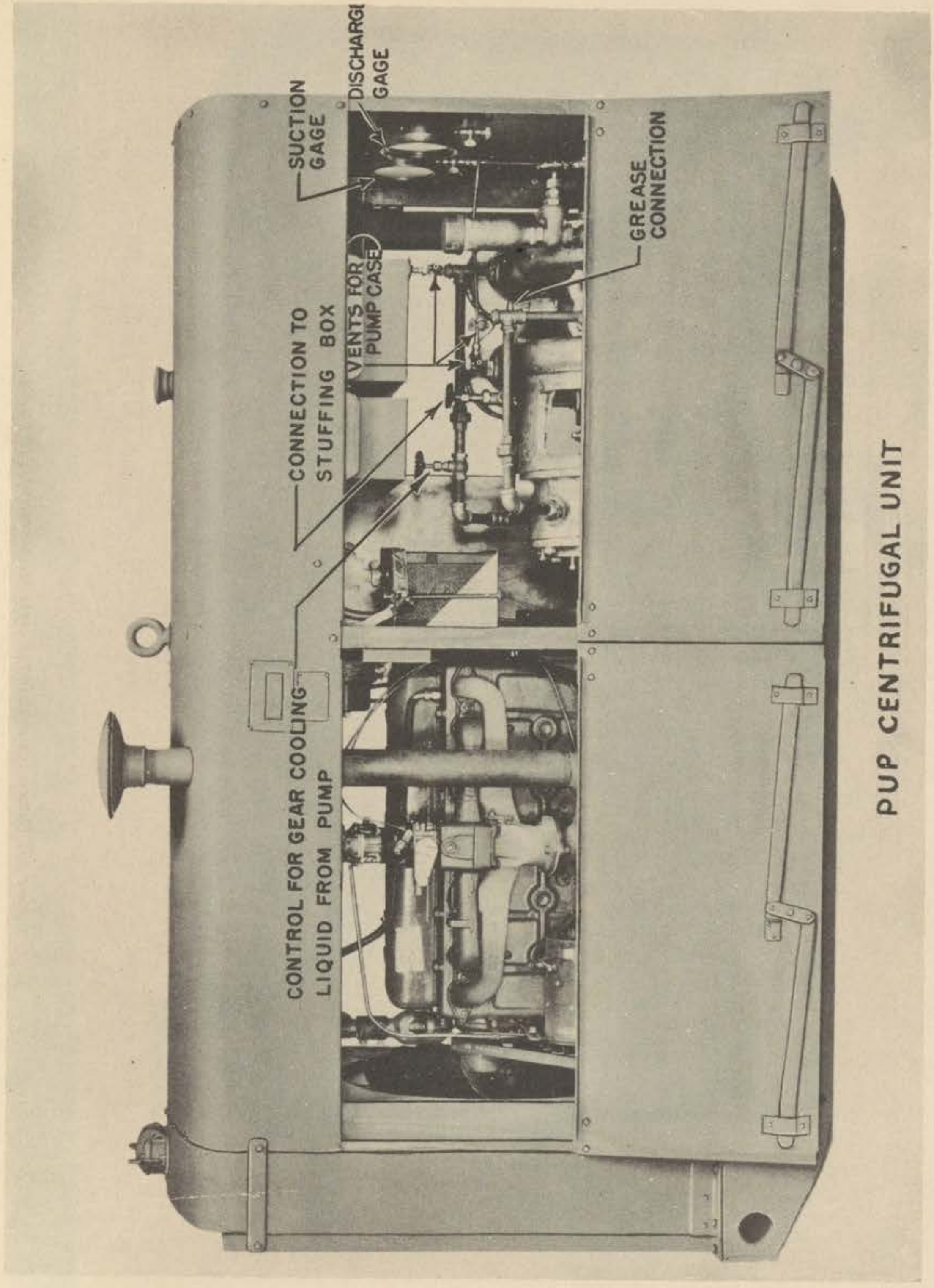


Figure 21. Rear view of centrifugal pump unit

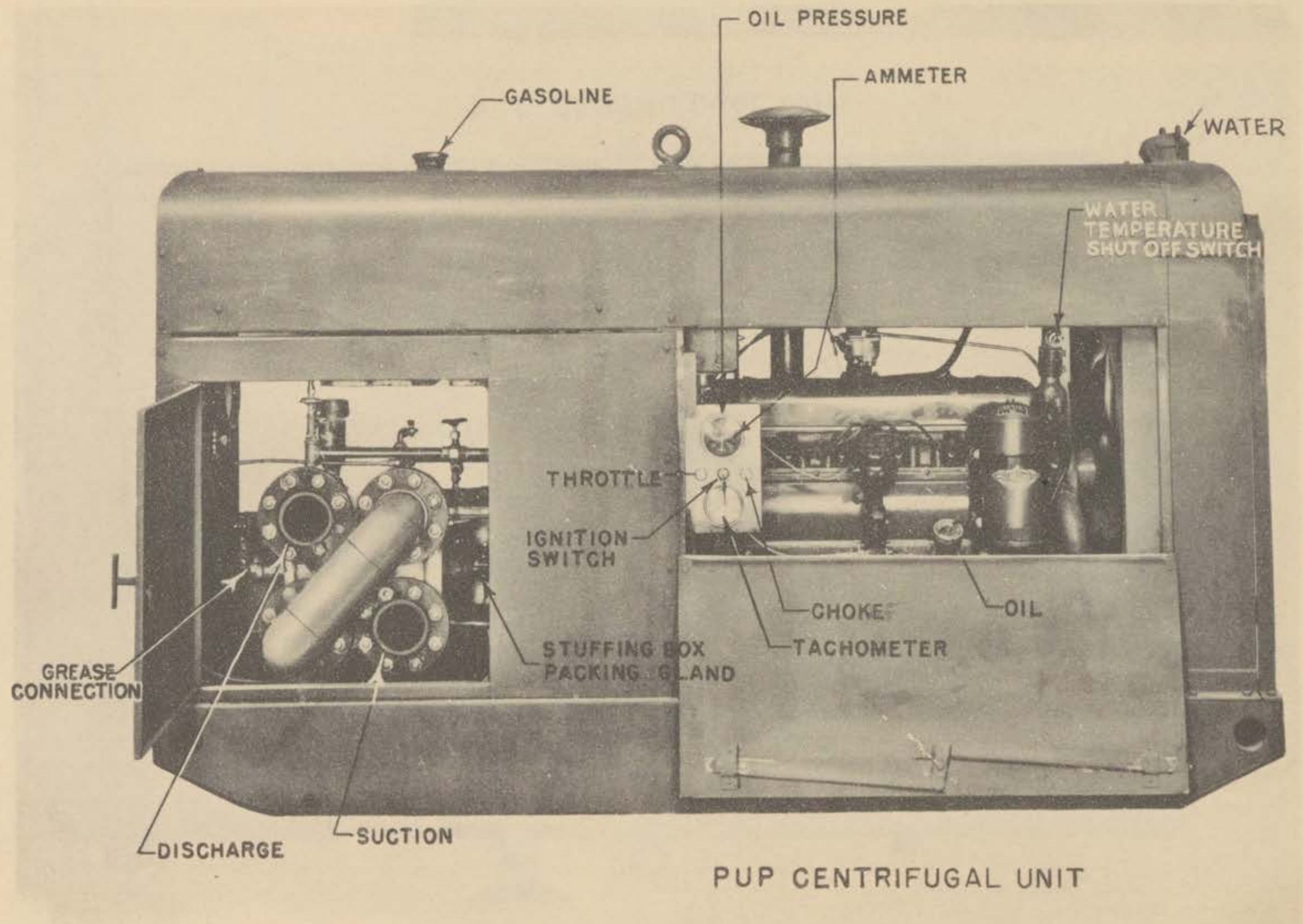


Figure 22. Front view of centrifugal pump unit.

DIMENSION DRAWING FOR PUP CENTRIFUGAL PUMPING UNIT

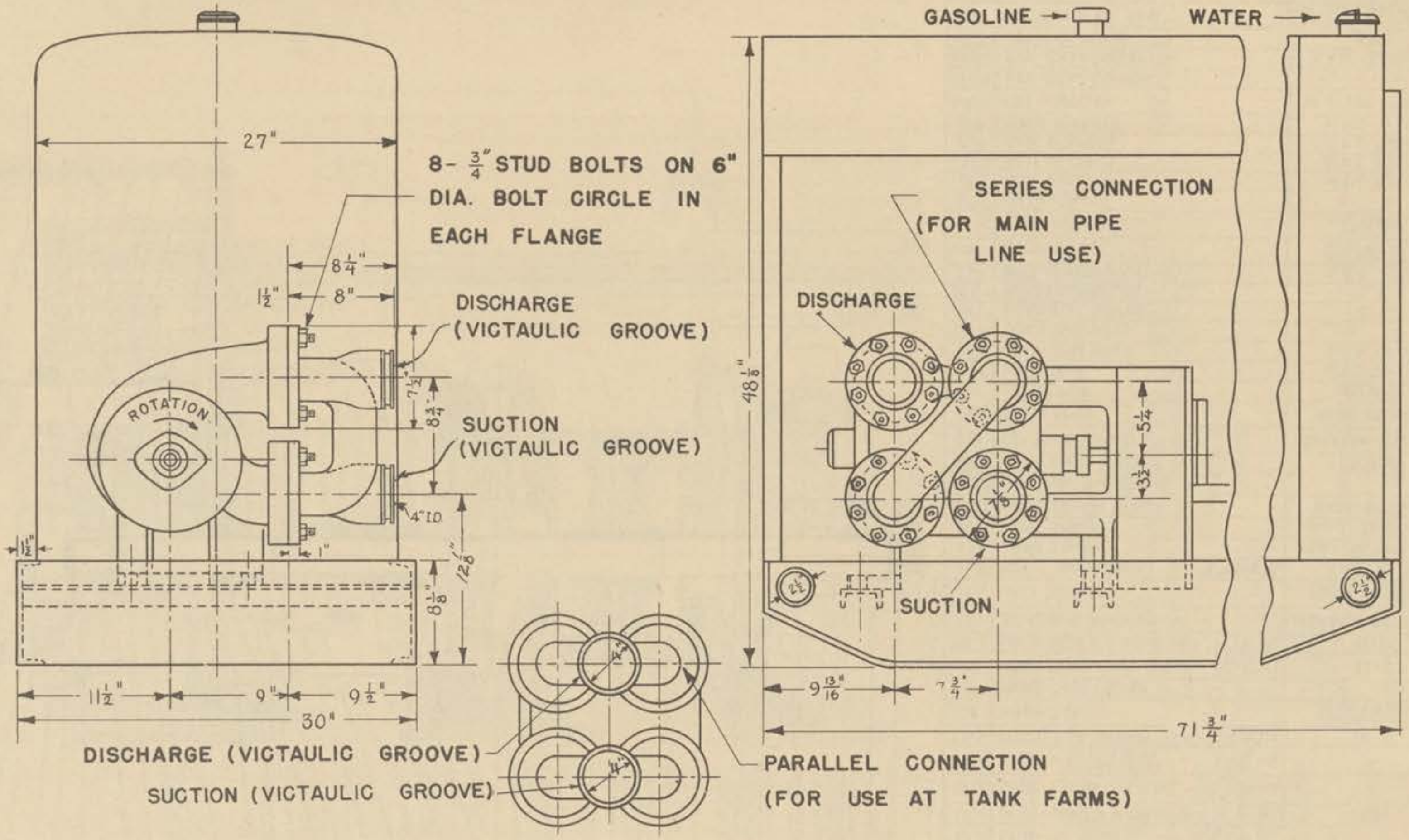
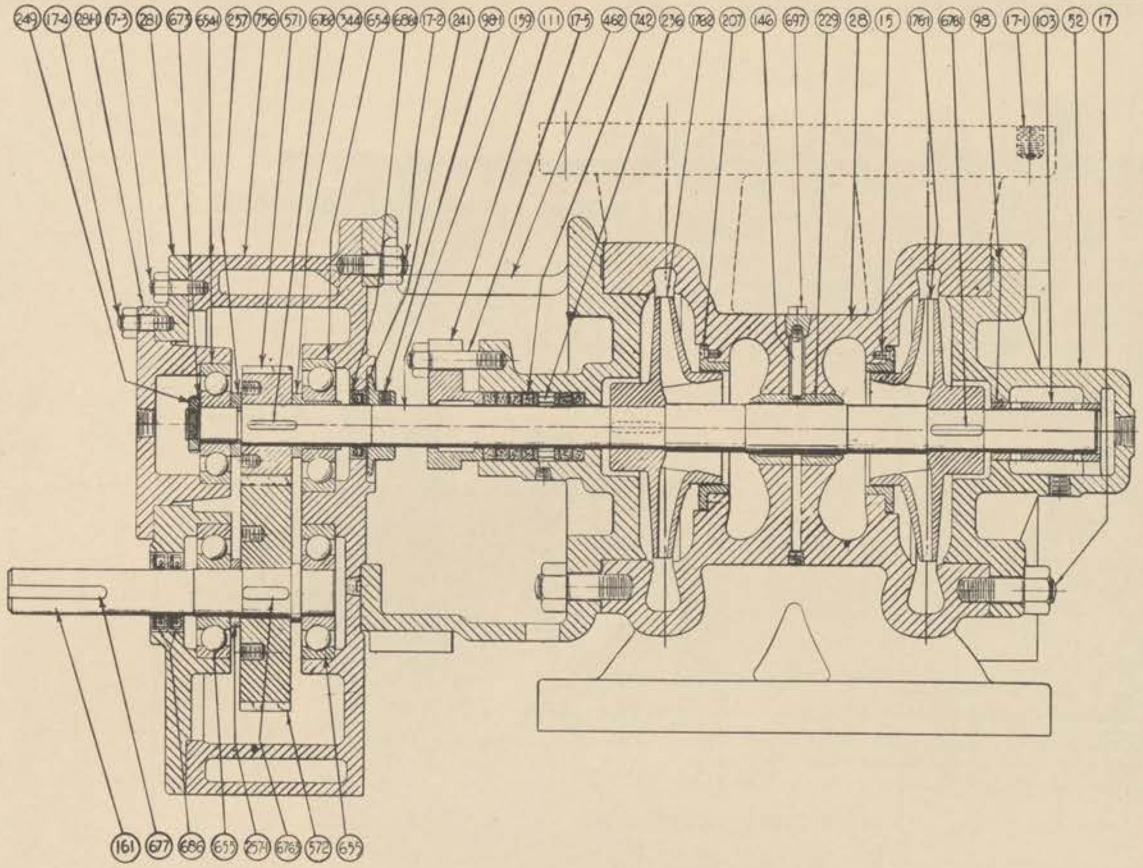


Figure 23. Dimension drawing of centrifugal pump unit.

PUP CENTRIFUGAL PUMP AND GEAR CASE



PART NO.	NAME OF PART	MATERIAL	QUAN. PER UNIT
15	FLAT HEAD MACH SCR'S: CASE 1/4"x1/2" LG. WR. RINGS	18-8	4
17	STUD - CASE TO COVER & TO CONNECTOR - 3/4"x3" LG.	S.A.E. 1040 H.T.	20
17-1	STUD - FLANGES - 3/4"x3" LG.	" " "	32
17-2	STUD - GEAR BOX TO CONNECTOR - 5/8" 2" LG.	STEEL	8
17-3	STUD - COVER TO GEAR BOX - 1/2"x1 3/4" LG.	"	12
17-4	STUD - BEARING HOLDER TO GEAR COVER - 1/2"x1 3/4" LG.	"	4
17-5	FITTED CAP GLAND - 1/4"x1 3/4" LG.	18-8	2
28	PUMP CASE	CHR. NICKEL C. I. 60.000 # TENSILE	1
52	PUMP CASE COVER	" "	1
98	LOCK SCREW - END BEARING - 1/4"x1/2" LG.	18-8	2
98-1	LOCK SCREW - DEFLECTOR - 3/8"x1/2" LG.	STEEL	1
103	BLIND END BEARING	BEARIUM BRONZE	1
111	SPLIT GLAND	HARD BRONZE	1
146	PIN - CENTER SLEEVE - 3/8"x3 3/4" LG.	S.A.E. 10 20	1
159	PUMP SHAFT	11.5-13% CHR.ST'L.	1
161	DRIVE SHAFT	S.A.E. 2340 H.T.	1
176-1	IMPELLER-1ST STAGE	HARD BRONZE	1
176-2	IMPELLER-2ND STAGE	" "	1
207	CASE WEAR RING	BRONZE	2
229	CENTER BUSHING	BEARIUM BRONZE	1
236	CAGE RING	HARD BRONZE	1
241	DEFLECTOR	BRONZE	1
249	LOCK NUT	MRC-N-06	1
257	LOCATING RING	S.A.E. 10-20	1
257-1	LOCATING RING	" "	1
281	GEAR BOX COVER	C. I.	1
281-1	BEARING HOLDER	C. I.	1
344	BALL BEARING SLEEVE	S.A.E. 1020	1
462	CONNECTOR	CHR. NICKEL C. I 60.000 # TENSILE	1
571	GEAR-DRIVEN	S.A.E. 1040 CASE HARDENED	1
572	GEAR-DRIVER	" "	1
654	BALL BEARING	MRC # 7407	1
654-1	BALL BEARING	MRC # 7406	1
655	BALL BEARING	MRC # 407R	2
673	LOCK WASHER	MRC-W-06	1
676-1	KEY-IMPELLER	11.5-13% CHR.ST'L.	2
676-2	KEY-GEAR-DRIVEN	" " " "	1
676-3	KEY-GEAR-DRIVER	S.A.E. 2340 H.T.	1
677	KEY-COUPLING	STEEL	1
686	NATIONAL OIL SEAL	No. 50049 FOR 1 1/4" SHAFT 200 FT/MIN. RUBBING SPEED	1
686-1	NATIONAL OIL SEAL	No. 50055 FOR 1 3/8" SHAFT 200 FT/MIN. RUBBING SPEED	2
697	SPECIAL LOCK PLUG - CENTER SLEEVE	S.A.E. 10-20	1
742	PACKING RING	JOHN CRANE	6
756	GEAR BOX	C. I.	1

Figure 24. Section drawing and parts list of Pup centrifugal pump.

DEEP WELL PUMPING UNIT

SECTION & DIMENSION DRAWING
FOR 6 STAGE - MODEL NO. PI - 606

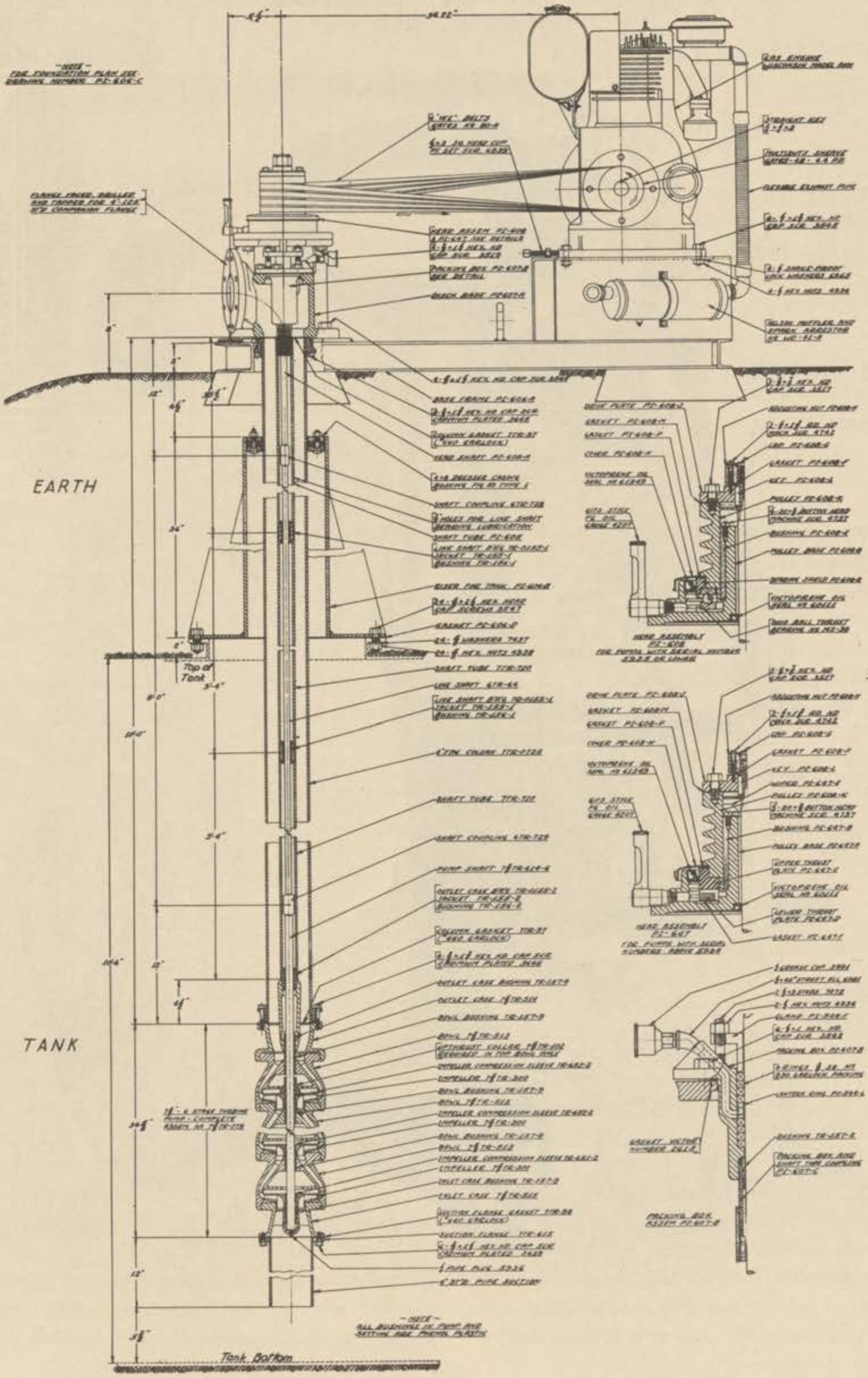


Figure 25. Section and dimension drawing of deep-well pump unit..

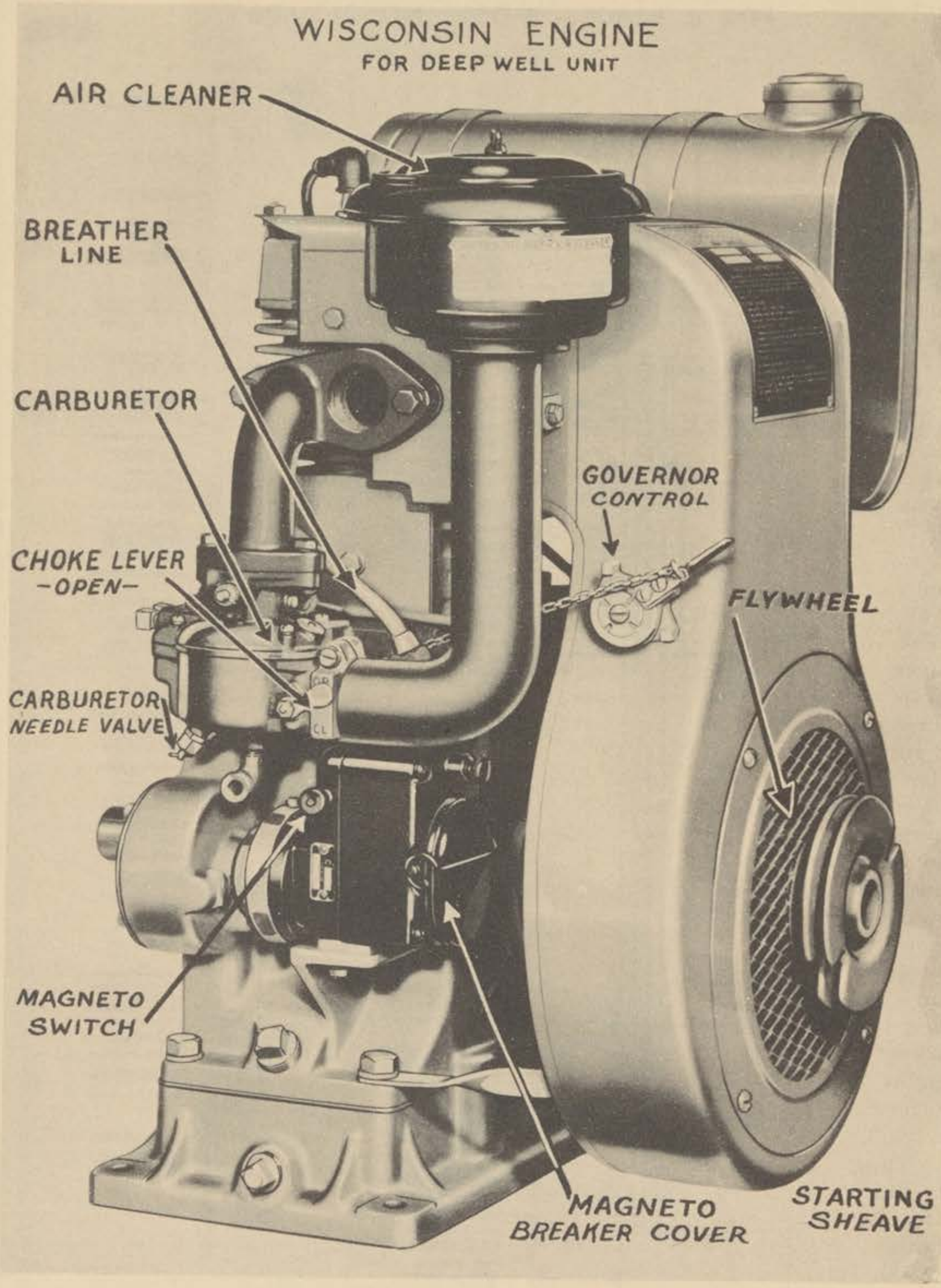


Figure 26. Front view of Wisconsin engine for deep-well unit.

CHAPTER 3
LAYOUT AND PLANNING

9. LOCATION OF PIPE LINE.

a. Reconnaissance.

(1) After study of existing maps the first step in determining the location of a pipe line is to make a ground reconnaissance of the country through which the line is to be laid. Knowledge of the topography thus gained will enable the engineer to choose the most suitable route for the line, both from the standpoint of military necessity and from that of good pipe-line practice. The most nearly level route should be chosen whenever possible. Natural cover, such as brush and trees, should be used in order to protect the line from enemy observation. A route along the bank of a stream is seldom desirable, especially where the stream is likely to overflow its banks.

(2) Wherever possible the pipe line should be located more or less parallel to an existing road or trail, in order to facilitate the transportation of pipe and requisite equipment along the route of the pipe line. Speed of construction will in a large measure depend upon the prompt supply of component parts of the pipe-line system along the site.

(3) If contour maps of the area are available, they can be used to great advantage in supplementing reconnaissance information. Airplane flights and aerial maps are also valuable aids in choosing the best route for a pipe line, particularly from the standpoint of locating the line so as to conceal it from enemy aerial observation.

b. Survey.

(1) When the approximate route for the pipe line has been chosen, a survey must be made to determine its bearing, length, and elevation changes (profile). There are several methods of surveying the route which are practicable and sufficiently accurate for designing a workable pipe-line system. Each of these methods will be outlined in some detail. As the survey progresses the course of the pipe line should be marked for the benefit of the construction and installation crews. Wooden stakes, placed at approximately 500-foot intervals in wooden areas and at approximately greater intervals in open areas, are used for this marking. In wooded and brushy areas the route can be plainly marked by tying small strips of cloth or drafting tape to trees and brush along the line between stakes. Notes should be made of the location of all clearings and wooded areas, stream and river crossings, road crossings, and other points of possible future interest.

(2) When the pipe-line system has been designed and the location of pump stations, block and check valves, and pressure-reducing regulators determined, their location along the line should be plainly marked with stakes. Following is a list of stake colors which may be used for this marking:

Location	Stake color	Remarks
Route	Plain	Number stakes in sequence.
Pump station	Blue	Mark pump station number on stake as well as distance from Station No. 1.
Gate block valve	Green	
Check valve	Yellow	
Reducing regulator	Red	
Loading station	Orange	
Branch line	White	Place 2 stakes, 1 on main route and 1 about 20 feet toward branch line.

(3) *Use of contour maps*. The course of the line is plotted on contour maps of the area to be traversed (fig. 28). Starting at the source (Station No. 1), a profile of the pipe-line route is plotted showing ground elevation at all critical points, such as ridges, valleys, and abrupt changes in slope, over the entire length of the line (fig. 29). This profile should be plotted with a vertical scale of 1 inch equals 500 feet and a horizontal scale of 1 inch equals 5 miles. If more detail of the route

between some of the stations is desired, the profile may be plotted with a vertical scale of 1 inch equals 500 feet, and a horizontal scale of 1 inch equals 2½ miles. When the course of the pipe line has been first laid out on a contour map, it will be necessary to transfer it from the map to the ground. This should be done using stakes as previously outlined. In addition, several significant elevation changes should be checked with a transit, level, or barometer, to be sure that the profile constructed from the contour map is an accurate representation of the ground.

(4) *Use of aneroid barometer and compass.*

(*a*) If no contour map is available, a simple, rapid survey can be made using an aneroid barometer and compass. Accompanying distances are obtained from a map or by chain, tape, foot pace, or automobile speedometer.

(*b*) When an aneroid barometer is used, elevation at all critical points along the proposed route should be recorded. Careful use of the barometer will insure the measurement of approximate elevations. At the time elevations are measured the location and length of the line are also obtained by compass survey. Data obtained by the compass survey consist of magnetic bearing and length of each segment of the line between the source and discharge. The length of each segment can be measured by chain, tape, or foot pacing. Where maps are available, or where the approximate route can be traversed by automobile, over-all distance thus obtained should be used, proportionate corrections being made in the individual segment lengths. A ground profile can be readily constructed from the elevation and distance measurements obtained.

(5) *Use of level and chain or transit and stadia.* Surveys by level and chain, or by transit and stadia are the most accurate, but they consume considerable time and are applicable only to areas which are relatively inactive.

(6) If reconnaissance of the proposed pipe-line route shows that the terrain to be crossed is fairly level and that the relief is compensating, a detailed elevation survey will not be necessary. The pipe line in this case can be laid in a straight line. Locations of the pump stations will depend on line friction, static head, and the suction pressure required at each station along the line, as will be discussed later in this manual.

10. DESIGN OF SYSTEM. Inasmuch as military pipe lines are to be constructed with standard sizes of pipe and pumping equipment, the problem of design need be based on the following considerations only: size of pipe available (4-inch or 6-inch), size of pumps available, and amount and kind of liquid to be delivered through the line. With these considerations established and with the ground profile plotted to a vertical scale of 1 inch equals 500 feet, and to a horizontal scale of 1 inch equals 5 miles, the next step is to compute the hydraulics of the system, in order to determine the number and location of pump stations and pressure reduction stations.

a. Modular System of Pipe-line Design. A detailed analysis of the hydraulics of a pipeline system is complicated; therefore a simplified method of pipe-line design, called the modular system, has been adopted, so named because it is a model measuring method of determining the location of pumping and pressure-reducing stations by combining static and friction heads on a hydraulic gradient triangle, the scales of which correspond to scales selected for the profile of the pipe-line route. This graphical method should be used by the survey engineer in the field during the progress of the survey.

(1) The procedure to be followed in using the modular system for pipe-line design is as follows:

(*a*) Knowing the kind of liquid and the rate at which it is desired to pump it, the friction pressure loss per mile is determined from figure 30 for 4-inch pipe, or from figure 31 for 6-inch pipe. For example, from figure 30 the friction loss for 4-inch spiral weld pipe carrying 200 barrels per hour of 0.70 specific gravity gasoline is 20 pounds per square inch per mile.

(*b*) Having determined the friction loss per mile, a right triangle called a hydraulic gradient triangle is next made from a piece of heavy bristol board or other suitable material about 10 inches square. This triangle is constructed in the following described manner. Figure 32 also outlines the procedure for construction. The finished triangle is shown on figure 33.

1. On the side of the piece of chosen material lay out a scale on its base or horizontal side using the same scale in miles per inch as was used on the profile. Make this scale cover a distance of at least 40 scale miles. Calibrate the scale in 1-mile divisions, or less if desired, although this is not essential. Make the zero point at the right angle of the triangle.

2. Lay out the vertical side of the triangle to represent 2,500 feet on the same vertical scale used in plotting the profile. For example, if the vertical scale is 1 inch equals 500 feet, the

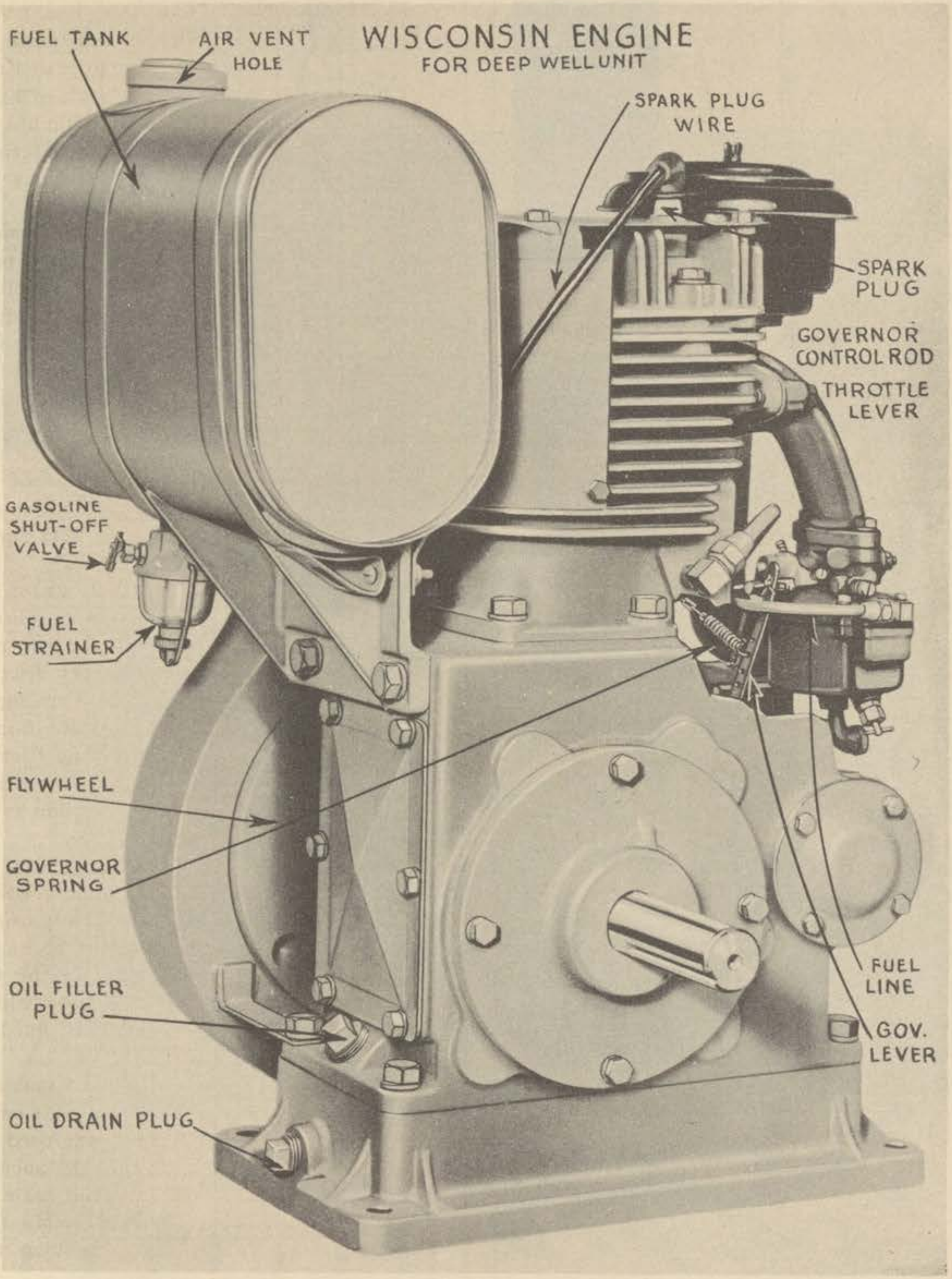


Figure 27. Front view of Wisconsin engine for deep-well unit.

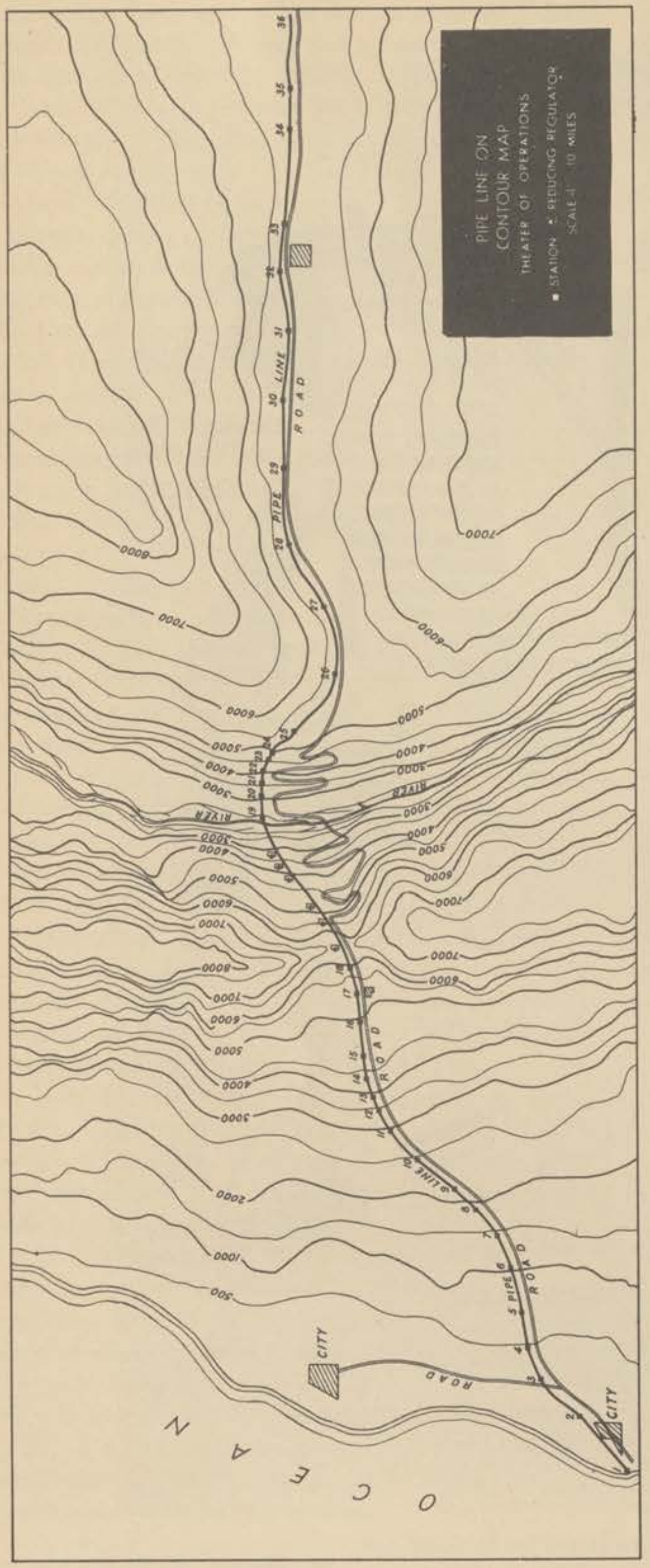


Figure 28. Route of pipe line on contour map.

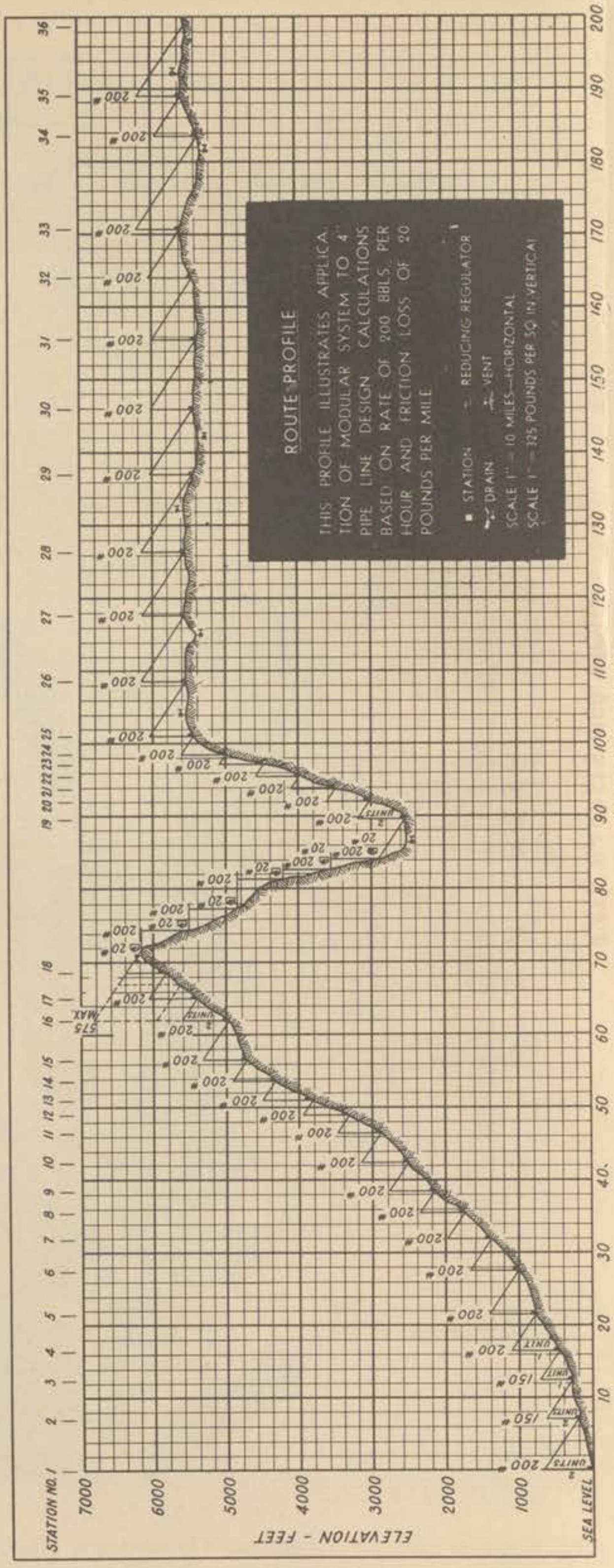


Figure 29. Profile of pipe-line route.

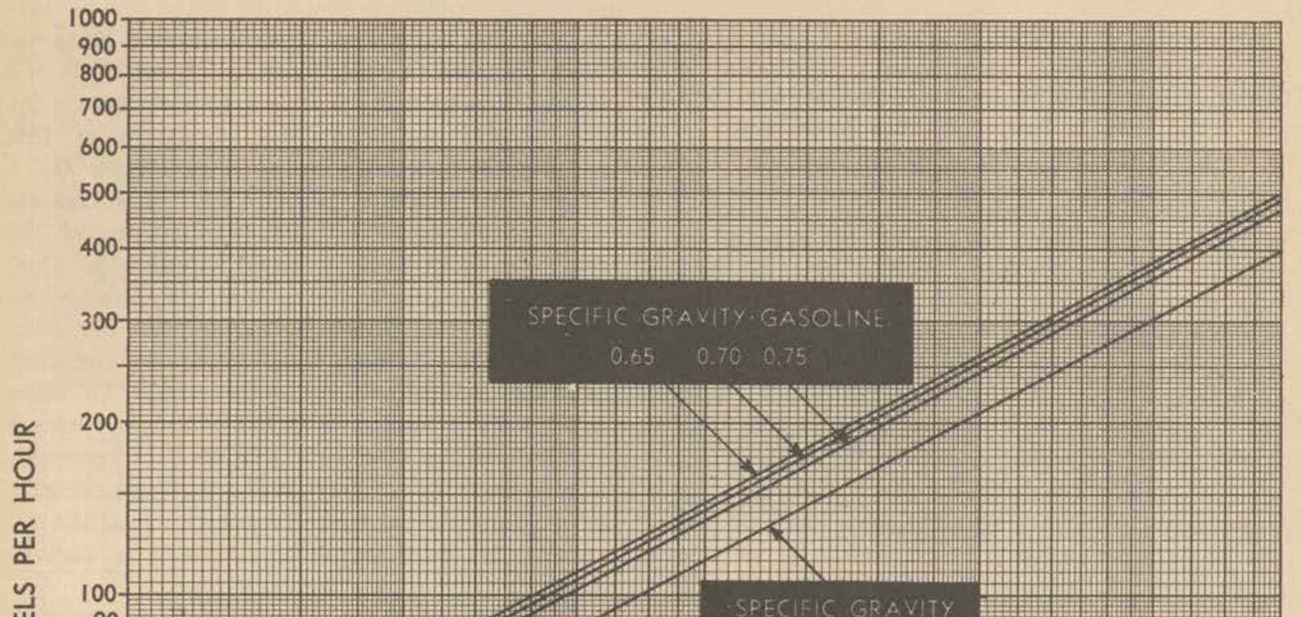


Figure 30. Flow of gasoline and water in 4-inch pipe.

side of the triangle will be 5 inches long. Graduate this vertical side in hundreds of feet with the zero point at the top of the triangle. This scale in feet represents the *static head in feet of the flowing liquid*. Convert this head in feet to *static head in pounds per square inch* by using the following equation:

$$P=\frac{H\times S}{2.31}$$

where P=pressure in pounds per square inch,
H=head in feet of flowing liquid, and
S=specific gravity of flowing liquid.

Using the above relation, compute the number of feet of head corresponding to 50 pounds per square inch static head. In the case of gasoline with a specific gravity of 0.70, this value will be 165 feet. Subdivide the vertical scale on the side of the triangle into units of 165 feet each, beginning at the zero end of the scale, each unit representing 50 pounds per square inch static head. In the example, these units will be plotted at 165 feet, 330 feet, 495 feet, etc., the 2,500 foot static head being equal to 758 pounds per square inch.

3. The friction loss in pounds per square inch per mile obtained above is used to establish the slope of the hypotenuse of the hydraulic gradient triangle by dividing the total length of the vertical scale in terms of pounds per square inch static head by the friction loss in pounds per square inch per mile. For example:

$$\frac{758}{20}=37.9$$

This factor of 37.9 denotes the point on the base, or horizontal side on the scale of miles used, from which a connecting line is drawn to the zero point on the vertical side of the triangle, thus delineating the hypotenuse. Complete the triangle by cutting along the hypotenuse. It should be noted that the slope of this hypotenuse represents the friction loss in pounds per square inch per mile for a particular size of pipe carrying a particular liquid at a predetermined rate. A change in either the size of pipe, the type of liquid, or the rate of flow requires the construction of another hydraulic gradient triangle.

b. Example. Determine the location of and the number of pumping stations required on the pipe line shown in plan on figure 28 and in profile on figure 29.

(1) Conditions:

Throughput	200 barrels per hour.
Pump pressure	30 pounds per square inch suction, 230 pounds per square inch discharge.
Pipe line	4 inch spiral weld.
Liquid	0.70 specific gravity gasoline.
Pump unit	small reciprocating.

(2) Several general statements regarding pipe-line design and operation should be noted before proceeding with the task of locating pump stations.

(*a*) The first consideration is to establish the pressure at which the pumps are to operate. On level ground and using the conditions of this example, the differential pressure at Station No. 1 will be 200 pounds per square inch only because there are 10 miles of 4-inch thin wall pipe and 200 barrels per hour being pumped through the pipe. Reference to figure 30 shows that the pressure loss in the pipe is 20 pounds per square inch per mile. If the pipe line extends uphill, however, the same quantity of liquid will not be moved 10 miles with the pump operating at 200 pounds per square inch differential pressure. In part 9 of figure 32, 60 pounds per square inch of the available pressure at the pump is used to lift gasoline and the remaining 140 pounds per square inch is used to overcome friction in 7 miles of pipe.

(*b*) A pipe line must be designed and operated so that there is sufficient pressure on the suction side of the pump. When handling gasoline, the suction pressure must not be below 30 pounds per square inch. Lower pressure may cause vapor lock in the system, thus impairing pipe-line efficiency. An exception to this rule will be the pressure on the suction side of Station No. 1, as described in chapter 4 of this manual.

(3) *Solution.*

(*a*) Place the hydraulic gradient triangle on the profile, figure 29, with the base of the triangle parallel to the datum line of the profile, with zero miles at Station No. 1 (source station), and with the desired pressure graduation on the side of the triangle on the line of the profile. In this example the 200 pounds per square inch graduation, representing the 200 pounds per square inch pressure differential between suction and discharge as desired at Station No. 1, is placed on the line of the profile.

(*b*) Draw a light vertical line along the edge of the triangle to the apex and then draw a line along the hypotenuse of the triangle until this line intersects the profile line. On figure 29, the hypotenuse will intersect the profile at a distance of 7 miles from Station No. 1. At this point the pressure on the line will be reduced to the same

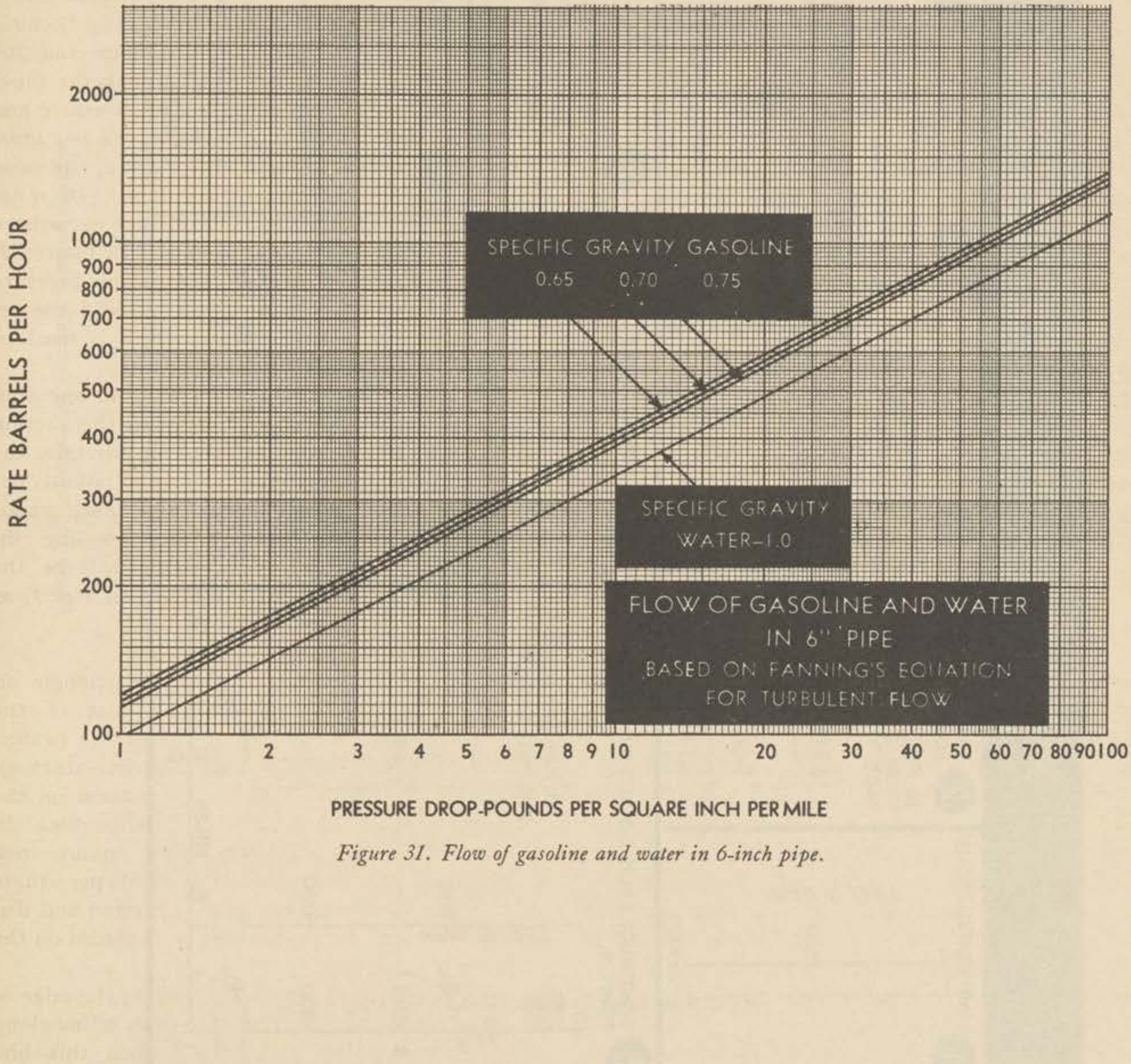


Figure 31. Flow of gasoline and water in 6-inch pipe.

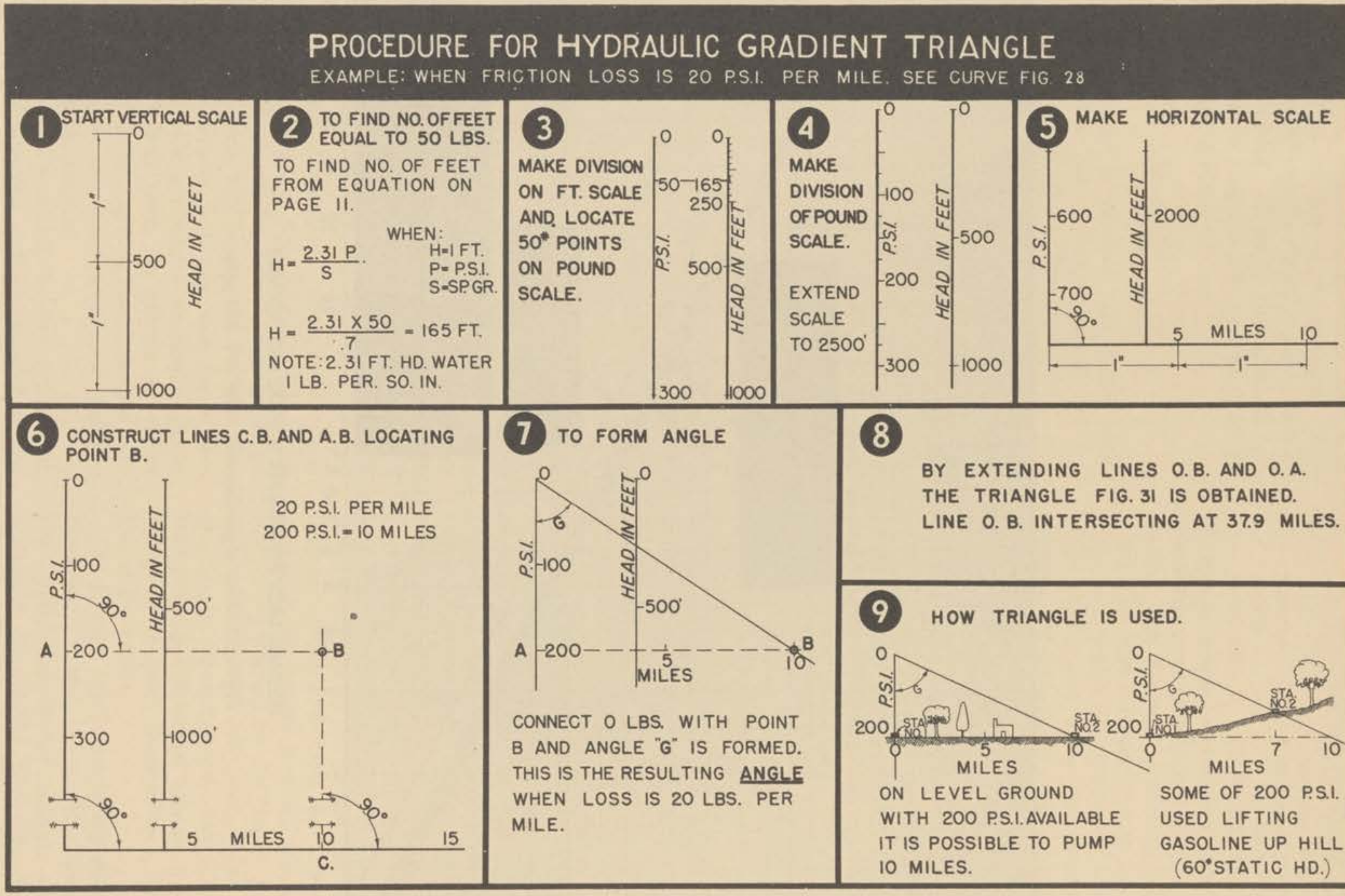


Figure 32. Procedure for hydraulic gradient triangle.

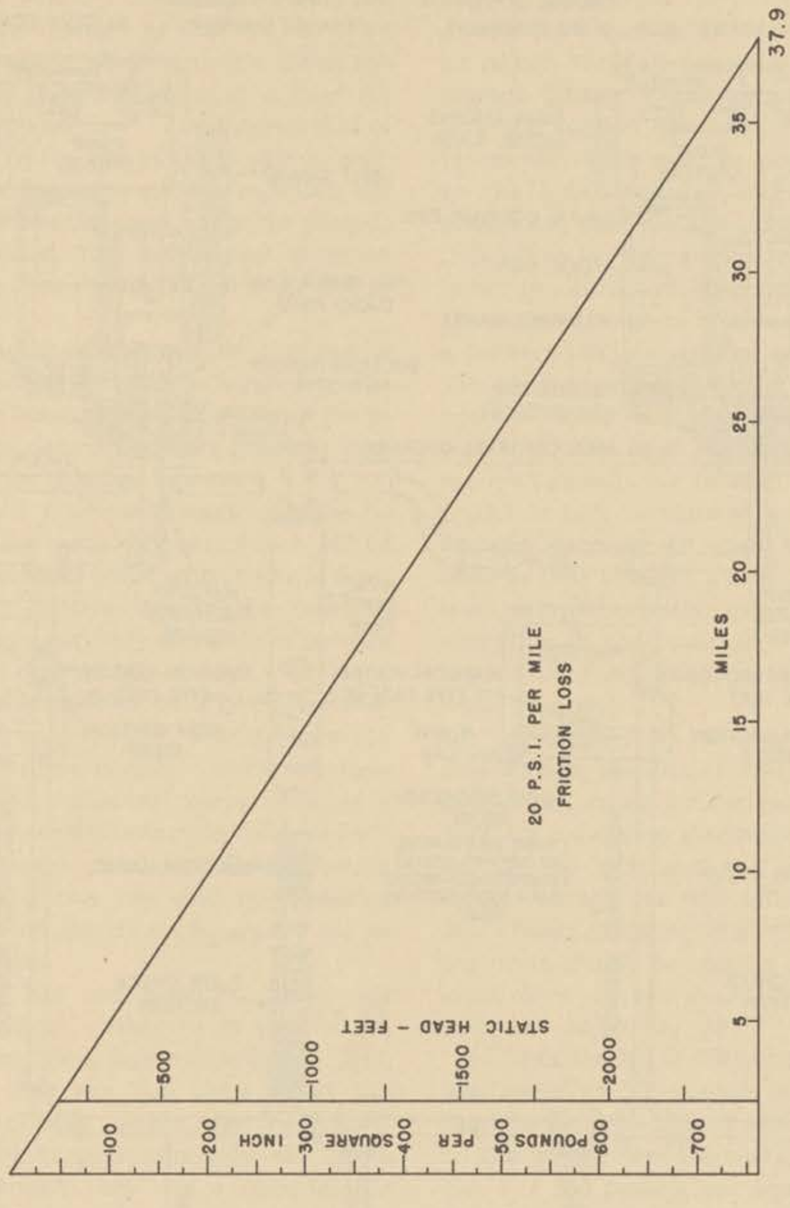


Figure 33. Finished hydraulic gradient triangle.

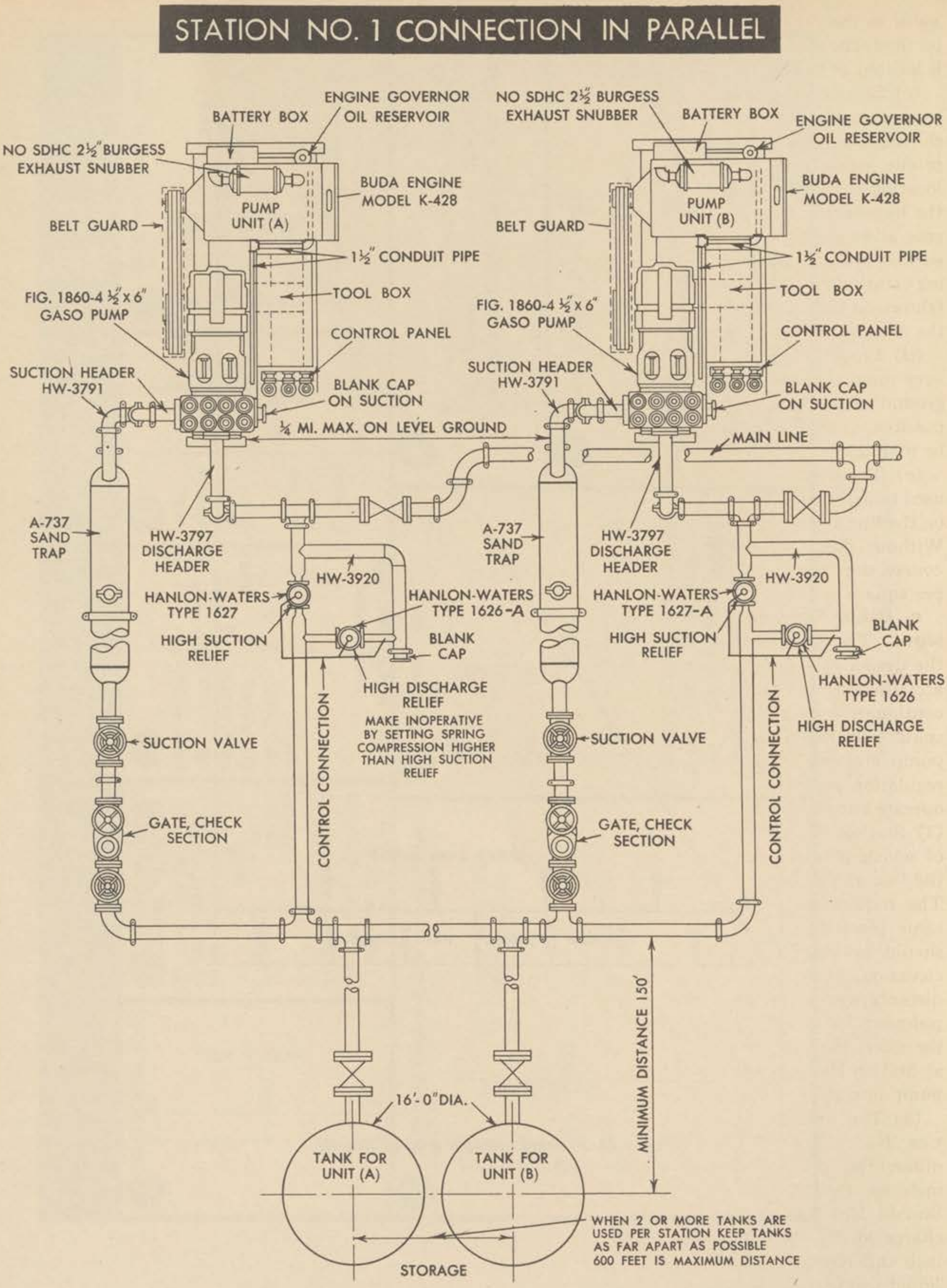


Figure 34. Arrangement of Station No. 1 (two small reciprocating units in parallel).

value as the pressure (30 pounds per square inch) on the suction side of Station No. 1. Station No. 2 is located at this point.

(c) Station No. 3 and succeeding stations are located in the same manner as Station No. 2 by shifting the hydraulic gradient triangle along the profile, using each station located as a base for locating succeeding stations. The intersection of the hypotenuse with the line of the profile in each case gives the location for a station at which the suction pressure will be the same as for the preceding station, provided the differential pressure (shown on the side of the triangle) is maintained at the designed value.

(d) Proper location of stations on the line is very important and they should be located on the ground as near the point indicated on the profile as possible, so that the desired pressure gradient may be maintained in the pipe-line system.

(e) The hydraulic gradient triangle can also be used to determine the actual pressure which will be on the line at any desired point when there is flow. Without flow, the friction loss in the pipe, of course, does not exist and only the scale of pounds per square inch on the triangle is used.

c. Other Considerations in Pipe-Line Design. There are many other consideration in the design of a pipe-line system. Some of these are discussed in the following paragraphs as a continuation of the design example for a 4-inch spiral weld line to carry gasoline. Reciprocating pump stations along this line and the pressure regulation stations on the downhill grades are to operate automatically.

(1) Station No. 1 has two pumping units, one of which is a stand-by connected in parallel on the line at the same place hydraulically (fig. 34). The requirement that the two units be at the same place hydraulically means that each unit should be installed at approximately the same elevation, even though they are a considerable distance apart. Station No. 1 sets the rate of pumping for the whole system. It is important, therefore, that the two pumping units be placed at Station No. 1 to be certain that the station can pump into the line under all conditions.

(a) The differential pressure controls on Station No. 1 are adjusted to hold a maximum differential pressure of 200 pounds per square inch on the line between Station No. 1 and Station No. 2 (230 pounds per square inch discharge at No. 1). This 200 pounds per square inch differential pressure sets the rate at which liquid will flow in the line.

(b) The high suction relief valve at Station No. 1 will be set so that it opens at 250 pounds per square inch. Connection to the diaphragm will be made from the discharge manifold. The double port opening of this valve is large enough to return the full capacity of the pump to the storage tanks. Connection to the tanks is made into the suction line behind the check valve between the tanks and the pump. The connection to the high discharge relief diaphragm will be plugged so that it stays closed.

(c) The low suction controller at Station No. 1 is set to control at 30 pounds per square inch if the suction pressure at this station is supplied by a booster pump operating on a storage tank. If the suction pressure at Station No. 1 is due to head of liquid in storage tank only, the low suction controller must be made inoperative and the station placed on manual control. This controller is not, in general, sufficiently sensitive to respond properly to small variations in pressure such as that brought about by change in the fluid level as liquid is withdrawn from a tank. Manual operation of the pump will necessitate maintaining an accurate check on tank gages at all times while pumping.

(2) (a) Station No. 2 is another two-pumping-unit station, one unit of which is a spare. Station No. 1 can pump no farther than Station No. 2 with its maximum discharge fixed at 250 pounds per square inch and the continued delivery of liquid through the line will depend upon Station No. 2 being operative at all times. The two pumping units should be located at approximately the same elevation, not over 1,000 feet apart, and connected in series (fig. 35).

(b) Station No. 2 differential pressure controller is adjusted for 300 pounds per square inch. With Stations No. 1 and No. 2 at the same elevation and no flow in the line, the suction pressure at Station No. 2 is 250 pounds per square inch. If Station No. 2 is at an elevation greater than that of Station No. 1, the suction pressure at Station No. 2 with no flow will be reduced by the difference in static head between the two stations. With this maximum suction pressure of 250 pounds per square inch, plus 300 pounds per square inch differential setting, the maximum discharge pressure and the setting of the high discharge relief valve will be determined. When Stations No. 1 and No. 2 are at the same elevation, or when Station No. 1 is located at a higher elevation than Station No. 2, the high discharge relief valve setting will be 550 pounds per square inch.

(3) Stations Nos. 3 and 4 are located only 150 pounds per square inch pressure differential from Station No. 2 and Station No. 3, respectively. This is required because:

(*a*) The high discharge reliefs at Stations Nos. 3 and 4 are set at 650 pounds per square inch maximum.

(*b*) Differential pressure controllers are set to control at 300 pounds per square inch differential pressure. With Stations Nos. 3 and 4 located only 150 pounds per square inch remote from Station No. 2 and Station No. 3, respectively, either one of these stations could be out of operation and normal flow maintained. Both Stations Nos. 3 and 4 cannot be down at the same time and have the line maintain its 200 barrel per hour capacity rate without overtaxing Station No. 2 with 500 pounds per square inch differential pressure. The differential pressure controller is used to insure that the engine of a pumping unit is not overloaded,

(*c*) When neither Stations Nos. 3 nor 4 are operating the spare unit at No. 2 should be started and the two units operated in series with 250 pounds per square inch differential pressure across each station. This is necessary because there is 150 pounds per square inch pressure loss between Stations Nos. 2 and 3, 150 pounds per square inch between Stations Nos. 3 and 4, and 200 pounds per square inch between Stations Nos. 4 and 5, a total pressure loss between Stations Nos. 2 and 5 of 500 pounds per square inch. A balancing pressure would be developed at Station No. 2 by operating both units there in series, as above outlined.

(*d*) Stations Nos. 2 and 3, and Nos. 3 and 4 can be only 150 pounds per square inch apart, because Station No. 2 is limited by its differential pressure controller to 330 pounds per square inch discharge pressure. Therefore, Station No. 2 is capable of pumping to Station No. 4, when Station No. 3 is out of service.

(*e*) The high discharge relief valve at Station No. 3 is set at the maximum discharge pressure of Station No. 2, plus 300 pounds per square inch differential setting, less the static head between Stations No. 2 and No. 3 when Station No. 3 is at a higher elevation than Station No. 2, but not to exceed 650 pounds per square inch. The high discharge relief valves at all stations beyond Station No. 3 are set at 650 pounds per square inch, except in the special cases discussed elsewhere in this chapter, thus allowing a maximum operating discharge pressure of 630 pounds per square inch when required.

(4) All other stations are located at 200 pounds per square inch differential pressure spacings.

(5) Figure 36 shows the hydraulic relationships of stations by means of a hydraulic gradient when various stations are out of service. In normal operation Station No. 1 has a discharge pressure of 230 pounds per square inch. Stations Nos. 2 and 3 each have discharge pressures of 180 pounds per square inch, and all stations beyond No. 3 have discharge pressures of 230 pounds per square inch. It should be noted that all pressure values shown in Figure 36 must be increased by 30 pounds per square inch, since minimum suction pressure at the pumping station has arbitrarily been assumed as 30 pounds per square inch. When one or more adjacent intermediate stations in a given pipe line are not operating, the increased load on the station immediately upstream is spread over the upstream stations, thus distributing the additional load uniformly. This is accomplished by the operation of the differential pressure controller which limits the differential pressure between suction and discharge on any station to 300 pounds per square inch.

(*a*) For example: Consider that Station No. 5 is not operating. Station No. 4 must discharge at 430 pounds per square inch to reach Station No. 6; therefore the suction pressure at Station No. 4 must reach 130 pounds per square inch and Station No. 3 must discharge at 280 pounds per square inch so that the suction pressure of 130 pounds per square inch can be maintained at Station No. 4. Station No. 2 is not affected since Station No. 3 can work against 300 pounds per square inch differential pressure if necessary.

(*b*) Suppose Stations Nos. 6 and 7 are not operating. Station No. 5 must discharge at 630 pounds per square inch to reach Station No. 8 which of necessity increases the suction pressure at Station No. 5 to 330 pounds per square inch, and Station No. 4 must discharge at 530 pounds per square inch to maintain 230 pounds per square inch suction pressure at Station No. 5; since Station No. 4 is only 150 pounds per square inch away from Station No. 3, the discharge at Station No. 3 is raised to 380 pounds per square inch to maintain a 230 pounds per square inch suction pressure at Station No. 4 and Station No. 2 must discharge at 180 pounds per square inch to maintain a suction pressure of 30 pounds per square inch at Station No. 3.

(*c*) The hydraulic gradient diagram in figure 36 shows that normally no more than two adjacent stations can be out of operation at the same time, and still maintain the desired rate of flow. Furthermore, if two adjacent stations are not in operation, the first four stations immediately upstream must be pumping to maintain operation at the designed rate. An illustration of pumping at a reduced rate in a pipe-line system, due to three adjacent stations not being in operation, is brought out by the following example: Assume a 20-station pipeline system, with Stations Nos. 9, 10, and 11 not in operation, and with a static head of 80 pounds per square inch between each station. This condition would require that Station No. 8 pump all the way through to station No. 12. The maximum allowable discharge pressure at station No. 8 is 630 pounds per square inch and the assumed suction pressure at Station No. 12 is 30 pounds per square inch. The available pressure for pumping liquid from Station No. 8 to Station No. 12 is, therefore, 600 pounds per square inch. Total static head between Station No. 8 and Station No. 12 is (80 times 4) 320 pounds per square inch, which leaves 280 pounds per square inch to be consumed as friction loss over the distance of 24 miles between Station No. 8 and Station No. 12. This represents a pressure loss due to friction of approximately 11.7 pounds per square inch per mile. Reference to figure 30 shows that a pressure drop of 11.7 pounds per square inch per mile in a 4-inch pipe line with gasoline of a specific gravity of 0.70 gives a rate of about 155 barrels per hour. This rate can be maintained with Stations Nos. 9, 10, and 11 not in operation.

(*d*) In case three or more adjacent stations are out of service the first upstream station will reach a pressure at which both the high discharge and high suction relief valves will open and the pump speed will be reduced to idling. This idling condition will prevail until the first downstream station which continues to pump pulls the line pressure down to such a value that the idling upstream station resumes pumping. After building up to the maximum predetermined discharge pressure, the upstream station will again bypass and slow down to an idling speed. This intermittent operation will continue until a sufficient number of stations have resumed pumping to permit the system to operate at the designed throughput of 200 barrels per hour.

(6) *Steep uphill gradients*. In pumping liquid over a steep uphill grade requiring more than one station where pressure reducing regulators are used on the downhill side to control pressure, it is necessary to place a standby pumping unit at the foot of the downgrade for the same reasons that one was placed at Station No. 1. The downhill line is equivalent to the storage tanks at Station No. 1, inasmuch as a limited suction pressure is available due to the action of the reducing pressure regulators. All successive stations should be spaced at the usual 200 pounds per square inch pressure intervals along the line.

(7) *Pump station locations on hill crests*. A pump station should not be placed at or near the crest of the hill shown, for example, on the profile in figure 29 at mile 72. The downhill slope beyond mile 72 is so steep that no pumping is needed. In the example illustrated in figure 29, two stations should be installed between the double pump station and the top of the hill to prevent the two-unit station from operating continuously against a high discharge pressure.

d. Use of pressure-reducing regulators. Pressure-reducing regulators are used to protect pipe on downhill grades from excessive pressures which are developed where static pressures greatly exceed friction losses.

(1) Normally, these regulators should be adjusted to reduce the pressure to 50 pounds per square inch on the downstream side and are spaced 200 pounds per square inch pressure differential apart. One regulator can be used for a 400-pounds-per-square-inch differential, but it is recommended that they be spaced at not more than 200 pounds per square inch apart when a series of them is required.

(2) The regulator is constructed so that failure of the diaphragm will allow the valve to open wide, with only the valve orifice restricting the liquid flow. This restriction would probably be enough to prevent the pressure from becoming excessive under flow conditions, but if a shut-down of the line occurred downstream from the broken regulator the line would not be protected against excessive static pressure.

(3) The Hydraulic Gradient Triangle should be used to locate both pump and pressure reduction stations all along the profile. There may be a condition when the profile and the hydraulic gradient (hypotenuse of the triangle) approximately coincide. When this is the case, both flow and static conditions should be investigated. In general, it is safe to locate pressure reduction regulators on the profile with the scale of pounds per square inch on the Hydraulic Gradient Triangle. This procedure is as follows:

(*a*) Place the zero point of the vertical scale of

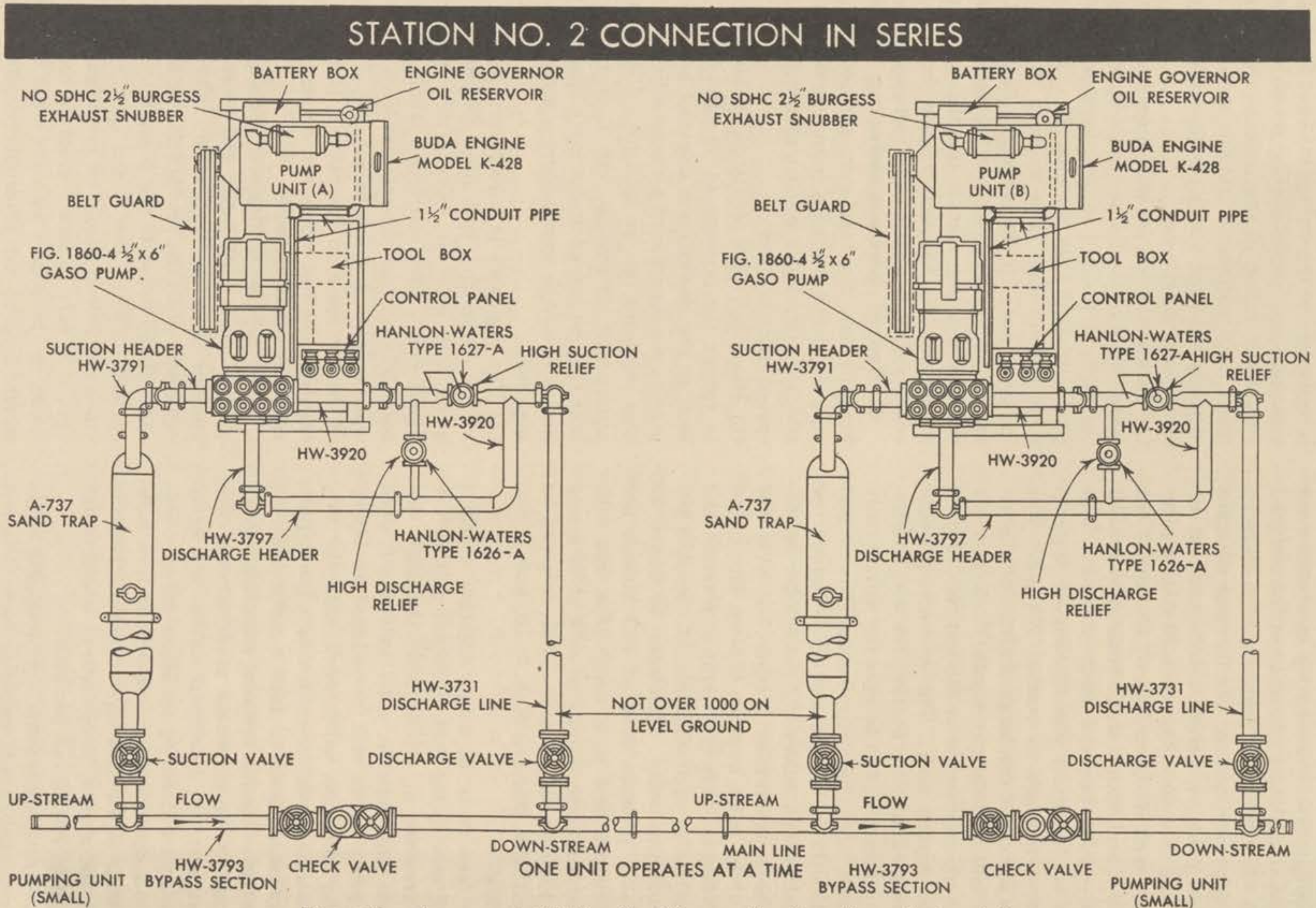
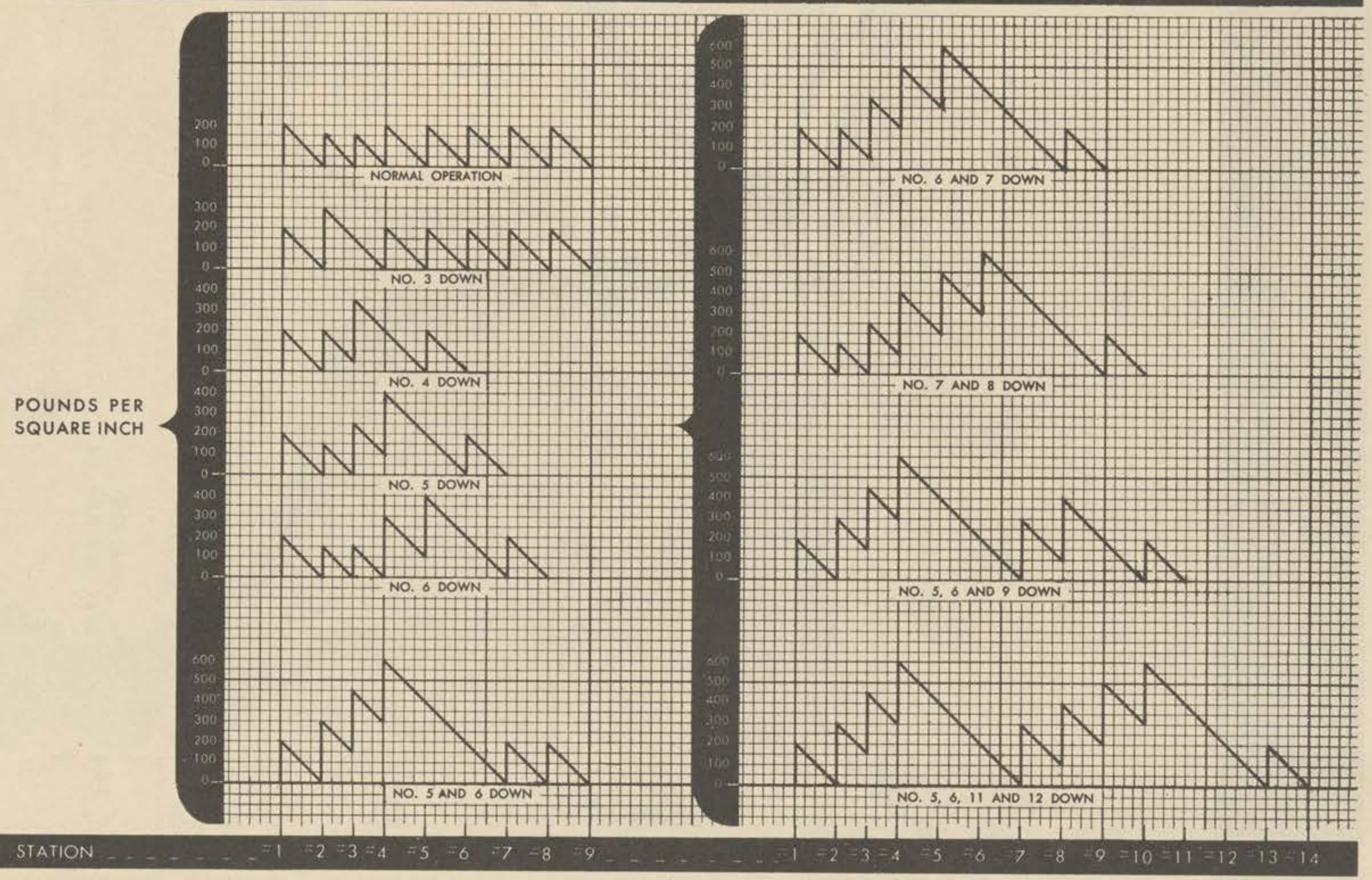


Figure 35. Arrangement of Station No. 2 (two small reciprocating units in series).

HYDRAULIC GRADIENTS : PRESSURES AT VARIOUS RECIPROCATING PUMP STATIONS



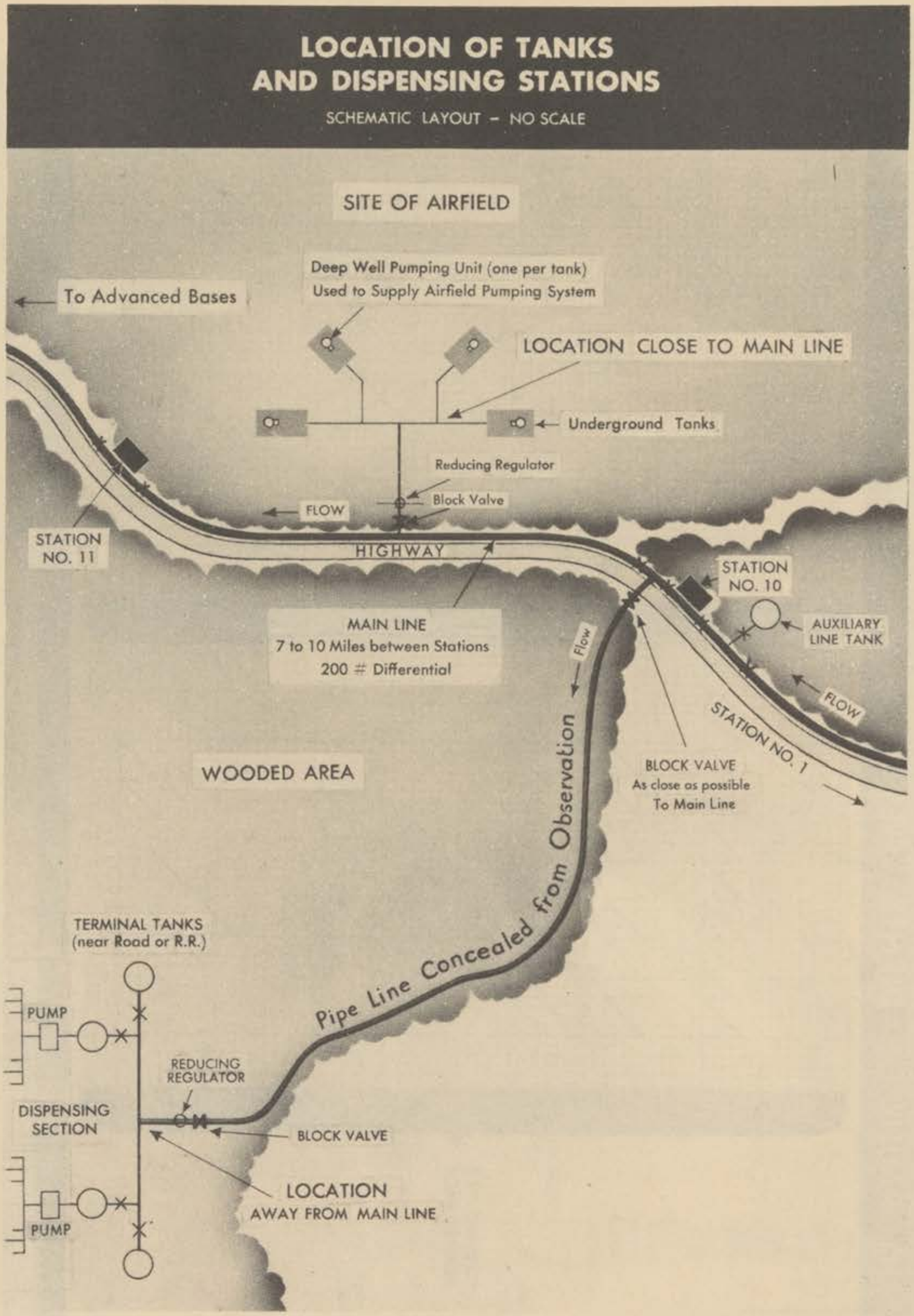


Figure 37. Schematic layout of tanks and dispensing stations along a main pipe line.

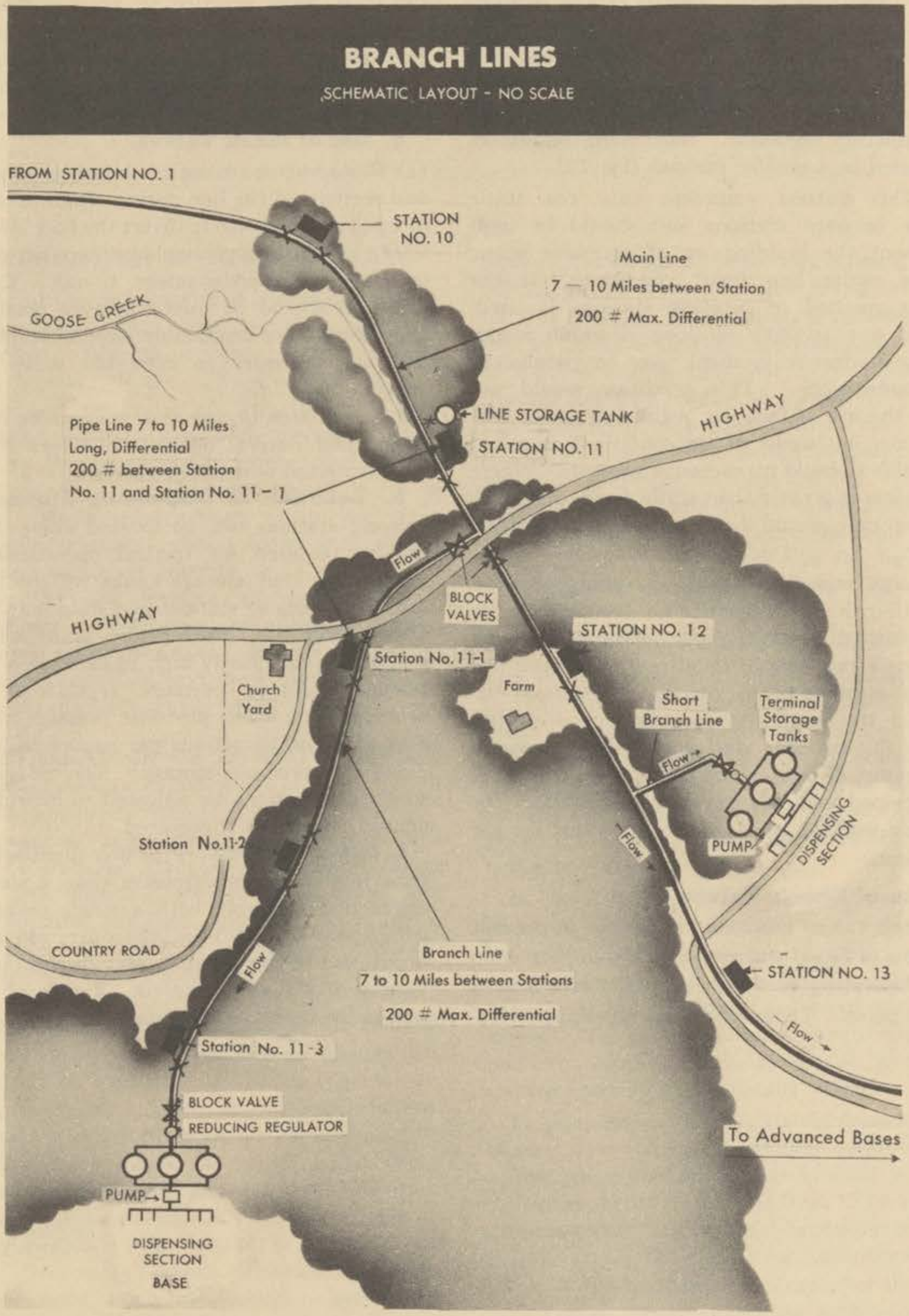


Figure 38. Schematic layout of a branch line.

the Hydraulic Gradient Triangle at the point representing the top of the hill on the vertical profile. The base of the triangle should be horizontal. Mark on the profile paper the 200 pounds per square inch point and extend this point with a line drawn horizontally until it intersects the profile. This is the location of a pressure reduction regulator. Succeeding regulators are located in a similar manner (fig. 29).

(*b*) This method considers only the static pressure between stations and should be used to prevent the building up of excessive static pressure under "no flow" conditions. If the gradient method of locating stations is used, there is a possibility on long downhill slopes that the hydraulic gradient may be parallel to the ground slope. This condition would not require the use of reducing regulators under flow conditions, but under static conditions it would be possible to build up excessive pressure. Where friction loss is greater than static head, a regular pumping unit would be installed in the usual manner.

e. Large reciprocating pumps equipped with 4- by 10-inch liners operate at 400 pounds per square inch differential pressure while pumping 200 barrels per hour through a 4-inch pipe line and with stations spaced at twice the normal distance for the small reciprocating pump service. It is for this reason a station cannot be bypassed as a pressure of 800 pounds per square inch would be developed and this value is greater than the allowable working pressure recommended for the equipment.

f. Use of Check Valves.

(1) Check valves are used in the line to prevent back flow of liquid when upstream pumping units are not operating, or when the uphill line is broken at some point. These valves are especially necessary on long uphill lines. They have no use on downhill lines.

(2) It is good practice to place a check valve section in the main line at the discharge side of each station. This prevents the backing up of liquid in the pump when the system is shut down and makes it easier to resume pumping operations.

g. Use of Block Valves.

(1) Block valves are used to isolate pump stations and sections of the line during repair in the event of breakage, and also to divert the flow into branch lines. A block valve should be placed in the line at intervals of approximately 1 mile. Concealed locations should be used wherever possible, and they should be reasonably accessible in case it becomes necessary to close the valve for any reason.

(2) The section of line most vulnerable to enemy action and natural destructive forces should be well protected with block valves.

h. Location of Dispensing Station. Dispensing stations will be located along the pipe line as required for tactical operations. It is anticipated that storage tanks will be provided for the dispensing stations and fluid may be withdrawn from the line at any point where the pressure is sufficiently high to cause flow into the tanks. Reducing pressure regulators will be provided to reduce pipe-line pressure to values around 10 or 15 pounds per square inch for delivery into products storage. The reducing pressure regulators can be adjusted to provide higher delivery pressures if required.

i. Branch Lines. Pipe-line distribution systems may be more extensive than a simple line connecting a supply with a single point of distribution. Branch lines, the operation of which is outlined in this manual, may be used in a wide variety of ways as required. Figure 38 shows a schematic layout of a branch line.

CHAPTER 4
CONSTRUCTION

11. PREPARATION OF RIGHT-OF-WAY.

a. Military pipe lines should always be laid out along a course which provides the maximum concealment. Benefits of this precaution will be lost, however, if the right-of-way is not prepared with a minimum of disturbance of natural cover. Obstructions such as small brush will be an inconvienience in laying the line but nonetheless should be left undisturbed so far as possible. Major obstructions, such as steep cliffs, large boulders, and deep ravines should be avoided, whenever possible.

b. Grading and leveling the right-of-way is not necessary. Flowing streams should be crossed by utilizing existing bridges. If none are available, simple suspension bridges of the type shown in figure 39 should be constructed.

12. INSTALLATION OF COMMUNICATION SYSTEM.

As soon as the course of the projected pipe line has been determined and the right-of-way prepared, a telephone or telegraph line should be installed along it for communication during the pipe-line construction period and for dispatching purposes when the pipe line is in operation. Alternative systems of communication are radio and messenger.

13. PRIMARY DISTRIBUTION OF PIPE.

Pipe, couplings, and miscellaneous fittings will be received at beach or rail head, (fig. 40) depending upon the location of the projected line. The primary distribution of the pipe should be to stock piles at about 20-mile intervals where road net permits stringing of pipe by truck. Pipe should be transported from stock piles to the right-of-way by truck or truck-drawn trailer. Over rugged terrain where manual stringing is necessary, stock piles should be established at shorter intervals, at points where trucks can reach the right-of-way. A Type I, two-wheel, utility pole type trailer, equipped with two load binders, drawn by a 2½-ton 6 by 6 truck, or other suitable prime mover has been found satisfactory for this service. The maximum permissible load for the trailer is approximately fifty 20-foot joints of light weight 4-inch pipe (4,500 pounds) on average dry dirt roads. (See figs. 41, 42, and 43 for examples of this equipment in use.) Trucks of conventional oil field design are being built for use of the pipe-line detachments (fig. 44). These trucks will be 2½-ton 6 by 6 prime movers, with rear mounted winch, flat bed, detachable A-frame. Such trucks may be used also for hauling the pumping units and spotting them.

14. STRINGING PIPE AND COUPLINGS.

a. Pipe in stock pile which shows pronounced rusting should be thoroughly swabbed with wire brush cleaner provided for this purpose and swept with compressed air before it is strung along the right-of-way for laying. Extreme care should be exercised when coupling the pipe in the field to guard against dirt and other objectionable particles being left in the completed line.

b. Since the pipe is lightweight, it can be strung by a two-man crew unloading from a slowly moving truck (fig. 45). Pipe must be distributed with care and laid end to end so that lengths will not have to be carried along the line by the coupling crews. This will also eliminate extra trips by the trucks to supply additional pipe at points where the stringing crew has already passed.

c. Couplings should be strung from a separate truck. One coupling, complete with bolts and gasket assembled, is laid out at each joint along the entire line (fig. 46). At least 15 percent more couplings than are actually necessary to connect the line should be on hand for replacements in the event of failure of any couplings after the line has been tested. They should be held in stock by the maintenance and repair crew at convenient locations along the line.

552517 O - 43 - 4

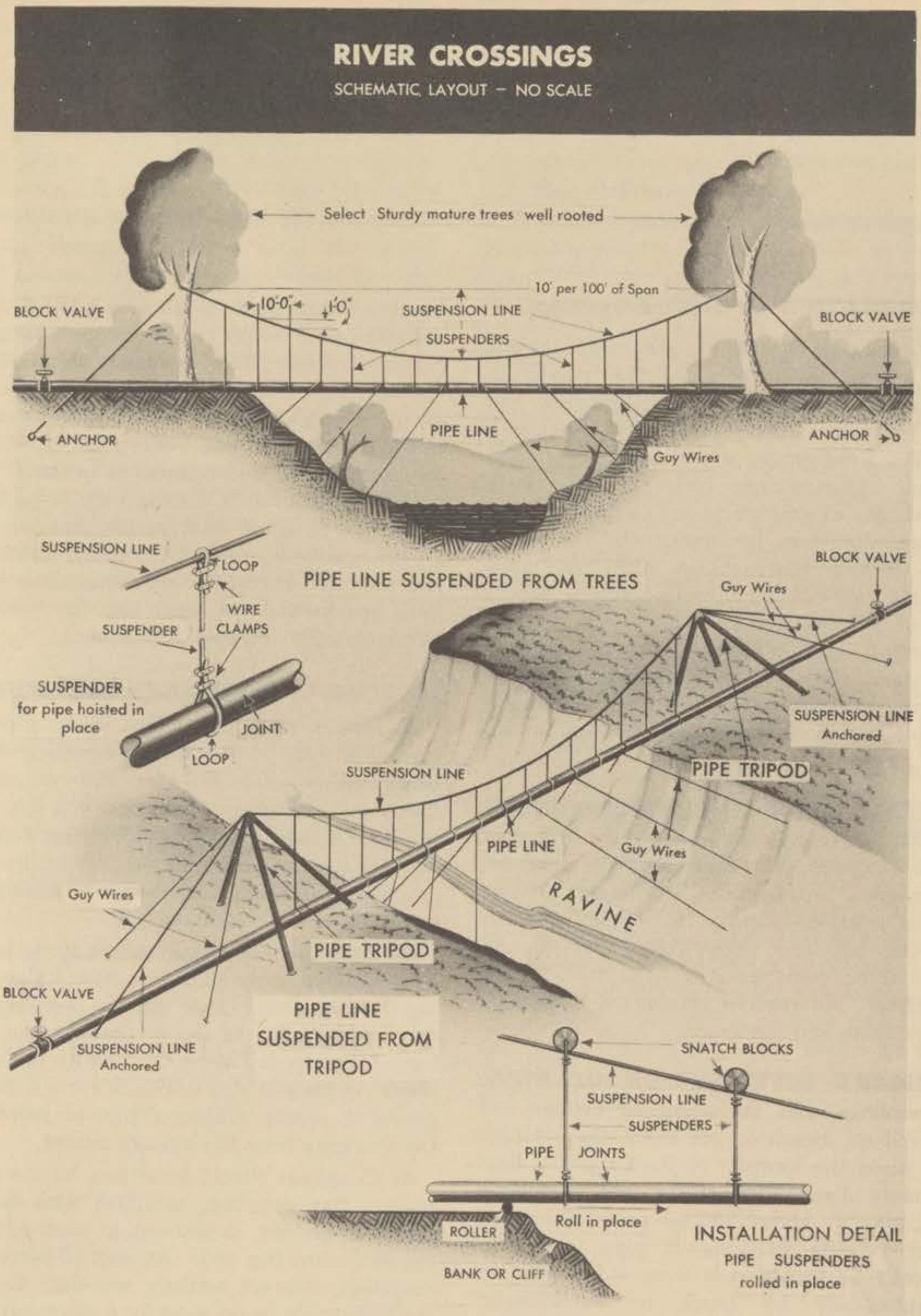


Figure 39. Schematic layout of suspension line.

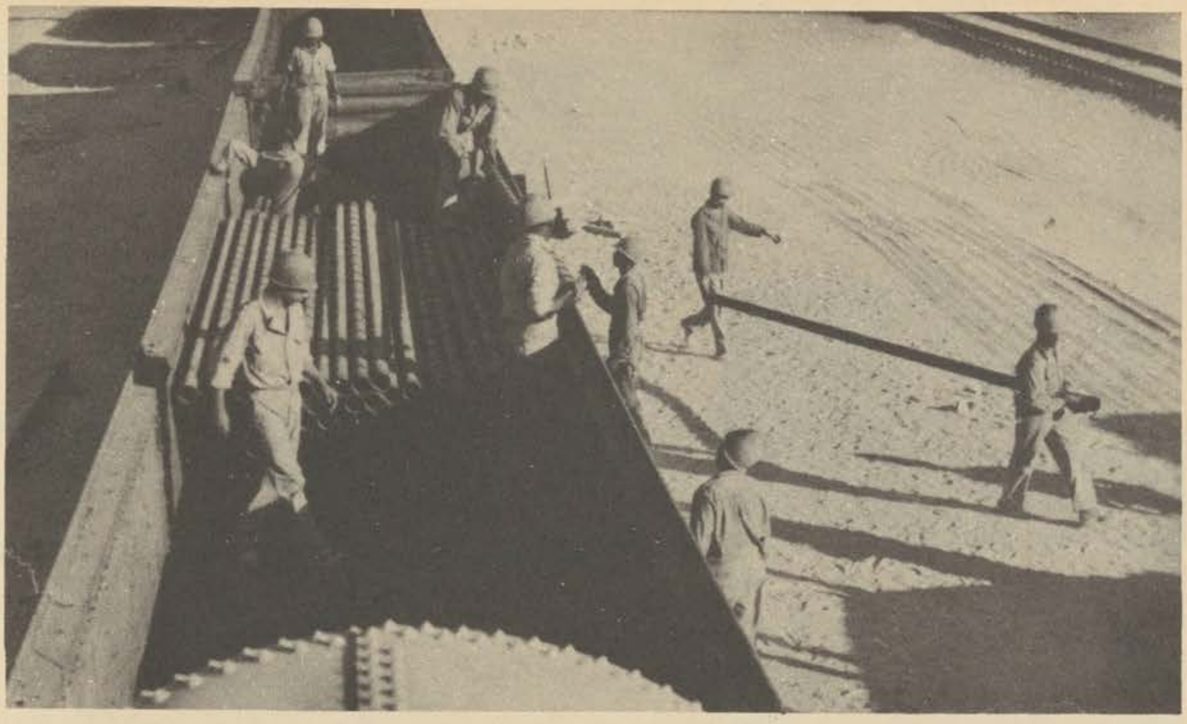


Figure 40. Unloading 4-inch spiral-weld pipe.

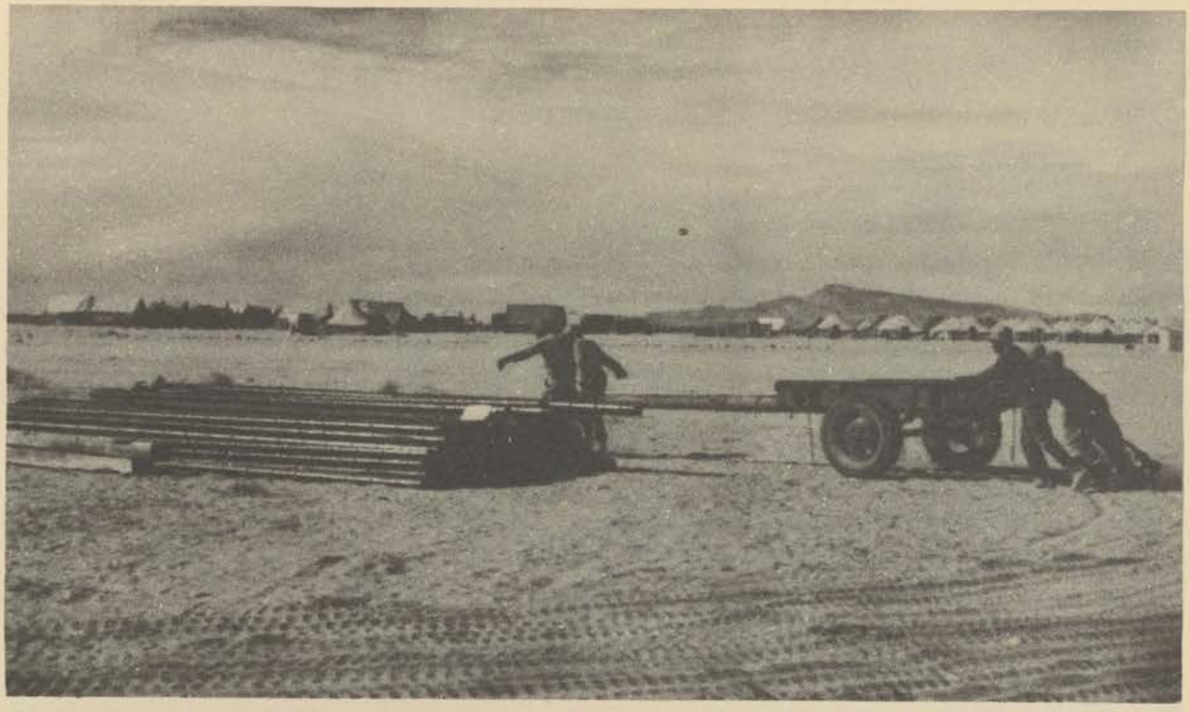


Figure 41. Preparing to load trailer at a pipe stock pile.

Figure 42. Two-wheeled ponton dolly loaded and hitched to a 2½-ton, 6 by 6 truck.

Figure 43. Removing booms during pipe string operation.

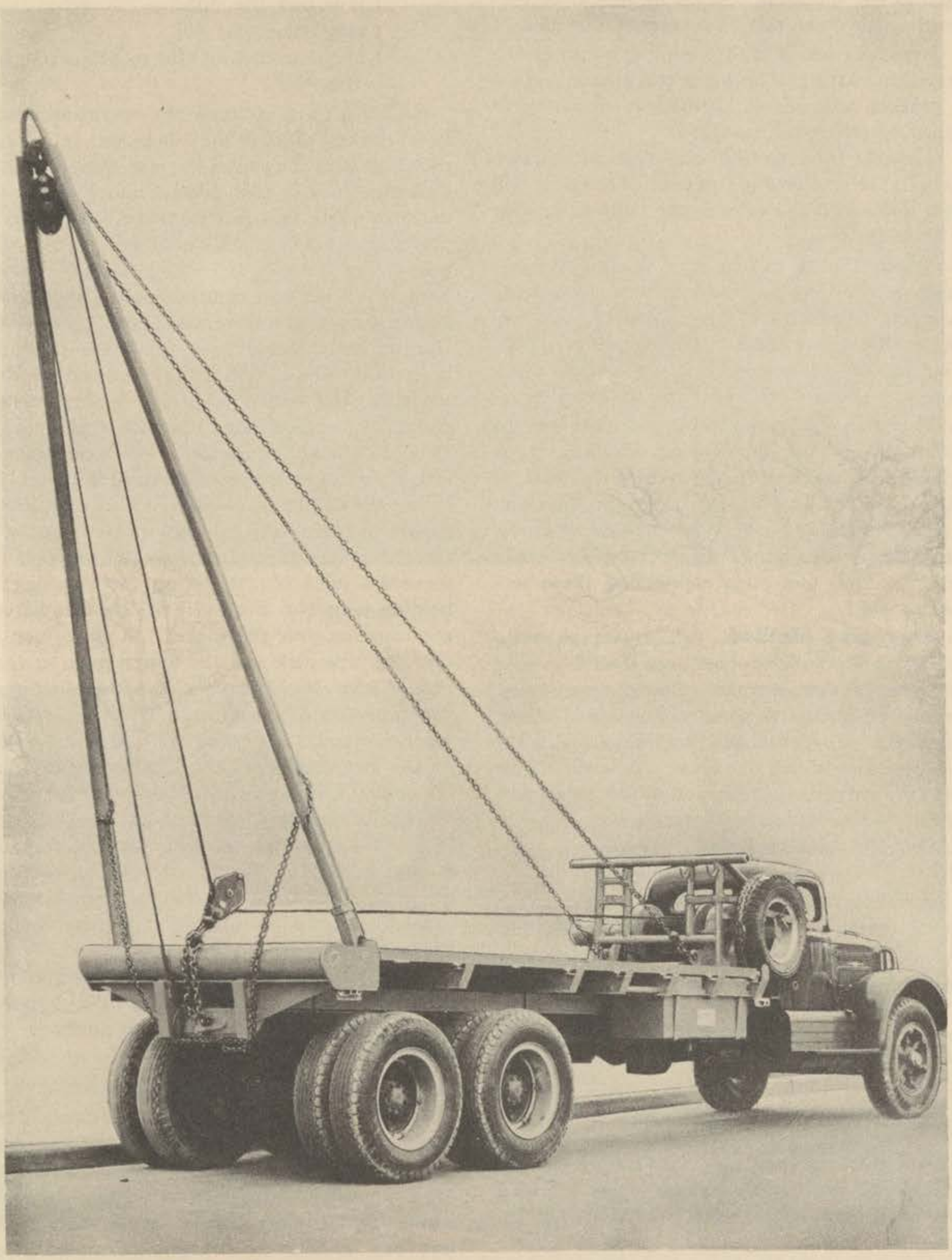


Figure 44. Conventional oil-field truck.

15. COUPLING THE LINE.

a. Prior to distribution and installation of couplings the following operations should be performed at the stock pile by a crew of four men:

(1) Grease the inside of the coupling housing with a very thin coating of ordinary cup grease, so that the gaskets will adjust themselves and not be pinched or otherwise damaged.

(2) Assemble the coupling with bolt nuts drawn up loosely, or so that the top edge of the nuts will be left flush with the ends of the bolts to protect bolt threads.

b. Where trucks can be used along the right-of-way, a coupling-distribution crew, consisting of a truck driver, truck driver's helper, and two basics, will use one truck. The couplings should be laid against the pipe in a nearly upright position to prevent dirt from entering the coupling.

c. There are two practicable methods for the installation of pipe lines using Victaulic type couplings. These are the stovepipe method of adding one joint at a time to the main line; and the grasshopper method which consists of stovepiping two or more joints together into an easily handled section and then connecting these sections (fig. 47).

d. Stovepipe Method. The stovepipe method of laying Victaulic coupled lines should be used to work across rough terrain. One four-man crew, under the supervision of a noncommissioned officer, is adequate. However, the progress of laying the line depends upon this one crew. It is the slower of the two methods of construction and should be used only where absolutely necessary.

e. Grasshopper Method. In the grasshopper method of construction, it is desirable to use five crews operating in any one sector. Four coupling crews of five men each, including four basics and one noncommissioned officer, proceed along the right-of-way, coupling the joints of pipe together (fig. 48). The fifth crew, consisting of five or more men (fig. 49) under the supervision of a noncommissioned officer and known as the connecting or tie-in crew, follows the coupling crews and joins the coupled sections of pipe to form the main line. Each coupling crew should connect one more coupling than there are coupling crews in a particular sector. In the case of four coupling crews, each crew will connect five couplings involving six joints of pipe. Tie-in crews cannot conveniently handle sections of more than eight joints of 4-inch pipe or six joints of 6-inch pipe.

f. Tools for Coupling Crew. Standard tool equipment for both connecting and coupling crews consists of—

1 pipe jack (fig. 50).
1 lazy board (fig. 50).
1 speed wrench of size to fit coupling nuts (fig. 48).

g. For a coupling crew the operation is as follows: the end of joint No. 1 is placed on the raised end flush with the end of the pipe (figs. 51 and 52). The pipe jack is then placed under joint No. 2, approximately four feet from the far end, so that joints Nos. 1 and 2 can be alined (fig. 52). The near end of joint No. 2 is raised opposite the end of joint No. 1, the pipe ends butted together, and the gasket slipped over the ends of both joints (fig. 54). Bottom and top halves of the coupling are then placed over the gasket (figs. 55 and 56), squeezed together, and bolted down evenly (fig. 57) until seated in the grooves on the ends of the pipe (fig. 58). In the above operation one man places the lazy board under the pipe and straddles joint No. 1, facing the end to be coupled. This man slips the gasket in place over the ends of both joints, and bolts the coupling in place. A second man straddles joint No. 2, facing the coupling, and holding joint No. 2 in place fits the two halves of the coupling over the gasket. A third man handles the pipe jack and the fourth man, at the far end of joint No. 2, assists with the alinement of the pipe during coupling. This man also disassembles couplings which were previously placed on the ground at each coupling location and slips the rubber gasket on the far end of the joint, ready for the beginning of another coupling operation. Pipe is lowered from the jack onto the lazy board so that the end of the pipe is not dropped on the ground. Keep the gasket and pipe end clean.

h. The coupling operation is the same for the tie-in crew, except that extra men are available to handle the heavier coupled sections. Two or four men hold joints, two men put the coupling on and one man goes ahead of the group checking joints and opening couplings.

16. STREAM AND RIVER CROSSING.

a. Gullies and streams less than 50 feet in width can be easily crossed by coupling 100 feet of pipe, dragging it across the gully or stream, and anchoring it securely to trees or to some form of deadman. Swift streams and gullies or rivers wider than 50 feet will have to be bridged. Coupled pipe in considerable length can be pulled across gullies and rivers by a winch. A 4-inch, 14-gage, spiral welded Victaulic-coupled pipe, filled with gaso-

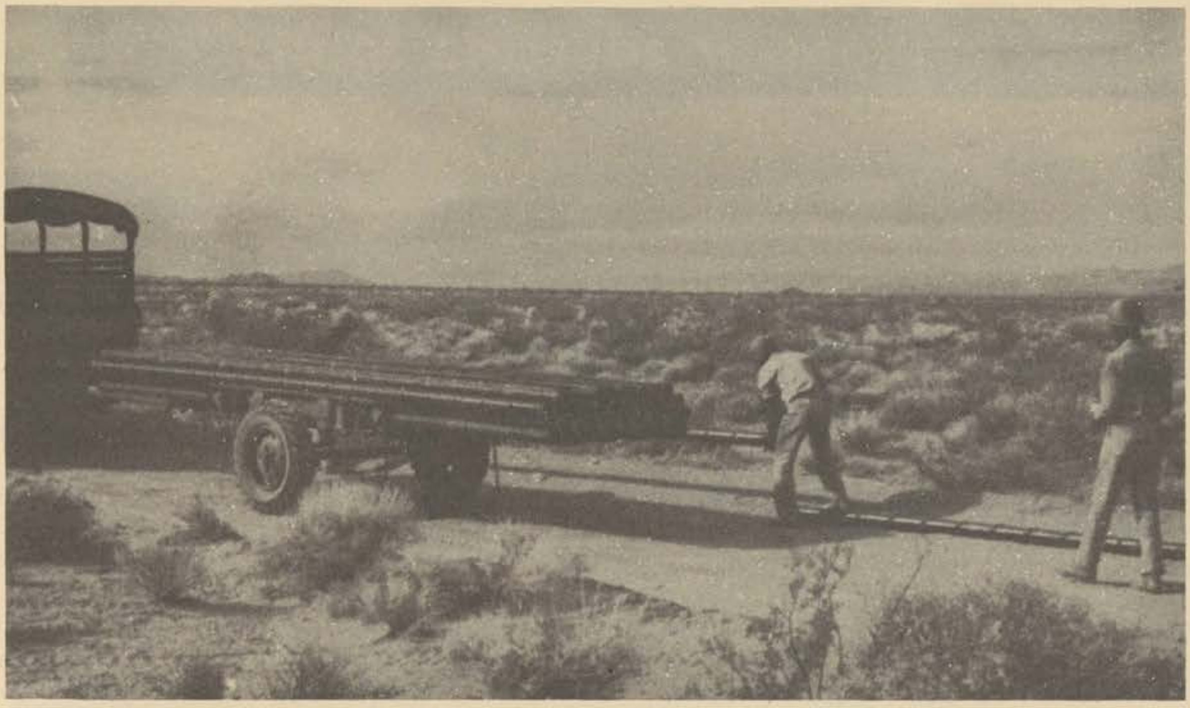


Figure 45. Stringing pipe from trailer.

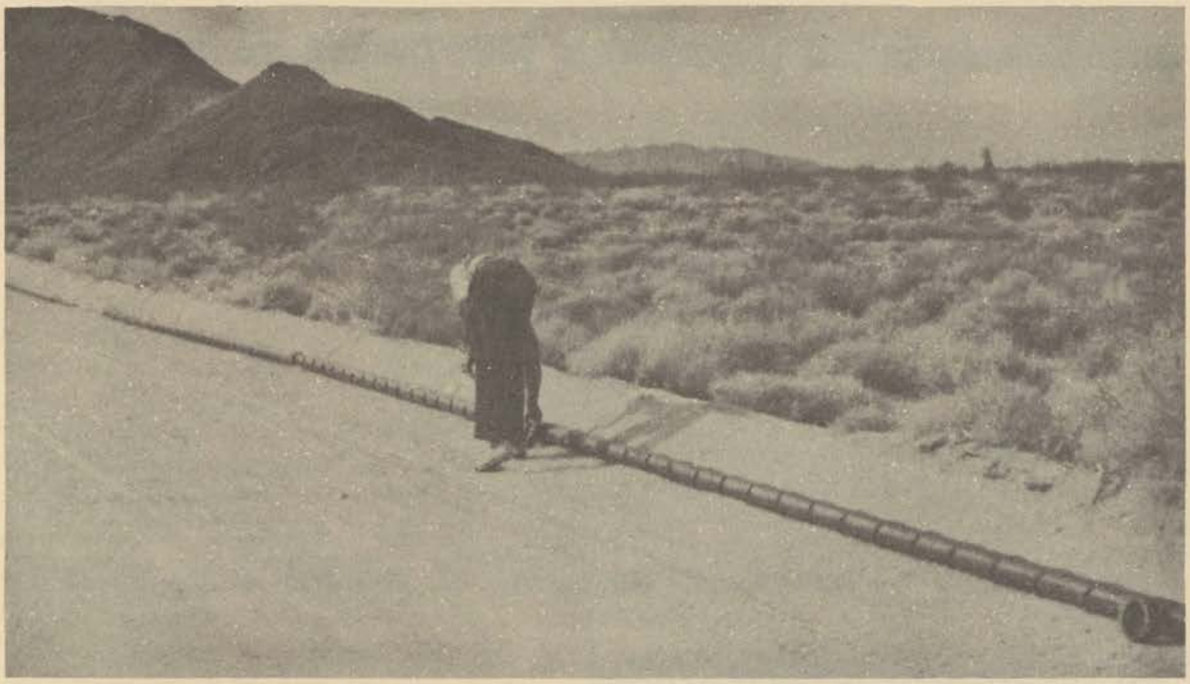


Figure 46. Stringing couplings along the pipe line.

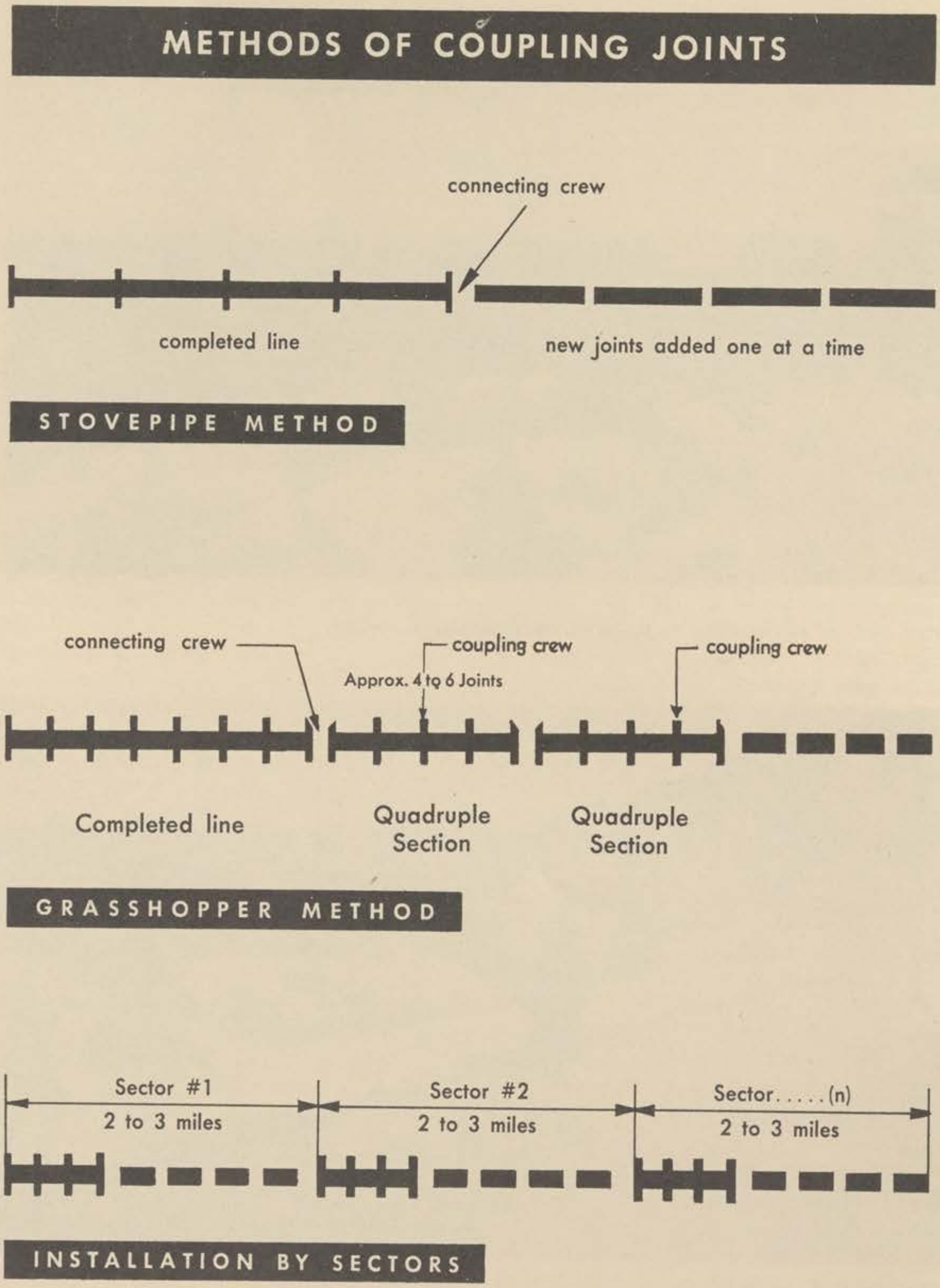


Figure 47. Methods of coupling joints.

Figure 48. Two four-man crews connecting pipe.

Figure 49. Coupling crew holding lazy board, jack, and speed wrench.

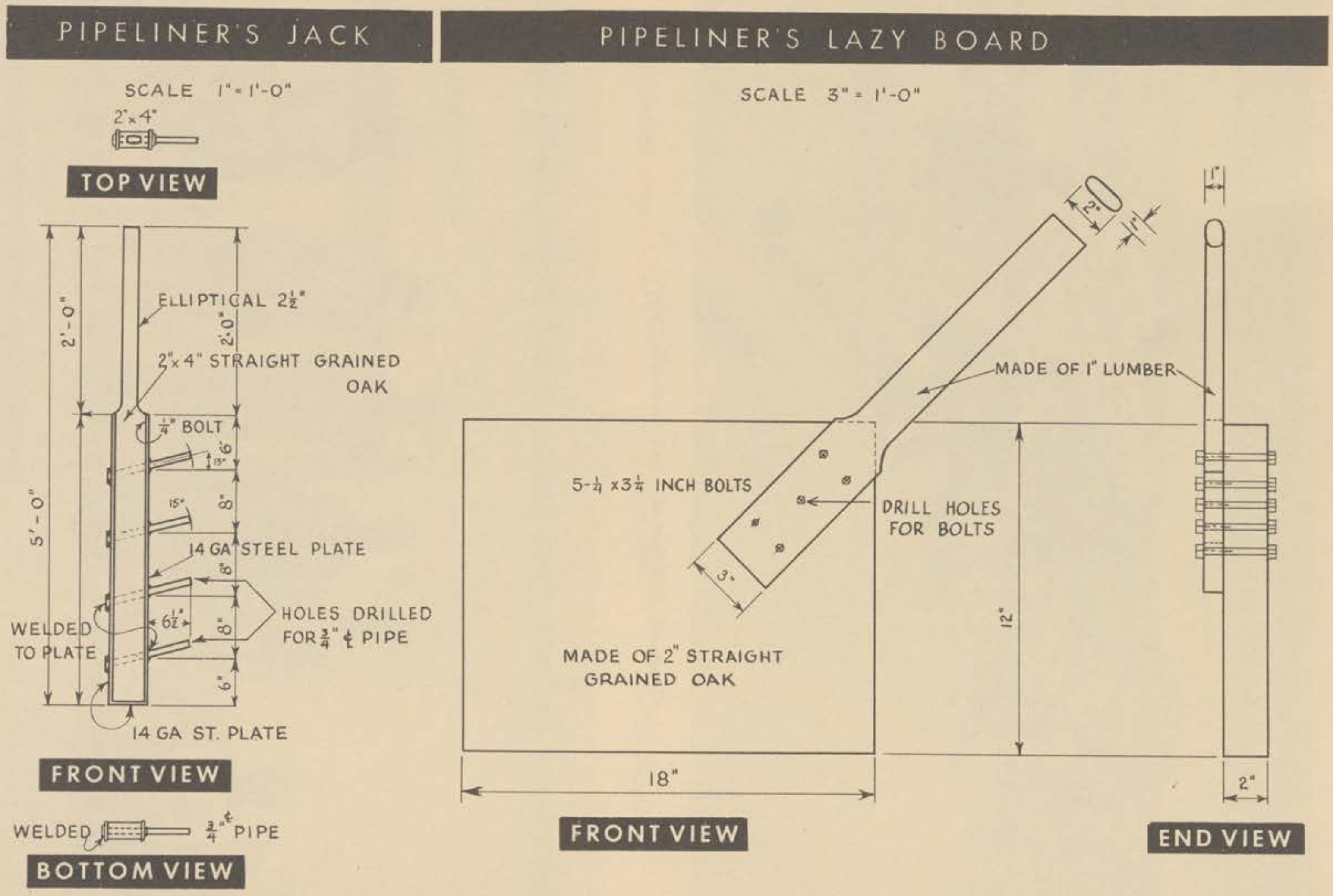


Figure 50. Detail drawings of pipeliner's jack and lazy board.

line, will span 650 feet without intermediate support with a safety factor of four. All spans must be anchored firmly at each bank or cliff, as the reciprocating pumps used cause a pulsation, the repeating action of which may result in fatigue failure of the pipe.

b. One valve section should be installed on each side of a crossing.

c. The general rule for sag in cable is 10 feet per 100 feet of span.

17. INSTALLATION OF RECIPROCATING PUMP STATION. Pump station sites should be chosen with a view of concealing the equipment by taking advantage of any natural cover that is available. The site chosen must be firm, level ground, large enough to permit the wide dispersal of all the equipment included in the installation.

a. The site for the pumping unit or units should be leveled. Pumps should be set on a wood-beam base, if possible, otherwise it must be set on solid ground. Filled ground is unsuitable for a pumping unit. Leveling up a pumping unit is important, since the proper functioning of the unit depends upon having the machinery level. For this purpose use a spirit level.

b. Procedure for Leveling Pumping Unit.

(1) Block up the skid frame on substantial timbers (6 inch by 6 inch or 8 inch by 8 inch) if available, so that the unit is nearly level and at the desired distance from the main line.

(2) With a spirit level placed on the pump skid, or a machined surface which can be used as a datum, level the unit in both directions by using wood or steel wedges or bars. The suction and discharge flanges of the pump then can be checked for plumb. A slight variation from plumb will be compensated for by the Victaulic couplings.

(3) Having leveled the unit in this manner, replace the temporary blocking with permanent blocking. If materials are available and time allows, pour a concrete foundation for the engine and pump, and anchor the skid frame to this base, with anchor bolts through the holes in the skid frame. Blocking is also required under suspended valves, relief valves, sand traps, and other unsupported parts.

c. Alinement of Pump and Engine, and Belt Drive.

(1) Use the adjusting screws on the skid frame that bear against the engine base plate to increase or decrease the spacing of the engine from the pump (fig. 59).

(2) Use a straightedge or string to aline the motor with the pump. A straightedge placed along the side of the driving sheave on the engine and along the side of the driven sheave on the pump should touch both sides of both sheaves at the same time.

(*a*) When the straightedge touches only one edge of the drive sheave and one edge of the driven sheave, the motor must be shifted in the proper direction toward or away from the front of the engine. This is done by means of the two adjusting screws at the base of the motor.

(*b*) Draw the adjusting screws up snugly to prevent any shifting in this direction while the drive belts are being adjusted.

(3) *Belt adjustment.*

(*a*) Check the tension of the belts after their installation by pressing down on them with the hand. It should be possible to depress each belt from 1 inch to 1½ inches when they are in proper adjustment.

(*b*) If the belts are too tight, the engine must be moved toward the pump in order to relieve the belt tension. This is done by use of the adjusting screws on the bed plate, being careful to maintain the alinement of the drive sheaves.

(*c*) If the belts can be easily depressed more than 1½ inches, or if they seem to be hanging loosely on the sheaves, they need to be tightened. This requires that the motor be moved farther away from the pump.

(*d*) When the belts have the right amount of tension and the sheaves are alined, the adjusting screws should be securely locked in place with the lock nuts provided. The engine and pump mounting bolts should then be securely tightened to the skid frame, to prevent any movement of one unit relative to the other, and a final check made for alinement and level.

d. Installation of Station Header Piping.

(1) When the engine and pump are properly set and alined, connect the station header piping to the pump and to the main line.

(2) The station header assembly consists of specially cut lengths of pipe, ells, flanges, valves and relief valves. Each section of pipe of this assembly as shipped from the factory has a part number stenciled on it corresponding to the numbers shown on the drawing.

(*a*) The station bypass section is installed in the main pipe line by removing the plain pipe section where it is desired to locate the station. The station bypass section is installed with the check valve set so that the discharge pressure will close it against the lower suction pressure. The check valve *must open* to allow fluid to bypass the station when the station is inoperative.

Figure 51. Placing gasket on pipe end.

Figure 52. Gaskets should be placed flush with pipe end.

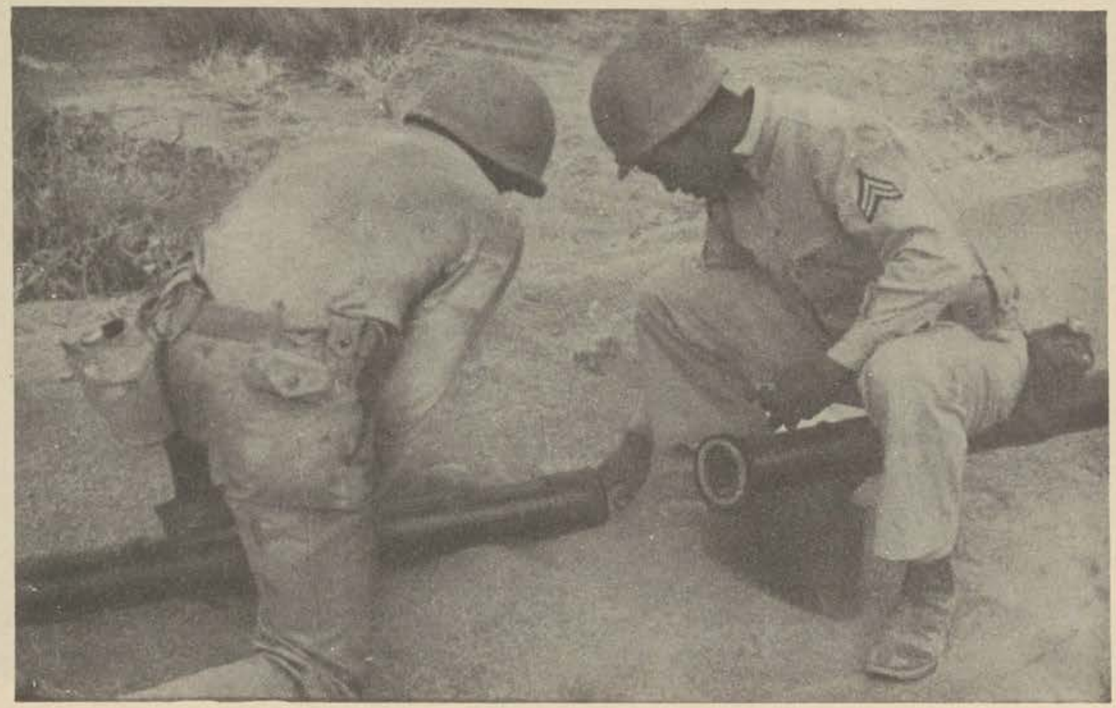


Figure 53. Preparing pipe joint for alinement. The end of the assembled pipe line is on the lazy board.

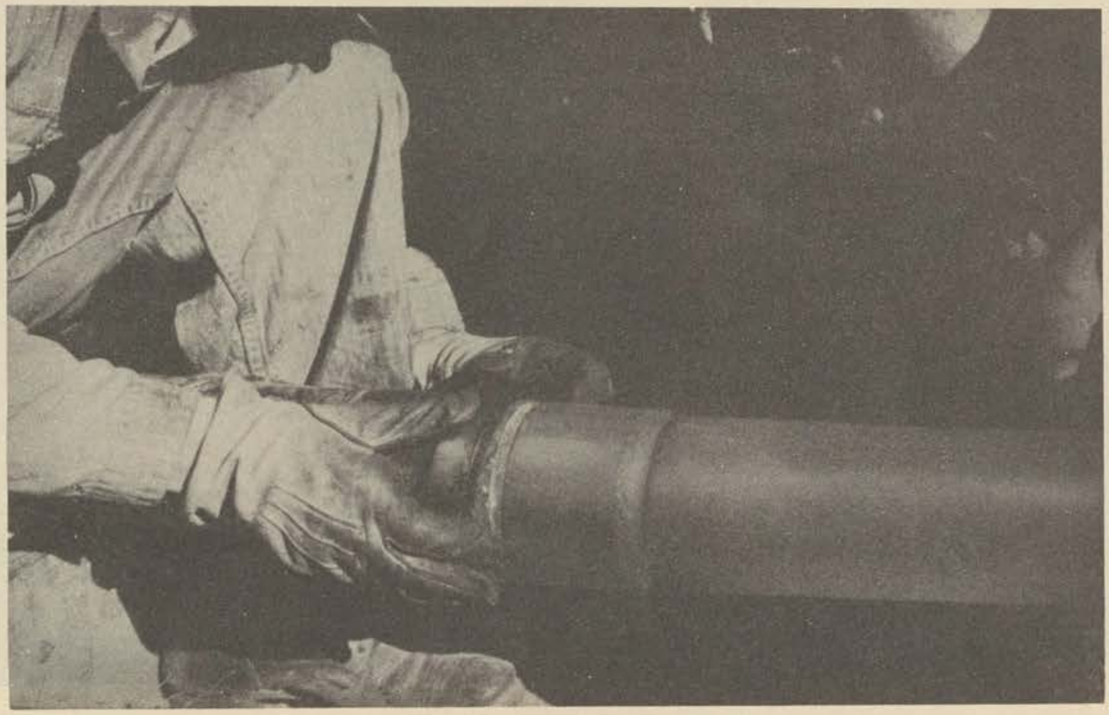


Figure 54. Slipping gasket over ends of pipe.

Figure 55. Placing bottom and top halves of coupling over the gasket

Figure 56. Holding coupling in place while bolting it together.

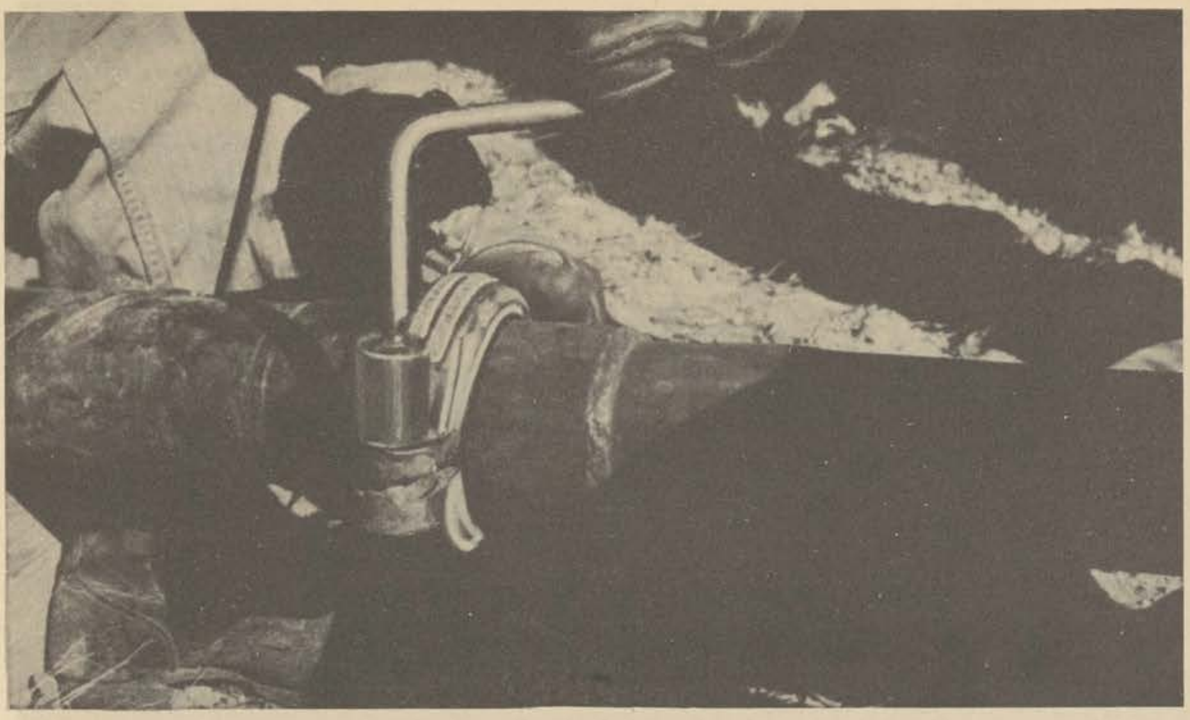


Figure 57. Turning the nuts down evenly.

Figure 58. Completed coupling.

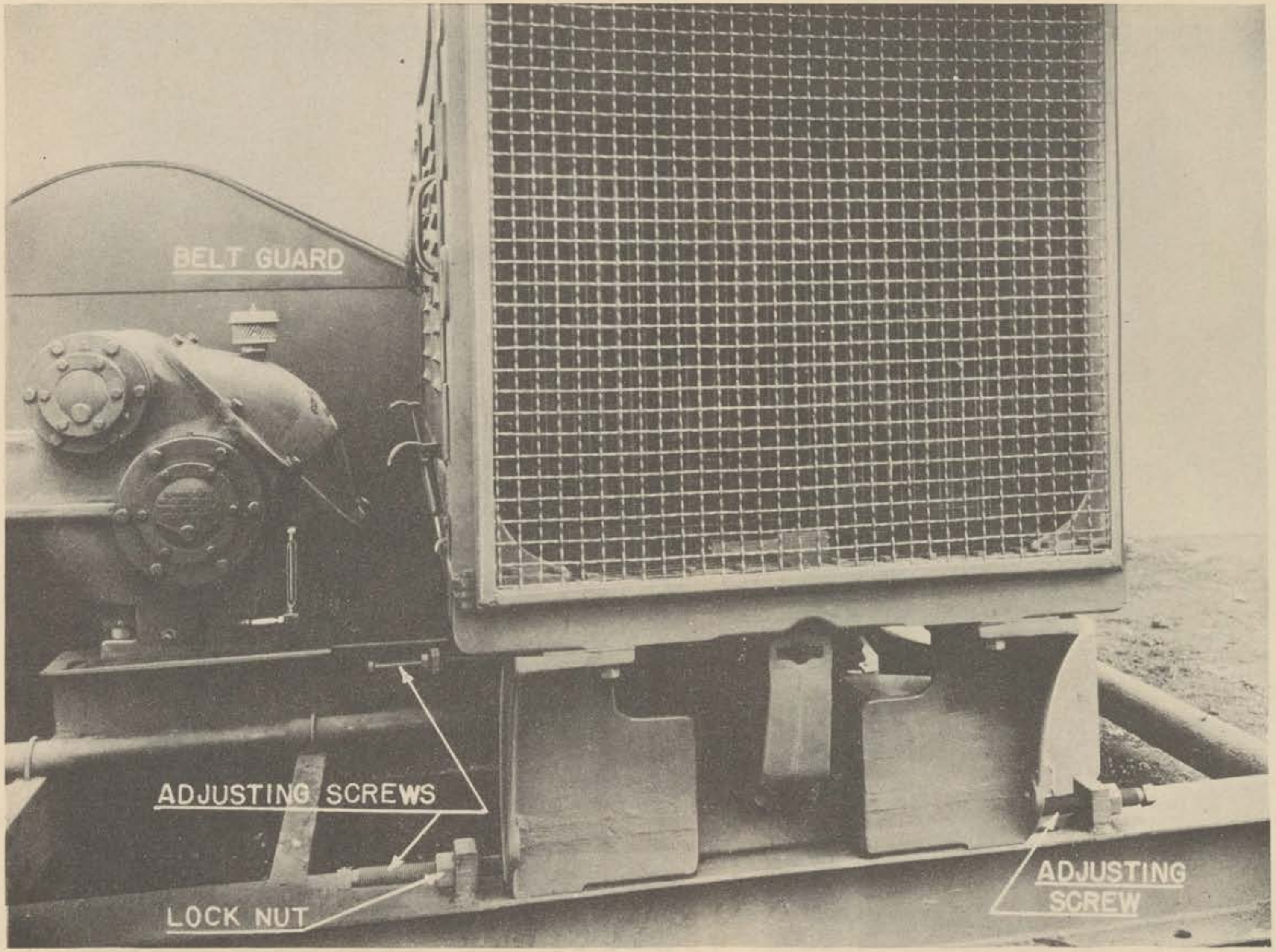


Figure 59. Location of adjusting screws to facilitate sheave alinement.

(*b*) Install the pumping unit adjacent to the main line whenever practicable.

(*c*) In the usual installation the sand trap section, with suction valve and discharge valve sections, are connected to the bypass section with an **L** coming out of the top of the main line pipe.

(*d*) All connections between the various pipe sections are made with Victaulic type couplings.

(*e*) Connection of the piping to the pumps is by means of flanges which are fabricated with adapter nipples for connection with Victaulic type couplings.

(*f*) Make flange connections according to the following procedure:

1. Clean the surface of the flanges to remove all grit and other foreign material.

2. Place flange halves together loosely, using the studs or bolts that are provided. Loosely engage the two bottom bolts and the next two bolts above these but below the center line of the flange.

3. Place the gasket into proper position on the raised faces of the flanges.

4. Check the flanges for alinement by centering the inside of the pipe with the port on the pump.

5. Tighten two diametrically opposite bolts first, then two opposite bolts 90° from the original two. Work around the flange tightening opposite bolts until the flange is pulled up evenly.

6. Check the tightness of all bolts again.

(*g*) When space is not available, it is not imperative that the pumping unit use the standard type of installation shown in fig. 60. A compact hook-up, shown in fig. 61, can be used. In this layout the station pump and engine are inclosed inside the piping of the station, the whole station occupying an area of 20 by 24 feet, whereas, in the standard installation an area of approximately 20 by 34 feet is required. In the event it is desired to pump backward through the line, the hook-up shown in figure 62 is suggested as a quick method of changing the direction of flow. The check valves and the piping must be reversed on all stations along the line before pumping is started. A thorough check must be made of the hydraulic design of that portion of the system through which it is proposed to reverse the flow as uphill and downhill gradients become reversed.

18. STORAGE TANKS.

a. Select tank sites to take full advantage of available natural cover. Tanks should be set on hillsides, if convenient, so that the tank installation may be pitted. (See illustration of typical tank pit installation, fig.63.) A hillside tank site has the additional advantage that it furnishes a positive gravity feed to the pump or dispensing stations located below it.

(1) If pump intake pressures are too low, gasoline will vaporize and cause a reduction in liquid pumping efficiency or even complete vapor lock of the pump. This gasoline vaporization can only be eliminated by maintaining a pressure in excess of the gasoline vaporizing (boiling) pressure throughout the system from storage tank to the lowest pressure point at the pump.

(2) Where gravity feed from tank to pump is to be employed there is a minimum elevation which a tank must be above a pump. This minimum elevation can be calculated for centrifugal pumps by adding pump entrance pressure loss constant to friction pressure loss for maximum liquid flow rate between tank and pump, and by converting the resultant total pressure from pounds per per square inch to feet of liquid head units. Reciprocating pump entrance pressure loss is more than equalized by suction effect, the net result being that gasoline can be "lifted" as much as 6 to 10 feet. In no case, however, should a reciprocating pump be located at an elevation above the supply tank outlet, as a positive prime must be maintained at all times.

(*a*) Pup centrifugal pump entrance pressure loss constants for maximum flow rates and minimum gasoline specific gravity are 2.2 and 4.9 pounds per square inch for 4- and 6-inch pipeline service, respectively.

(*b*) Figure 64 shows pipe friction loss for various lengths of 4- and 6-inch pipe transmitting 200 and 400 barrels per hour of maximum specific gravity gasoline, respectively. Figure 65 shows the frictional effect of pipe fittings expressed in terms of equivalent straight pipe. The total equivalent length of pipe for the pipe fittings between tank and pump should be added to the actual pipe length to obtain the maximum flow rate friction pressure loss from figure 64.

(*c*) *Example*. A tank is located 600 feet from a centrifugal pump. Gravity feed of 0.68 specific gravity gasoline through a 4-inch pipe from tank to pump is required. There are six ells in the line which, from figure 65, have a resistance to flow equivalent to 10 feet of straight pipe each, or a total of 60 feet. Add 2.2 pounds per square inch pump entrance pressure loss and 3 pounds per square inch friction pressure loss for the 660 feet of equivalent pipe, giving a total of 5.2 pounds per square inch. Convert to feet of head by multiply-

552517 O - 43 - 5

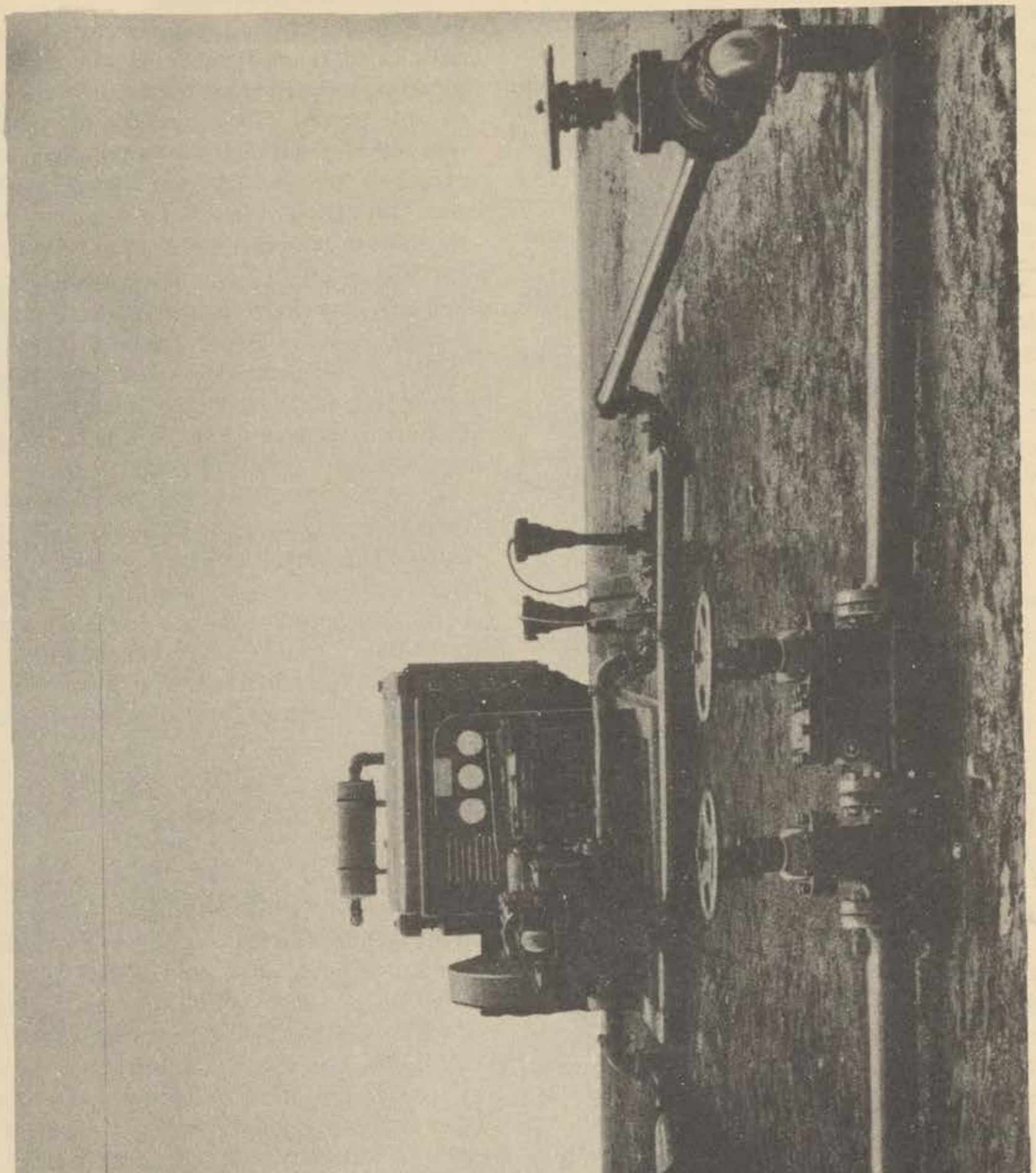


Figure 60. Standard small reciprocating unit installation.

PUMPING UNIT, SMALL (COMPACT HOOK UP)

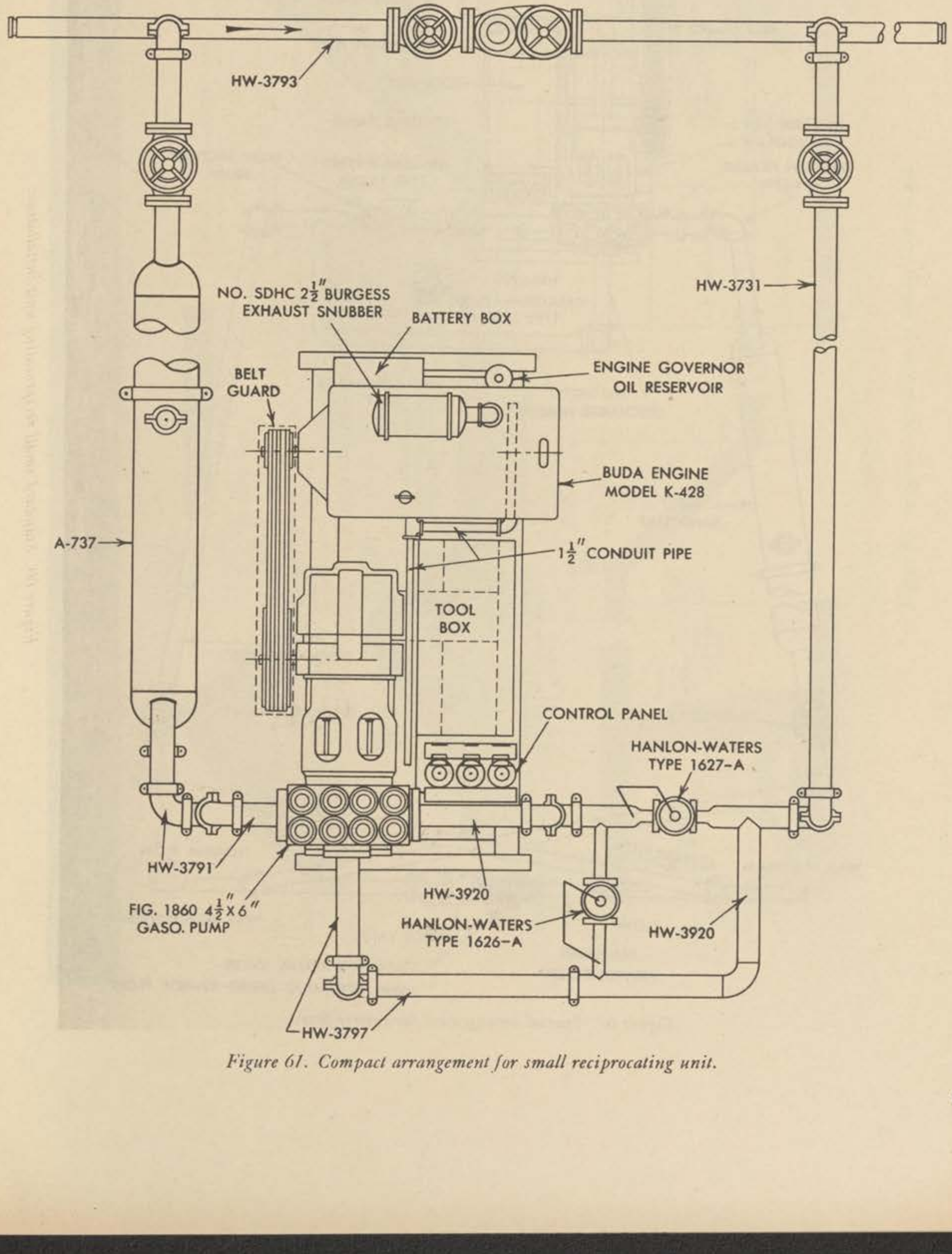


Figure 61. Compact arrangement for small reciprocating unit.

SPECIAL HOOKUP FOR REVERSE FLOW

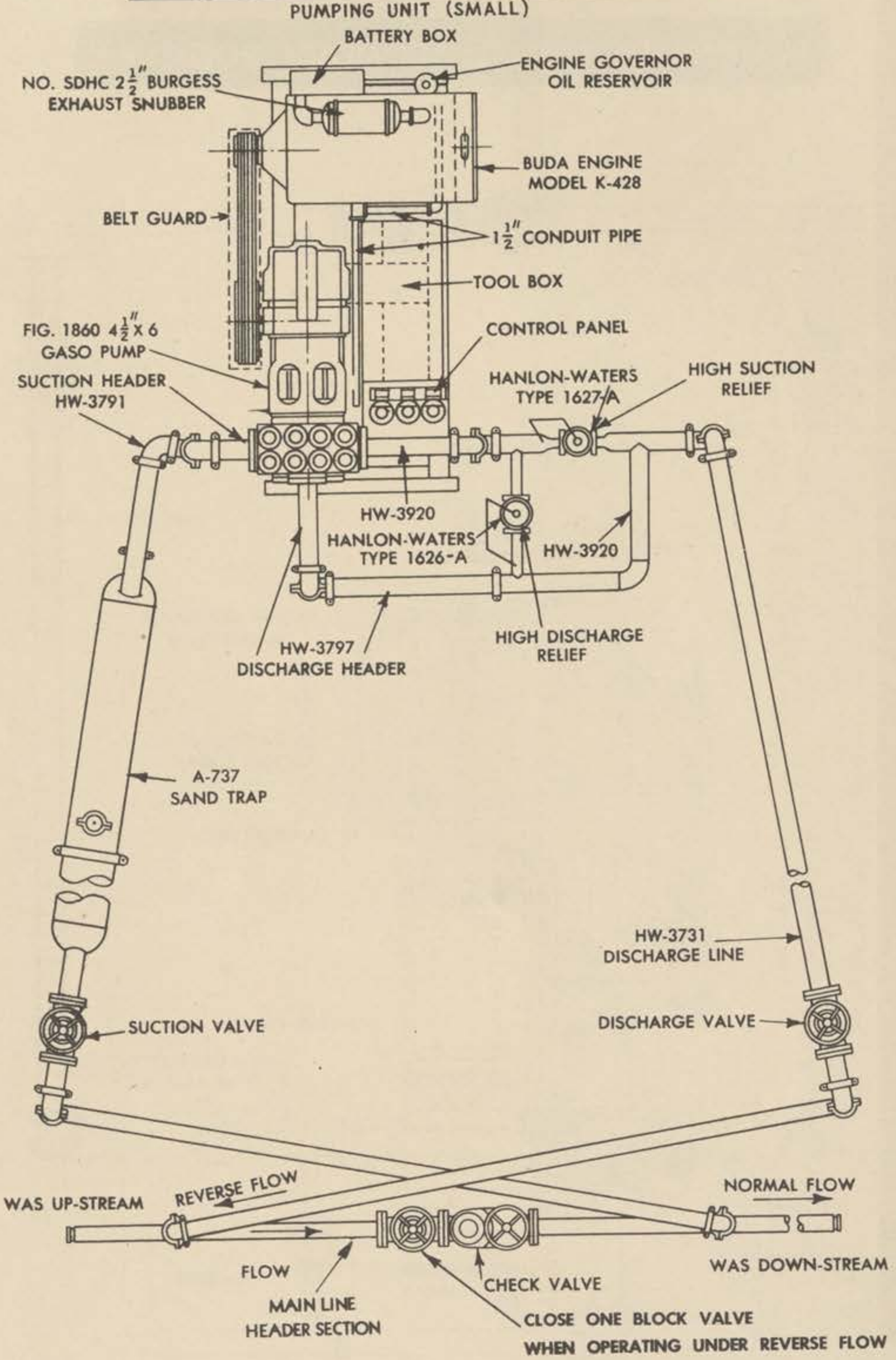


Figure 62. Special arrangement for reverse flow.

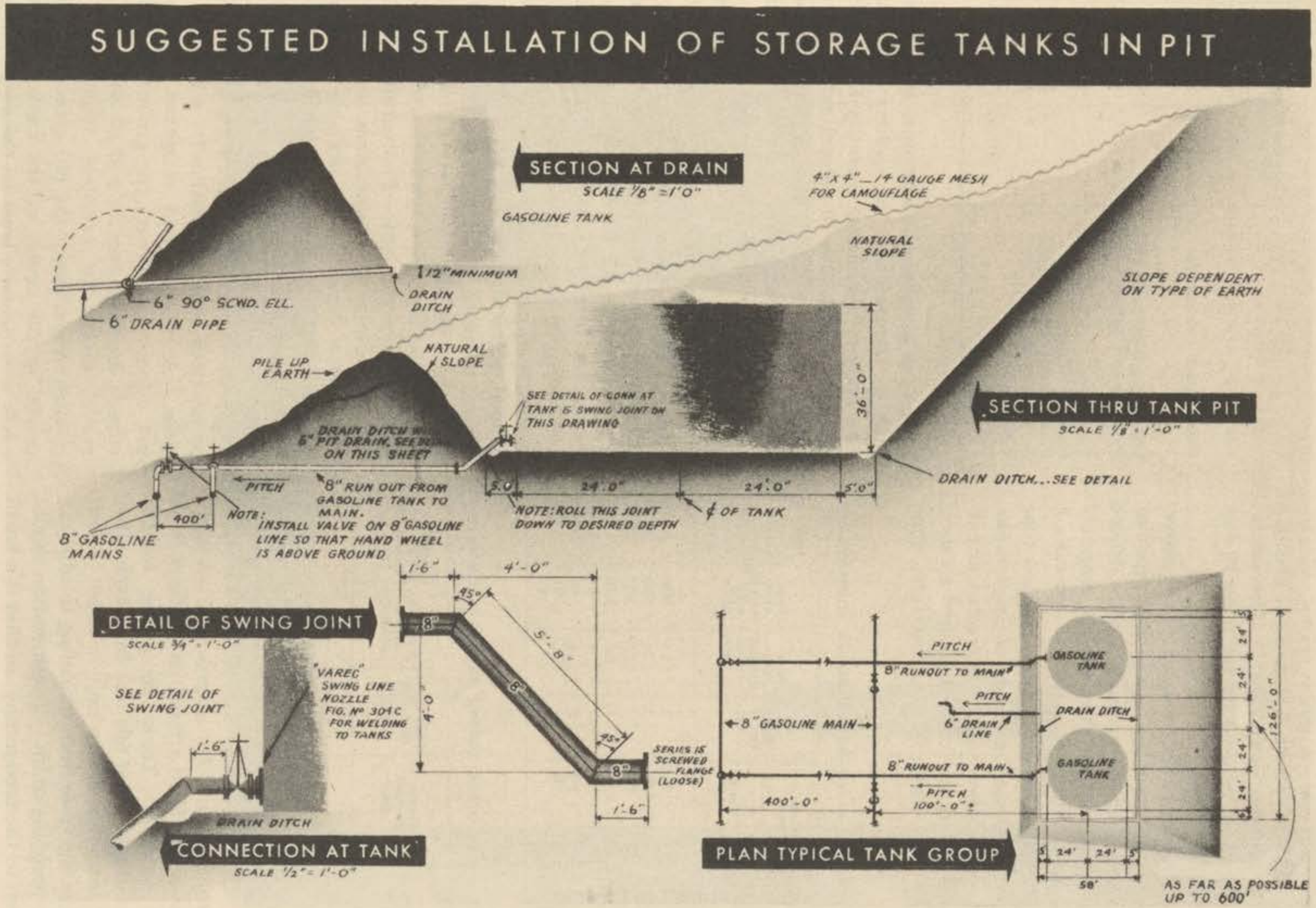


Figure 63. Suggested installation of storage tanks in pit.

ing by 3.4, obtaining 17.7 feet, the vertical distance the tank must be above the centrifugal pump. For reciprocating pump service the entrance pressure loss can be disregarded, giving a required tank elevation of 10.2 feet. If necessary, this 10.2 feet can be reduced by the 6- to 10-foot lift of the pump suction.

b. Bolted steel tanks are standard for the above-ground storage of gasoline in military pipe-line systems. Tank sizes range from 100 to 10,000 barrels. Specifications on the various standard sizes of bolted steel tanks are given in appendix I.

c. The following tables show the erection time in manhours for all standard sizes of single tanks, and for three sizes when tanks are erected in batteries. Times given are for well-trained crews of maximum efficient size and are, therefore, minimum ones.

Minimum time to erect bolted tanks individually

Nominal capacity (barrels)	Dimensions in feet		Number of rings	Maximum number of men in crew	Erection time in man-hours	Erection time in crew-days (10-hour days)
	Height	Diameter				
10,000	24	55	3	25	800	3. 20
5,000	24	39	3	20	450	2. 25
1,000	16	22	2	12	180	1. 50
1,000	8	30	1	12	120	1. 00
500	8	22	1	6	60	1. 00
250	8	16	1	6	40	0. 65
100	8	9	1	6	20	0. 35

Minimum time to erect bolted tanks in batteries

Nominal capacity (barrels)	Number of tanks in battery	Maximum number of men in crew	Erection time in man-hours	Erection time in crew-days (10-hour days)
10,000	4	100	3, 200	3. 20
5,000	4	80	1, 800	2. 25
1,000	8	96	960	1

Choose solid ground for a tank site. A tank must not be set on filled ground unless there is no alternative location. Tanks should be located at minimum distances of 600 feet from each other and from the nearest pump unit in order to prevent a fire in one tank from spreading to adjacent tanks or to pumping units. Consideration should also be given to the topography, so that if a burning fuel leak occurs in a line or storage tank liquid will not flow past a pump station, tank, or other critical installation.

d. Each tank is shipped with the following connections and accessories:

	5,000- and 10,000-barrel tanks	500- and 1,000-barrel tanks	100- and 250-barrel tanks
	Inch	*Inch*	*Inch*
Wall outlet connection	1–8 1–6 1–4	1–6 1–4	1–6 1–4
Water draw-off connection	1–4	1–2	1–2
Pressure and vacuum relief valve.	1 or more–8	1–8	1–8
Thief hatch	1–8	1–8	1–8
Outside ladder	1	1	1
Field erection tool kit	2	2	1
Seal compound	1 can	1 can	1 can
Clean-out	1–24 x 24-inch flush with bottom, for all tank sizes.		

Each tank assembly also includes special countersunk or recessed nuts or washers and Neoprene ring washers in sufficient quantity for proper erection of the tank plus 10 percent extra.

e. With each tank there is furnished a complete set of instructions on the preparation of tank foundation and the erection of the tank. The important details of these instructions follow:

(1) *Instructions for erection of bolted steel tanks.* Study these instructions carefully and completely before starting the erection of a tank. They apply to all sizes of standard (American Petroleum Institute) bolted steel tanks of from 100- to 10,000-barrel capacities. The general construction of each tank is similar. All have pie-shaped segmental bottoms and decks which fit around a center plate, shell sections (staves) 96½ inches high by approximately 60 inches wide, and all bolt together with synthetic rubber strip gaskets between the laps. Photographs illustrating the preparation of foundations and erection of tanks show details. The drawing which accompanies each tank must be studied. It will show the number and arrangement of interchangeable parts.

(*a*) *Tank foundation.* Firm graded dirt is a satisfactory tank foundation for almost all conditions. A concrete pad or spread foundation is not warranted. Where the ground is moist and subsoil drainage poor, a pad of uniformly sorted gravel makes an excellent foundation. Level ground with a sweep (fig 66) attached to a stake driven in the center of the tank location. By using a carpenter's level on the sweep the ground can be dragged level. The leveled area should be 2 feet larger in diameter than the tank. *The tank deck will not fit unless the tank bottom*

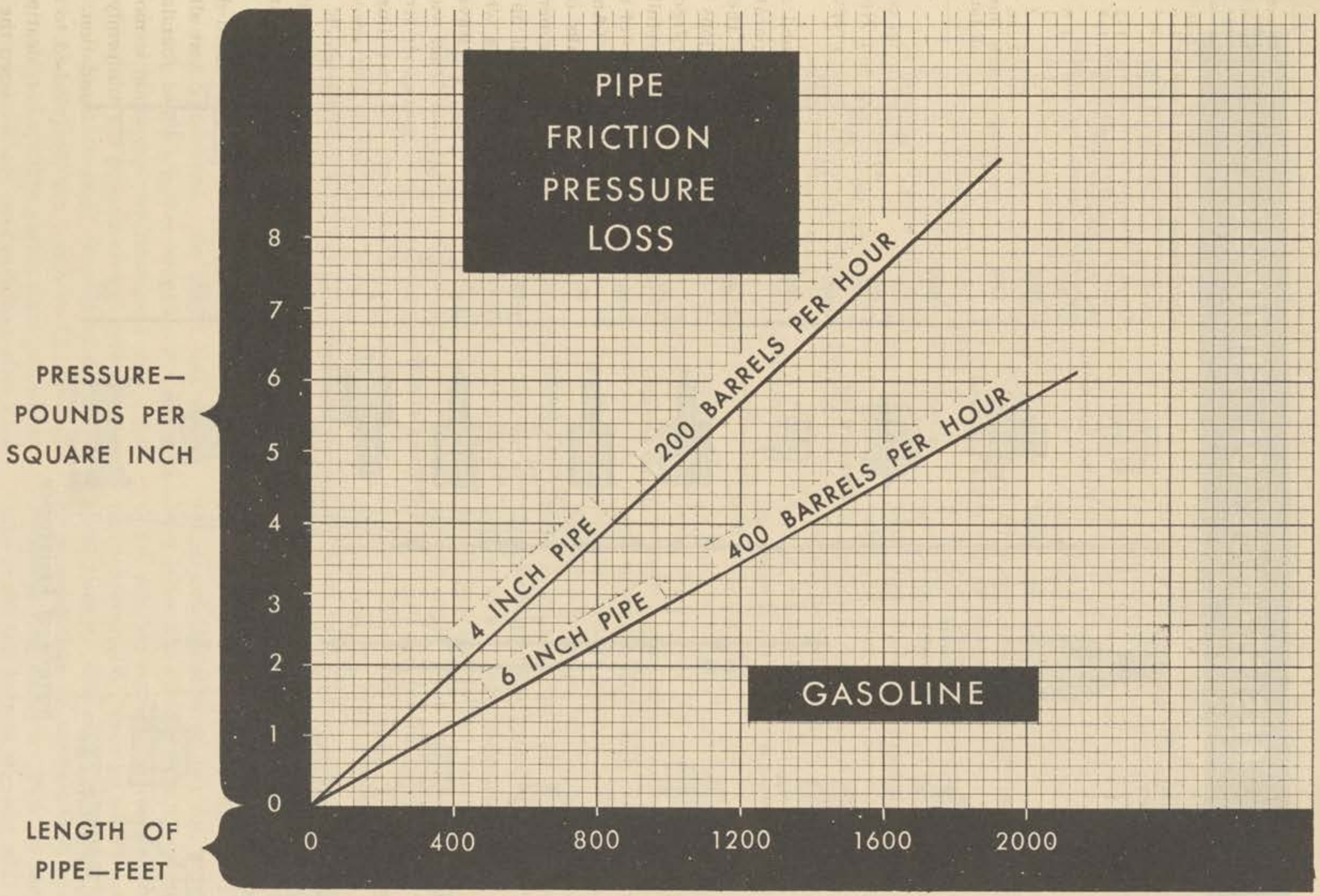


Figure 64. Pipe friction pressure loss.

RESISTANCE OF FITTINGS

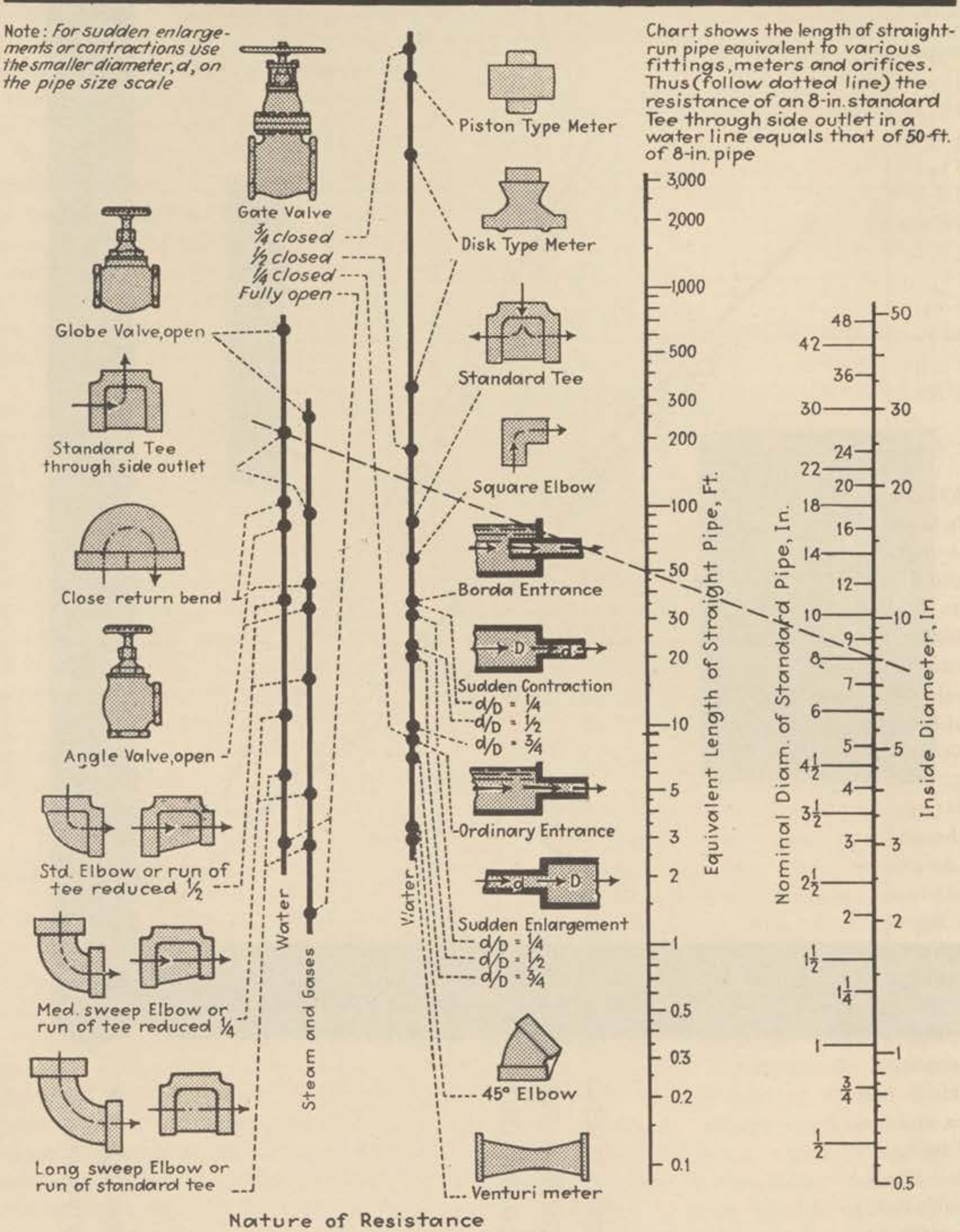


Figure 65. Resistance of fittings.

is level. If the ground is corrosive (sour) a 2-inch layer of clean sand or gravel, or a sheet of tar paper spread over it, will protect the tank bottom.

(*b*) *Tools.* Two sets of field erection tools are furnished with all tanks of 500-barrel capacity and greater, and one set with each 100- and 250-barrel tank. Each set consists of—

- 3 speed wrenches.
- 5 ½-inch short sockets.
- 4 ½-inch long sockets.
- 3 ⅝-inch by 12-inch drift pins.
- 3 ⅝-inch by 18-inch drift pins.
- 3 8-inch crescent type adjustable wrenches.
- 2 deck rope hooks.
- 2 ⅝-inch by 6-inch flat cold chisels.
- 2 ⅝-inch by 6-inch diamond point chisels.
- 2 14-pound ball peen hammers.
- 24 patch bolts.
- 2 3-inch flat paint brushes.
- 1 Ampco metal No. C–3 flat caulking tool. and
- 1 Ampco metal No. H–3 ball peen hammer.

Some of these tools are shown in figure 67.

(*c*) *Bottom section.* All sizes of tank bottoms are made up of pie-shaped segments assembled around a circular center plate. There are two rows of segments in the 5,000- and 10,000-barrel tanks. The center plate of the 10,000-barrel tank is in two halves.

1. Spread out all pieces of the bottom section in approximate position on the foundation (fig. 68). If the center piece is in two halves, bolt them together with a bolt-head retaining channel on the underside and a strip of punched gasket between the halves. The channel must not cover the end holes, but the gasket must extend all the way from end to end of the seam. Use countersunk or recessed nuts or washers and Neoprene ring washers throughout the bottom-section assembly as a precaution against leakage around the bolts.

2. The outer gasket for the circular center plate is furnished unpunched. To install this gasket place a strip of plain gasket over the circumferential holes and punch down through it with a drift pin, rolling the pin around several times to clear the hole. Place one short channel on the underside of each hole; and use ½-inch by 1¼-inch bolts. String a strip of straight gasket from bolt to bolt, pressing it down firmly over each bolt after a hole has been punched through it. The puckers in the gasket will not prevent making a tight joint. Center plates of the small tanks are fabricated to hold bolt heads so that bolt-head channels are not needed; and gaskets are furnished in three pieces cut to a circle. A molded chime lap gasket is placed flat side up beneath the circumferential strip gasket at each bottom plate seam. When more than one single piece of gasket is used, the pieces must be spliced by overlapping them the distance between two bolt centers (fig. 69).

3. Fasten each inner pie-shaped piece to its outer pie-shaped piece in the same manner the two halves of the center plate were fastened. The outer piece laps over the top of the inner piece; the bolt-head retaining channel must not cover the holes at either end; but the gasket must extend from end to end of the seam.

4. Place strips of punched gasket on both edges of the starting segment (fig. 70). Note that the inner part channels are not the same length as the outer part channels. Keep the innermost end of the inner channel clear of the hole which will lap over the bottom center plate; keep the outermost end of the outer channel clear of the chime hole; and extend the gasket a bit beyond both ends of the seam (fig. 71).

5. Place a strip of punched gasket on the right-hand (looking at the center plate) edge of each pie-shaped piece after having first placed a bolt-head channel underneath the edge of the plate with the bolts in place. A loosely placed nut on a bolt at each end of the channel will hold the channel in place, but these nuts must be removed before the plates are laid together. Work around the bottom in a counterclockwise direction to the last pie-shaped piece. The last plate will lap on top at both edges. The bottom is now assembled.

6. To bolt the bottom plates together slide a 1- by 4-inch board under each edge of the starting segment (fig. 72). Take off the nuts which had been used to hold the bolt-head channel in place. Insert a molded chime lap gasket, smooth side down, under the right-hand edge of the segment where it laps over the center plate. Pick up the next bottom segment to the right (counterclockwise direction) and set its left-hand edge holes down easily over the right-hand edge of the starting segment, starting at the inner end and working out. Spin all of the nuts onto the bolts loosely. Use only the special countersunk or recessed nuts or washers with accompanying Neoprene ring washers. Pick up the right-hand edge of the last bottom segment laid, pull out the 1- by 4-inch plank from under the left-hand edge and re-lay it under the right-hand edge (fig. 73). Continue around the tank bottom in this manner.

Figure 66.

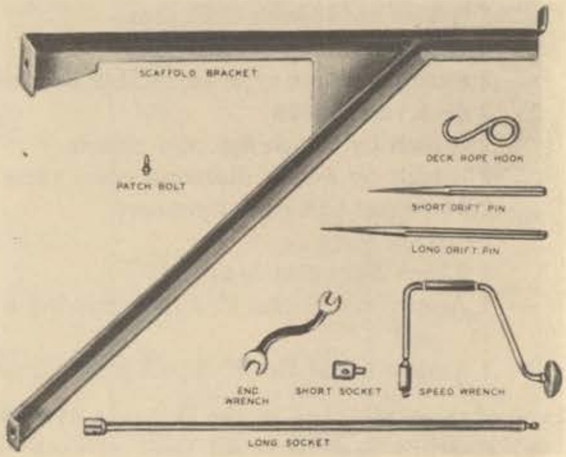


Figure 67.

Figure 68.

Figure 69.

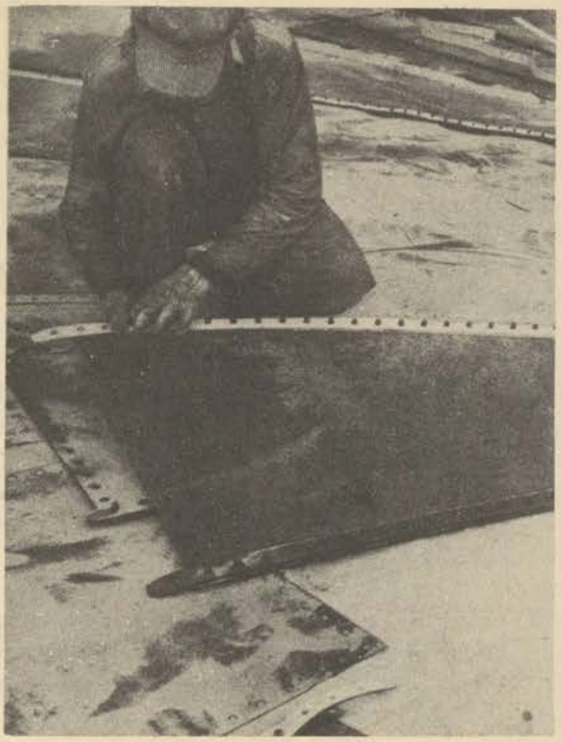


Figure 70.

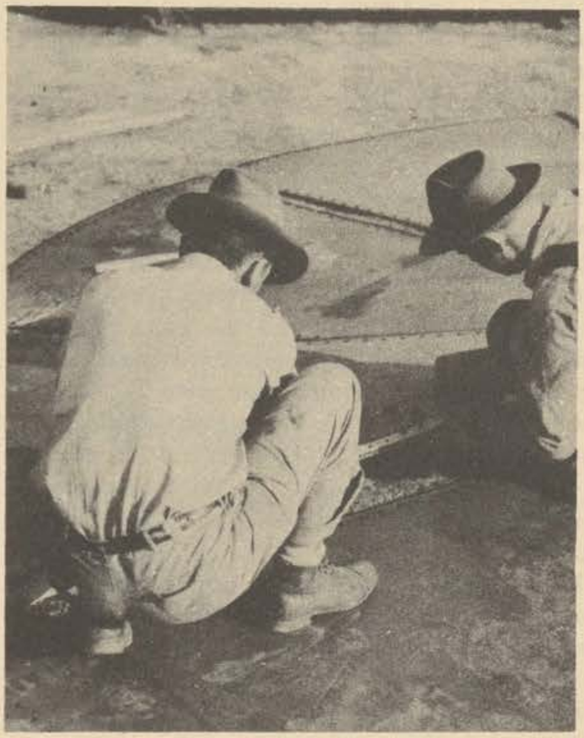


Figure 71.

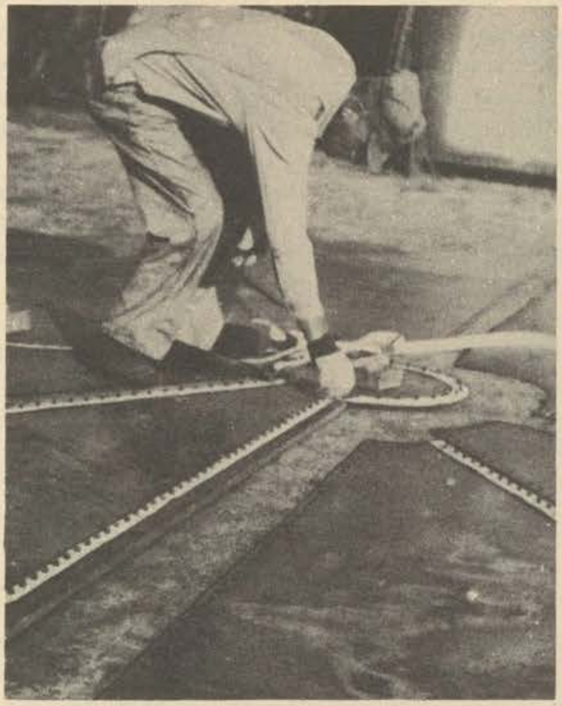


Figure 72.

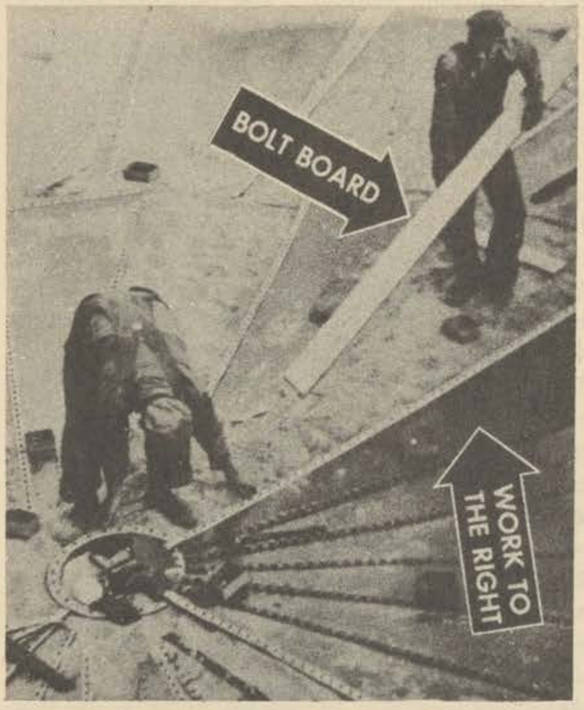


Figure 73.

The last segment to finish the tank bottom will overlay on the top side at both edge overlaps. All of the 1- by 4-inch boards should be removed from under the tank bottom, when the last segment has been laid.

7. Before tightening all the bottom bolts (see that only the countersunk or recessed nuts or washers have been used on these bolts), the tank assemblers should experiment to determine just how tight they should be. If the bolts are too tight, the gasket will be crushed away from the bolts and the tank will leak; if they are too loose, the tank will leak. Tighten the bolts until the gasket just begins to push out at the edge. Take the first seam apart after tightening it to make sure that the gaskets have not been crushed and that the right amount of force was used in tightening the bolts. When this has been determined, all of the tank bottom bolts should be tightened (fig. 74).

8. Block up the edge of the bottom with 4- by 4-inch blocks, so that the chime bolts can be inserted (fig. 75). Bolt head channel irons are not used under the chime. Do not dig a ditch under the chime as it may allow settling of a part of the tank bottom and cause leaks.

(*d*) *Staves*.

1. Place a gasket on the tank-bottom chime in the already described manner. Use punched gaskets, overlapped at gasket joints, and molded chime lap gasket smooth side up under this chime gasket at each joint in the bottom (fig. 76). Drive a drift pin to fair up each bottom lap hole (fig. 77). Determine where stave sheets will fit onto the chime and leave out each stave sheet end bolt. This is done so that a pin may be inserted to line up the staves.

2. Scatter the first ring of staves in an orderly fashion around the outside of the bottom section leaving about 4-foot clearance between the staves and the bottom. The staves should be concave side up (outside of tank down), with the chime crimp to the left. The drawing which accompanies each tank should be consulted to determine what prepunched connections there are in the staves so that they may be properly oriented.

3. Successively, block up the right edge of each stave, lay the bolt head retaining channel back side down over the holes, and push bolts down through the channel, the stave and the prepunched gasket. Be sure that the gasket extends one free hole beyond the stave at both ends. On staves that have two rows of bolts, use separate gaskets on each row. Bolts should be left out of the fourth hole from each end and out of about three other holes so that these holes can be used for pinning. Catch nuts are not needed to hold gaskets and head channel in place.

4. Place gaskets and bolt-head channels on both edges of the starting stave (fig. 78). The starting stave is the only one which does not have a crimp on either edge. The starting stave is located adjacent to, and to the right of, the cleanout stave. There is no starting stave on either the second or third ring, and on some tanks there is no starting stave on the first ring. A gasket is placed on the right-hand side of all of the staves in these two rings, without exception.

5. In setting up the starting stave, care should be taken to place it so that its joints will not coincide with the bottom-section joints. Put nuts on all of the chime bolts with the exception of the end ones. Dip a small strand of asbestos in bolt seal and fit it beneath the vertical stave gasket in the crotch where the stave flanges out to form the chime (fig. 79). Place a similar strand under each vertical seam gasket.

6. Place a chime-lap gasket with its smooth side up, under the right-hand chime end of the starting stave (fig. 80), and each successive stave as it is erected. Raise the second stave, leaving a man to steady the starting one (fig. 81). Slip the lower, left-hand, crimped end in place first. Run a pin through the lap hole to center the second stave (fig. 82), place a bolt in the first hole to the right of the lap hole, and put a nut on it. Work around to the right placing nuts on the chime bolts. Next, insert a pin in one of the vertical holes and press downward on the handle end of the pin (fig. 83). This will pull the channel iron up against the inside of the tank. A bolt next to the pin should then be pushed through from the inside of the tank and a nut made up on it. This process should be repeated at intervals up and down the vertical seam, wherever a bolt hole was left vacant. The remainder of the bolts should then be pushed home from the inside of the tank and nuts placed upon them and tightened. In order to be sure that all of the boltheads are fitted snugly in the channel iron (fig. 84), tap each one with a hammer. The remaining staves of the ring are erected in a similar manner. Steady the stave until three or four have been attached. If there is a strong wind blowing, it may be necessary to brace the staves with guys to stakes in the ground.

7. Before the last stave of the first ring is erected

Figure 74.

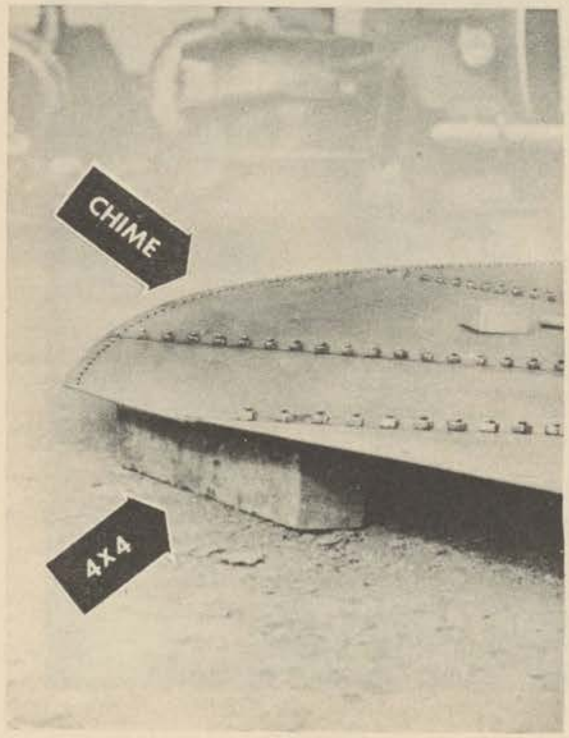


Figure 75.

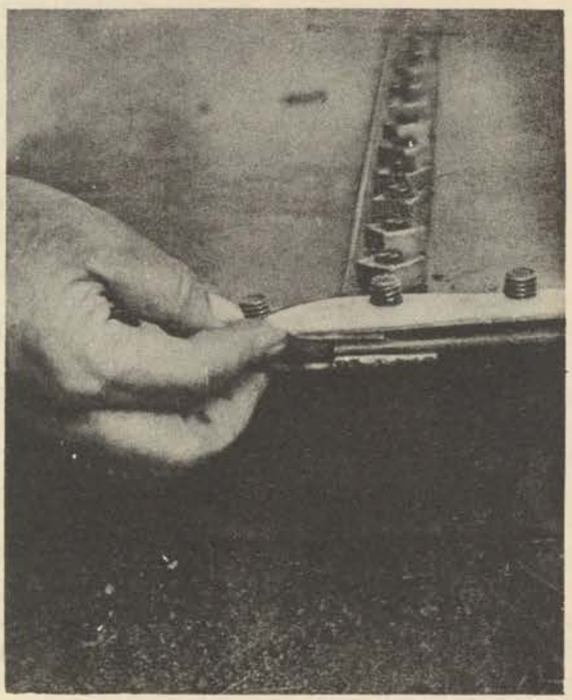


Figure 76.

Figure 77.

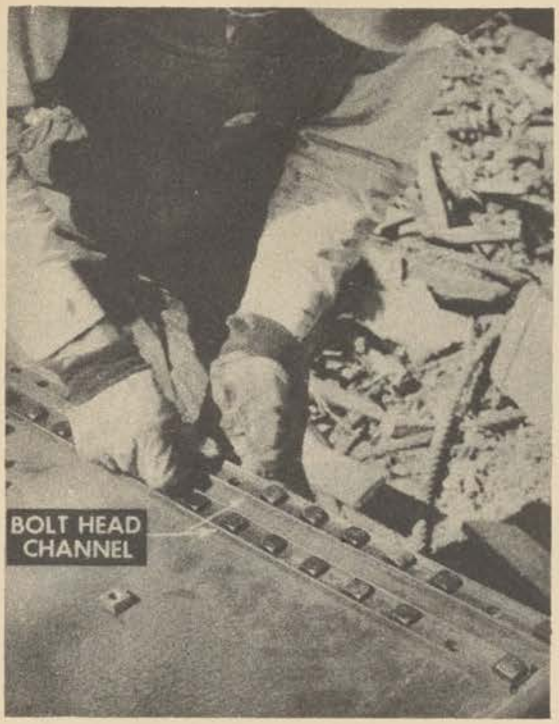


Figure 78.

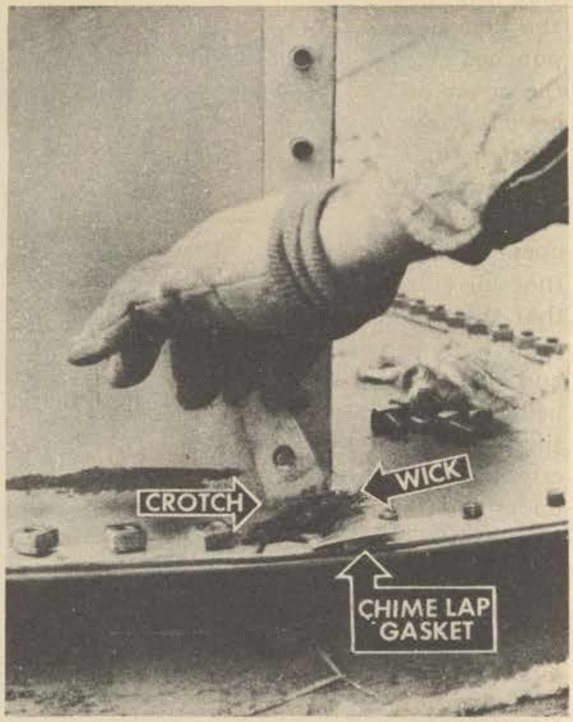


Figure 79.

Figure 80.

Figure 81.

the center pole and rafters should be taken inside the tank. The last or finishing stave of the first ring has both edges crimped and a prepunched clean-out connection. Do not place the cover on the clean-out connection; it should be left clear as an access to the tank during construction.

8. Tighten the chime bolts, using the extension, socket, speed wrench on the nuts and an open-end wrench on the boltheads. Be sure that all chime bolts are tight, but not so tight that the gasket is crushed. Then, take two ball-peen hammers; hold one underneath the chime and pound the chime lap down with the other, being sure to strike between the bolts. Check the chime bolts again to be sure they are properly tightened. Remove all of the blocks from under the edge of the bottom.

9. Second and third ring staves are erected with the aid of brackets (fig. 85). These brackets are furnished with all tanks which are more than one stave high, and in the following tabulated quantities:

Capacity of tank barrels	*Number of erection brackets*
1,000	14
5,000	26
10,000	37

Erection brackets should be hung near the top of every second stave, around the tank. Fasten the top of the bracket on the third and fourth bolts from the top of the stave and the bottom where it will keep the bracket level. Lay one good quality, 2-inch by 12-inch by 14-foot or 16-foot board between each successive pair of brackets.

10. Fair up the chime lap holes on the top of the first ring of staves (fig. 86) and place a punched gasket on the chime and molded lap gaskets at each stave joint, just as was done on the bottom chime.

11. Scatter the staves for the second ring and affix gaskets and bolt-head channels to the right-hand side of each one. There are no starting or closing staves on either the second or third tank rings. Lean the staves up against the tank so that they can be lifted up inside of the scaffold and set in place (fig. 87).

12. Install the second ring staves in the same way the first ring ones were installed (fig. 88). To place the last stave, free the left-hand end of the lower chime of the first stave placed, wedge the first stave chime joint open with a nut, and slip the lower right-hand end of the last stave chime into this "chime gap" from the inside of the tank. Remove the wedging nut and insert one or two bolts in the chime. Fasten up the right-hand edge of the last stave before fastening the left-hand edge. Be prepared to guy the second ring staves during erection, for strong winds may require it.

13. The vertical seam bolts of the first ring staves can be tightened during the erection of the second ring. Because of the hazards of falling objects, the men tightening the first ring bolts should not work directly under those erecting the second ring.

14. Third ring staves should be erected in a similar manner. Ropes can be used to lift the staves (fig. 89.) Always guy the staves against the wind.

15. In order to get at the inside vertical seams of the second and third rings a "flying cage" of metal or wood (fig. 90), a scaffold, or a ladder must be used.

(*e*) *Gin pole and rafters.*

1. Slip bottom telescoping extension inside the gin pole, slide this bottom end over against the shell of the tank and pull on the top of the pole with ropes until it is in a vertical position (fig. 91). Loosely fasten two rafters to the gin pole cap (fig. 92) and skid the pole over to the center of the tank, using planks for a skidway (fig. 93).

2. The outer end of each rafter has a bent gusset which fits between the bolthead retaining channel and the stave, and is affixed with the two top bolts. Where there are two rows of bolts the left-hand one should be used (fig. 94). Inner ends of rafters lap over and bolt to the cap of the gin pole. Adjust the pole as necessary by raising or lowering it on its telescoping foot piece, to fit last few rafters.

3. Bolt in the short, cross, jack rafters which span from one main rafter to another (fig. 95).

(*f*) *Roof or deck.*

1. The top chime should be prepared for the deck just as the lower chimes were for the stave rings.

2. Tank decks are composed of pie-shaped segments and a center plate similar to those of the bottom and should be similarly assembled. In assembling the deck see that the outer segments fit in under the inner segments, in the manner of roof shingles, to provide water drainage. Place gaskets and bolthead retaining channels on both sides of the starting segment, using catch bolts. This may be done on the ground on one side of the tank from where the segments can be raised with a rope to the tank top (fig. 96).

3. Outlet connections on the deck should be located and oriented before assembling the deck.

Figure 82.

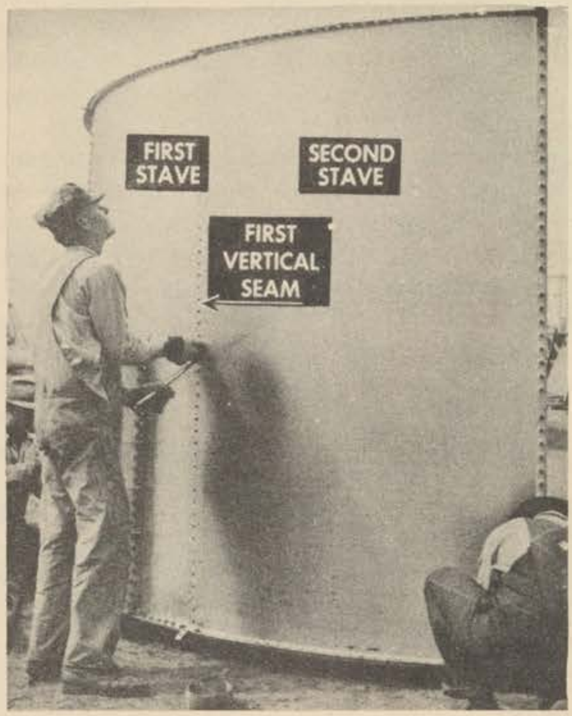


Figure 83.

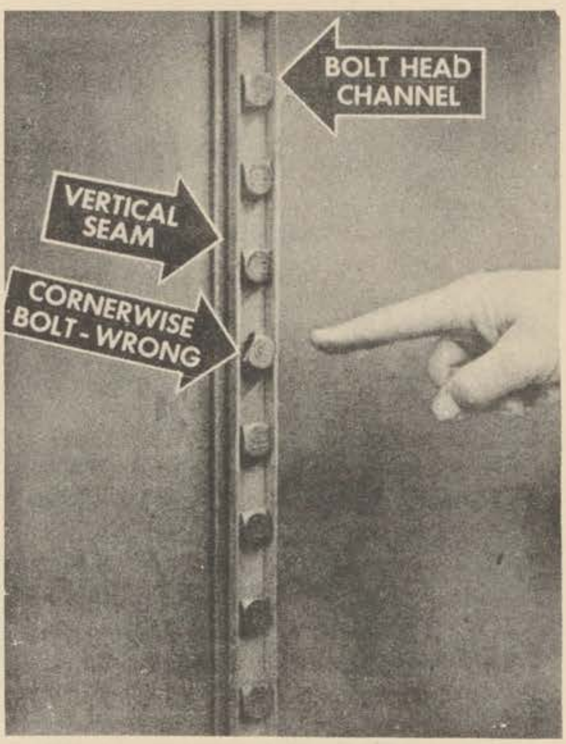


Figure 84.

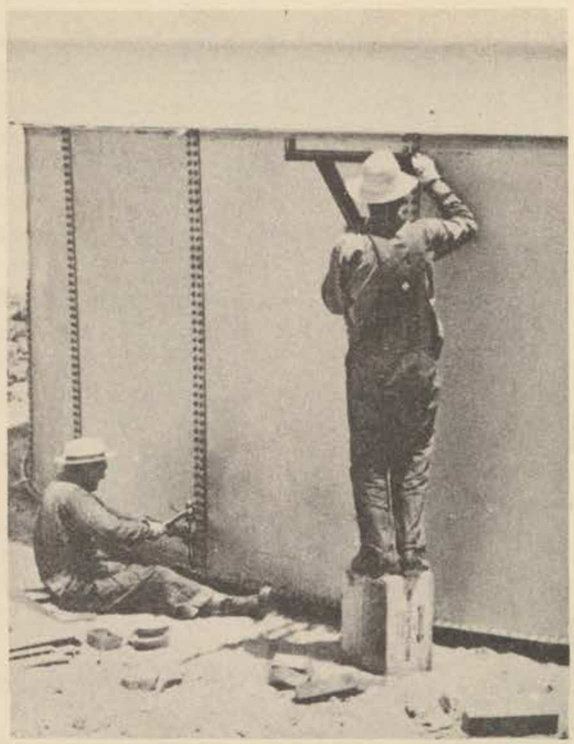


Figure 85.

Figure 86.

Figure 87.

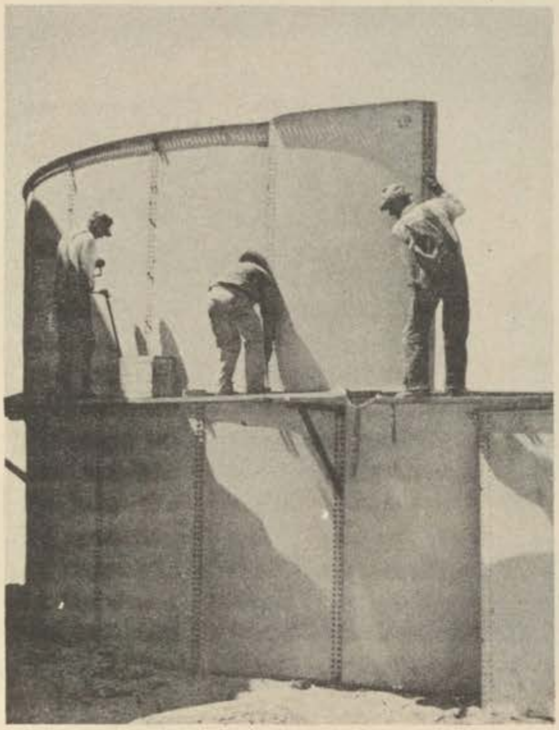


Figure 88.

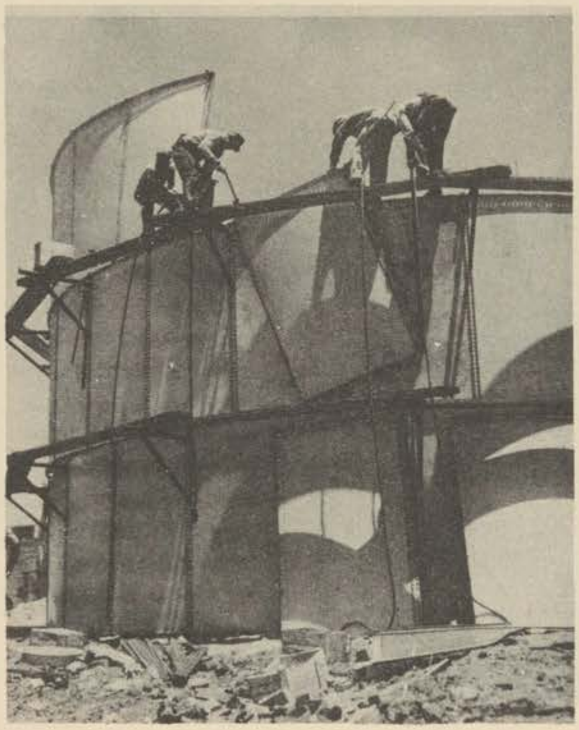


Figure 89.

Figure 90.

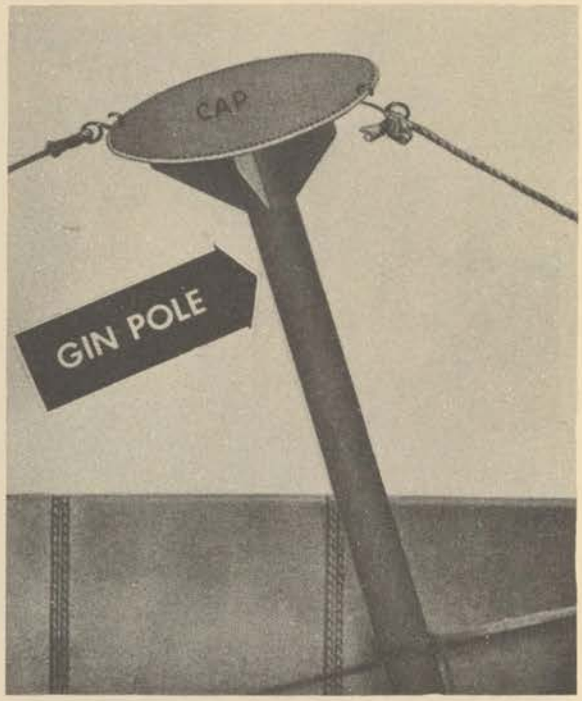


Figure 91.

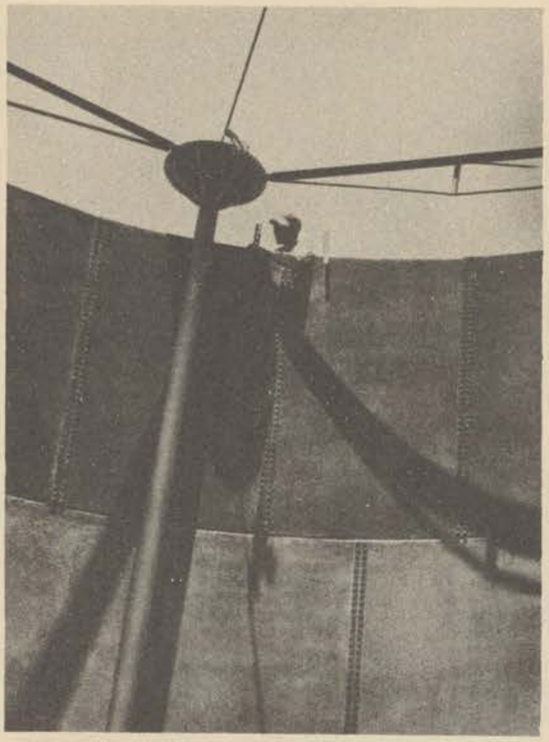


Figure 92.

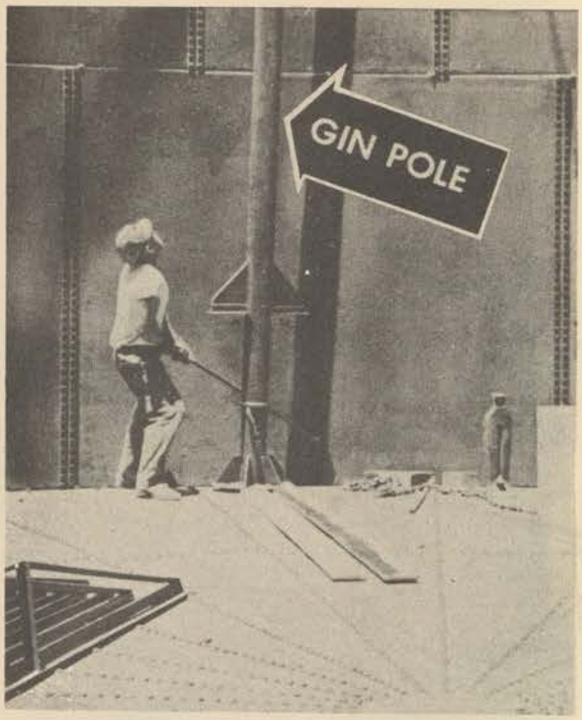


Figure 93.

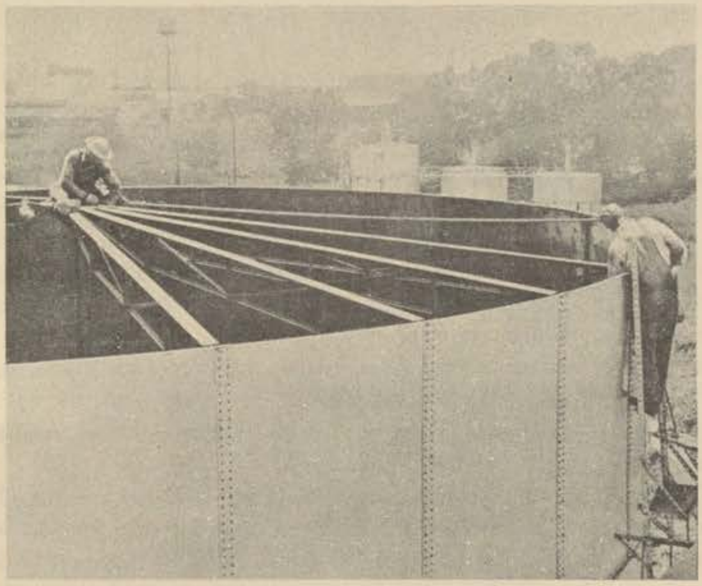


Figure 94.

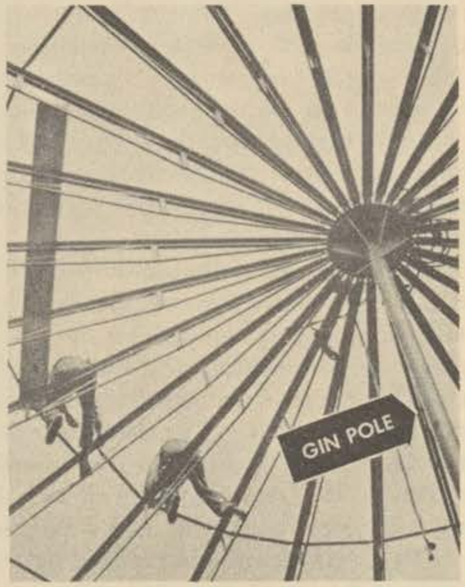


Figure 95.

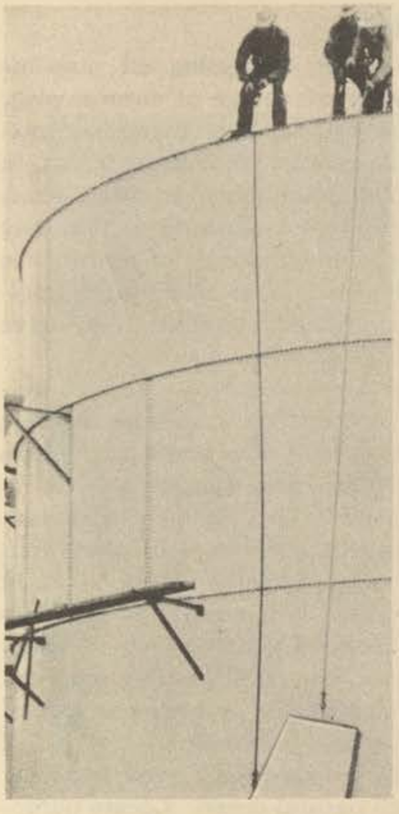


Figure 96.

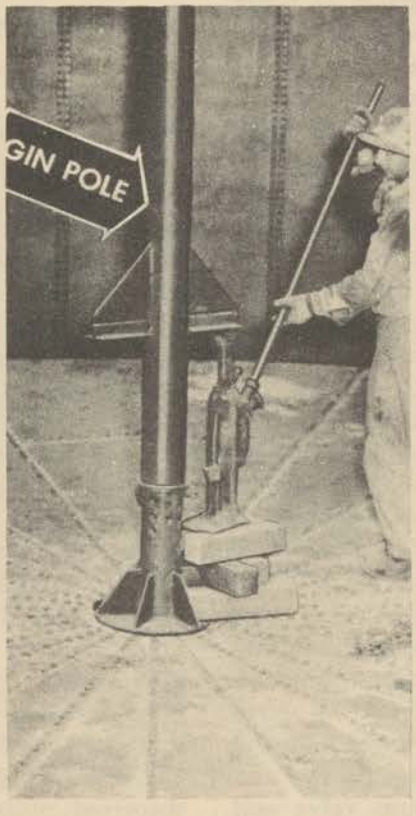


Figure 97.

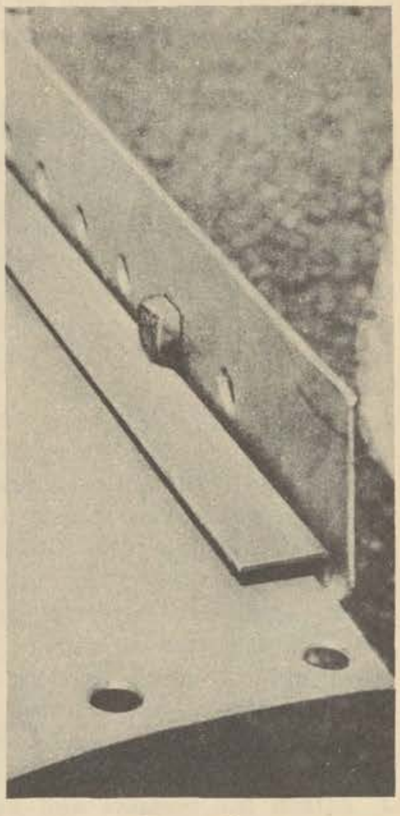


Figure 98.

4. Place radial deck seams squarely over the rafters so that seam boltheads will be held in place. Thin box boards can be used to hold bolts in place at the center plate and inner ends of all segments. Do not tighten any of the bolts during assembly of the deck and attachment to the chime.

5. When deck assembly is complete, jack up the gin pole as far as possible and fit the pole pin in the highest clear hole (fig. 97). The lift against the center of the deck will stretch the deck smooth, and round out the tank shell. Finally tighten all deck bolts.

6. Decks on some tanks do not have separate rafters or gin poles. Instead, the right-hand edge of each segment is flanged to form a stiffener (fig. 98). A ladder, adjustable in length, takes the place of the gin pole and supports a flanged dome-center manhole plate. The inner ends of the deck segments fit, with gaskets, to the lower flange of the dome. Bolt-head (½- by ¾-inch bolts are used) retaining channels fit with the channel up, the back of the channel being held by a few bolts in the row of holes in the supporting rim.

(*g*) *Patch bolts.* As will be noted in the list of tools, each field erection set contains 24 patch bolts. These are special repair bolts with both head and point on one end. They can be inserted from the outside of a tank, even though it contains liquid, into any bolt hole from which the bolt has been lost and tightened up with two outside wrenches.

(*h*) *Connections and accessories.*

1. Assemble and attach the outside tank ladder to the tank at a location convenient to the thief hatch. A short length of 2- by 12-inch planking should serve as a foundation sill for the foot of the ladder.

2. Assemble cast flanges in pairs at each connection outlet. One flange of a pair goes on the inside of the tank and one on the outside. Place preformed and punched gasket between each flange and the tank shell. Bolt flanges securely together, with the nuts on the outside. Screw appropriate street L assembly into the inside flange, leaving the L opening pointing downward. A small piece of wicking dipped in sealing compound and wrapped around the shank and just under the head of each flange bolt will aid in reducing leakage at this point.

3. Attach the pressure and vacuum valve and the thief hatch to the tank deck. Insert gaskets between the accessory and the deck. Bolt nuts should always be on the outside. Some tanks will be equipped with a pressure and vacuum-thief hatch combination assembly. Sweep the deck clean.

4. Paint all inside seams with three coats of sealing compound after all excess gasket material has been trimmed away. A period of approximately 2 hours should be allowed for each coat to dry. Bolt head retaining channels should be used as there will no longer be access to the tank interior.

(*i*) *Paint.* All tank plates and accessories are shop painted on the inside with one coat of No. 9 olive-drab paint. This paint will have an infrared reflection and will afford the tank a reasonable degree of protection from the elements. This single paint coat will be suitable as a base coat if additional coats are required.

1. As a rust preventive, paint the nuts and outer ends of all the bolts on the tank shell, deck, connections, clean-out, and accessories. Use the paint furnished with the tank.

2. Before shipment the inside of each tank plate will be free of any trace of paint and coated with flushing oil as a rust preventive. Washed wiping rags are furnished with each tank for removing flushing oil during erection.

19. CAMOUFLAGE.

a. The necessity for concealing all pipe-line equipment by taking advantage of natural cover or by using camouflage has been mentioned previously. Special attention should be given to camouflage for pipe-line equipment in desert areas.

(1) Make a careful reconnaissance before any construction work is undertaken. In routing the pipe line and setting the tanks and pumping stations every precaution should be taken to preserve all natural vegetative growth and cover.

(2) Lay pipe lines on a meandering course, utilizing depressions in the terrain, such as roadside ditch; bank dirt along both sides of the pipe, where possible, without destroying natural growth, to eliminate pipe shadow. The line may be camouflaged by painting it a base color of olive drab and by a further application of desert colors in the form of disruptive patterns. Desert colors are: Standard Camouflage Colors No. 3 sand, No. 6 earth yellow, and No. 8 earth red, and black. Colors should be flat or lusterless and of material that will adhere to the pipe.

(3) Place tanks in recessed pits, always widely dispersed; utilize all natural cover. Locate pumping equipment three or four hundred yards from tank sites. Two methods of camouflaging these installations follow:

(*a*) Place a series of terrace flat-tops of nets

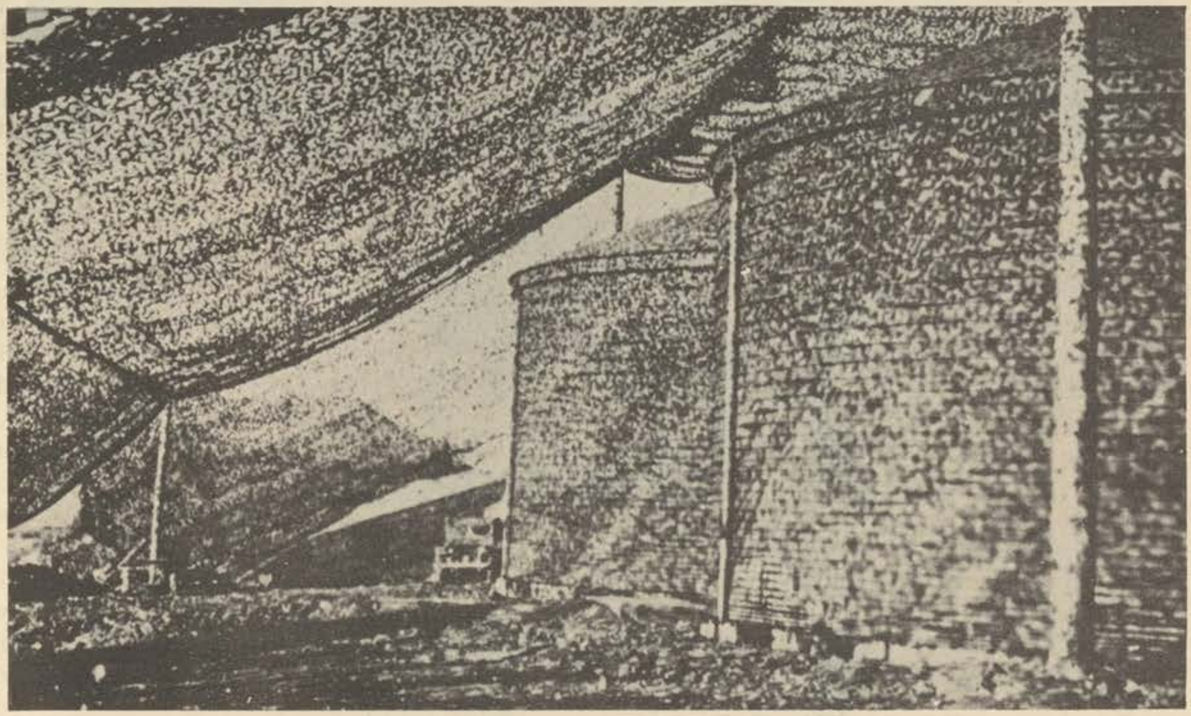


Figure 99. Method of camouflaging water tanks.

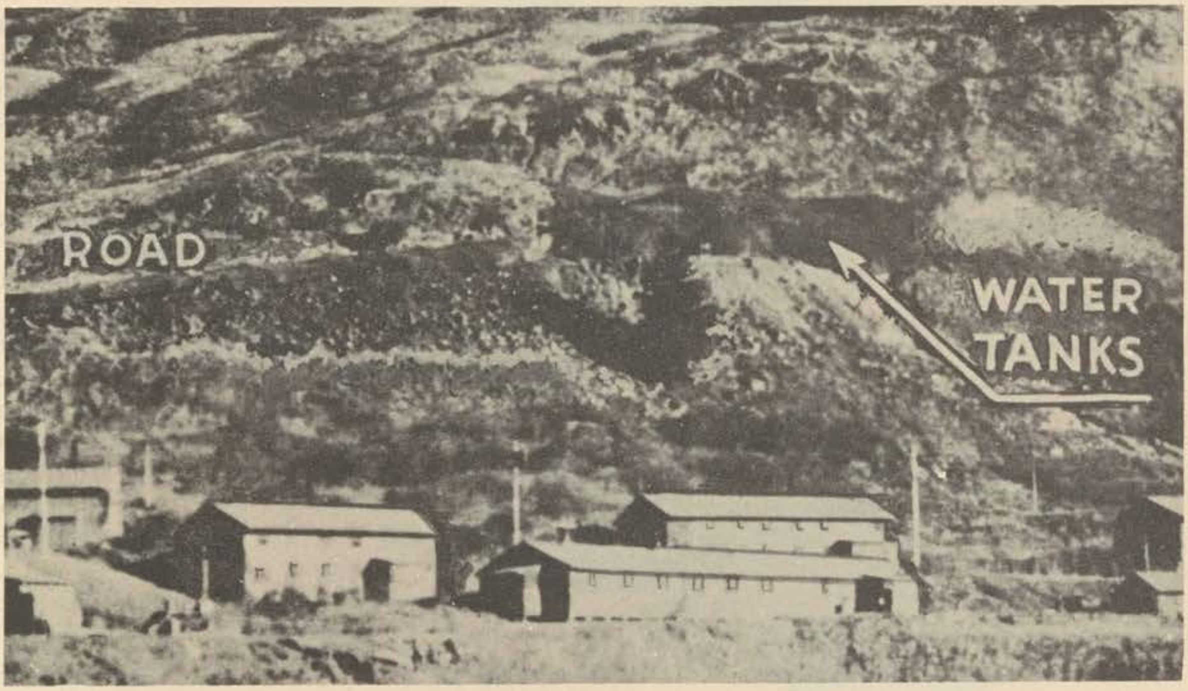


Figure 100. Result of camouflaging.

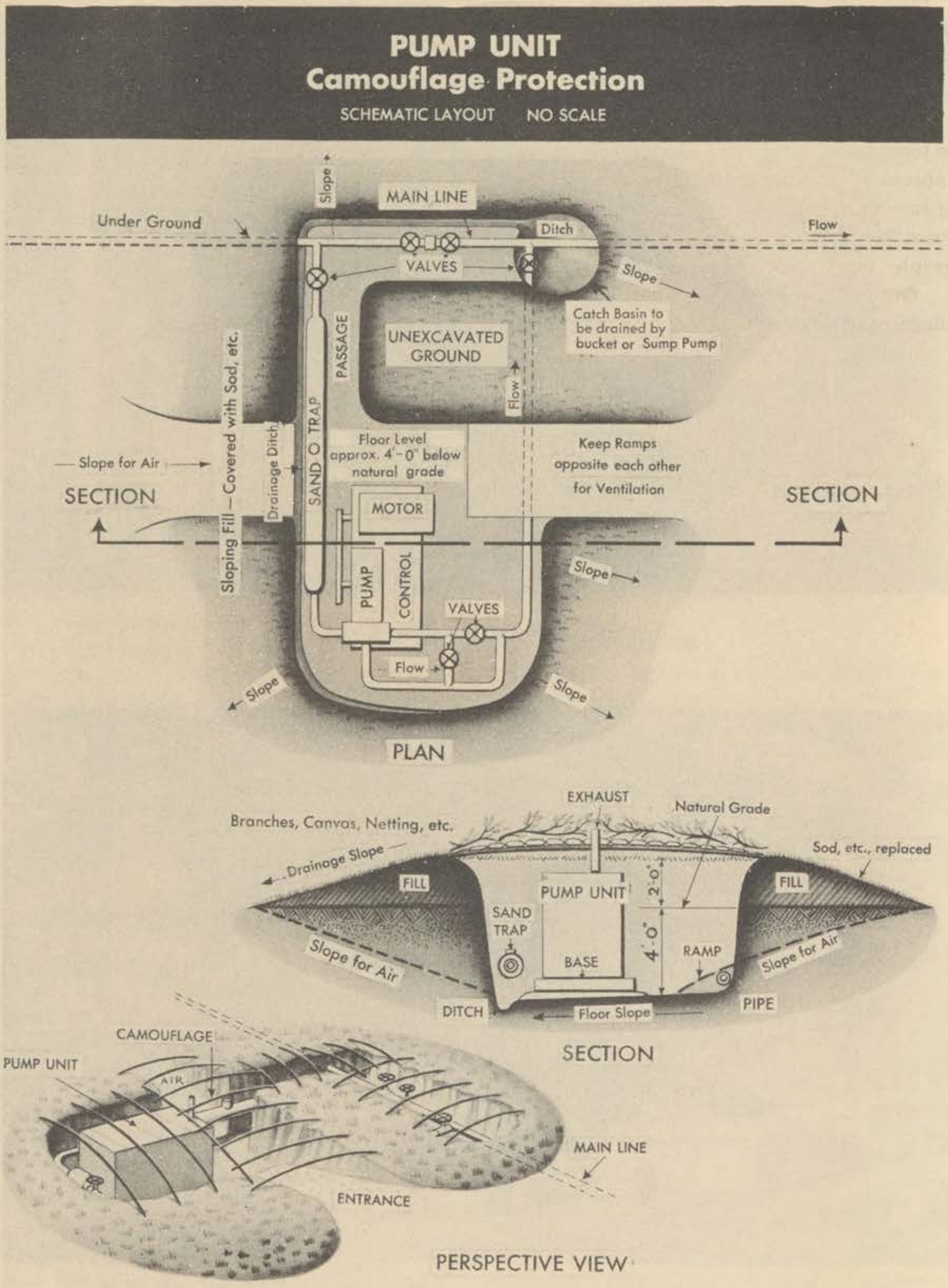


Figure 101. Suggested layout of a pump station for both camouflage and protection from direct enemy fire.

appropriately garnished in desert colors over the tanks. Place similar type fly-tops over the pumping equipment (figs. 99 and 100). Reestablish the natural appearance of the surrounding terrain where flat- or fly-top construction is used.

(*b*) Paint tanks and other installations, using a single tone-down or graduated tone-down colors, with appropriate ground painting to assist in disrupting cast shadows.

b. Prior to starting construction have aerial photographs taken at 5,000 and 10,000 feet elevation. Obtain similar photographs during the camouflage construction work and at the conclusion of the work, so that a final check-up and adjustment of camouflage effects can be made.

c. With respect to concealment of pipe lines in wooded or partially wooded areas, reference should be made to figures 37 and 38.

d. In figure 101 there is shown a suggested layout of a pump station both camouflaged and protected from direct enemy fire. The station is installed in a pit and concealed by branches, canvas, netting, or other suitable material. This installation must have adequate ventilation at all times, as the tendency for gasoline vapors to settle in low places creates a serious hazard from the standpoint of fire and asphyxiation.

CHAPTER 5
OPERATION

20. TESTING OF PIPE LINE.

a. As each section of pipe line from one station to another is complete, including the pumping unit, it should be tested, unless specifically instructed otherwise. Pump the line full of water, raise the pressure to 650 pounds per square inch and close the line. Any drop in pressure will indicate leaks. If leaks are indicated, inspect the line, marking all leaky couplings, valves, and joints. Then drain the line; repair or replace al' defective parts. If the pipe line is to carry gasoline or other petroleum fuel, care must be taken to drain it completely. Drain valves should be placed at the bottom of each dip or valley to facilitate clearing the water from the line.

b. If the line is being laid in an active theater of operations, there will probably not be time available for testing. In this event serious leaks will have to be repaired without disassembling joints. Use stirrup or split repair clamps in the case of leaky joints; use Dresser type coupling leak clamps on leaky couplings.

21. STARTING THE RECIPROCATING PUMP.

a. After the line has been tested, section by section, in the manner outlined above, the suction line of Station No. 1 should be connected to the source supply of the liquid to be pumped. Set all controls at Station No. 1 to maintain the desired differential pressure between suction and discharge (200 pounds per square inch in the example cited in fig. 29). The pump is then started. Open bleeder valve or other vent immediately upstream from Station No. 2 to allow air to escape from the line as it is displaced by the pumped liquid. Close the bleeder valve when all the air is out of the line and the pressure on the suction side of Station No. 2 has built up to 30 pounds per square inch. If the line is left full of water from the testing operation, as may be the case where the system is to be used for water, normal pumping operation should be started all along the line and water discharged at the terminal. Otherwise, Station No. 2 is started with the controls set to maintain the differential pressure between the suction and discharge contemplated in the design of the system. In the example, the differential pressure is 150 pounds per square inch under normal operation, although the differential controller is set at 300 pounds per square inch.

b. Before starting any station the operator should make the following inspection:

(1) *Engine.*

(*a*) Crankcase oil level.
(*b*) Radiator water level.
(*c*) Battery water level.
(*d*) Condition of air filter.
(*e*) Change date on air filter cartridge.
(*f*) Date engine was last greased.
(*g*) Fuel supply.
(*h*) Fuel pump.
(*i*) Fuel tank and connections for leaks.
(*j*) Hand throttle connections.
(*k*) Fan belt tension.
(*l*) Clutch adjustment.
(*m*) Drive V-belt tension.

(2) *Control system.*

(*a*) Oil level in reservoir.
(*b*) Control system piping.
(*c*) Control system pump chain drive connection and lubrication.
(*d*) Engine diaphragm throttle connection to throttle arm.
(*e*) Operation of high discharge, high suction relief, and differential pressure controller.
(*f*) Locknuts on the lower stem of the pressure reliefs and controller to see that they are tight.

(*g*) Pressure gage dial to see that it "zeros" properly.

(3) *Pump.*

(*a*) Piping to control and pressure gages to see that they are connected.

(*b*) Pressure snubber opening to insure that suction and discharge pressure gages will properly record. (Recheck after starting pump.)

(*c*) Oil level in pump gear box.

(*d*) Bearing lubrication.

(*e*) Packing glands to see that they have been tightened evenly and are not too tight.

(4) *Header system.*

(*a*) Check the check valve in main line to see that it seats properly and that the clapper works in the proper direction.

(*b*) Operation of all gate valves. (They should be left open.)

(*c*) When starting a station the procedure is as follows:

1. Disengage the clutch by pulling the clutch lever outward from the engine.

2. Open the hand throttle slightly, turn on the ignition, and depress the starter button. Use the choke, if necessary, to get the engine started. Allow the engine to warm up at a fast "idle speed." Open the hand throttle wide as soon as the automatic control governor pressure reaches 16 pounds per square inch, thus placing the engine on automatic control.

3. The suction and discharge valves to the pump are open.

4. Engage the clutch by slowly pushing the clutch lever forward till the pump is started in motion. The clutch lever should then be moved forward until it is engaged. Do not slam the clutch into engagement.

5. The pump is now in operation and the governor system will control the engine speed.

(*d*) Other stations are started in a similar manner. Care should be taken to vent all air out of the line before each successive station pump is started.

22. STARTING THE PUP CENTRIFUGAL PUMP.

a. Following an inspection of the pump station equipment as outlined above, the pump engine should be started and allowed to idle until warm, with the centrifugal pump suction valve open and discharge valve closed. Vent cocks of the pump casing should be opened from the start, so that the flow of liquid from the tanks forces all the air out of the pump suction line and case. When the pump engine is properly warmed, slowly open the pump discharge valve and increase the engine speed to allow the pump to fill the pipe line. As the pressure requirement of filling the line increases, the discharge valve will have to be further opened and the engine accelerated. Appropriate pump performance curves should be consulted and care taken not to overload the engine during these initial operations.

b. Other stations along the line are started in a similar manner, care being taken to vent all air out of the line before each successive station pump is started. Vent cocks on pump casings should be left open until a continuous liquid stream is emitted and the pump is fully primed.

23. STARTING THE DEEP-WELL CENTRIFUGAL PUMP.

a. An engine inspection should be made in a manner similar to that outlined for other pump engines. With the pump discharge valve closed, the engine is started as follows (figs. 26 and 27):

(1) Open the gasoline supply valve in the strainer assembly.

(2) Close the choke on the carburetor air inlet horn by depressing the choke lever. This choke automatically opens when the engine starts.

(3) Open the carburetor needle valve ¾ to 1¼ turns, or more as required in cold weather.

(4) Turn the magneto switch clockwise to the ON position.

(5) Install and pull the starting rope, giving the engine crankshaft a brisk clockwise spin. Repeat as required.

(6) If fuel drips from the carburetor, the choke should be opened.

(7) Refer to the manufacturer's manual, if the engine fails to start.

b. When the engine is properly warmed, the pump discharge valve should be slowly opened.

24. INTERMITTENT PUMPING. During the operation of the pipe line under campaign conditions, it is not probable that the line will be in operation continuously since the fuel requirements of the tactical units served might not equal the line capacity. When this is the case, pumping through the line will be intermittent.

a. Assume that the pipe line has been in operation for sufficient time to meet all demands for fuel at the terminal dispensing station and that the line is closed at that terminal. This will cause the nearest upstream station to bypass on high discharge pressure and the pump engine to throttle to idle speed. This will proceed upstream successively to each station on the line, back to the source station. When it becomes evident to station operators that no more withdrawals are to be made for a considerable length of time and no order is received to shut down the line, they will disengage the engine clutches and then shut the engines down.

b. Where there are branch lines along the route, stations upstream from the branch must be kept in operation so long as there are withdrawals on a branch line. When there are no withdrawals at any point along the whole system all stations may be shut down.

c. As withdrawals of liquid from the line are required, pumping may be started in two ways:

(1) A general pipe-line order may be issued stating that withdrawals will start at a certain time and that all stations should start pumping at that time. If such an order is issued, Station No. 1 should start up and pump the line to maximum pressure about 10 minutes before withdrawals are to start. This will insure full delivery of fuel as soon as withdrawal is commenced. The pressures on the line will drop when withdrawal starts and the downstream terminal pump will then pull down the discharge pressure at the next upstream station. Observing this the station attendant will start the pump at his station and pump into the line. This will be repeated successively all along the line back to the source station, when all pumps will again be in operation. The length of time required to get all stations back on the line will depend upon the rate of withdrawal and the length of the line from the source to the withdrawal point.

(2) If withdrawal is intermittent and will be resumed within a few minutes, it is not necessary to shut down the pumps. Pumps may be left on the line holding the pressure on the whole system at from 400 to 500 pounds per square inch, due to the bypassing of the pumps. When withdrawal is started, each station starting from the first station upstream from the withdrawal point will automatically start to pump as its discharge pressure is lowered and the high suction relief valve is closed.

25. RESTRICTED WITHDRAWALS.

a. When withdrawals are continuous but do not reach maximum line capacity, it is not necessary that all stations be operated. The source station and only enough intermediate stations need be operated to maintain pressure in the line. On fairly level terrain this may allow as many as five or six stations in succession to be down. In hilly terrain, where the static head between stations is a large part of the resistance to flow, a sufficient number of stations must operate both to lift the liquid and to maintain pressure.

b. Leaks along the line, which are small and are not detected by the patrols, will cause the line pressure to drop slowly, and this will require that more stations be operated to maintain line pressure.

c. With all stations operating at maximum discharge pressure and with suction and discharge equalized, it is *imperative* that all leaks in the line be stopped and that all outlets be tightly closed. If these leaks are not repaired, or if the terminal valves are not tightly closed, an intermittent starting-up and shutting-down cycle will be started in the system, which will be repeated so long as the leak or slight withdrawal exists and all stations are kept running. To prevent this, the leaks or withdrawal must be stopped, or the units should be shut down until larger quantities can be pumped.

26. DISPATCHING.

a. One-Product Delivery.

(1) Before delivery of a product, the contents of the terminal storage from which delivery is to be made should be carefully gaged and sampled. Actual shipping should not start until it has been established that the tender, if it is gasoline, is free from water and meets the required specifications. When approval for delivery has been obtained from the base laboratory, the officer in charge of dispatching will, after checking with the officer in charge of the receiving terminal, start the "head" of the tender into the line through the base pump station at a certain fixed time. Additional samples can be dispatched to relay stations and to the receiving terminal for color checks in the event the sample does not exactly conform with the color standard set. (See Hourly Pumping Form, fig. 102.)

(2) All of the pump-station operators along the line, as well as the receiving terminal operator, should be advised of the time, amount, route, and destination of the tender. Deliveries and receipts are reported on proper forms at all terminals.

b. Two or More Product Delivery. When two or more grades of gasoline are to be run through one pipe line, it is essential that extreme care be taken to insure that each grade is

HOURLY PUMPING REPORT

Quota =
Pumped =
Balance =

Tender No.________

____________________ Station ____________________ Date

____________________ Product

	TANK		Tank	Water	Gross	TAPE		FLOAT		GAUGE	GALLONS	TOTAL GALLONS
	On	Off	Temp.		Gauge	Ft.	In.	Ft.	In.	GALLONS	THIS HOUR	PUMPED
Mid. 12												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
Noon 12												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
Mid. 12												

60° CALCULATIONS

Figure 102. Hourly pumping report form.

delivered to the proper tanks and that contamination be prevented.

(1) The dispatcher will control the movement of the tender from the time it enters the pipe until the time it reaches the final storage. He will notify all relay pumping stations and the receiving terminal of the quantity, color, and specific gravity of the product to be moved, the pumping pressures to be maintained, and the delivery rate expected. He should inform stations when the "head" and when the "tail" of the tender is expected to reach and pass each station.

(2) On receipt of word from the dispatcher that a shipment is contemplated, the receiving terminal officer should check the receiving tanks to see that there is sufficient room for the tender and that the tanks are clean, and advise the dispatcher if for any reason the delivery must be deferred.

(3) While the position of a tender in the line can be determined by calculating the line volume and the pumping rate, it must be verified by accurate checks at each pump station and at a sample test station. The sample test station should be located about 1 mile ahead of the receiving terminal. As soon as a tender passes a station the time of the "cut point" should be accurately noted and all of the other stations, as well as the dispatcher and the terminal operators notified by telephone or whatever other communication system is in use. As the "head" will normally move at about 3 miles per hour, the receiving terminal operators will have about 20 minutes' notice from the time the "head" passes the check station.

(4) All tank manifold valves should be marked to indicate the grade of gasoline to be placed in that tank. When any one grade is being run, valves to tanks containing other grades should be securely closed and preferably locked. When a change is made in the grade of a product being received at the terminal, the contents of the line containing the grade of product last received, should be run into the tanks receiving that grade.

(5) Regulating the flow from the pipe line to tanks must be done by tank inlet valves. The dispatcher must be informed when a valve is about to be closed so that compensations, such as the opening of another tank inlet valve, can be made.

(6) Where there is more than one tank for each product, changing from one tank to another should be accomplished by opening the valve on the branch line of the tank to be filled before closing the valve to the tank just filled.

(7) As the tanks are filled, it will be necessary to give the dispatcher the actual gallonage delivered each hour. This will enable him to have control over the product pumped. (See Delivery Report, fig. 103.)

(8) At the time a change is made between the grades of gasoline being received at the terminal, there will be a certain amount of contamination. This mixture of two grades should be run into either lower grade storage or into slop tanks before the new grade is run into its tanks. Specific examples of the disposal of mixed grades are as follows:

(*a*) Contaminated 87-octane gasoline should be put into the 80-octane tanks.

(*b*) Contaminated 100-octane gasoline should be put into 87- or 80-octane tanks.

(*c*) Kerosene mixed with gasoline must not be run into a kerosene tank, but into either a slop tank or one containing 80-octane gasoline, provided that the percentage of the contaminated products is less than 1 percent of the total contents of the tank.

c. Contamination Tests. To reduce as much as possible the contamination of one delivery with another, specific gravity and color tests can be used. These tests should be adequate to locate the point of change from one tender to another.

(1) Specific gravities are determined by measurement with a hydrometer, corrected for temperature. There will be a gravity difference of from 0.2° to 0.5° A. P. I. between grades of aviation gasoline and considerably greater differences between aviation and motor gasoline.

(2) Each grade of gasoline will have a characteristic color, samples of which will be furnished as standards. While color checks do not identify gasoline grades as accurately as do specific gravity measurements, it is well to make them for use with the specific gravity determinations.

d. Shutting Down the Line.

(1) When a line is to be shut down, orders should be given by the dispatcher to all stations to shut down when a tender reaches a certain station. When the tender reaches the station specified, as determined by specific gravity measurement, the operator should shut down that station pump, close the station block valve, and notify all other stations. Other station operators will stand by to shut down their pumps, when they note a pressure change in the line, and to close station block valves. When this procedure is

DELIVERY REPORT

QUOTA = ____
DELIVERED = ____
BALANCE = ____

TENDER NO. ________

TERMINAL ________ PRODUCT ________ DATE ________

TIME	GALLONS DELIVERED		LINE TEMP.	LINE PRESS.	TANK TEMP.	REMARKS
MID. 12						OPERATOR
1						
2						
3						
4						
5						
6						
7						
8						OPERATOR
9						
10						
11						
NOON 12						
1						
2						
3						
4						OPERATOR
5						
6						
7						
8						
9						
10						
11						
MID. 12						

60° CALCULATIONS	WEATHER 7 A.M.

Figure 103. Delivery report form.

followed the mixing of two products in the line will be reduced to a minimum.

(2) When a line is first put into operation it is advisable to insert a small amount of dye-colored gasoline in the line and to observe the diffusion of this "color plug" as it progresses from station to station. Results from such a test will show the approximate gasoline contamination to be expected during normal operations.

e. Delivery Through Branch Lines. If for any reason a delivery from the main line is to be diverted through a branch line, the entire delivery through the main line should be switched into the branch line and the balance of the main line cut off as the front of a tender reaches the branch. When the delivery through the branch line has been completed, the entire stream should be switched back into the main line so as to avoid any contamination due to the slowing down of the flow in the main line to a velocity at which the two tenders would mix.

f. When pumping different products through a pipe line the quantity to be shipped, the liquid velocity in the line, the amount of product contamination, and the exact time of departure and calculated arrival should be known. Adequate storage space for each product must be provided for at the receiving terminal.

27. GAGING TANKS. Liquid volumes contained in tanks are calculated from tank circumferential and liquid level measurements. Circumferential measurements are made with a steel tape and used to calculate the containing volume of the tank. For convenience, tables may be made showing the tank volume per foot of gage depth. The more a tank deviates from a true cylinder the closer together the circumferential measurements should be made. Liquid level measurements are made with a steel tape and plumb bob. When gaging gasoline a definite procedure should be followed and certain safety precautions observed, as follows:

a. When lowering the tape from the hatch into the tank, care should be taken that the point of the plumb bob just touches the tank bottom. Chalk, rubbed on the numbered side of the tape is readily water wet and will show where the water-gasoline contact is. A mixture of grease and lamp black applied to the smooth side of the tape will aid in recording the top level or surface of the gasoline. Chalk and grease should be used sparingly, applied to the tape only in the vicinity of the level to be measured, and completely removed upon the completion of the gage measurement. When gaged volumes are to be corrected to a base temperature, a thermometer should be lowered into the tank through the gage hatch and left at a fixed position long enough to record the liquid temperature.

b. Upon mounting a tank containing gasoline it is important that the bottom of the ladder be touched with all metal objects, such as the measuring tape and thermometer chain. When actually gaging the tank the tape should be continuously grounded by dragging it against the thief hatch rim while unreeling and reeling. These precautions will eliminate the possibility of there being sparks between the gage line and tank, caused by the collection of static electricity on the gage line.

c. During electrical storms, thief hatches must be kept closed and no gaging done, as tank fires can be started by the spark ignition of petroleum vapors escaping through open hatches. Individuals must remain off tanks and tank walks during such storms.

d. Care of Gaging Tape. Gaging tapes should be cleaned with a wiping cloth after each use. When a tape is hung up between uses, the plumb bob should be removed so as to preclude accidental kinking of the tape. Two tapes will be furnished each pipe-line terminal and they should be carefully maintained as they are an essential part of the terminal equipment.

28. MAINTENANCE AND REPAIR.

a. Pipe Line.

(1) Normally, a maintenance and repair crew will be based at each station and will be under direct supervision of the noncommissioned officer in charge of the station. Security patrols will be maintained along the line at all times to prevent sabotage, to search for small leaks, and to report other mishaps to the line, such as those that may be caused either by enemy action or natural forces. These patrols are equipped with field telephones for communication with the pump station. A patrol will operate from its station to points approximately half way to the upstream and downstream stations, the exact locations being determined by the terrain. The normal length of a patrol zone will be from 7 to 10 miles. Security patrols are equipped to make minor repairs to the line. Leaks or breaks which the patrol cannot repair are reported to the noncommissioned officer in charge of the station, who will dispatch

a repair crew to the location of the trouble. The maintenance and repair crew operates with a light truck, capable of carrying 20 joints of pipe, 50 complete couplings, tools, and leak clamps, and is capable of making most emergency repairs.

(2) Convenient stock piles of pipe, couplings, and various types of leak clamps are maintained along the main line where extensive damage may be expected from enemy action. Normally, there will be items for about 25 percent replacement of complete pumping stations maintained in depots or in nearby areas for ready repair or replacement of units that are made unserviceable. When needed, complete units are transported to the station site and installed by a crew maintained for that purpose.

(3) *Pipe leaks.*

(*a*) Small leaks are repaired by the use of saddle and split repair clamps (figs. 10, 11, and 12). The two steel half-shells of the split repair clamp can be used individually, being held in place with stirrup or U-bolts. The clamp is installed by fitting the stirrup bolts around the pipe, placing gasket material in the half-shell, and bolting the half-shell tightly against the leak.

(*b*) Large leaks, which result from direct hits by machine-gun fire or by shell fragments, but which do not require the replacement of pipe joints, may require closing the block valves on both sides of the leaks. After the pressure in the isolated section is bled off through the leaks, repairs are made with leak clamps. Once repairs are made, the block valves are opened and pumping resumed. Pump station operators must be advised that valves in the line are to be closed or opened.

(4) *Pipe breaks.*

(*a*) Pipe breaks differ from leaks, in that the pipe is actually broken to such an extent that a joint or several joints must be replaced. Pipe may break where it bends over fulcrum points and is intermittently stressed with each pressure impulse of the pumps. Under these conditions spiral weld pipe breaks along the spiral upset on the side opposite the welded part of the seam. Such breaks, small at first, rapidly lengthen and cannot be repaired by using clamps. This type of break leaks enough to greatly reduce the output on the line and requires immediate replacement of the damaged sections.

(*b*) Wherever pipe is subjected to intermittent stresses, such as those resulting from the action of reciprocating pumps, it must be securely anchored. After a fatigue break has been repaired, the line should be blocked in position with available logs, boards, rocks, or dirt to prevent the pipe from flexing under pump pulsations. It may be necessary to bury the pipe at such locations, or to alter its course locally.

(*c*) Abnormal bending stress on couplings at sharp bends, or in places where external forces can affect the pipe, such as at river crossings, may cause couplings to part unless they are carefully installed.

(*d*) In case of a gasoline pipe-line break accompanied by fire, the break should be isolated by closing the block valves on both sides of the break. Allow the fire to burn itself out. While the gasoline is burning, a new line should be strung around the break, working at a safe distance, and coupled into the main line (fig. 104). Pumping can then be resumed immediately upon opening the block valves. This method is also practical when a break has occurred at a river crossing or other points where the damaged pipe cannot be easily reached.

(5) *Coupling leaks.*

(*a*) Dresser type coupling leak clamps, consisting of a housing which will surround the leaking coupling and pack off against the pipe, are furnished for use where required. To install these leak clamps, the plug in the top of the housing should be removed, and the two halves of the clamp put around the pipe. The large side bolts of the clamp should be drawn up tightly and the small packing set screws around the ends of the housing tightened evenly, bringing the end gaskets into contact with the pipe and forming a seal between the clamp and the pipe. The plug should then be placed in the top of the housing and secured.

(*b*) In the case of small leaks at couplings, it may be possible to stop them by tightening up on the bolts of the coupling while the pipe is being lifted up and down and moved from side to side. Moving the pipe in this manner will move the gasket on the surface of the pipe so that a new sealing surface will be made. This method often works and may save the installation of a coupling leak clamp.

b. Pump station. Normal maintenance and minor repairs of pumping equipment on the pipe-line system will be performed by members of the operating personnel of the several pump stations. Major repairs to pumps, motors or controls will be handled by a special repair crew. The manufacturers' manuals for service and repair of the units making up the station, should be

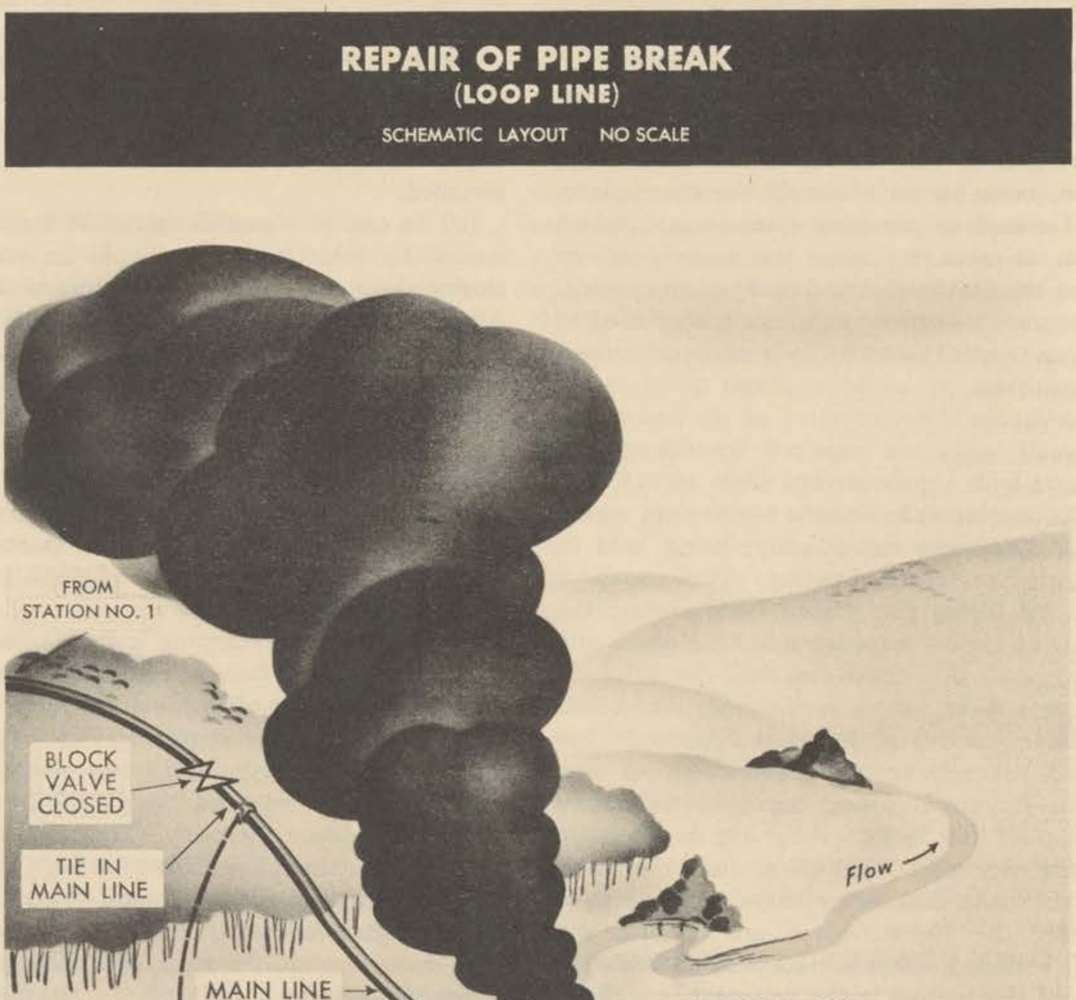


Figure 104. Repair of pipe break by stringing new line around it.

consulted in connection with all repair work. These manuals are a part of the tool equipment of each station and the information therein should be completely understood by the station personnel. In the maintenance of the pump station particular attention should be given to the following:

(1) *Lubrication.* Engine and pump should be lubricated each day in accordance with the instructions given in the manufacturers' service manuals. Pressure grease guns and oil cans are supplied as part of the tool equipment and their regular use is required. Necessary grease and oils will be provided for each station from a supply base or depot.

(2) *Water.* The water used in the engine radiators should be reasonably clean. Engine temperature should be maintained at 180° F. to obtain maximum engine efficiency and to prevent condensation of moisture in the crankcase and the accompanying deterioration of the quality and effectiveness of the lubrication oil.

(3) *Battery.* The battery should be checked with a hydrometer at least twice each week and distilled water added as required to maintain the proper level.

(4) *V-Belt drive.* Check adjustment of the belt drive frequently and adjust to maintain the proper belt tension. If the belt is too tight or too loose, excessive wear will result.

(5) *Pump packing glands.* Condition of the pump packing glands should be observed frequently. If leaks develop either on the fluid or power end, the glands should be tightened just enough to stop the leak. If glands are set up too tightly, the piston rod will be scored and it will be impossible to stop leaks unless a new rod is installed.

(6) *Pump suction and discharge valves.* Action of the pump valves should be noted at frequent intervals. This can be done by placing the ear against the valve case or by using a screwdriver, or other metallic tool, as a stethoscope. The use of a screwdriver is recommended for this purpose, as the sound can be localized at each valve, and it is much easier to isolate valve trouble. There should be a characteristic sound of the fluid passing through the valve port, followed be a distinct tap indicating the seating of the valve. Any hissing sound while the valve is seated indicates a leaky valve. When leaky valves are indicated by sound, by operating characteristics of the pump, or by "loping" (uneven distribution of power), the pump should be shut down, the valve covers removed, and the valves repaired, either by grinding or by replacement, whichever is required.

(7) *Pump liners and piston packing.* The condition of the pump liners should be checked periodically by removing the heads of the cylinders and examining the cylinder walls. Any evidence of scoring should be reported to the operations officer immediately and he will examine the pump. If this wear is excessive and it is evident that the pump is not operating at capacity, due to leakage from one side of the piston to the other, the liners should be replaced and new piston rings installed. This is not a difficult job and should be accomplished in the field in one or two hours' time.

(8) *Controls.*

(*a*) Packing glands on all controllers should be kept snug enough to prevent leakage of the control oil but not so tight as to cause binding of the stems. When it becomes evident that the packing is worn so that leakage cannot be stopped without binding the stem, the packing should be replaced.

(*b*) In the event there is a diaphragm failure on a controller, it can be repaired easily by removing the top of the diaphragm casing, inserting a new diaphragm, and replacing the diaphragm casing head. A study of the drawing of the control will assist in planning its repair.

(9) *Relief valves.* Packing glands on the relief valves should be kept tight enough to prevent leakage. These packing glands are provided with grease cartridge lubricators. A special grease cartridge lubricant should be used for this service. A half-turn of the lubricator screw each day should provide sufficient lubrication to keep the valve from leaking and in working order.

(*a*) If a relief valve diaphragm fails, the control piping should be disconnected by closing the main suction and discharge valves in the station header (figs. 105 and 106). The diaphragm casing can then be removed, after first backing out the spring adjusting screw until it is fairly loose. Count the number of turns this screw is backed out so that it may be returned to its original setting. Replace the diaphragm with a new one and reassemble the diaphragm casing. Return the adjusting screw to its original setting and connect up the control piping; then check the adjustment of the relief valve.

(*b*) Inner valves often become scored or cut out after long periods of intermittent pump bypassing. A scored or cut inner valve may be located by listening to the valve for "blow-by."

552517 O - 43 - 7

In order to repair a defective inner valve, it is necessary to remove the valve from the line. This is done by shutting down the station and closing the main suction and discharge valves. The flanges of the valve may then be unbolted from the station header. Remove all studs and pry the header lines apart enough to allow the valve to be removed from the line. Take care not to destroy the gaskets. Remove the bottom plate of the valve and examine its condition. Release the spring compression, noting the number of turns the screw is backed out, so that original adjustment can be established. Count the threads on the lower stem between the locking nuts and the end of the thread so the lower stem can be screwed back into approximately its original position. The lock nuts should then be released, and the lower stem and inner valve unscrewed from the upper stem. Remove the lock nuts from the stem and pull the stem out through the bottom of the valve. Either replace the Micarta disks on the inner valve stem with new disks, or replace the entire inner valve and stem assembly with a new one. Assemble by screwing the inner valve and lower stem back to their original positions on the upper stem, being careful to replace the two lock nuts. Place this new assembly in the same position as the one which was removed and lock the lock nuts to the upper stem. Replace the bottom plate and put the valve back in the line, being certain it is installed with the flow in the same direction as before removal. Bolt up the flanges securely and hook up the control connection. Open the main discharge valve slowly and allow the line pressure to reach the relief valve. Check flanges for leaks. Adjust the spring compression to its original setting. Check the adjustment of the relief valve as described under control adjustment.

(10) *Sand trap*. The sand trap should be inspected frequently to determine if there is any deposit of foreign material there which would eventually cause trouble in the pump or control valves. Make this inspection by closing the header valves, removing the cap on the drain connection, and allowing the contents of the trap to drain out. Draining of the contents of the trap will usually be sufficient, but if some foreign material remains remove it with a scraper. If the pipe-line system is in gasoline service use a wooden scraper. Avoid using a metallic scraper or tool that would cause a spark and ignite gasoline vapors. If practicable, the clean gasoline in the trap should be drained through an auxiliary line and transferred to a reservoir for use in the pump engine.

(11) *Oil bath air cleaner*. Service air cleaners periodically, preferably each week in areas which are not very dusty. Where there is a large amount of dust and soot this filter may require servicing as often as several times each day. The filter is serviced by removing its lower portion, after releasing the two snap holders. Clean out the dirty oil inside and wipe clean. Replace the oil to the oil level line, using the same grade oil as is used in the engine crankcase. Frequent and careful servicing of this filter will materially increase the life of the engine.

c. Tank.

(1) In cleaning a tank, drain it first and then remove the cleanout plate or the manhole cover. Liquid remaining below the cleanout should be drained, either by syphoning through the cleanout opening or by pumping through the water draw-off valve. Petroleum gas in the tank should be removed by displacement with steam or air. Before entering the tank, test the atmosphere inside with a gas detector. Sludge on the tank bottom should be removed from the tank by an operator, using a wooden shovel. The operators should work in pairs, one man working inside, and one remaining outside prepared to assist the inside man in case he is overcome by gas. The operator on the inside of the tank *must always wear a gas mask*. Sludge from a tank should always be taken to a remote area and buried. After the sludge has been removed, the bottom of the tank should be cleaned and dried. *Never enter or use welding equipment* on, or in, any tank until a thorough test has been made with a gas detector and it is found to be free from explosive gas and, therefore, safe to enter.

(2) If a tank has to be repaired, observe all the precautions given in (1) above. After the tank has been cleaned, replace the faulty section.

(3) In case a badly damaged tank has to be rehabilitated, the extent of damage should be determined by inspection and the necessary repair material assembled. In some cases, it will be found that the plates from a badly damaged tank may be used to repair those less damaged. In all cases of tank repair, salvaged material should be used wherever possible.

(*a*) Small holes in tank bottoms can be repaired by welding plates over the damaged portions. Extensively damaged or badly corroded bottoms must be repaired by installing false bottoms. This may be done by placing 12

2" HIGH DISCHARGE RELIEF

PARTS LIST

HW-137-A	BODY GASKET
HW-142-B	SPRING
HW-574	GASKET
HW-912	STUFFING BOX BODY
HW-1221	GREASE RING
HW-1520	TRAVEL POINTER
HW-1651	BODY
HW-1744	SPRING
HW-2332	PACKING NUT
HW-2333	PACKING FOLLOWER
HW-2812	SEAT RING
HW-2882	YOKE
HW-2888	TRAVEL PLATE
HW-3697	UPPER HALF STEM
HW-3767	ADJUSTING SCREW
HW-3769	SPRING SEAT
HW-3802	UPPER PLUG COMPOSITION DISK
HW-3803	UPPER BACK-UP PLATE
HW-3810	PLUG GUIDE
HW-3822	LOWER HALF STEM
HW-3913	BOTTOM PLATE
HW-4302	DIAPHRAGM PLATE
HW-4303	DIAPHRAGM
HW-4304	UPPER DIAPHRAGM CASING
HW-4305	UPPER GUIDE ASSEMBLY
HW-4318	PACKING
A-862	LOWER DIAPHRAGM CASING

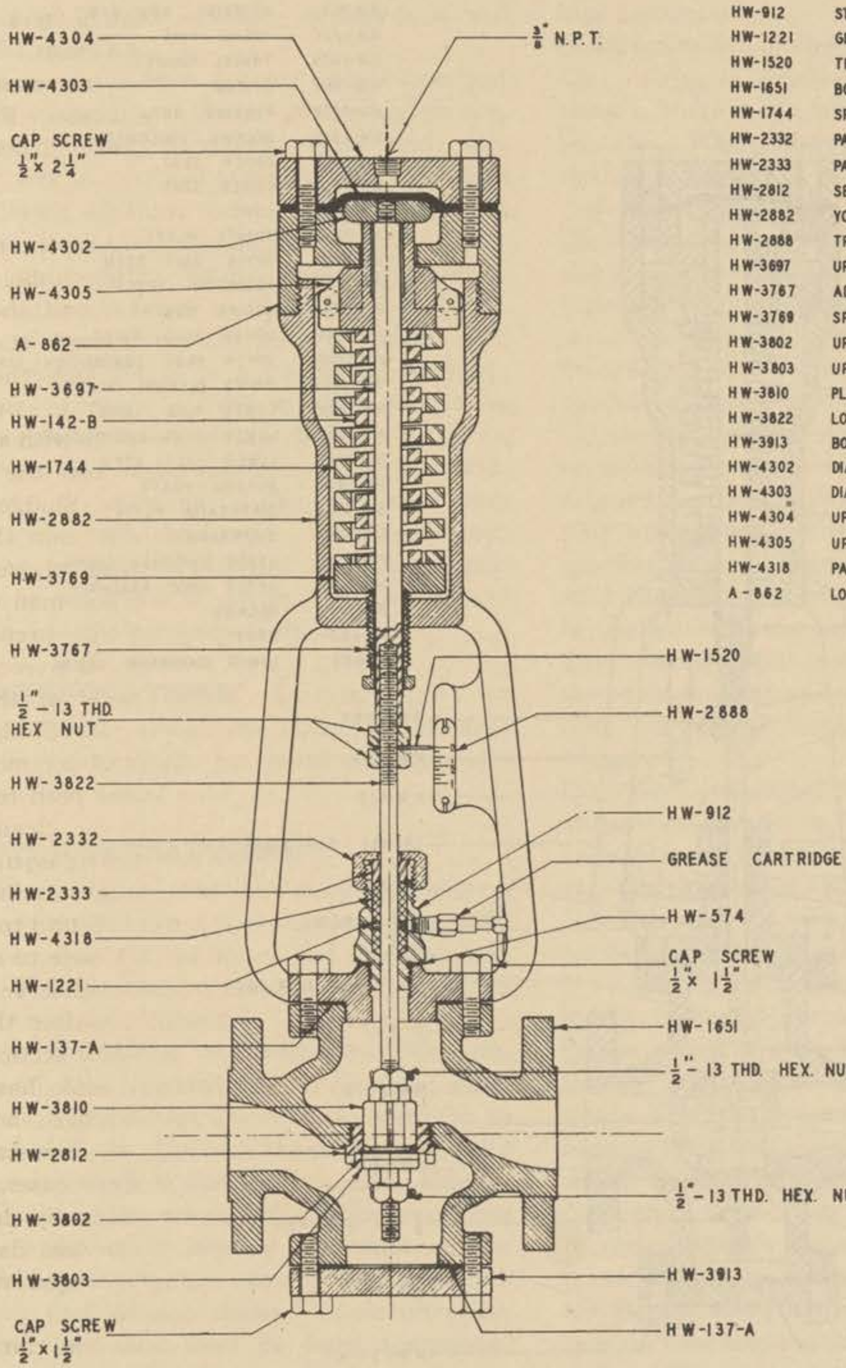


Figure 105. Section and parts list of high discharge relief (Hanlon-Waters type 1626–A).

2" HIGH SUCTION RELIEF

PARTS LIST

HW-137-A	BODY GASKET
HW-142-B	SPRING
HW-574	GASKET
HW-912	STUFFING BOX BODY
HW-1221	GREASE RING
HW-1520	TRAVEL POINTER
HW-1744	SPRING
HW-2332	PACKING NUT
HW-2333	PACKING FOLLOWER
HW-2812	UPPER SEAT
HW-2813	LOWER SEAT
HW-2882	YOKE
HW-2888	TRAVEL PLATE
HW-3697	UPPER HALF STEM
HW-3767	ADJUSTING SCREW
HW-3769	SPRING SEAT
HW-3801	UPPER PLUG GUIDE
HW-3802	UPPER PLUG COMPOSITION DISK
HW-3803	UPPER BACK-UP PLATE
HW-3804	LOWER PLUG GUIDE
HW-3805	LOWER PLUG COMPOSITION DISK
HW-3823	LOWER HALF STEM
HW-3913	BOTTOM PLATE
HW-4302	DIAPHRAGM PLATE
HW-4303	DIAPHRAGM
HW-4304	UPPER DIAPHRAGM CASING
HW-4305	UPPER GUIDE ASSEMBLY
HW-4318	PACKING
A-457	BODY
A-862	LOWER DIAPHRAGM CASING

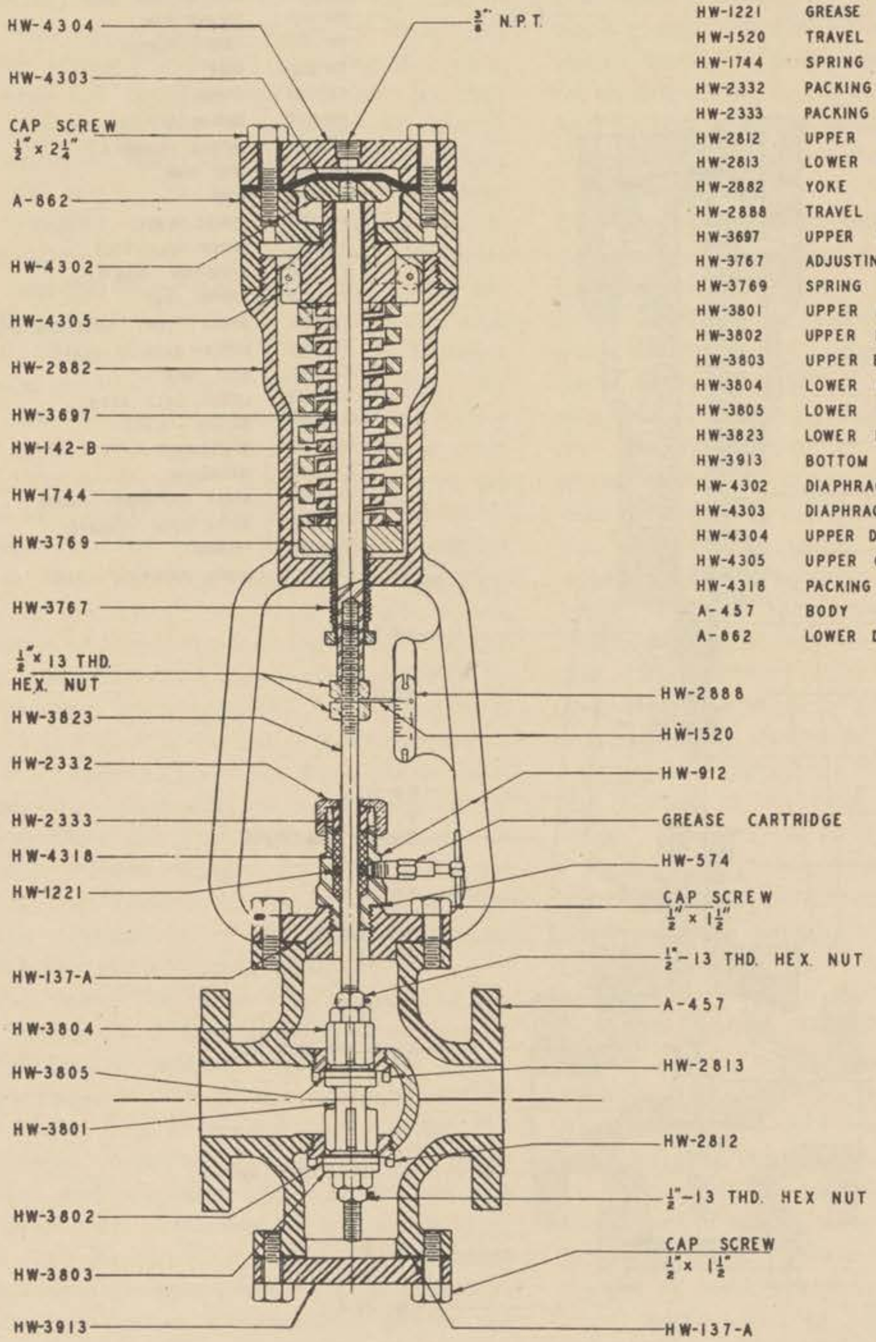


Figure 106. Section and parts list of high suction relief (Hanlon-Waters type 1627–A).

inches of well-tamped earth over the damaged bottom and installing a new steel bottom on this tamped earth. In such cases, all outlets and inlets in the bottom ring of the tank must be raised to fit the new bottom.

(*b*) If the tank shell or roof is damaged, a patch may be welded over the hole, or a rivet or patch bolt inserted if the hole is small. If a large part of a plate is badly damaged, it will have to be replaced.

(4) Remove water from bottom of gasoline and fuel tank frequently. Water has a higher specific gravity than petroleum fuels and will, therefore, settle to the bottom of the tank and can be drawn off from there. After a tank has been filled, its content should be allowed to settle as long as possible before being withdrawn. This precaution is taken to allow water to settle. Samples of tank contents must be taken with an oil thief and tested in a centrifuge to determine water content. Thief samples should be taken at various levels within the fluid to determine the gasoline-water contact within the tank. Check level of water every day so that it does not reach the tank discharge. Whenever tanks containing gasoline are found also to contain appreciable quantities of water, this fact should be reported to the company commander.

29. COMMUNICATIONS. Communication equipment used along the pipe-line system should be maintained by personnel specially trained for this work.

30. SAFETY PRECAUTIONS.

a. Each individual who is to work with a pipeline system must have a complete understanding of safe practices for his job. The premises surrounding any installation must be kept clean and free from cans and rubbish.

b. Safe Handling of Gasoline. Men entrusted with the responsibility of handling gasoline have an important function to perform in furnishing fuel to planes, tanks, trucks, and other gasoline-fueled equipment. Any careless act of any one man may result in the grounding of a whole fighter or bomber command, or the immobilizing of armored ground forces due to insufficient fuel for operations. It is, therefore, important that each man be fully acquainted with the hazards of handling gasoline.

c. Gasoline is both an explosive and a highly combustible material. Its fire hazard, however, can be largely eliminated if proper precautions are taken. A gasoline fire cannot be started unless all three of the following conditions are present:

(1) Gasoline must be present in vapor form.

(2) There must be sufficient air present to support combustion.

(3) The gasoline vapor-air mixture must be ignited by flame, spark, or some other source of sufficiently high temperature.

(4) Elimination of any of these factors will prevent fire. Thus, if gasoline is stored in closed containers, there is not sufficient air to support combustion. When, however, the gasoline is exposed to the air, sources of ignition should be eliminated.

d. Fire hazards.

(1) Spills, leaking joints, leaking hoses, and nozzles are the most common causes of fires, and these leaks should be carefully guarded against. Leaks should be repaired as soon as they are found. Spilled gasoline should be wiped up and the gasoline-soaked rags disposed of at once.

(2) Gasoline-soaked clothing should be removed as soon as possible and the parts of the body exposed to the gasoline washed thoroughly with soap and water. Wearing clothing soaked with gasoline creates a dangerous fire hazard, and painful blisters may be caused by the gasoline coming in contact with the skin. Burns caused by such direct contact with gasoline should be treated in the same manner as burns caused by fire. Gasoline containing tetraethyl lead is especially dangerous.

(3) *"No Smoking" signs and regulations should be posted in the danger zones and the regulations strictly enforced. Smoking or striking matches near gasoline refueling stations or near breaks in lines or at pump stations must be prohibited.*

(4) Open flames or lights, other than the approved safety type vaporproof lights, should never be permitted on or near storage tanks, tank trucks, loading stations, pump stations, or other areas where there is a possibility of gasoline vapors accumulating. *The personnel working in these areas should not carry either matches or lighters. This rule should be rigidly enforced.* Always be on the safe side, even though it requires a little more time and effort.

(5) Do not allow gasoline to remain in open containers; containers should be tightly closed at all times. Do not use gasoline to clean floors, start fires in stoves, or to wash pump engines or other machine parts; use special safety solvent or kerosene.

(6) Hammering or pounding on any line or fitting which contains gasoline under pressure must not be permitted. Caution must be taken to relieve line pressure before breaking into any line, such as by removing a pressure gage or plug. Valves should never be opened or closed unless accurate information has been obtained as to just what purpose they serve. A leaking valve on a high pressure line must never be stopped with a bull plug; a nipple and an extra valve should be used, the second valve being open while making the connection.

e. *Precautions to be taken while repairing leaks on gasoline pipe line.*

(1) Trucks and cars should stay a safe distance from a leak and always approach from the windward side.

(2) Gasoline vapors are heavier than air; therefore, never approach a leak with a car from a lower level.

(3) Repair crews must know first aid, and especially how to give artificial respiration and treatment for burns.

(4) Adequate first aid material, including burn ointment and blankets, should always be available.

(5) Only nonsparking tools (hardened beryllium copper) should be used in repairing leaks.

(6) Goggles should be worn by men making repairs.

(7) It is necessary for men to use rubber or Duprene leakproof boots when standing in gasoline.

(8) Every precaution possible must be employed to prevent a spark while removing and replacing sections of pipe line.

(9) Pit holes must not be spot-welded; use clamps.

(10) Even after a leak has been repaired, continued care must be taken to prevent a flash and fire. Two or three days may be necessary to make the vicinity gas free. Test should be made with an approved gas indicator.

f. Static Electricity.

(1) A combustible mixture of gasoline and air may be ignited by an electric spark resulting from static electricity. A static-electrical discharge is caused by a difference in static-electrical potential between two objects. An example of one way in which static-electrical potential may be built up is by the friction which develops when walking with leather-soled shoes across a carpet. If, under conditions just described, the person reaches out to touch a metallic object which is at a lower potential, such as a door knob, a spark will jump just before the metallic object is touched. Similarly, a static-electrical potential is built up on a gasoline-tank truck as the truck moves along a road. The accumulation of a static charge on any object and sparks resulting therefrom can be prevented by keeping that object at ground potential.

(2) In the case of gasoline trucks the following precautions should be observed:

(*a*) Ground the truck to the loading-rack piping before the fill-cap is removed from the truck. The truck should be grounded as long as the tank is being filled because a considerable static charge is generated by the flow of the gasoline through hose, nozzle, and air while flowing into the tank.

(*b*) Each tank truck should be provided with a drag chain connected to the truck chassis, axles, and tank itself, to maintain all parts of the truck at the ground potential.

(3) Railroad rails frequently carry an electrical current, and where this occurs, care should be taken to prevent a spark at any point where cars are unloaded. This is usually done by insulating the loading rack section of the tracks from the spur or main line, grounding this section by bonding the rails together with copper cable, and connecting the cable to the same ground connection as the car unloading piping. This brings the car to the same potential as the piping and unloading equipment and keeps it that way during unloading operations.

(4) Above-ground piping and tanks should always be grounded. If the tanks and piping are underground, no further precaution is necessary.

g. Demolition. All operating personnel of a pipe-line system should be instructed in the proper methods of demolishing the system, in case it becomes necessary to prevent it from falling into enemy hands. The completeness with which any pipe-line demolition program can be carried out depends upon the time available. A simple and effective method of demolishing a system which is being used to transport gasoline is to break the fuel line to the gasoline engine which powers the pumping unit and set the pump station on fire. Setting fire to gasoline in tanks will destroy them effectively. Where water is being handled the tanks should be filled and then destroyed by charges of explosives. Explosives may also be used to quickly and efficiently demolish pump stations. The demolition of the pipe line presents a more difficult problem. Where time is available, the line can be rendered unserviceable by smashing the cou-

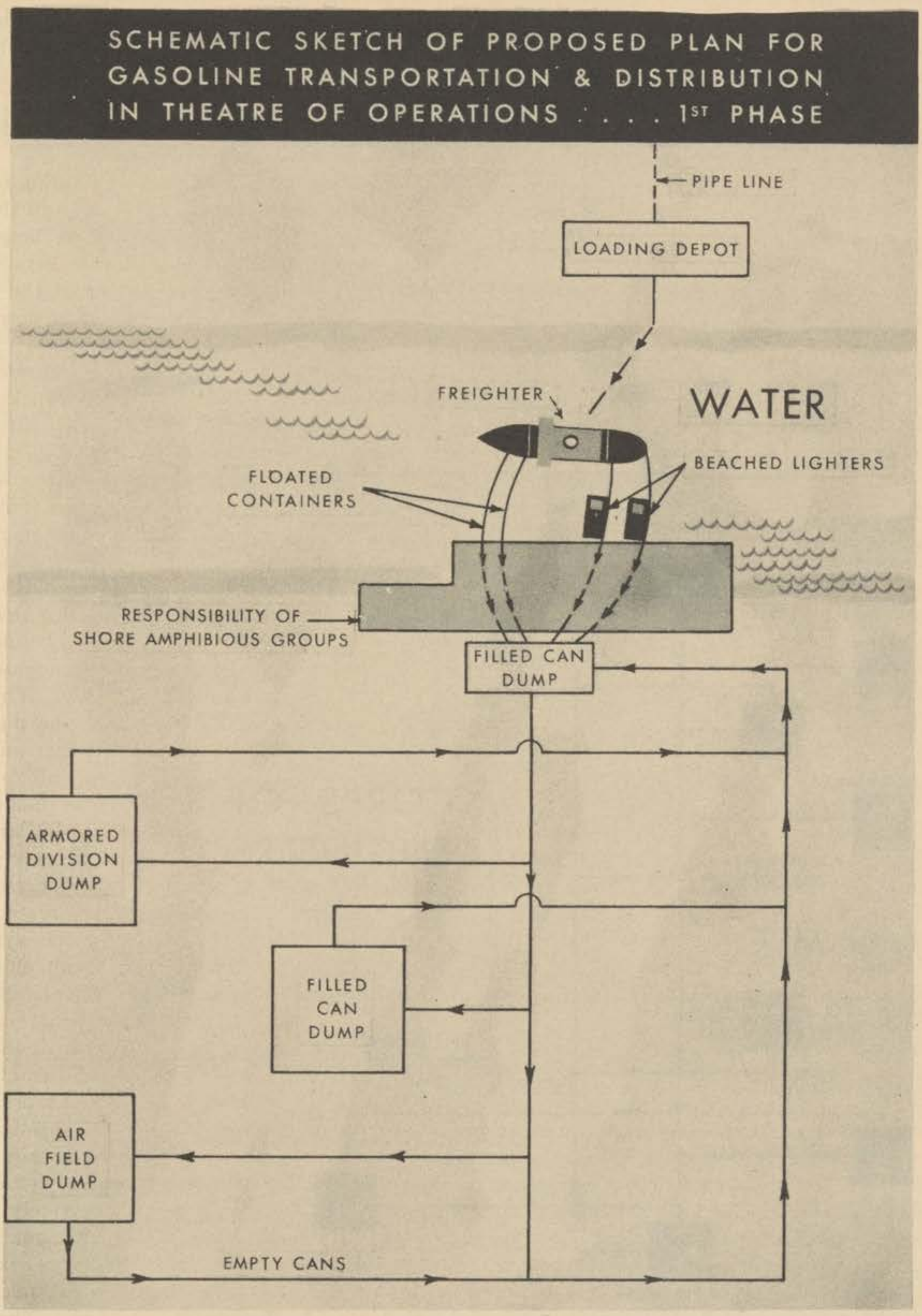


Figure 107. Schematic sketch illustrating initial phase of gasoline transportation and distribution.

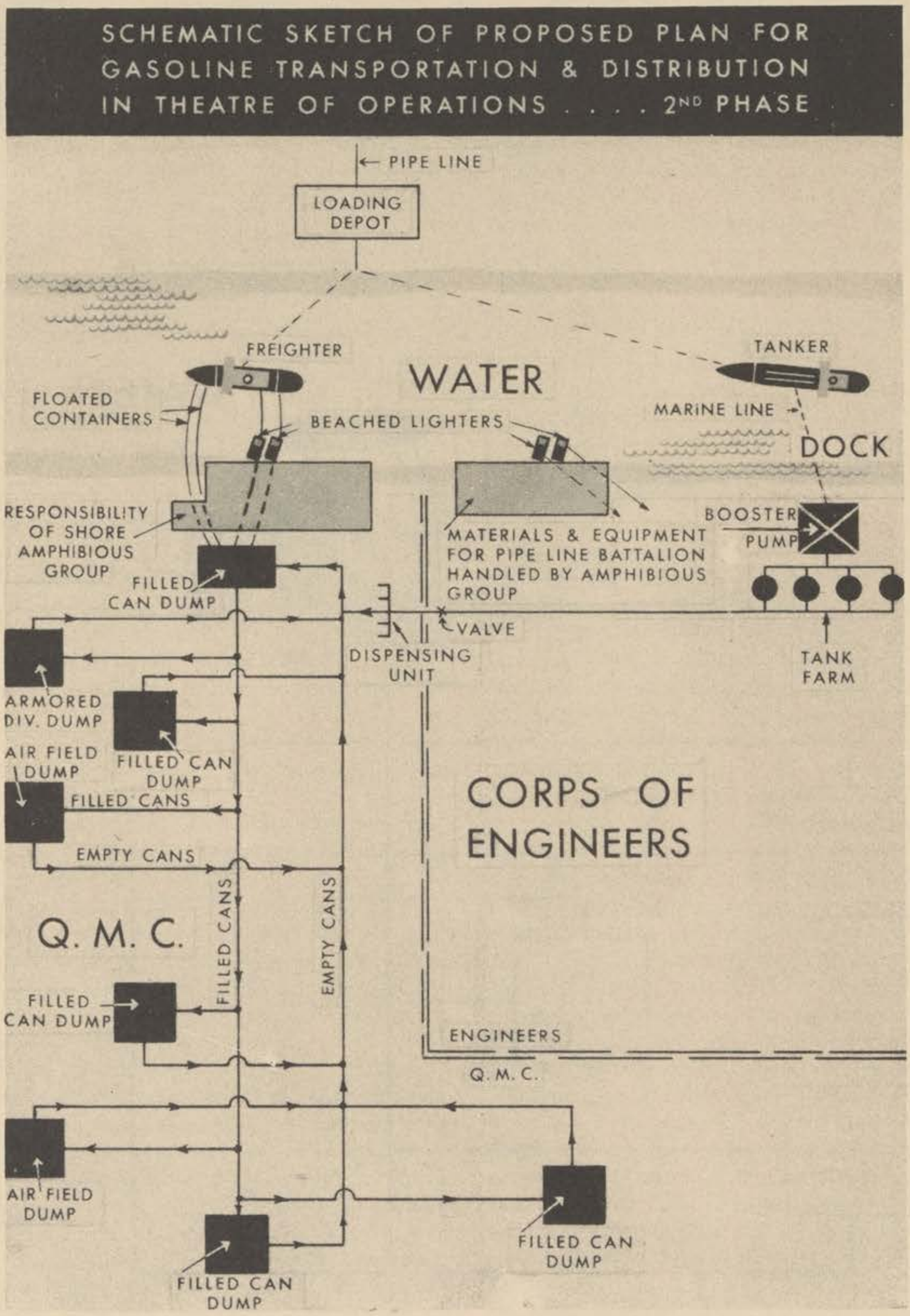


Figure 108. Schematic sketch illustrating second phase of gasoline transportation and distribution.

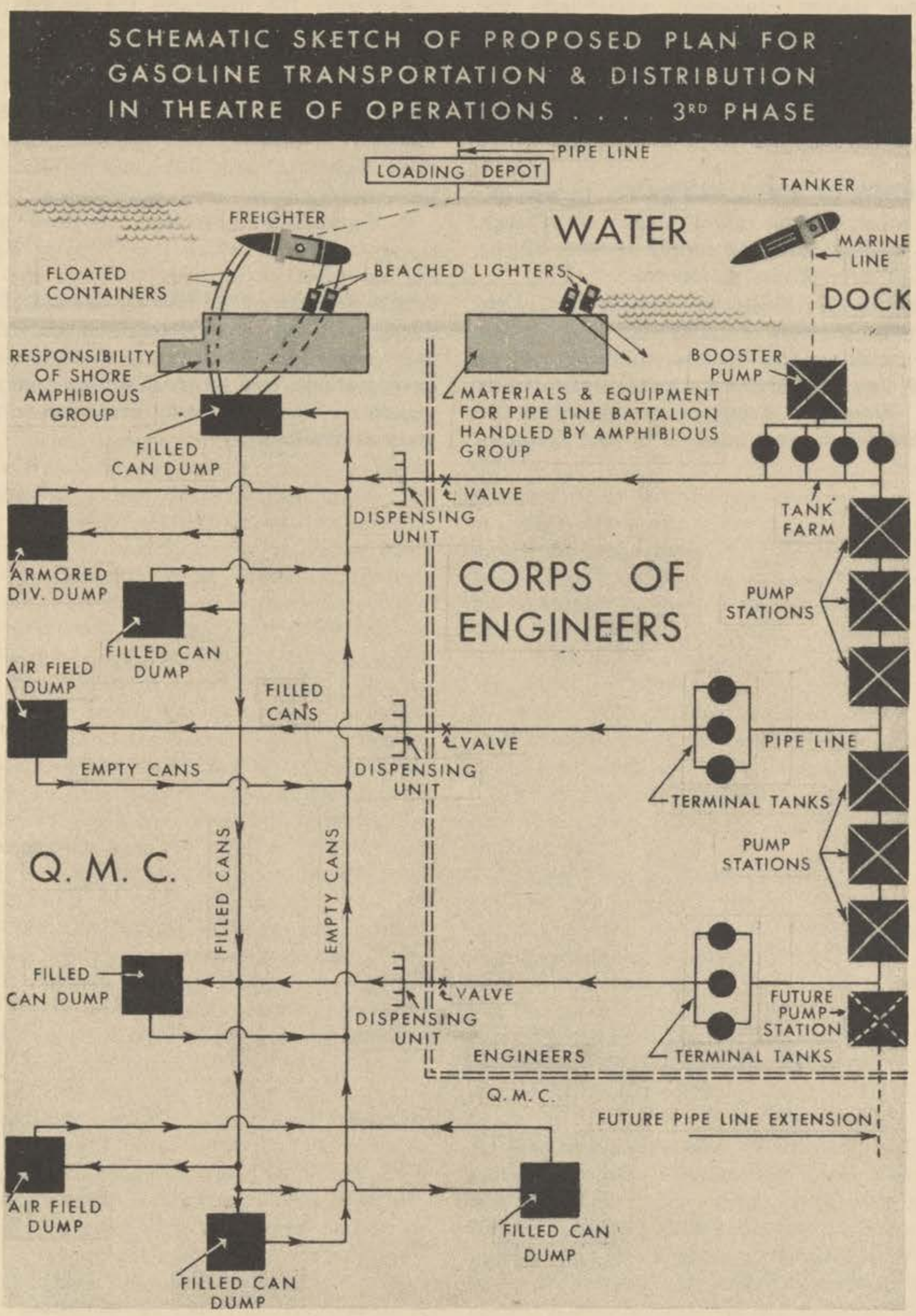


Figure 109. Schematic sketch illustrating third phase of gasoline transportation and distribution.

plings with sledge hammers and flattening the pipe. The important part to be destroyed is the pump station equipment, particularly the engines and pumps. There will be assurance that serviceable pumps and engines cannot be assembled from damaged ones if identical parts, such as pump casings and engine distributors and carburetors are destroyed on all units.

31. PHASES OF FUEL SUPPLY. In any operation involving the establishment of a beach head or landing point the supply of fuels will be handled in three phases, as follows:

a. Figure 107 illustrates the initial phase in which fuel required is transported to the beach head in freighters and lighters, or floated ashore in metal cans or containers where it is stored in dumps. From these dumps or storage points the containers are moved forward by the Quartermaster Corps to points of use. Empty cans are returned to beach head for refilling.

b. Figure 108 illustrates the second phase of operations in which the Corps of Engineers has made its initial installation for the bulk storage of fuel in tanks, augmenting that stored by the Quartermaster Corps in cans. The Engineer function is to install and operate a marine line from tanker to tank farm and to distribute to the Quartermaster Corps dump through pipe lines.

c. Figure 109 illustrates the third phase of the operations in which the Corps of Engineers has extended its facilities to serve the various dumps established by the Quartermaster Corps during the first and second phases. This has been accomplished by the installation of pipe lines, stations, and terminal-storage tanks. Provisions are made for future expansion to forward areas as required.

CHAPTER 6
AUTOMATIC AND MANUAL CONTROL

32. AUTOMATIC CONTROL FOR RECIPROCATING PUMPS. This type of pump is controlled by a hydraulically operated diaphragm throttle connected directly to the carburetor of the gasoline engine used to drive the main line pump. Figure 110 illustrates the hydraulic engine control system. The complete control system, including relief valves, is shown in figure 112. Pressure in the hydraulic engine control system is maintained by the small rotary oil pump (OP) which circulates a mixture of kerosene and motor oil through the system. Any increase in pressure in this system brought about by restricting the flow of the control fluid is reflected directly on the head of the diaphragm throttle (DT), which in turn moves the carburetor arm toward a closed position and reduces the engine speed. A drop in pressure in this system caused by decreasing or removing the restriction to flow of the control fluid lowers the pressure on the diaphragm throttle and allows the spring in the throttle head to move the carburetor arm toward the open throttle position and increase the engine speed.

a. Control Oil Pump. The control oil pump is a small, rotary, positive-displacement type pump, chain-driven from the magneto shaft of the engine. Under normal operating temperatures, the control system fluid is made up of a mixture of 70 percent kerosene and 30 percent SAE 10 motor oil. In hot climates the mixture should be 50 percent kerosene and 50 percent SAE 10 motor oil. In extremely cold climates this mixture should be 90 percent kerosene and 10 percent SAE 10 motor oil. These mixtures have sufficient lubricating characteristics to prevent excessive wear in the control oil pump. *Do not experiment with other lubricants.*

b. Oil Relief Valve. The control system is protected against excessive pressure by a diaphragm-actuated, spring-loaded relief value (RV), shown in figure 110, which can be adjusted to open and relieve at a predetermined pressure. Excessive pressure in the control system will result when any restriction approaches or becomes a complete closure against the discharge of the control oil pump. Control oil pressure acts continuously against the diaphragm of the oil relief valve, and when the predetermined relieving pressure is reached this relief valve will open immediately and allow the control oil to flow directly to the oil reservoir (OR). When the pressure falls due to the reduction or complete removal of the restriction in the control oil system, the relief valve will close and normal oil circulation through the system will be resumed.

c. Orifice Valve. The orifice valve is a standard type of hand-operated needle valve placed in the system for use in adjusting the automatic controllers and relief valves. It may also be used in changing over from automatic to manual control and as a means of limiting the maximum engine speed.

d. Low Suction Controller.

(1) The low suction controller (LSC) regulates the engine speed so that the pumping unit will, within certain limits, handle all the liquid delivered to the suction side of the pump and at the same time maintain a constant predetermined minimum suction pressure. The low suction controller is of the spring-loaded, diaphragm-actuated type and is installed in the control oil system as shown in figure 110.

(2) The diaphragm space in the head of the low suction controller is connected to the pump suction by a small copper tubing. A pressure snubber (SPS) is installed in this line to reduce the transmission of suction pressure impulses to the controller diaphragm. By means of a spring adjusting screw, the controller spring is set to cause an upward force on the lower side of the diaphragm. In a state of equilibrium, this spring force must balance the force exerted by the suction pressure

HYDRAULIC ENGINE CONTROL SYSTEM

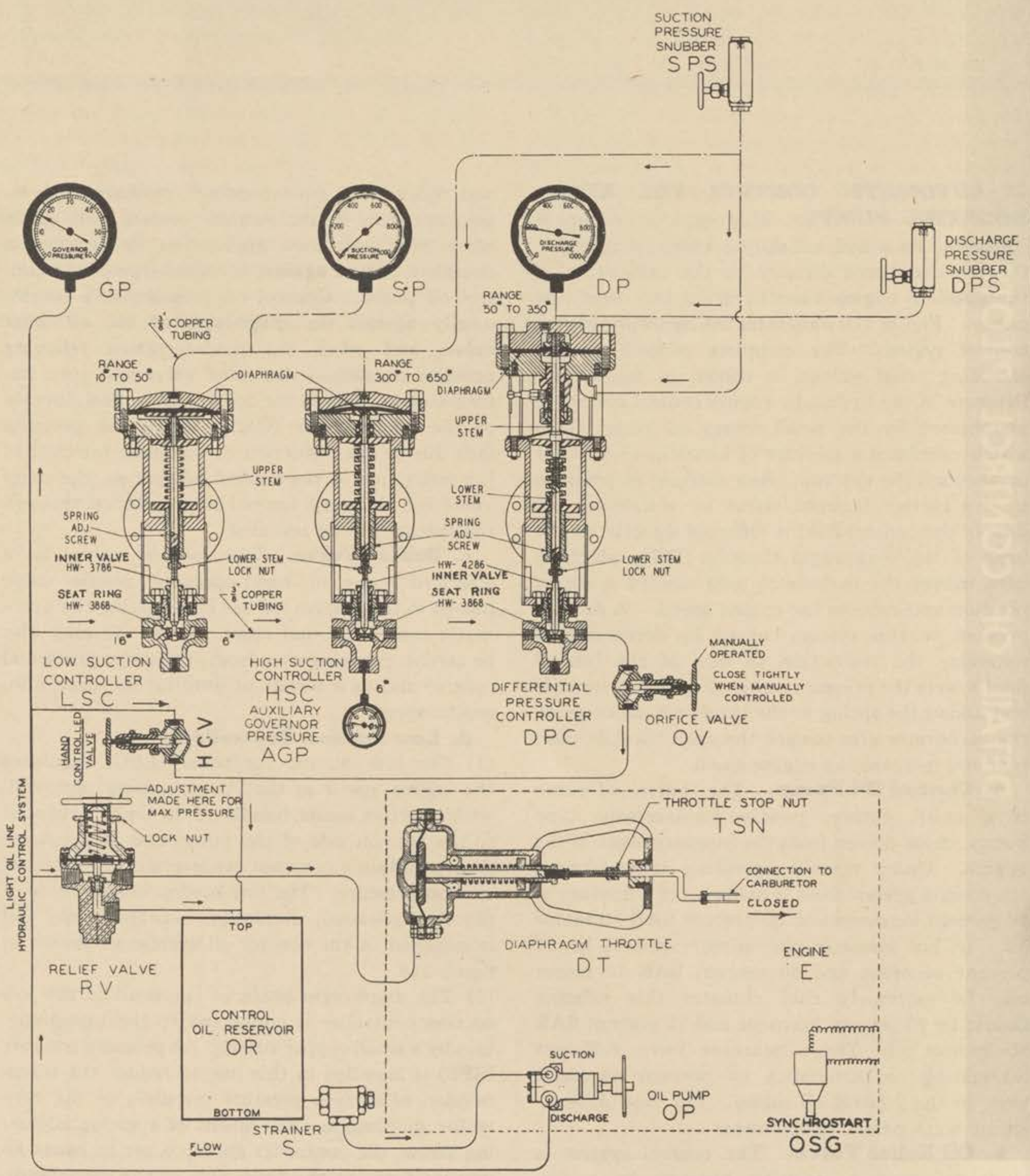
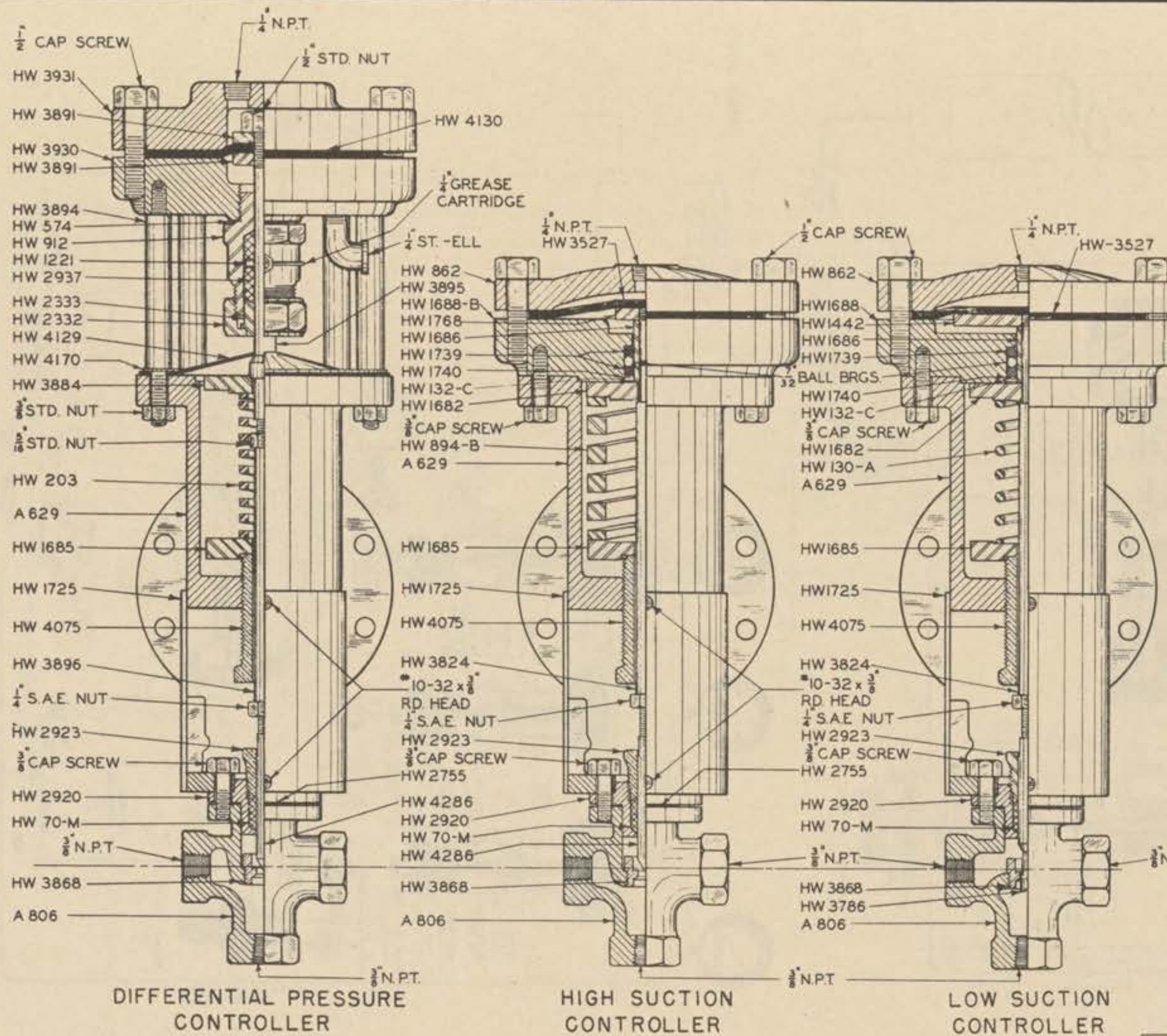


Figure 110. Hydraulic engine control system.

DETAIL OF CONTROL PILOTS



PARTS LIST

HW	70-M	PACKING
HW	130-A	SPRING
HW	132-C	SNAP RING
HW	203	SPRING
HW	574	STUFFING BOX GASKET
HW	862	UPPER DIAPHRAGM CASING
HW	894-B	SPRING
HW	912	STUFFING BOX BODY
HW	1221	GREASE RING
HW	1442	DIAPHRAGM PLATE
HW	1682	UPPER SPRING SEAT
HW	1685	LOWER SPRING SEAT
HW	1686	STEM GUIDE SLEEVE
HW	1688	LOWER DIAPHRAGM CASING L.P.
HW	1688-B	LOWER DIAPHRAGM CASING H.P.
HW	1725	YOKE COVER PLATE
HW	1739	FELT WASHER
HW	1740	RETAINING WASHER
HW	1768	DIAPHRAGM PLATE H.P.
HW	4129	DUST SEAL
HW	2332	PACKING NUT
HW	2333	PACKING FOLLOWER
HW	2755	BODY GASKET
HW	2920	BONNET
HW	2923	PACKING FOLLOWER
HW	2937	PACKING
HW	3527	DIAPHRAGM
HW	3786	I. V. LOW SUCTION
HW	3824	UPPER STEM
HW	3868	SEAT RING
HW	3884	UPPER SPRING SEAT
HW	3891	DIAPHRAGM PLATE
HW	3894	DISTANCE PIECE
HW	3895	UPPER STEM
HW	3896	STEM SUB.
HW	3930	LOWER DIAPHRAGM CASING
HW	3931	UPPER DIAPHRAGM CASING
HW	4075	ADJUSTING SCREW
HW	4130	DIAPHRAGM
HW	4170	HOLD DOWN RING
HW	4286	INNER VALVE
A	629	YOKE
A	806	BODY

CONTROL PILOTS — TYPE 1625 — B248
HANLON-WATERS, INC. TULSA, OKLA.
SCALE 3/4" = 1" DATE 8-10-42

Figure 111. Details of control pilots.

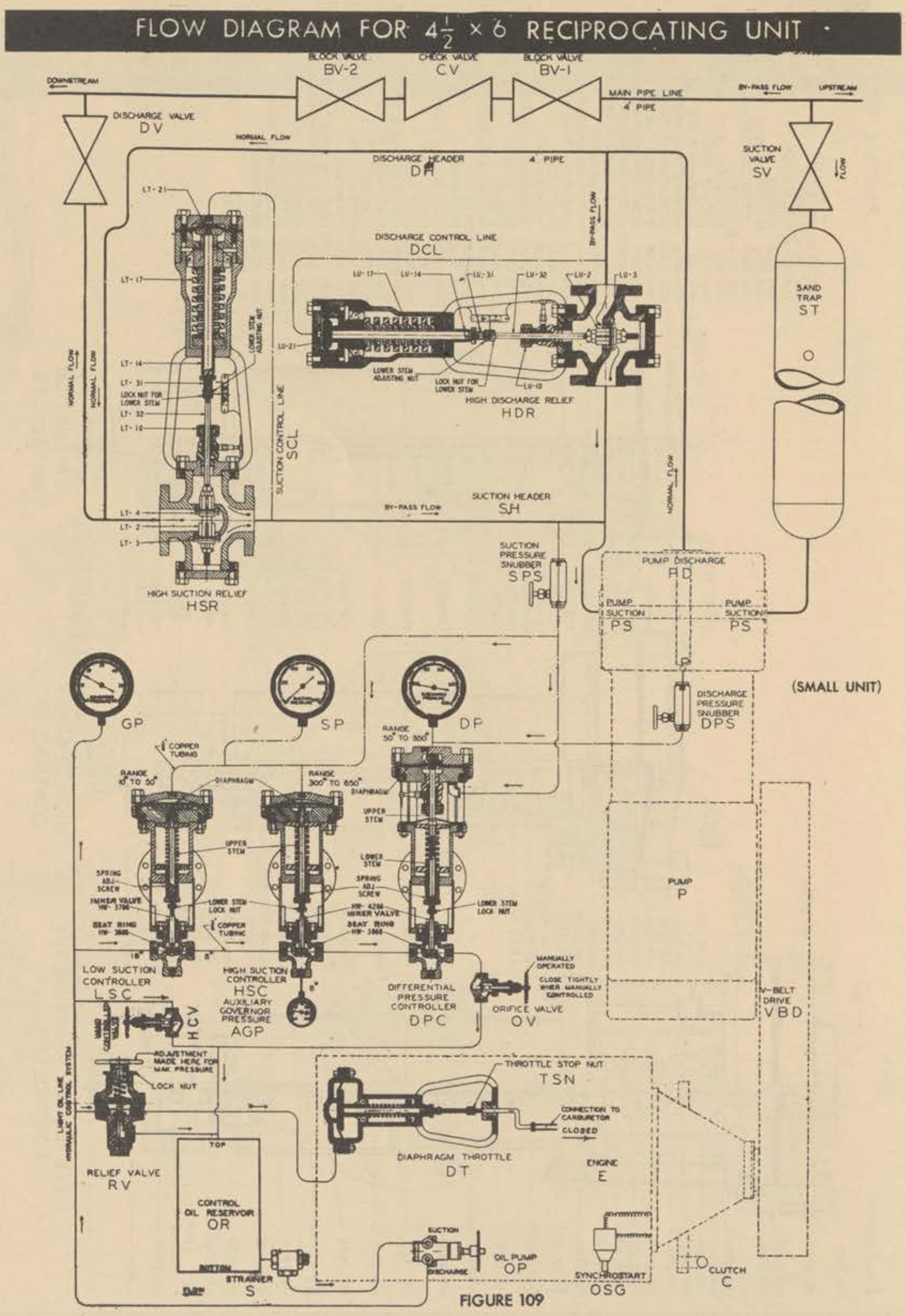


Figure 112. Complete flow diagram for small reciprocating unit.

PRINCIPLES OF CONTROLLER

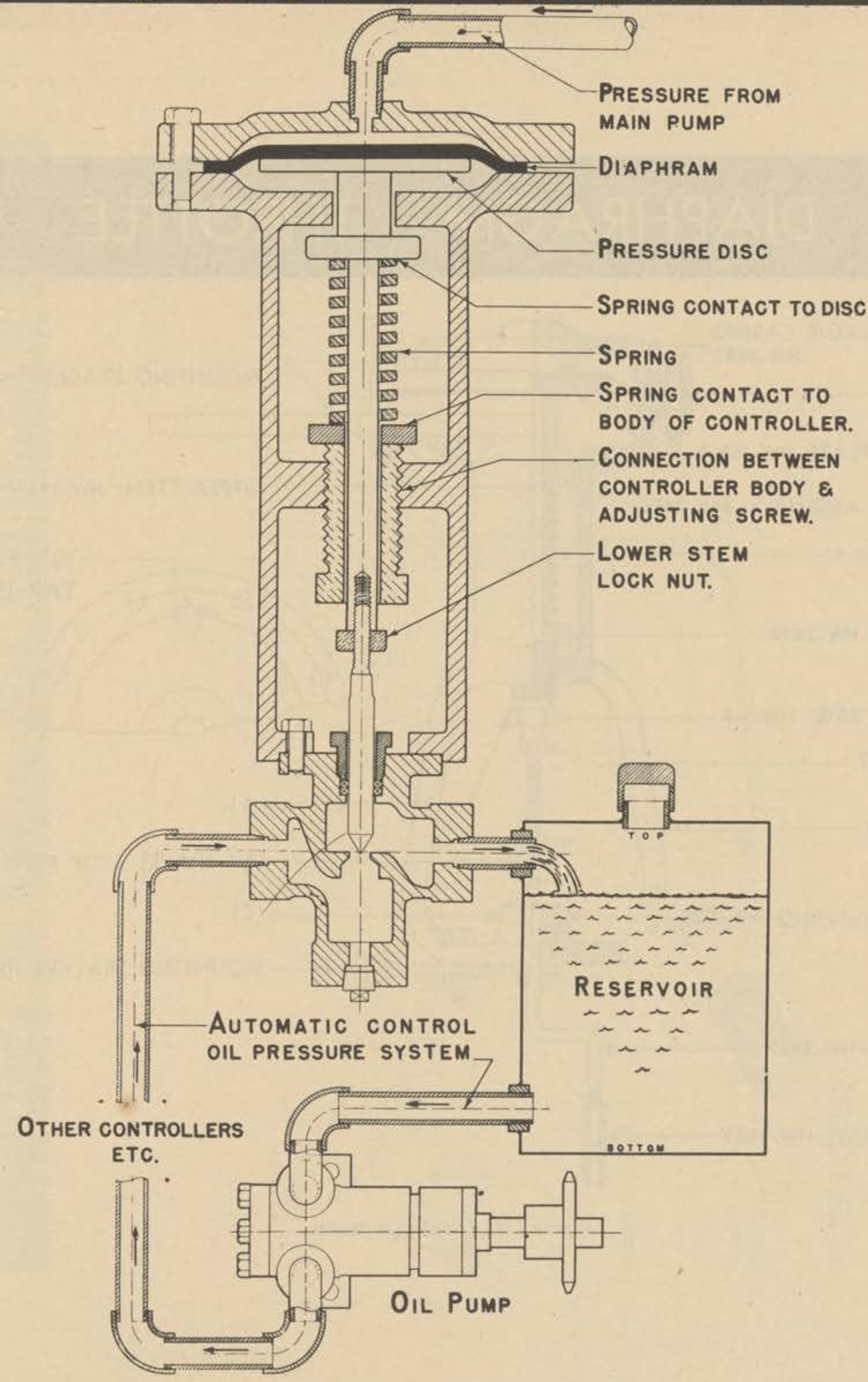


Figure 113. Principles of controller.

DIAPHRAGM THROTTLE

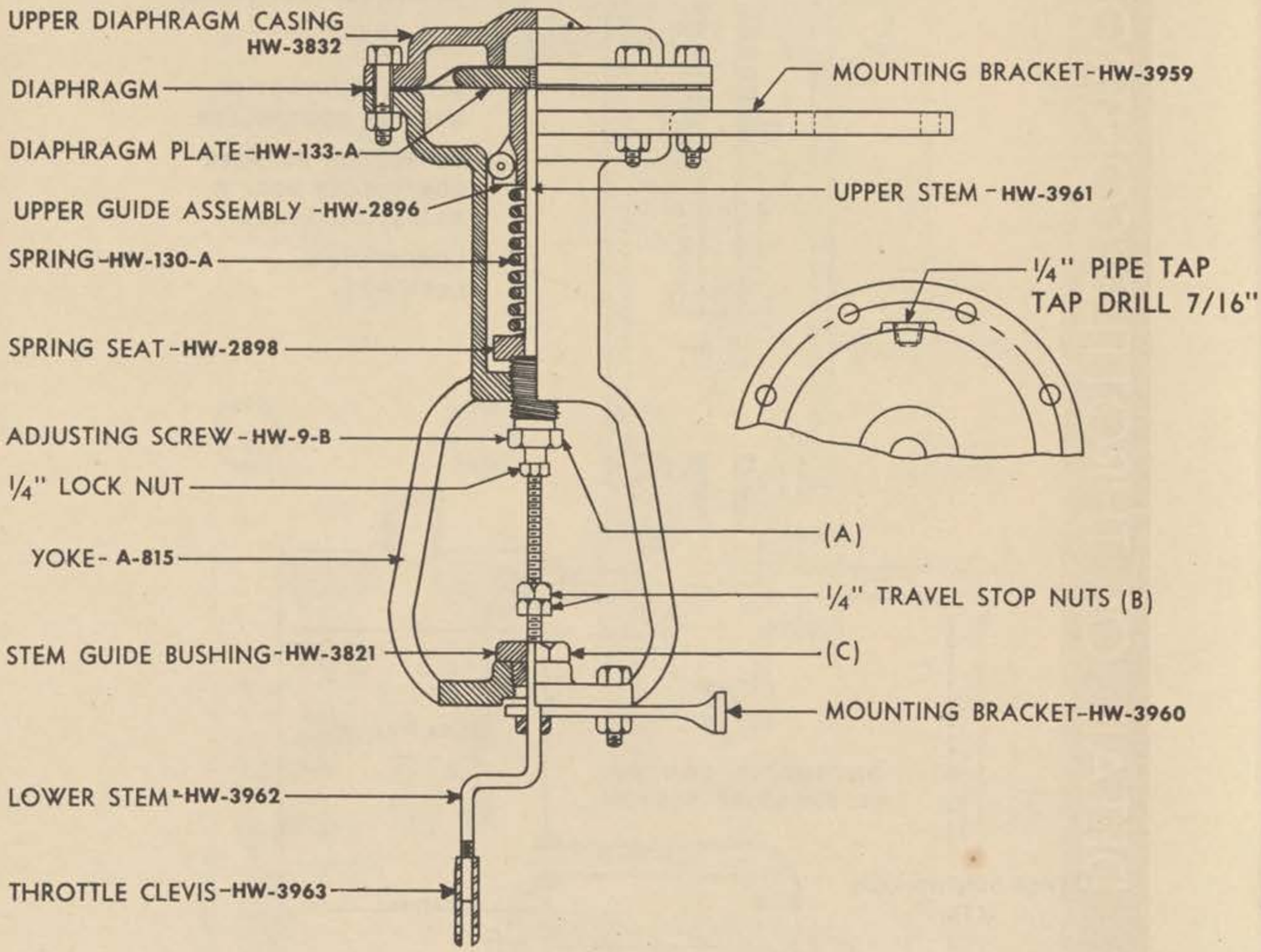


Figure 114. Diaphragm throttle.

DETAIL OF THROTTLE CONTROL

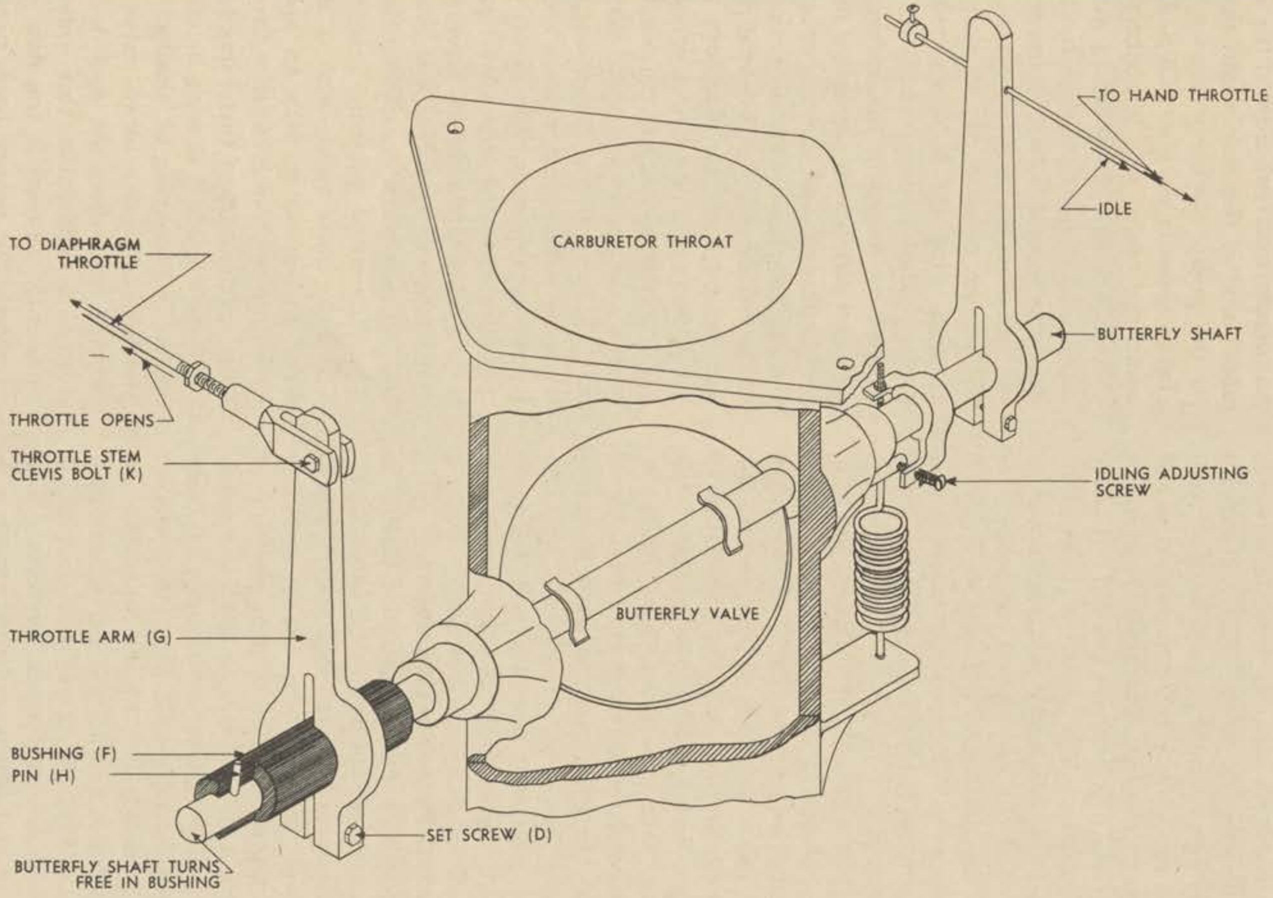


Figure 115. Detail of throttle control.

on top of the diaphragm. Any change in either the spring compression or the suction pressure will disturb this state of equilibrium and alter the position of the valve stem. A decrease in suction pressure, requiring a reduction in engine speed, causes the valve stem to move upward, thus partially closing the valve. An increase in suction pressure, requiring an increase in engine speed, causes the valve stem to move downward, thus further opening the valve. The low suction controller inner valve cannot be completely closed, as the taper of the valve stem is such that it will move completely through the seat, reaching a maximum restriction as it moves upward but never shutting off entirely. The valve is tapered to obtain a uniform variation in liquid flow across it. The inner valve on the low suction controller is in the oil control line and any variations in the position of the valve stem influence the pressure in this system which, in turn, alters the position of the diaphragm throttle.

(3) With the low suction controller in use, the pump can be operated at the desired rate of speed and the suction pressure controlled. This control of suction pressure, on any station except the source, or No. 1 Station, requires the pump to move all of the liquid, within the limits of the pump capacity, that it receives from upstream. It is a fundamental requirement that the rate of pumping set at the source station must be maintained through the whole length of the line. Otherwise, an excessive pressure will be built up gradually on the stations upstream from any station which is not carrying the load.

e. Differential Pressure Controller.

(1) The differential pressure controller (DPC) is a diaphragm-actuated, spring-loaded valve which controls the maximum differential between pump suction pressure (SP) and discharge pressure (DP). It is placed in the control system, as shown in figure 110, and acts to limit the maximum loading on the pump and engine. Under design-operating conditions, when the suction pressure is 30 pounds per square inch and the discharge pressure is 230 pounds per square inch on all stations, except No. 2 and No. 3 at which design conditions are 30 pounds per square inch suction pressure and 180 pounds per square inch discharge pressure, the differential pressure controller has no effect on the control system and therefore does not influence the engine speed. When conditions are not normal, however, as when a station or stations may be down and the load distributed over other operating stations, the differential pressure controller then functions to limit the load any given pumping station will assume under such abnormal operating conditions. The extra load brought about by stations being down is thus distributed over several stations without overloading any particular station.

(2) The differential pressure controller differs from the low suction controller in that the former has pressure on both sides of the diaphragm. The upper side of the diaphragm casing is connected to the pump discharge header through the discharge pressure snubber (DPS, figs. 112 and 116), while the under side is connected to the pump suction header. In order to maintain a balance across the diaphragm, the force exerted by the discharge pressure on the upper side of the diaphragm must be equalled by the force exerted by the suction pressure on the under side of the diaphragm, plus the force exerted by the control spring. If the compression on the spring is increased by means of the spring adjusting screw, a greater differential pressure is required to balance the diaphragm and spring combination. Thus, if the suction pressure remains constant, an increase in the setting of the differential pressure controller will require a greater discharge pressure to bring the differential pressure controller into balance.

(3) In order to control the maximum differential pressure between suction and discharge, it is necessary to decrease the power output of the engine when the differential pressure rises to the pressure for which the controller is set. It is essential, therefore, that the differential pressure controller lowers (closes) the inner valve in the oil control system when the differential pressure is too high and opens it when the differential pressure is low. The differential pressure controller upper stem closes the inner valve with a downward movement and opens it with an upward movement. This type of valve is called a direct acting throttle valve. The port of this valve has a taper of 30° to cause a gradual change in engine speed when the valve is opening or closing. The differential pressure controller inner valve can seat completely, but when the unit is pumping at the maximum differential this valve is closed only sufficiently to restrict the flow of the control oil to create the proper back pressure against the diaphragm throttle and hold the engine speed at the desired maximum rate.

f. High Discharge Relief Valve. In the event one station between two others is down, the discharge pressure on the upstream station will rise to the pressure necessary to reach the

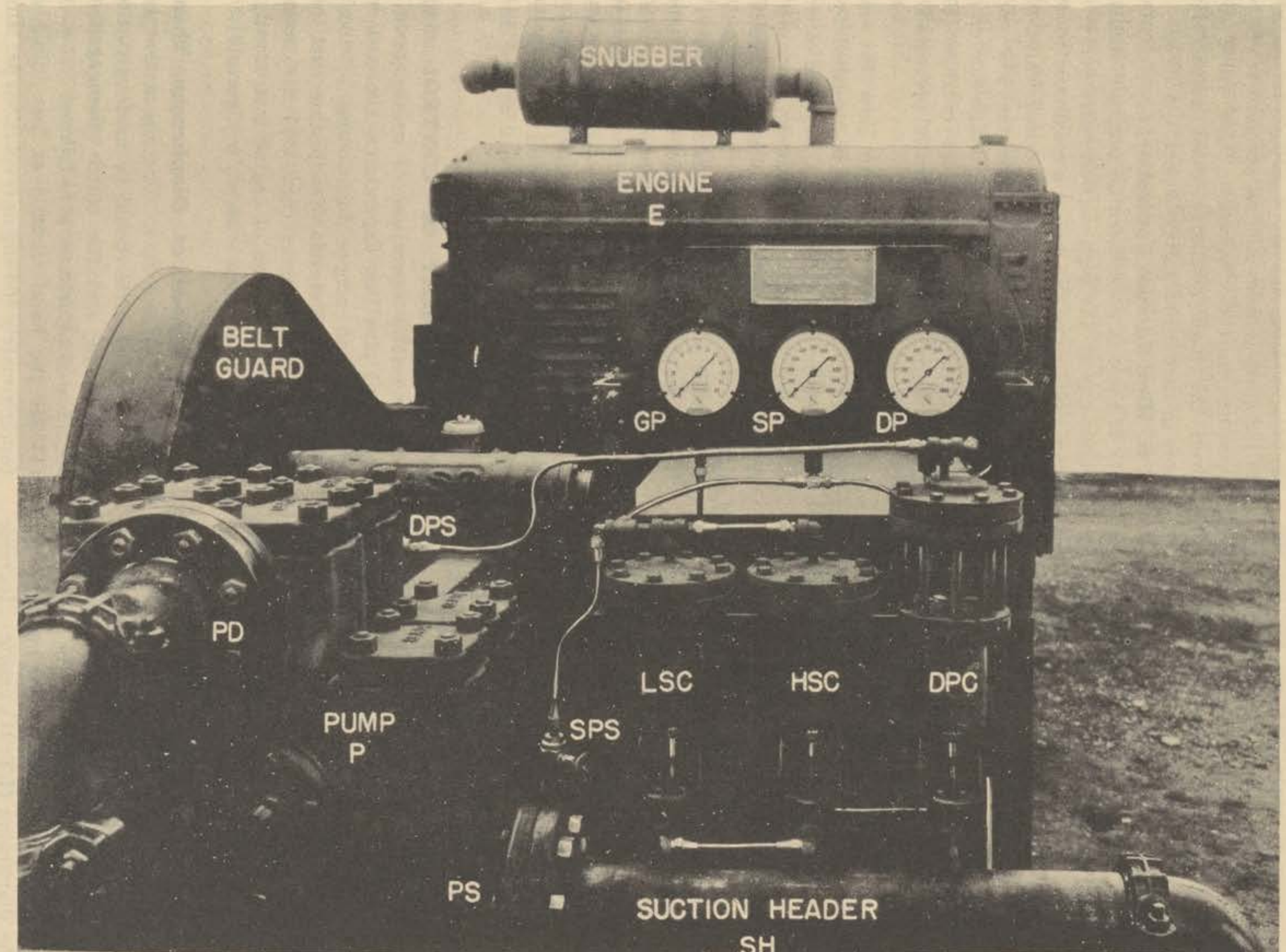


Figure 116. Line to upper side of diaphragm.

station downstream from the station which is not operating. Assuming that the station spacing shown in figure 29 is used, the pressure will rise to 430 pounds per square inch, if the differential pressure controllers are set for 300 pounds per square inch. Proceeding on the same assumption, if two adjacent stations are shut down, the discharge pressure on the first upstream station which is operating will reach 630 pounds per square inch, the pressure required to pump across the two stations that are shut down. Therefore, if more than two adjacent stations are not in operation, the discharge pressure could increase sufficiently to rupture the pipe and cause damage to the pumps. This would happen also if a valve is closed on the discharge of the pumps or anywhere else along the line. In order to prevent pump pressure from exceeding a set limit, a high discharge relief valve (HDR) is employed. This valve is of the spring-loaded, diaphragm-actuated type and is constructed as shown in figure 105. It is connected from the pump discharge (PD) into the pump suction (PS) and has a discharge control line (DCL) connected into the discharge line and to the top of the diaphragm. The high discharge relief valve is of the reverse acting type, constructed so that pressure on the diaphragm opens the valve port (LU–3) against spring compression. Spring compression is set at the desired relieving pressure by means of an adjusting screw. With this valve on the pump discharge, any increase in discharge pressure above the relief valve setting will cause it to open, pass liquid into the suction, and reduce the pressure. This relieving action puts a heavy load on the engine and pump, because the pump has to recirculate liquid with a differential pressure of approximately 600 pounds per square inch. This will cause the pump to heat rapidly. To prevent this overheating a high suction relief valve has been added.

g. High Suction Relief Valve. In order to prevent the recirculation of liquid under the conditions outlined in **f** above, a high suction relief valve (HSR, fig. 106), is connected from the suction header (SH) into the discharge header (DH). The suction control line for this valve (SCL) is connected from the suction header to the top of the diaphragm (LT–21) casing. Increase in the suction pressure (SP) above the desired setting opens the high suction relief valve and dissipates the discharge pressure (DP) into the suction header (SH), thus raising the suction pressure considerably above the setting of the high suction relief valve and keeping the suction relief valve open. Under these conditions the pump is not working against a differential pressure, as pumping is from suction pressure to an equal pressure on the discharge. This valve differs from the high discharge relief valve (HDR) only in that it has a double port.

h. High Suction Controller.

(1) If there is no differential pressure across the pump due to the high suction relief valve being open, the engine will run at a maximum governed speed as determined by the orifice valve (OV), because under this condition the low suction controller (LSC) is open due to high suction pressure, and the differential pressure controller (DPC) is open since there is no differential pressure across the main pump (P).

(2) The necessary control to slow the engine down under these conditions is furnished by the high suction controller (HSC), installed in the oil control line between the low suction controller and the differential pressure controller. An increase in pressure on the diaphragm lowers (closes) the inner valve and a decrease in pressure causes it to raise (open). The high suction controller is adjusted with the spring adjusting screw, so that the inner valve will just start to move downward at approximately the same pressure at which the high suction relief valve (HSR) is set to open. This prevents any lag in control which otherwise would allow the engine to speed up and damage the pump.

33. ADJUSTMENT OF CONTROL UNITS.

The successful operation of an automatically controlled pipe line depends on the correct adjustment and proper functioning of the control system. Methods of adjusting each of the units of this system (fig. 112) are described below. The location of engine instruments and auxiliary equipment is shown in figures 117, 118, and 119.

a. Adjustment of Diaphragm Throttle. (see figs. 114 and 115). The adjustment of the diaphragm throttle should be made with the engine running and the clutch disengaged. The sequence of adjustment is as follows:

(1) Set the hand throttle at fast idling speed (approximately 400 engine revolutions per minute).

(2) Close the orifice valve completely, and on the pumping units so equipped; also close the hand control valve.

(3) Adjust the oil relief valve until a governor control pressure of 5 pounds per square inch is indicated on the governor control pressure gage (GP). The oil relief valve is adjusted by releasing the lock nut and turning the handle clockwise to increase the oil system pressure, or counterclockwise to decrease the pressure. Tighten the lock nut after adjustment is completed.

(4) Referring to figure 114, set the spring adjusting screw (A) so that about ¼ inch of threads is showing (approximately 2 threads). Set the travel stop nuts (B) ⅝ inch from the stem guide bushing (C).

(5) Referring to figure 115, loosen the setscrew (D) until the butterfly valve shaft bushing (F) turns freely in the throttle arm (G).

(6) Readjust the oil relief valve until a control oil pressure of 16 pounds per square inch is indicated on the governor control pressure gage. At this pressure the travel stop nuts should contact the stem guide bushing. If contact with the bushing is not made, loosen the spring adjusting screw until the travel stop nuts bear properly against the bushing stop.

(7) Referring to figure 115, rotate the butterfly valve shaft bushing so that the shoulder on the bushing makes contact with the butterfly valve shaft pin (H) on the side of the pin nearest the diaphragm throttle. Hold the bushing in this position and push the throttle arm firmly against the diaphragm throttle stem clevis bolt (K) in the direction of the diaphragm throttle. With the bushing and throttle arm in this position, tighten the setscrew until the butterfly valve shaft bushing is firmly held by the throttle arm. ***Caution:*** ***Do not tighten the setscrew excessively, as this will cause the bushing to bind on the butterfly valve shaft.***

(8) Set the engine hand throttle at the wide open position. This should cause no increase in engine speed.

(9) Slowly tighten the spring adjusting screw until the travel stop nuts just move away from the stem guide bushing, then gradually back off the spring adjusting screw until the stop nuts just bear against the bushing stop. When proper contact is finally made between stop nuts and stem guide bushing, the engine should be at a fast idling speed with the governor control pressure at 16 pounds per square inch. The diaphragm throttle is now in proper adjustment to function with the automatic control system.

b. Adjustment of Oil Relief Valve. With the diaphragm throttle in adjustment, the engine running and clutch disengaged, the oil relief valve is adjusted as follows:

(1) Close both the orifice valve and the hand control valve completely.

(2) Adjust the oil relief valve in the manner previously described until a governor control pressure of 18 pounds per square inch is indicated on the control pressure gage, then lock adjusting screw in this position. The oil relief valve is now adjusted to prevent pressures in excess of 18 pounds per square inch being placed on the control system. The 18-pounds-per-square-inch setting is 2 pounds higher than the pressure required to bring the engine to an idling speed.

c. Adjustment of Inner Valves on High Suction Controller and Differential Controller. The following procedure will apply to inner valve adjustment on both the high suction controller and the differential controller, although the adjustments are not made simultaneously.

(1) Set the spring adjusting screw so that ¼ inch of threads is showing on the differential controller, and the threads on the spring adjusting screw are just hidden on the high suction controller.

(2) Obtain zero suction and discharge pressure on the diaphragms of the low suction controller, high suction controller, and differential controller by closing the suction and discharge pressure snubber valves and disconnecting the copper tubing lines to the diaphragms at some convenient union.

(3) Loosen the lock nut and unscrew the inner valve until it seats. This is determined by feeling the inner valve as it makes contact with the seat.

(4) Screw the inner valve up off the seat 2½ turns and lock in this position with the lock nut.

(5) The inner valves of both the high suction controller and differential controller are now adjusted so that proper pressure settings may be made in the manner to be outlined later.

d. Adjustment of Low Suction Controller. With the engine running, clutch disengaged, and zero suction and discharge pressure on the controller diaphragms obtained by closing the suction and discharge pressure snubber valves and disconnecting the copper tubing lines to the diaphragms, open the orifice valve completely. The hand control valve should be left closed in this and all subsequent adjustments.

(1) Set the spring adjusting screw so that it is made up as far as possible.

(2) Loosen the lock nut and screw the inner valve up as far as possible.

(3) Reconnect the suction and discharge pressure

copper tubing lines to the controller diaphragms and open the pressure snubber valves.

(4) With the next upstream and the next downstream stations in operation, place the station being adjusted on the line and begin pumping operations.

(5) Slowly unscrew the inner valve until the desired suction pressure of 30 pounds per square inch is obtained and held by the pump, then lock in this position. Allow the pumping unit to become stabilized after each adjustment. ***Caution:*** When the above adjustment of the low suction controller has been made, it may later be found that the valve will not have the required movement to allow sufficient clearance for the control oil to circulate without objectionable restriction. The effect of undue restriction will be to prevent the governor control pressure falling low enough to allow maximum throttle opening necessary for operation at a differential pressure of 300 pounds per square inch. In the event it is necessary to adjust further the inner valve, this may be accomplished by slowly lowering valve by unscrewing until the desired differential pressure is reached. It may be found that a weak spring in the low suction controller will not permit a pressure of 30 pounds per square inch on the suction and 300 pounds per square inch differential pressure to be maintained simultaneously. If this should occur, the unit must operate at a pressure slightly lower than 30 pounds per square inch as a differential pressure of 300 pounds per square inch must always be obtainable.

e. Adjustment of High Suction Relief Valve. With the next upstream and downstream stations continuing to operate, the station being adjusted should be taken off the line by disengaging the clutch.

(1) Close the station block valves in the main line section completely and partially close the station discharge valve until a suction pressure of 350 pounds per square inch is reached.

(2) Adjust the spring adjusting screw until the high suction relief valve just begins to open at 350 pounds per square inch. (Backing off the spring adjusting screw lowers the setting pressure; tightening the spring adjusting screw increases the setting pressure.)

f. Adjustment of High Suction Controller. With the same station operating conditions as set out in **e** above, further close the discharge valve until a suction pressure of 375 pounds per square inch is reached. Adjust the inner valve by unscrewing until it just seats at 375 pounds per square inch, then lock in this position.

g. Adjustment of Differential Controller. With the same station operating conditions as indicated in **f** above, place the station being adjusted on the line by engaging the clutch and adjust the discharge valve until a discharge pressure of between 400 and 450 pounds per square inch is indicated. Adjust the inner valve until a differential pressure of 300 pounds per square inch is maintained by the pump, then lock in this position. As mentioned in **d** above, it may be necessary to make a further adjustment of the low suction controller in order to establish a 300-pound-per-square-inch differential pressure.

h. Adjustment of Orifice Valve. With the station operating conditions as in **g** above, begin closing the orifice valve until an increase in governor control pressure is indicted, then open the orifice valve until the governor control pressure just ceases to drop. With this setting as a reference point, further open the orifice valve one-quarter turn. This permits a governor control pressure sufficiently low to reach a 300-pound-per-square-inch differential pressure, but does not allow a governor control pressure low enough to cause the engine to speed up beyond a safe limit.

i. Adjustment of High Discharge Relief. With the same station operating conditions as in **h** above, further close the station discharge valve until a discharge pressure of 650 pounds per square inch is reached. Adjust the spring adjusting screw until the high discharge relief valve just begins to open at 650 pounds per square inch. (Unscrewing the spring adjusting screw lowers the setting pressure; tightening the spring adjusting screw increases the setting pressure.)

Caution: If there is any reason to believe that the high discharge relief valve is not operating properly, a man should be stationed at the engine clutch lever (C) at all times with instructions to disengage the clutch and close the manual throttle simultaneously in the event the discharge pressure reaches 750 pounds per square inch with the high discharge relief valve still closed. Permission should also be obtained from the operations officer before adjusting the high discharge relief valve, to be certain that relief valves on all upstream stations are functioning. It is important to check the adjustment of the high pressure relief valve at least once each week because this is the *only protection the system has against excessive discharge pressures. This relief valve must open without fail.*

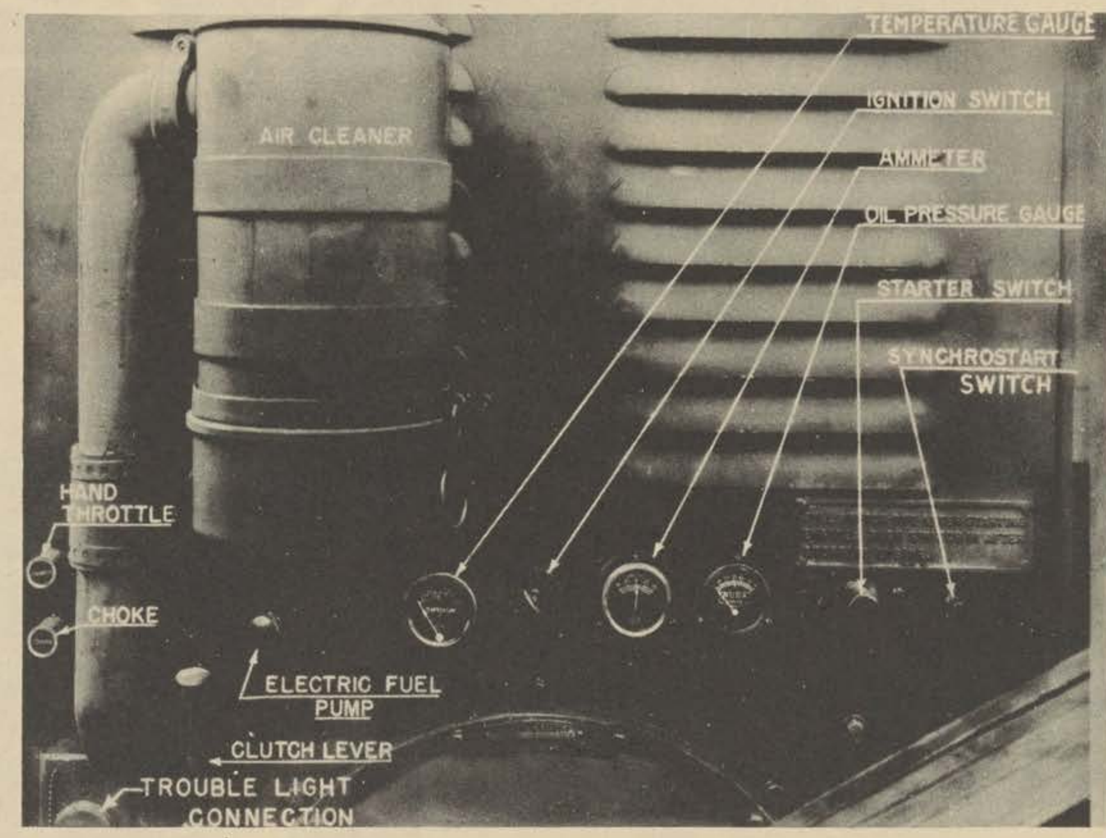


Figure 117. Location of engine instruments.

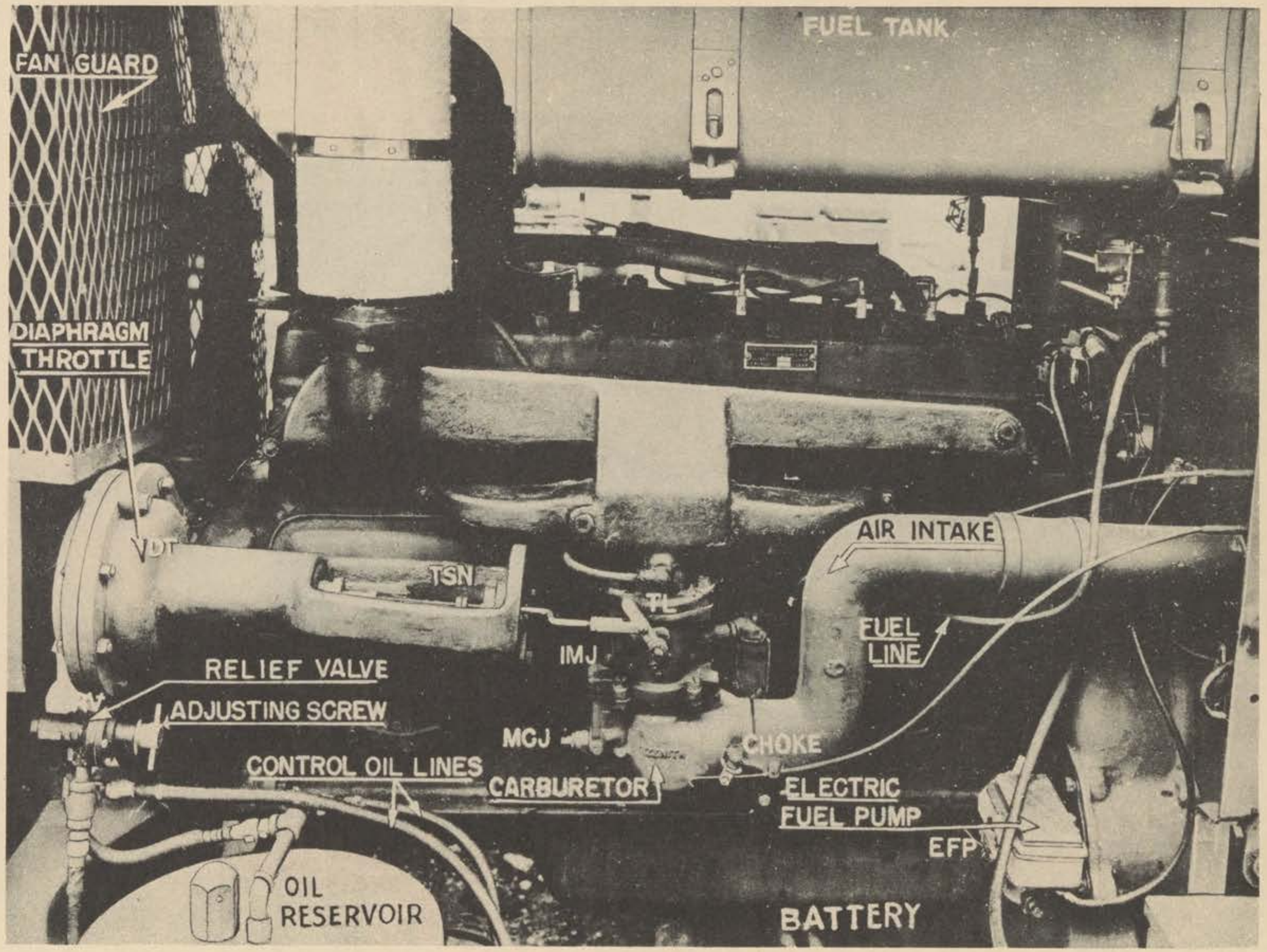


Figure 118. Location of engine instruments.

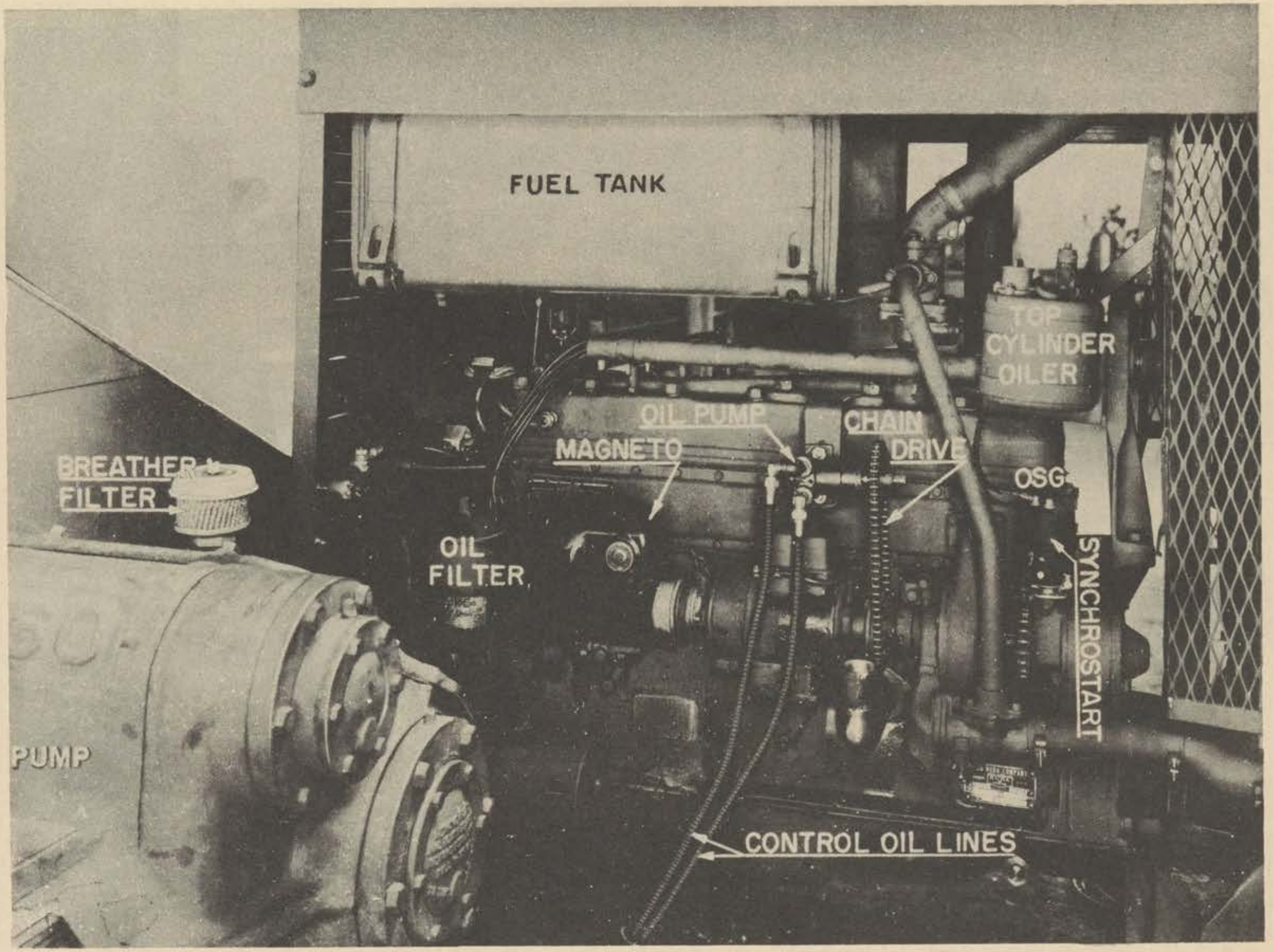


Figure 119. Location of engine instruments.

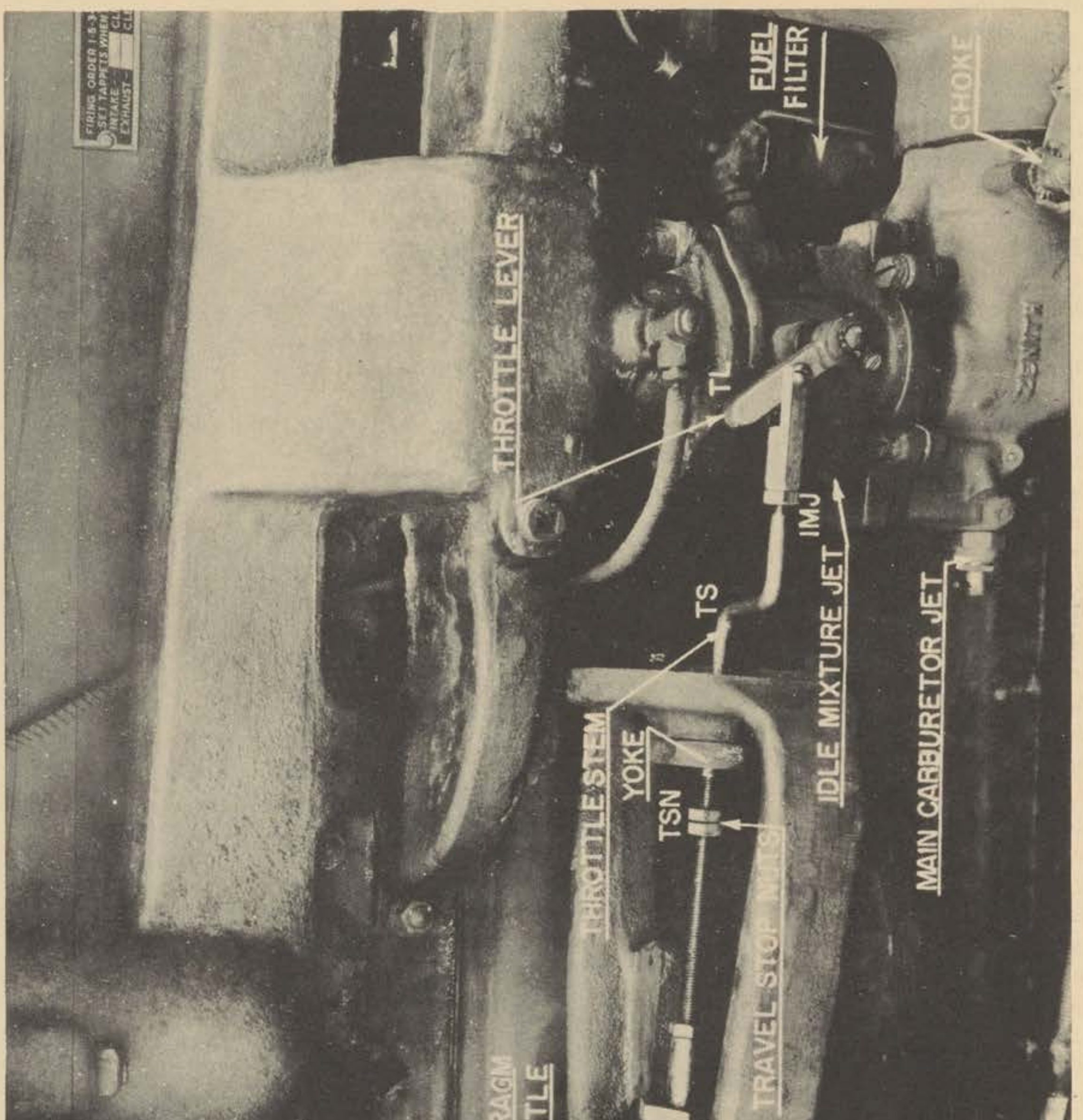


Figure 120. Carburetor throttle stop.

j. Adjustment of Pressure Reducing Regulator.

(1) The pressure reducing regulator is used on long downhill grades where pipe-line pressures exceed 600 pounds per square inch. This regulator reduces the line pressure to the desired pressure, which may range from 50 to 200 pounds per square inch, depending upon the requirements of the line. The regulator is a double-port, reverse-acting, spring-loaded, diaphragm-actuated, self-contained, pressure reducing valve.

(2) Pressure from the downstream side of the valve is applied to the under side of the diaphragm which closes the valve when the downstream pressure increases to a point where the force on the diaphragm exceeds that exerted by the spring. To increase the downstream pressure at which the valve will close, remove the cap and turn the spring adjusting screw so that it moves downward. To decrease the downstream pressure at which the valve will close, turn the spring adjusting screw so that it moves upward.

k. Checking Adjustment and Operation of Controllers and Relief Valves.

(1) To check operation of the low suction controller, close the suction valve (SV) on the station header and allow the pump (P) to decrease the suction pressure (SP). The engine speed should change to a slow idling condition without stalling after the suction valve has been completely closed. The suction valve should then be opened slowly because the next upstream station may have built up a high pressure against this valve. When the valve is opened the pump will speed up because the suction pressure is above normal for a short period of time. The pump should quickly pull the suction pressure down to the point at which the low suction controller is set. If the suction pressure, however, does not rapidly reach this control point it is possible that the engine is being throttled by some restriction in the control system. This throttling action may be due to the orifice valve, differential controller, or high suction controller. Check the orifice valve by opening it a part of a turn, and if this adjustment does not allow the engine speed to increase and reduce the suction pressure to the control point established by the low suction controller, change orifice valve setting to the original position. Check the differential controller and high suction controller separately by raising the inner valve a definite number of turns, being careful to note the exact setting before making this change in adjustment. By checking each of the three units in the control system separately, it can be determined which one is out of adjustment and throttling the engine. After the pumping unit has resumed normal operation, the control unit which was found to be out of adjustment should be reset according to the procedure previously outlined in this manual.

(2) To check the operation of the differential controller, close the main line block valve at the station and slowly close the station discharge valve (DV) until the pump discharge pressure (DP) increases to between 400 and 450 pounds per square inch. If the differential pressure controller is in correct adjustment, the suction pressure should increase until it reaches a value of 300 pounds per square inch less than the discharge pressure. If the differential pressure between the suction and discharge is more than 300 pounds per square inch, the differential pressure controller should be adjusted in accordance with the procedure previously described. On the other hand, if the differential pressure between the suction and discharge is less than 300 pounds per square inch, it is possible that the orifice valve or one of the other controllers is restricting the flow of control oil and therefore throttling the engine.

(3) The setting of the high suction relief valve and high suction controller may be checked in one continuous operation as follows: disengage clutch on the engine so that pump is shut down, then close the station main line block valve. Slowly close station discharge valve until a suction pressure of 350 pounds per square inch is reached. At this pressure the high suction relief valve should just begin to open, as indicated by a downward movement of the stem. If the valve does not open under this condition, a pressure of 350 pounds per square inch should be held and the valve adjusted by unscrewing the spring adjusting screw until it does start to open. If the high suction relief valve opens at a pressure less than 350 pounds per square inch, this pressure should be held while tightening the spring adjusting screw until the valve is closed, and then slowly unscrewing the spring adjusting screw until the valve just begins to open. Further close the discharge valve until a suction pressure of 375 pounds per square inch is obtained. At this pressure the inner valve of the high suction controller should just seat and simultaneously slow down the engine. If the inner valve seats before the 375 pounds pressure is reached, screw up the inner valve off the seat, past the control point, and then unscrew it until it just seats while holding 375 pounds per square inch suction pressure. With this suction pressure

and with no differential pressure across the pump, the low suction controller and differential controller will ordinarily not be so far out of adjustment as to interfere with the checking of the high suction controller.

(4) To check the setting of the high discharge relief valve, the engine and pump must be in operation. Close the main line block valve and slowly pinch down on the station discharge valve until a discharge pressure of 650 pounds per square inch is reached. The high discharge relief valve should just begin to open at this pressure. If the high discharge relief valve does not open, hold the 650-pound discharge pressure and slowly unscrew the spring adjusting screw until it does just begin to open. If the high discharge relief valve opens before 650 pounds discharge pressure is reached, it will be necessary to tighten the spring adjusting screw beyond the control point, and then open station discharge valve until normal operating conditions prevail before rechecking the relief valve setting. This is necessary because the unit will bypass with equal suction and discharge pressures and slow the engine down to idling speed, due to the action of the high suction controller when the high discharge relief valve opens.

(5) If there remains any doubt as to the cause of abnormal operation after checking the adjustment of an individual controller or relief valve, it is best to undertake the entire sequence of adjustment on all controllers as outlined previously rather than to make hit-and-miss adjustments to eliminate the trouble.

34. MANUAL CONTROL.

a. There are two ways in which these units may be controlled manually. The first method is to adjust the throttle as required to obtain the desired speed by changing the direct mechanical connection to the carburetor; and the second method is to change the hand-controlled valve (HCV), as shown on figure 112, to obtain a change in pressure on the diaphragm throttle. In order to adjust by the first (mechanical) method, the hand-controlled valve is opened wide so that no pressure is built up on the diaphragm throttle. With the second (hand-controlled valve) method, the *orifice valve has to be closed* tightly so that all variations in pressure will be as a result of hand-controlled valve adjustment. This type of manual control will produce finer adjustment, but cannot be depended upon alone as the hydraulic control system must be in operation for it to work.

b. Manual control for reciprocating pumps is similar to that for centrifugal units, in that the operator must watch closely both suction and discharge pressures.

35. TROUBLE SHOOTING.

a. Pump station crews must familiarize themselves with the general operation of the pipe-line system under normal conditions so that unusual conditions in the operation of a station will be immediately apparent. A daily pump station report should be made using the form shown in figure 121.

b. When a long line, with a number of stations, is operated at full capacity, each station will have a working pressure which is a characteristic of the length and gradient of the line to the next station, and at any given rate of output this pressure will remain approximately constant.

c. The pump itself is a fairly accurate meter. A definite number of barrels per hour will be delivered for a given number of strokes per minute. At each station, when the line is in normal operation, there will be a definite discharge pressure for each rate of pumping, for each product handled. These rates and pressures can be plotted against each other to provide a reference curve which will serve to check relative operating conditions at any time. Each station operator should plot curves for his particular station for each product handled, showing the relation between pump strokes per minute and discharge pressure. He must see that the station pump is operating efficiently, that there are no leaks in the pipe line downstream, and that the suction pressure of the downstream pump station is at its normal operating value when pump speed and discharge pressure values are recorded for operation-curve construction. Current pump operation should be checked regularly against these curves to determine the efficiency of the system. If pump speed and pressure values do not coincide with those which are plotted and which represent normal, efficient operation, it indicates that there is a leak in the pipe line downstream, or that an excessive amount of liquid is bypassing the pump pistons.

d. The volume of liquid pumped is directly related to pump speed and can be determined by applying a slip factor to pump displacement. For example, a duplex, double-acting, displacement pump with a 4½-inch bore and a 6-inch stroke displaces 382 cubic inches on each stroke cycle.

DAILY PUMPING STATION REPORT

STATION NO.______

TIME	PUMP OPERATION				MAINTENANCE			REMARKS
	DISCH. PRESS.	SUCTION PRESS.	ENGINE CONTROL PRESS.	R. P. M.	NO. GALLONS OF GASOLINE USED	NO. QTS. OF OIL ADDED	TIME UNIT IS GREASED	
MID. 12:00								Example: Such as sudden increase or loss of suction or discharge pressure. Keep record of exact time change took place. Note all adjustments made to unit.
12:30								
1:00								
1:30								
2:00								
2:30								
3:00								
3:30								
4:00								
4:30								
5:00								
5:30								
6:00								
6:30								
7:00								
7:30								
8:00								
8:30								
9:00								
9:30								
10:00								
10:30								
11:00								
11:30								
12:00 NOON								

Figure 121. Daily pumping station report.

At 90 strokes per minute (revolutions per minute) 34,380 cubic inches, or 149 gallons per minute, would be displaced if there was no slippage past the pump pistons. Estimating slippage at 6 percent, this volume would be reduced to 140 gallons per minute or 200 barrels per hour. The pump discharge pressure required to pump 200 barrels per hour can be calculated by adding the downstream pump suction pressure, the static head between the two stations, and the friction loss in the line between the two stations. Values of strokes per minute and corresponding pressures can be plotted to form a smooth curve. This curve should be nearly identical to the operation curve (fig. 122).

e. Conditions indicating that the efficiency of a pipe-line system is low, along with probable reasons and suggested remedies, are listed and discussed below:

(1) *Low discharge pressure*. Low discharge pressure may be caused by leaks or a break in the downstream pipe line; by the pump pistons bypassing an excessive amount of liquid; by a leak in the station bypass check valve; or by a leak in the high discharge relief valve. Pipe-line leaks can be located by patrols. Methods of pipe repair or replacement have been outlined elsewhere in this manual. If line pressure returns to normal when a downstream block valve is closed, the bypass check valve leaks. It should be disassembled and repaired, or replaced. A leak through a closed high discharge relief valve usually can be detected by the hissing noise of the leaking liquid. In order to repair or replace this valve, the station must be shut down.

(2) *Leaky pump valves*. A leaky pump valve usually can be detected by listening to the operation of the valves themselves. A hissing sound during the closing of a valve indicates that it is not properly seating. An unusual discharge pressure pulsation or variation in the engine speed may also indicate leaking pump valves. The remedy is to remove the valve covers, clean, grind, and adjust the valves.

(3) *Leaky pump piston packing*. Piston packing may be worn and need replacing, although this will usually be done during the periodic overhauls. If replacement is necessary at any other time the packing can be replaced in the field with the regular tools supplied with the unit.

(4) *Slipping clutch or drive belts*. Overheating is characteristic of both clutch and belt slipping. A clutch that is too loosely adjusted can be detected by the free action of the clutch lever. Adjust belt and clutch tensions as required.

f. High discharge pressures indicate either restrictions in the pipe line downstream or that one or more immediately downstream pump stations are out of service.

(1) If the immediate downstream station is out of service, liquid must be pumped approximately twice the normal distance. This condition arises quite often, and a set of curves should be prepared to show the relationship between pump strokes and discharge pressures under these conditions. This set of curves can be made by combining those, made as previously described, of two successive stations, care being taken to subtract the suction pressure of the intermediate station from the total pressure. Pumping under these conditions is known as "two section operation." The curve will show about double the normal pressure for the station. Pumps will operate on differential pressure controller instead of low suction controller. During this type of operation the discharge pressure will come up to the line characteristic pressure, and the differential pressure between suction and discharge will be about 300 pounds per square inch. If this differential pressure exceeds, or is less than, 300 pounds per square inch, the differential pressure controller should be adjusted accordingly. The low suction controller being open during this type of operation, the governor and the auxiliary governor pressures should be approximately equal.

(2) When two successive stations are not in operation the first upstream operating station will have to pump approximately three times normal distance. For this contingency suitable curves should be prepared to show the relationship between pump speed and discharge pressure. Under this "three section operation" the pump also will be governed by the differential pressure controller instead of the low suction controller. Pump discharge pressure will be about 630 pounds per square inch and suction pressure will be 330 pounds per square inch, without bypassing.

g. Intermittent Bypassing. If the valve at the end of the line is partially closed, all of the stations on the line will build up discharge pressures to a point where the pumps will bypass and cut out until the receiving station takes enough liquid from the line to require each station to resume pumping. This cycle will be repeated as long as the withdrawal of liquid at the receiving station is restricted by a partially closed valve. Therefore, there should be

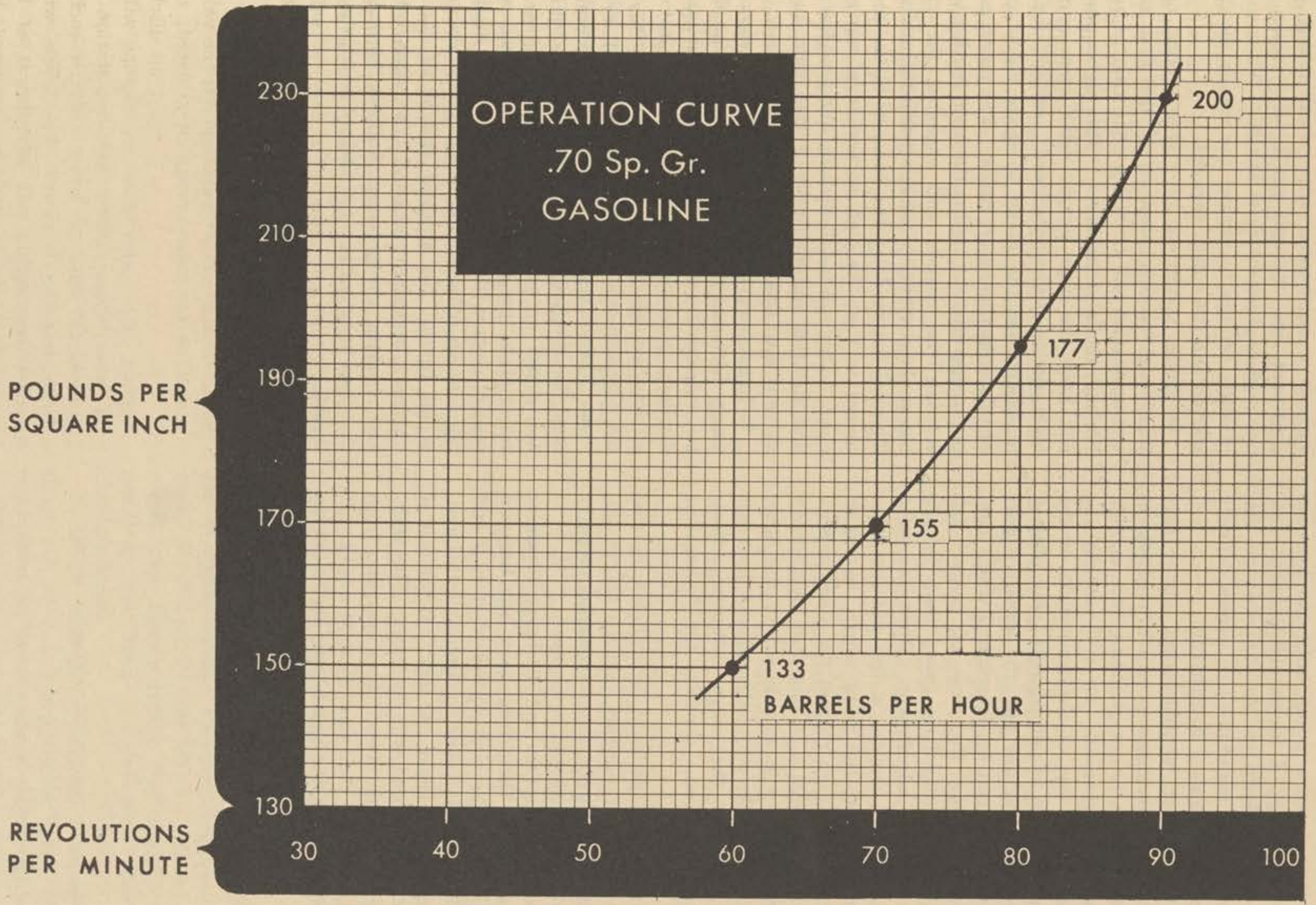


Figure 122. Operation curve for small reciprocating pump.

either capacity withdrawal from the pipe line or it should be shut down. An experienced operator can recognize intermittent bypassing and will shut down a pump until the line can operate at capacity. Care should be taken during such a shut-down to see that enough discharge pressure is maintained to assure delivery when it is again required downstream.

h. If the suction pressure rises above normal while the discharge pressure remains at normal, the pump is not pumping fast enough and should be checked. It will usually be found that either one of the controllers or the orifice valve is out of adjustment. By observing the engine governor and the auxiliary governor pressures it can be determined which controller is restricting the flow of control oil. In most instances it will be found that the orifice valve is out of adjustment. Open this valve a little at a time, waiting a few minutes after each change to note the point where the engine speed increases enough to pull the suction pressure down to normal. If this does not correct the trouble, check the adjustment of the other controller and make any adjustments that are necessary. Where the more complex adjustments are involved, consult the operations officer.

i. If the suction pressure drops below normal while the discharge pressure remains at normal, the low suction controller is not operating properly and its adjustment should be checked.

j. If both the suction and discharge pressures drop at a station, there may be a leak between that station and the next upstream station and the line should be patrolled to determine this and, if so, to locate and repair the leak. If the leak is large, the pump speed will decrease. The withdrawal of liquid from branch lines upstream from a station will have the same effect as a leak. If this condition arises, the clutch lever on the engine should be pulled out and the pump stopped for a short period of time. If the suction pressure does not rise it is evident that there is either a large leak or a substantial withdrawal taking place upstream, and the unit can be shut down until the suction pressure starts to rise. When suction pressure returns to normal the engine should be started and the clutch engaged.

k. Under conditions of "three section operation," the suction pressure of the first downstream station will be higher than that for which the high suction relief is set. This higher pressure will keep the high suction relief open and the high suction controller closed, and will make it impossible for the pump to move liquid unless certain adjustments are made. The pump can be put in operation by closing the main suction valve, starting the engine, and engaging the clutch before the governor pressure reaches its maximum. This will pump down the pressure in the suction header so that the high suction relief valve will close. The pump will pick up the pipe-line load and function automatically if the main suction valve is then gradually opened.

l. In general, it can be stated that above-normal pump discharge pressures are not cause for alarm, but subnormal ones are. The cause of subnormal discharge pressures should be investigated at once, as they indicate trouble either at the pump or in the pipe line downstream from the pump station.

m. The suction and discharge pressure snubbers must be checked regularly to see that they are not closed or plugged with sediment, as it is essential to proper operation of the automatic control system that the true suction and discharge pressure are reflected on the controller diaphragms at all times. No attempt should be made to interpret irregular operating conditions without first checking the pressure snubbers to ascertain that they have not become plugged or accidentally closed.

CHAPTER 7
CENTRIFUGAL PUMP OPERATIONS

6. GENERAL. Information on the operation f centrifugal pumps is set forth in this chapter nd supplements information on the operation of eciprocating pumps given in previous chapters.

7. PUP CENTRIFUGAL PUMP. Perform-nce curves for Pup centrifugal pumps handling asoline and water are shown in figures 123 to 129.

a. Pump capacities are shown in barrels per our and in gallons per minute. Pump dis-harge pressures are shown in pounds per square nch and in feet of head of the liquid pumped.

b. These performance curves, one for each f several liquid specific gravities, are shown for oth series and parallel pump operation. Pipe-ne systems will be designed for series operation. hould a pump be connected and operated in arallel, its capacity will be double and its dis-harge pressure one-half that of series operation.

c. Lines of constant brake mean effective ressure are shown, as they represent loading of he engine. The brake horsepower, correspond-ng to any brake mean effective pressure and ngine revolutions per minute are shown as a art of figures 123 and 124. These charts are haracteristic of the General Motors model 270 ngine, and apply to all the performance curves. This engine will give continued satisfactory peration service as long as the brake mean ffective pressure does not exceed 70 pounds per quare inch. Within reasonable limits, slower peeds and accompanying lower brake mean ffective pressures will give longer engine-service fe.

d. When liquid of relatively high specific ravity is pumped, the pump engine must be perated at a lower speed so that the limiting rake mean effective pressure will not be exceeded. comparison between the pump performance urves for gasoline and water will show the great ffect that liquid specific gravity has upon centrifugal pump performance and power requirements.

e. Pump performance curves for conditions where oil is being pumped are not included, for, unlike gasoline and water, oil viscosities vary between wide limits with attendant effects on pump power requirements.

f. There will be one pump per station on the 4-inch line, manifolded as shown in figure 130.

g. Pump stations operating on 6-inch pipeline service will consist of two pup units each, although normal operations will require the continued use of only one. These two units are connected with a manifold, as shown in figure 131. Valves A, D, H, and I should always be open when pumping. For normal one-unit operation either valves B and C, or E and F, should be open and valve G always closed. For normal two-unit parallel operation, valves B, C, E, and F are open, and valve G is closed; and for special two-unit series operation valves B, F, and G are open and valves C and E are closed. This latter method of operation compounds pressure and holds liquid volumes to the capacity of a single unit and should, therefore, only be used where specifically required.

h. For short lateral lines or service at tank farms pump manifolding for parallel and series operation is shown in figures 132 and 133, respectively.

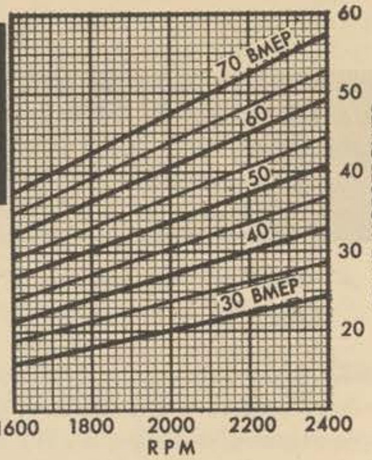
38. PUMP STATION OPERATION WITH 4-INCH PIPE LINE. Pup centrifugal pump stations, located at 10-mile intervals along a level 4-inch pipe line, pumping 0.68 specific gravity gasoline, will have the following operational characteristics:

a. Under normal operations, successive stations will have a pump engine speed of 1,950 revolutions per minute and a differential pressure of 200 pounds per square inch while pumping liquid at the rate of 200 barrels per hour.

552517 O - 43 - 9

PERFORMANCE OF PUP UNIT PUMPING GASOLINE 0.68 SPECIFIC GRAVITY PIPED IN SERIES AND IN PARALLEL AND DRIVEN BY GMC-270 ENGINE

THE CHART TO THE RIGHT SHOWS THE CHARACTERISTICS OF THE GMC-270 ENGINE GIVING BRAKE HP. AS A FUNCTION BRAKE MEAN EFFECTIVE PRESSURE (BMEP) AND REVOLUTIONS PER MINUTE (RPM)



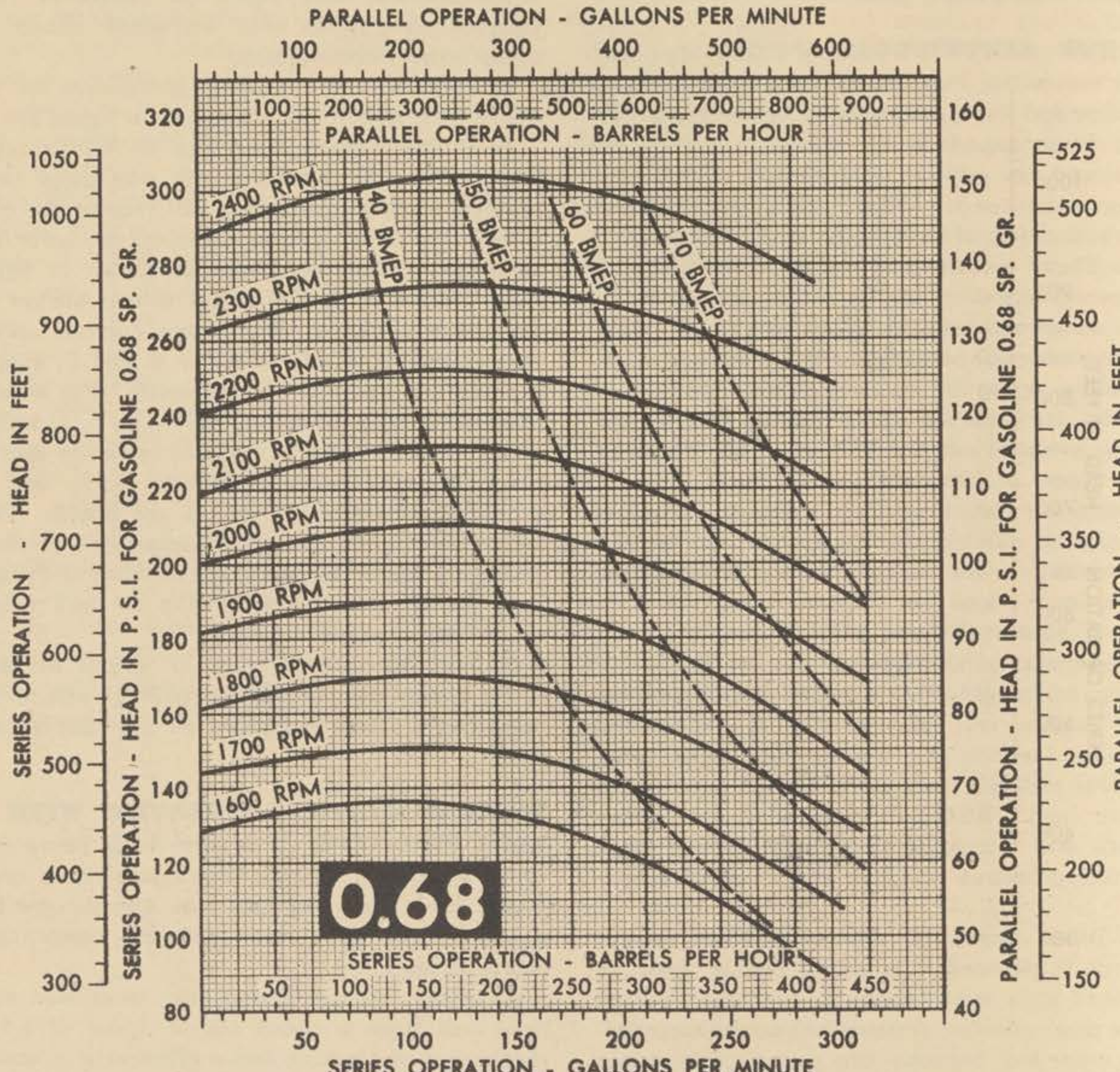
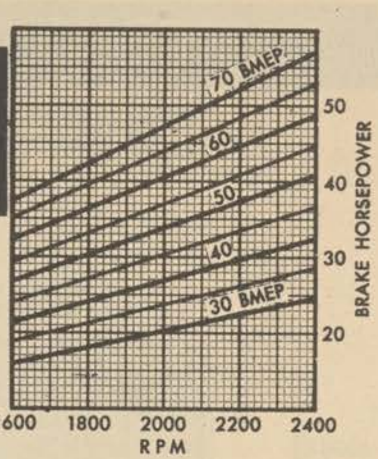


Figure 123. Performance of pup unit pumping gasoline of 0.68 specific gravity.

PERFORMANCE OF PUP UNIT PUMPING GASOLINE 0.70 SPECIFIC GRAVITY PIPED IN SERIES AND IN PARALLEL AND DRIVEN BY GMC-270 ENGINE

THE CHART TO THE RIGHT SHOWS THE CHARACTERISTICS OF THE GMC-270 ENGINE GIVING BRAKE HP. AS A FUNCTION OF BRAKE MEAN EFFECTIVE PRESSURE (BMEP) AND REVOLUTIONS PER MINUTE (RPM)



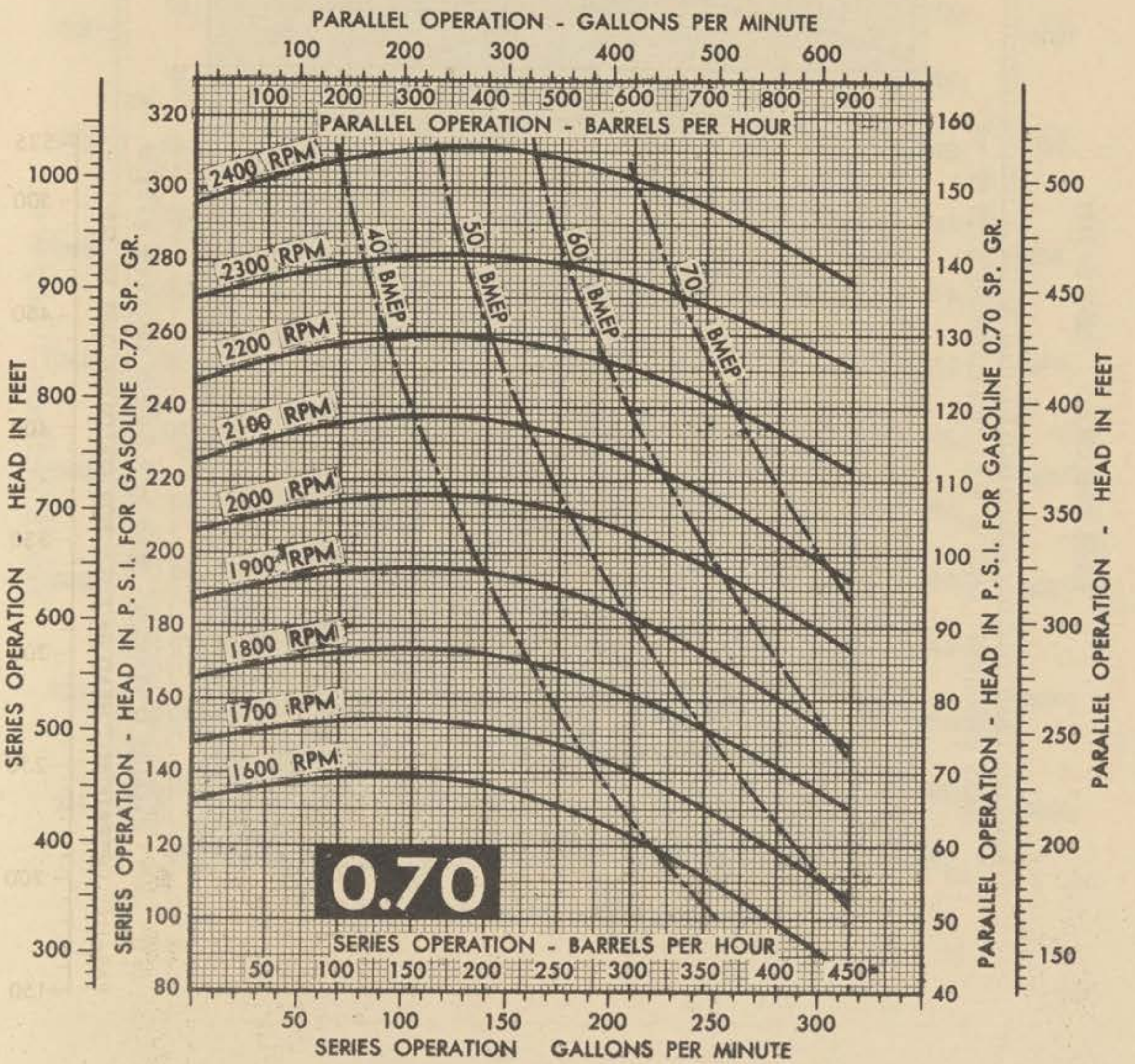


Figure 124. Performance of pup unit pumping gasoline of 0.70 specific gravity.

PERFORMANCE OF PUP UNIT PUMPING GASOLINE 0.725 SPECIFIC GRAVITY PIPED IN SERIES AND IN PARALLEL AND DRIVEN BY GMC-270 ENGINE

FOR BRAKE HORSEPOWER CORRESPONDING TO ANY BRAKE MEAN EFFECTIVE PRESSURE (BMEP) AND SPEED SEE FIGURE 118

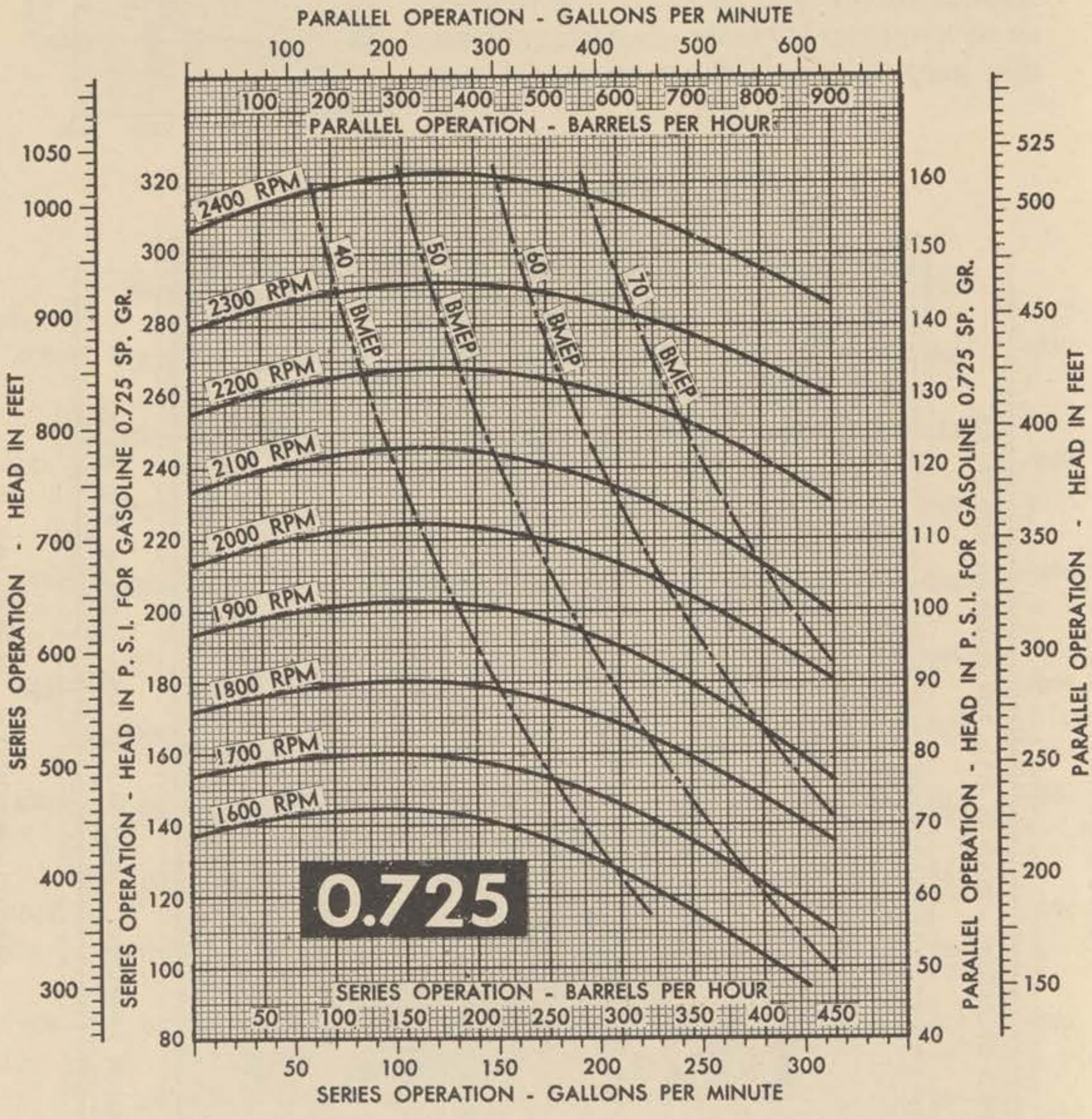


Figure 125. Performance of pup unit pumping gasoline of 0.725 specific gravity.

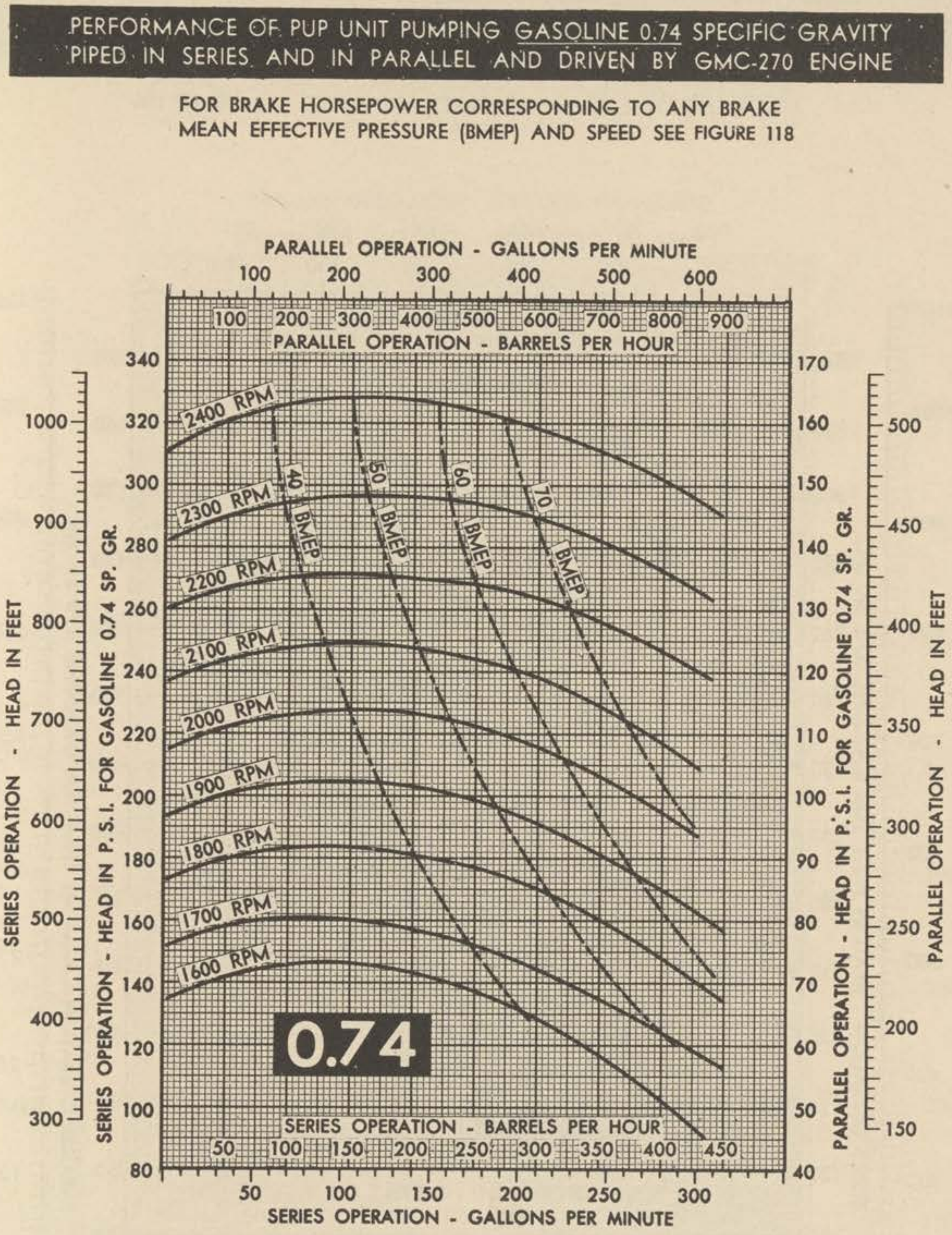


Figure 126. Performance of pup unit pumping gasoline of 0.74 specific gravity.

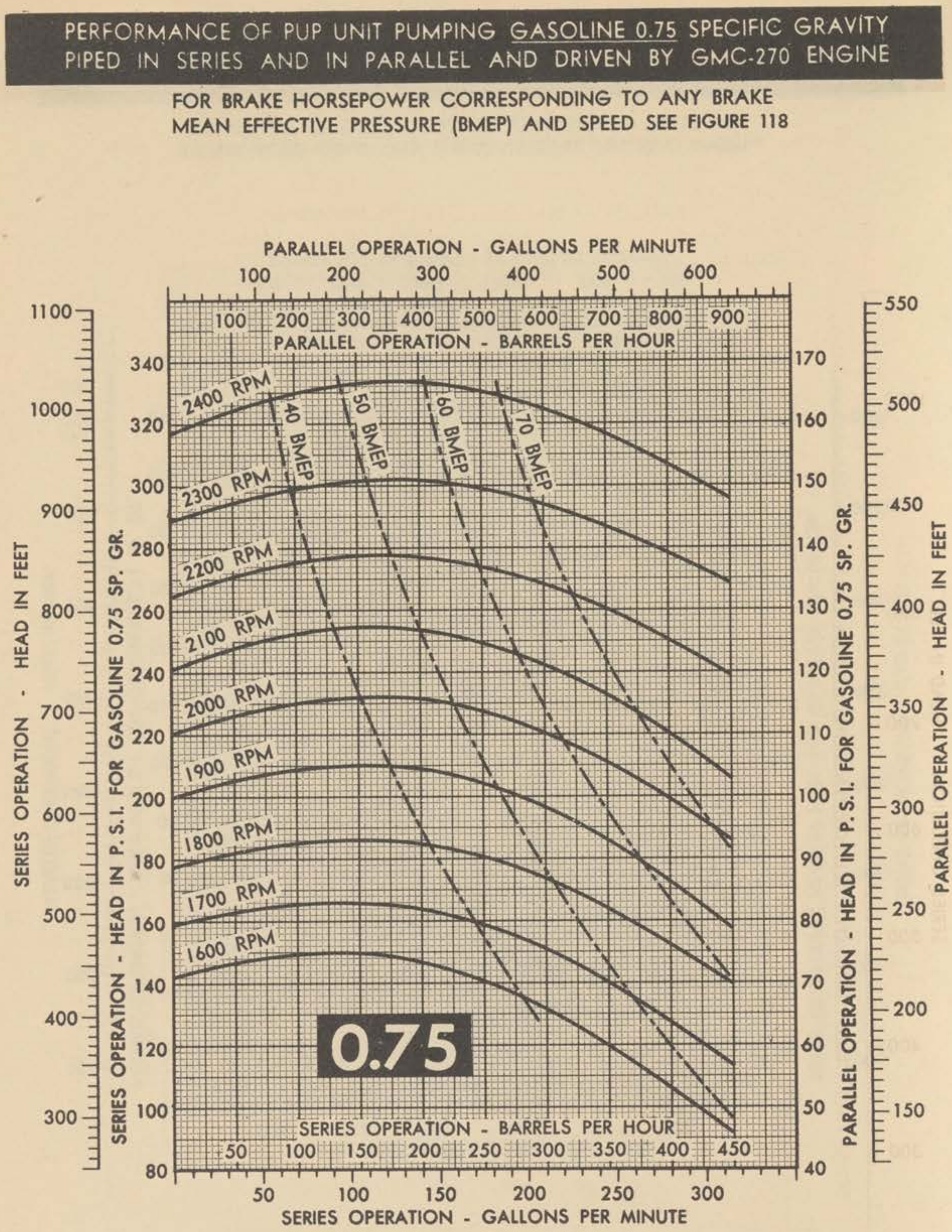


Figure 127. Performance of pup unit pumping gasoline of 0.75 specific gravity.

PERFORMANCE OF PUP UNIT PUMPING GASOLINE 0.80 SPECIFIC GRAVITY PIPED IN SERIES AND IN PARALLEL AND DRIVEN BY GMC-270 ENGINE

FOR BRAKE HORSEPOWER CORRESPONDING TO ANY BRAKE MEAN EFFECTIVE PRESSURE (BMEP) AND SPEED SEE PC-18518

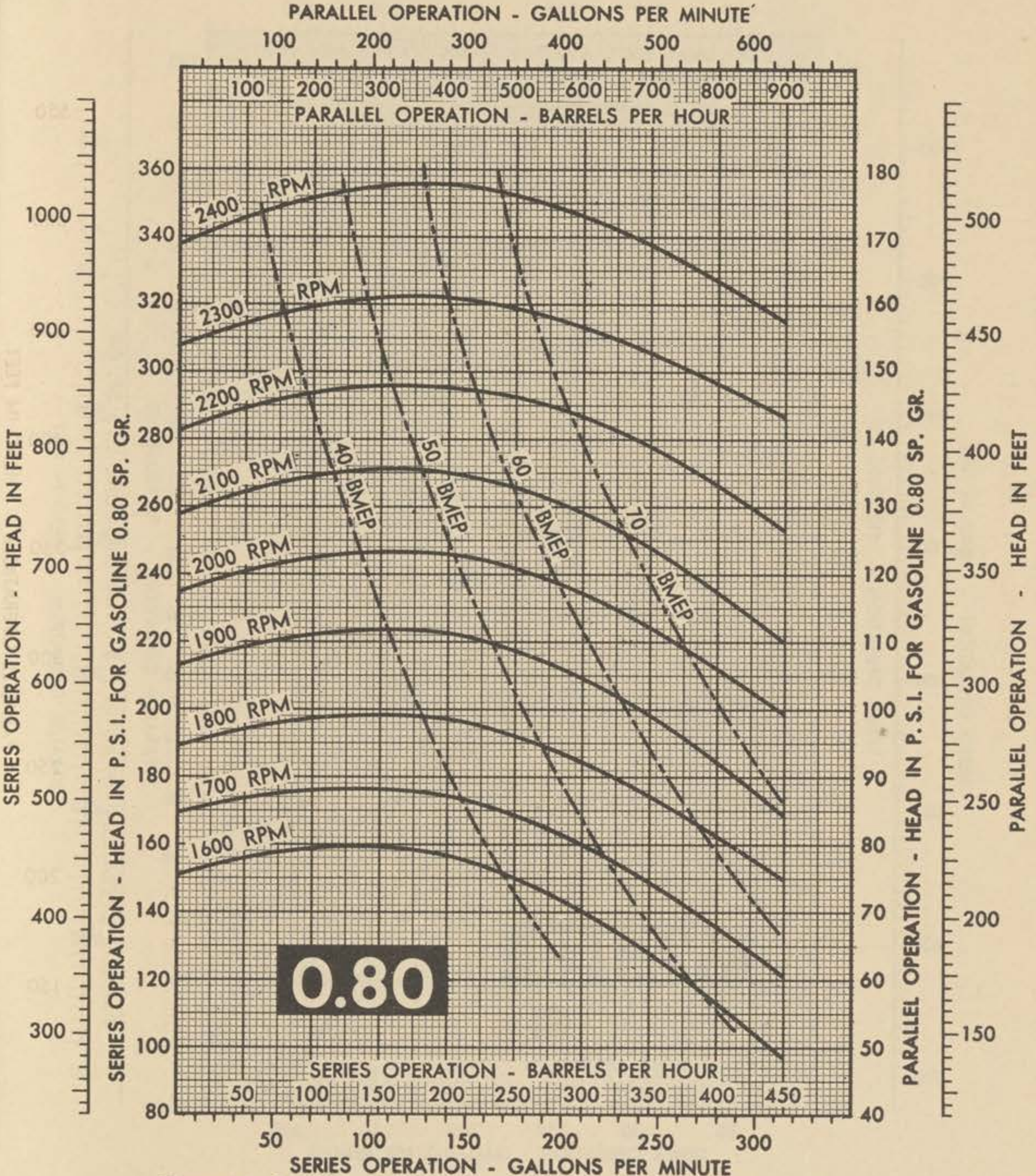


Figure 128. Performance of pup unit pumping gasoline of 0.80 specific gravity.

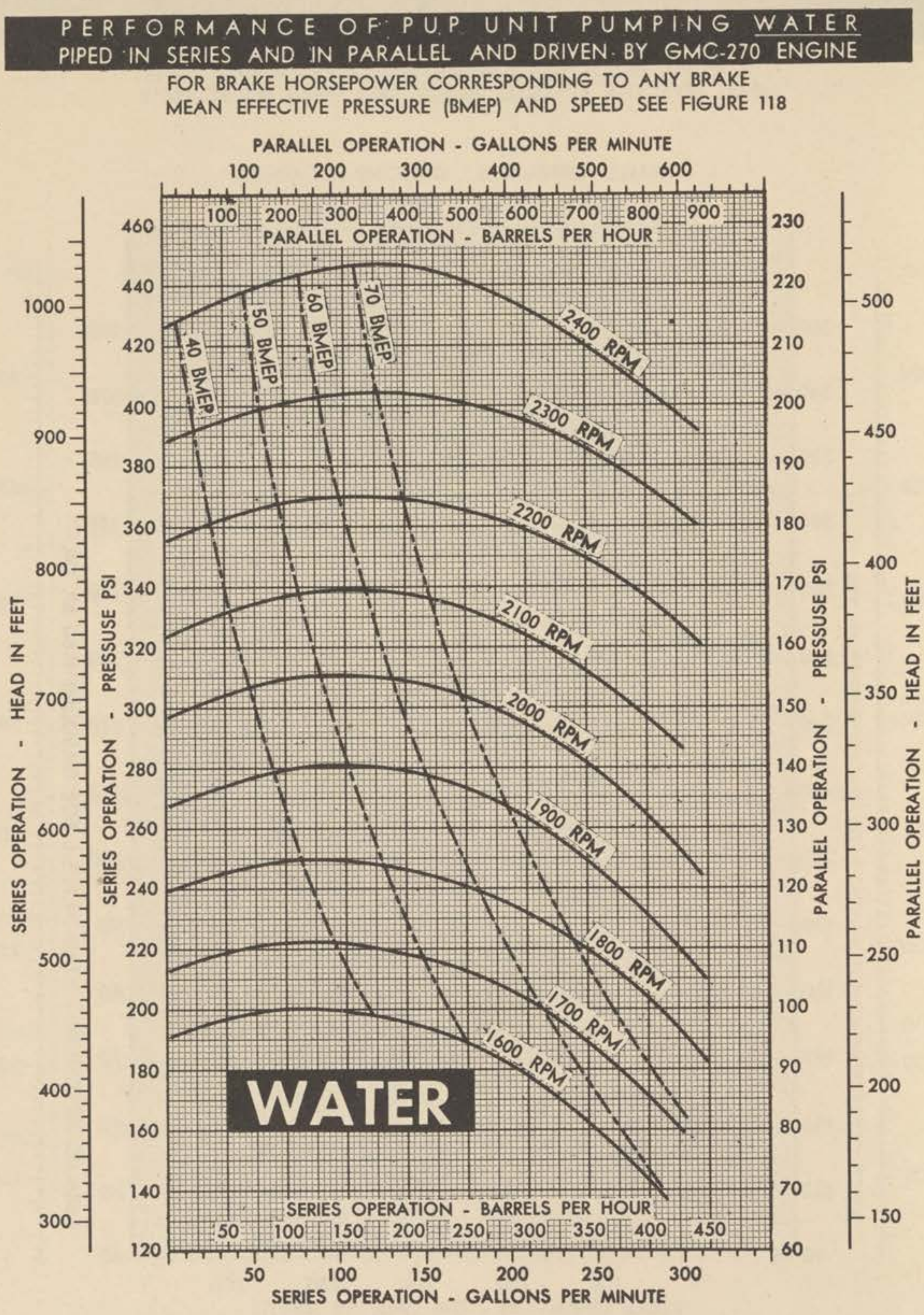
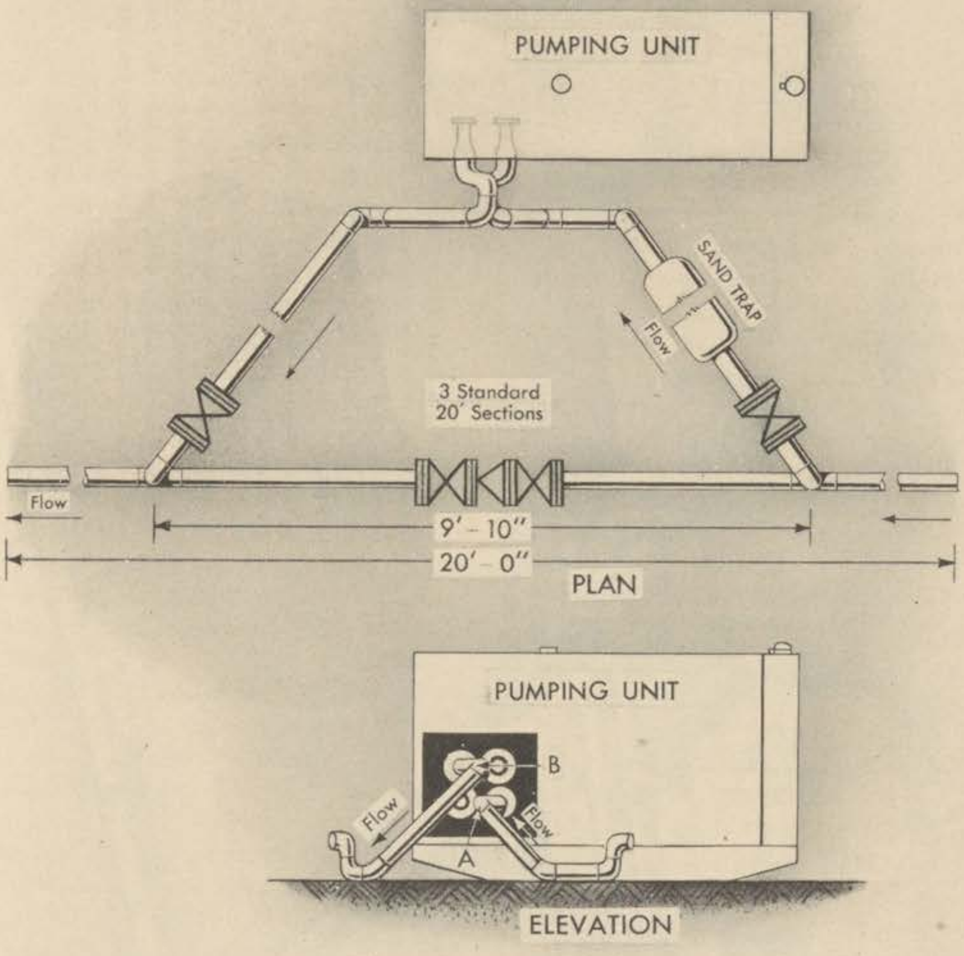


Figure 129. Performance of pup unit pumping water.

ONE UNIT MANIFOLD (4" PIPE LINE)
PUP CENTRIFUGAL PUMPING UNIT
One Pump Series Operation



NOTE: 1. When the units are installed on the opposite side of the pipeline, with flow in the same direction as that shown, the portions of the manifold shown in the elevation should both be rotated 90° about A and B.

2. To reverse the direction of flow thru the pipeline, turn the portions of manifold shown in the elevation 90° about A and B.
Remove the clapper in the check valve. If time permits the sand trap section may be moved to its proper position so that it again becomes the suction line.

Figure 130. Manifold for pup unit when operating on 4-inch pipe line.

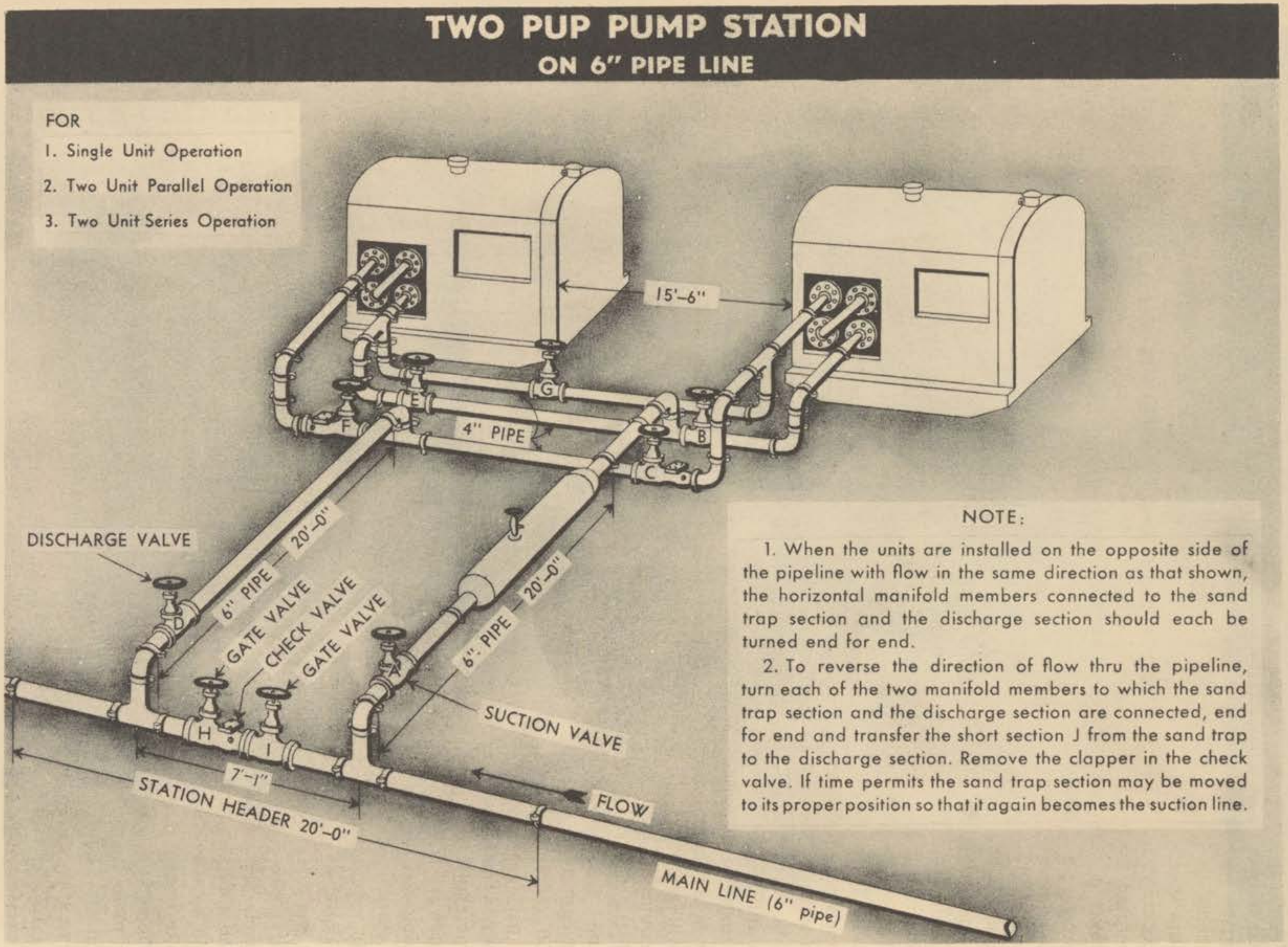


Figure 131. Manifold for pup units when operating on 6-inch pipe line.

Figure 131. Manifold for pup units when operating on 6-inch pipe line.

b. When, for example, the second station along he line is not in operation, the pumping load normally carried by that station will have to be handled by the first station. Pup pumps are lesigned to operate at approximately 300 pounds per square inch maximum differential pressure vhile being driven by an engine running at a naximum speed of 2,400 revolutions per minute. t is recommended, however, that pup pumps be not operated continuously at the speed of 2,400 evolutions per minute. For this example, 285 pounds per square inch pump differential pressure nd 2,350 revolutions per minute engine speed naximums will be used. Since pressure loss due to he friction of 200 barrels per hour flow through a -inch line is 20 pounds per square inch per mile, 00 pounds per square inch would be required to pump liquid from the first to the third station, 20 miles distant. With only 285 pounds per square nch available, the liquid flow rate could not exceed 75 barrels per hour (14.2 pounds per square inch riction loss per mile). The third, and all successive stations, will pump the 175 barrels per hour vith a differential pressure of 142 pounds per quare inch (14.2 pounds per square inch friction oss per mile times the 10 miles between stations), vhich will require an engine speed of 1,650 revolutions per minute.

c. If the third station along the line is not operating, the first two stations should be operated at capacity. The first station will operate at 2,350 revolutions per minute, pumping 200 barrels per hour with a differential pressure of 285 pounds per square inch. This liquid will arrive at the second station with a pressure of 35 pounds per square inch, 20 pounds per square nch being lost per mile between stations. The second station will operate with an engine speed of 2,350 revolutions per minute and will discharge liquid at a pressure of 85 plus 285 or 370 pounds per square inch. As previously stated, t requires 400 pounds per square inch to move 200 barrels per hour of liquid through 20 miles of 4-inch pipe line. Since this pressure is not available at the second station, a 200-barrel per hour rate cannot be maintained. If the above calculations are repeated, it will be found that slightly more than 190 barrels per hour can be delivered at the fourth station. The fourth and successive stations would operate with an engine speed of 1,850 revolutions per minute and a discharge pressure of 175 pounds per square inch.

d. If the fourth or any other single subsequent station is out of operation it will be possible to build up a pressure in the three preceding stations which will maintain a 200-barrel per hour liquid flow through the pipe line.

e. When two successive stations are inoperative such as, for example, the third and fourth of a series, liquid will have to be pumped through 30 miles of pipe. Using figures 30 and 123 and following the method of calculation previously used, it will be found that 175 barrels per hour of liquid can be pumped through the line with the first station operating at 2,350 revolutions per minute and 285 pounds per square inch discharge pressure; the second station operating at 2,350 revolutions per minute, 145 pounds per square inch suction pressure, and 430 pounds per square inch discharge pressure; and the fifth and all subsequent stations operating at 1,650 revolutions per minute and 140 pounds per square inch discharge pressure.

f. For this example, centrifugal pump differential pressures have been used. Pump suction pressures are additive. There will be a corresponding increase in liquid flow rates, with a net decrease in suction pressure.

39. PUMP STATION OPERATION WITH 6-INCH PIPE LINE.

Pump stations, located at 10-mile intervals along a level 6-inch pipe line and pumping 0.68 specific gravity gasoline, will have the following operational characteristics:

a. Under normal or single-unit operations, successive stations will have a pump engine speed of 1,625 revolutions per minute and a differential pressure of 100 pounds per square inch while pumping liquid at the rate of 400 barrels per hour.

b. If the second station along the line is inoperative, the first station will have to pump through to the third station. This can be done by a single unit operating at 2,100 revolutions per minute and with a differential pressure of 200 pounds per square inch, since the pressure loss due to friction in the 20 miles of line between the first and third station is approximately 200 pounds per square inch.

c. When, for example, the second and third stations along the line are not in operation, liquid will have to be pumped for the 30-mile distance between the first and fourth stations. The first station would operate both pump units in parallel, at 285 pounds per square inch differential pressure and 2,350 revolutions per minute. Allowable friction loss along the 30-mile line would be 285 pounds per square inch, or 9.5 pounds per square inch per mile. From figure 30 it can be found

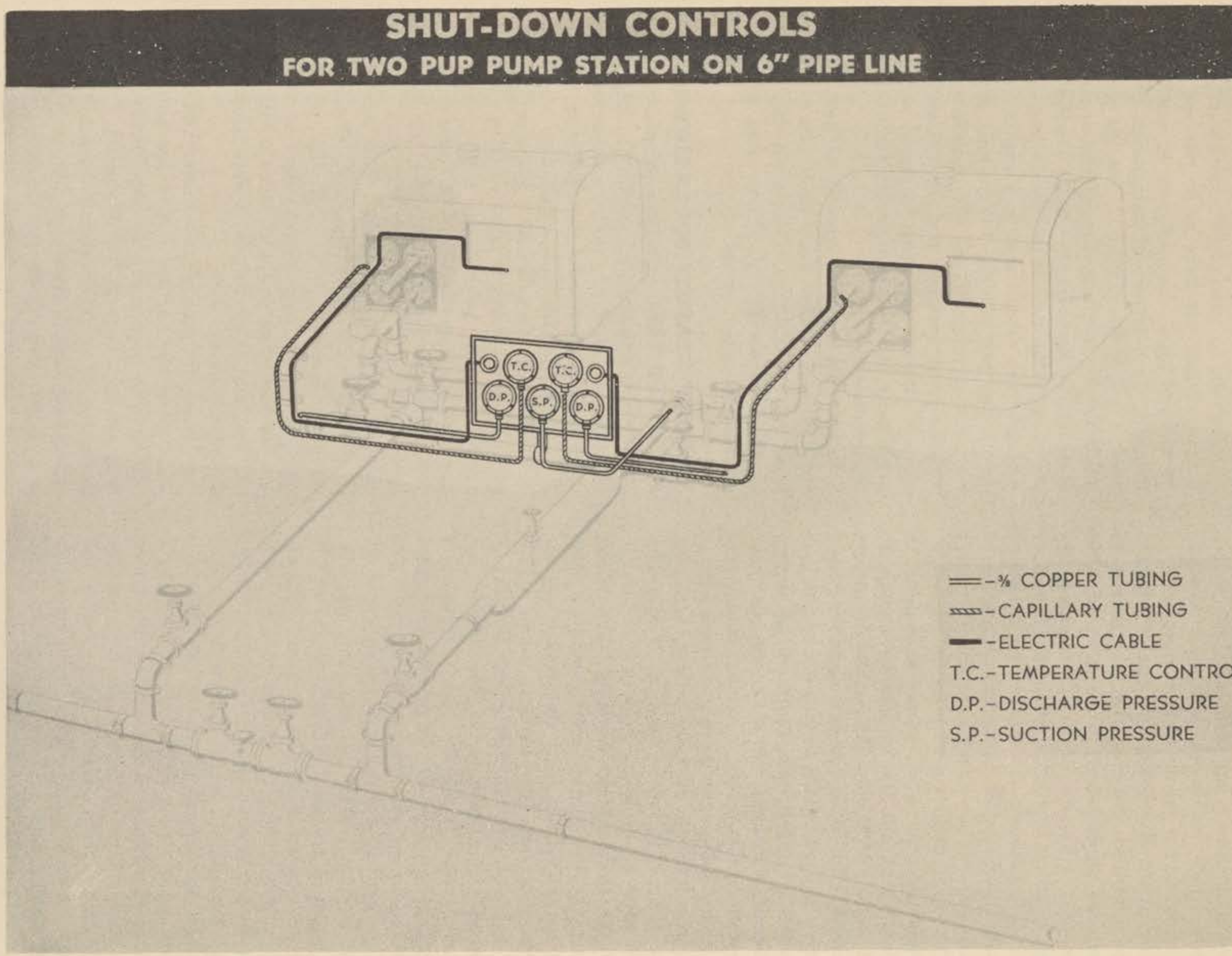


Figure 132. Shut-down controls for two-pup pump station on 6-inch line.

Figure 132. Shut-down controls for two-pup pump station on 6-inch line.

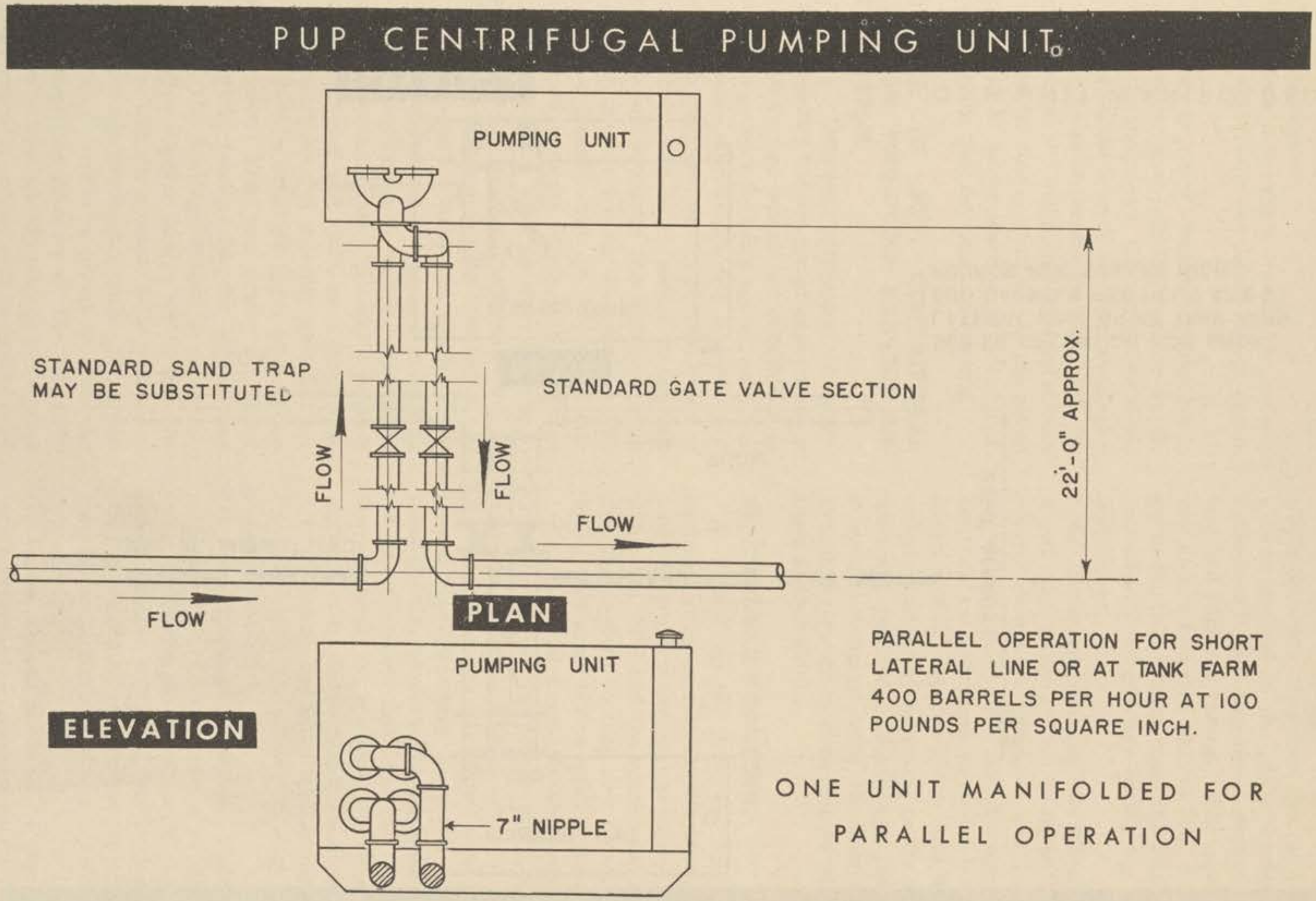


Figure 133. Manifold for pup units when operating on short lateral lines (parallel operation).

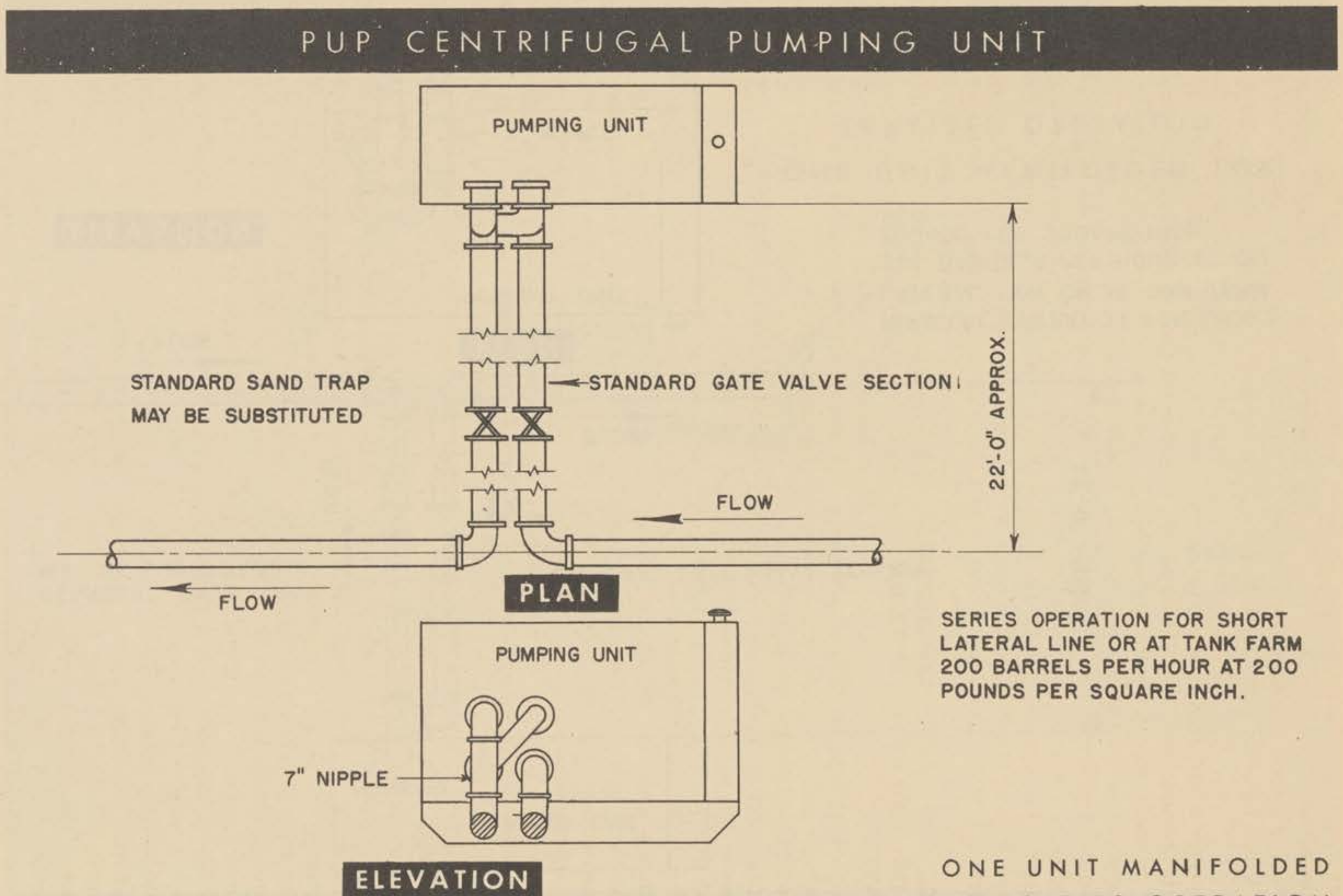


Figure 134. Manifold for pup units when operating on short lateral lines (series operation).

hat this friction allowance will provide for a iquid flow of 380 barrels per hour. The fourth nd subsequent stations will operate at 1,600 evolutions per minute and 95 pounds per square nch differential pressure.

d. Pump suction pressures are additive, as was escribed for 4-inch pipe-line pump station operaion.

e. There may be times when it is impossible to btain the proper pump suction pressure at the rst station. In such cases, the units themselves ill have to be operated with impellers in parallel s will the two units of the station (fig. 135). A ump engine speed of 1,400 revolutions per minute recommended for this operation. At the sound f a sharp "crackle" pump speed must be reduced, s this is a warning that cavitation is starting.

0. CONTROL OF PUP CENTRIFUGAL PUMP ON TWO-PUMP STATION INSTALLATION.

a. *General.* Automatic safety shut-down conrols will be provided for pup centrifugal pumps at nstallations where two pumps are manifolded as n figure 131 to protect the units against excessive ischarge pressure, abnormally low suction presure, and high temperature. The shut-down of he pumping units will be by means of mercury witches which will interrupt the ignition circuit f the gasoline engines driving the pumps. The hut-down instruments will be supplied with anual reset mechanisms which will allow the ercury switches to be hand set after the pumps ave been stopped. In some instances it will be esirable to start a pump turning over before the ressure or temperature condition which caused he unit to be stopped has changed sufficiently to ermit the mercury switch to reset automatically. he manual reset mechanism will make it possible o start up a pumping unit under such conditions.

b. The pressure control mercury switches are f the Bourdon tube actuated type, snap action ith manual reset. They are factory set to act t a predetermined pressure but the setting may e changed in the field as outlined in figure 17. he low suction control is factory set to stop the ump when the suction pressure falls to a value f around 5 pounds per square inch. The high ischarge pressure control is preset to shut the ump down when the pressure on the discharge ide of the station reaches 700 pounds per square ch. These controls will be automatically reset hen the pressure values have changed sufficiently pproximately 10 pounds for the suction pressure instrument and about 30 pounds for the high discharge pressure instrument).

c. The temperature control switch is of the vapor pressure operated type with Bourdon tube power element. The complete control consists of a bulb inserted in the pump discharge which is connected to the instrument proper by means of armored capillary tubing. The controls supplied will have a range of 100° to 200° F. and may be set in the field to shut down the pumping units at any desired temperature within the range of the instrument.

d. The arrangement of shut-down controls on a two pup pump station along with location of control points for pressures and temperature is shown in figure 132. All pressure tubing and electrical cable between control points and instruments will be installed in the field in a neat and orderly manner by attaching to the header piping wherever possible. (*Warning:* Installation instructions supplied with the mercury switches should be referred to when making adjustments on these instruments).

41. TROUBLE SHOOTING.

a. It will be the duty of the pump station operating crew members to familiarize themselves with the construction and auxiliary piping of the pump (fig. 135) and the operational details of the pipe-line system so that any unusual conditions which may arise will be quickly recognized.

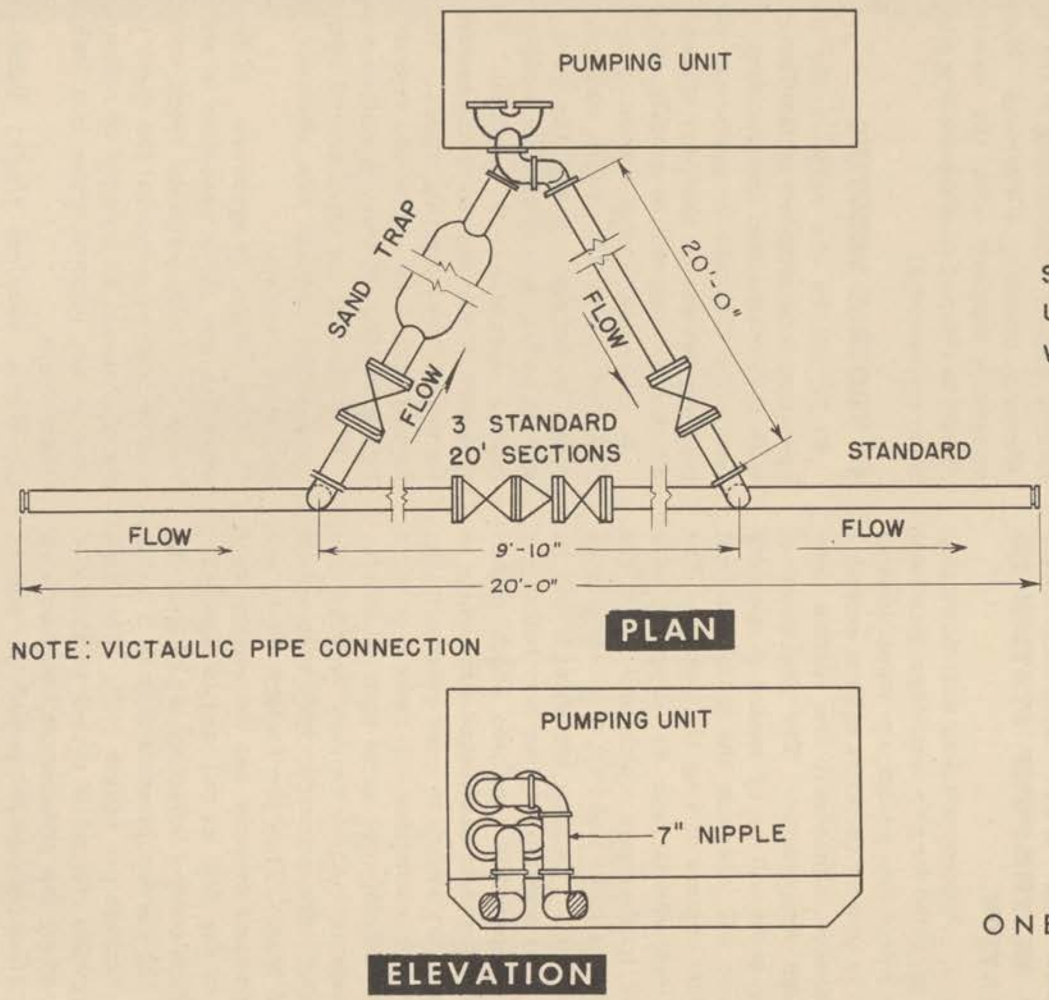
b. Individual pump station operation will be characterized by the length and gradient of the pipe line between it and the next downstream station and, at any given flow pump pressures will remain approximately constant. These pump pressures may be plotted on the performance curve for the various operating speeds. The curve thus formed should be constantly referred to so that high operating efficiency is maintained.

c. Following are listed several operating conditions which indicate low efficiency, along with suggested remedies:

(1) *Low discharge pressure.* If discharge pressures are low check operation of station bypass valve by closing adjacent block valve. If pressure is restored to normal the check valve is leaking and should be repaired or replaced. If pressure is not restored there is a leak in the line downstream.

(2) *Worn wearing rings.* Pump speed will require progressive increases to maintain normal discharge pressure if the pump wearing rings are worn. This change will be gradual, taking place

PUP CENTRIFUGAL PUMPING UNIT



SPECIAL ARRANGEMENT MAY BE USED FOR NUMBER ONE UNIT WHEN SUCTION PRESSURE IS LOW.

ONE UNIT MANIFOLDED FOR PARALLEL OPERATION

Figure 135. Special manifold arrangement for pipe-line service.

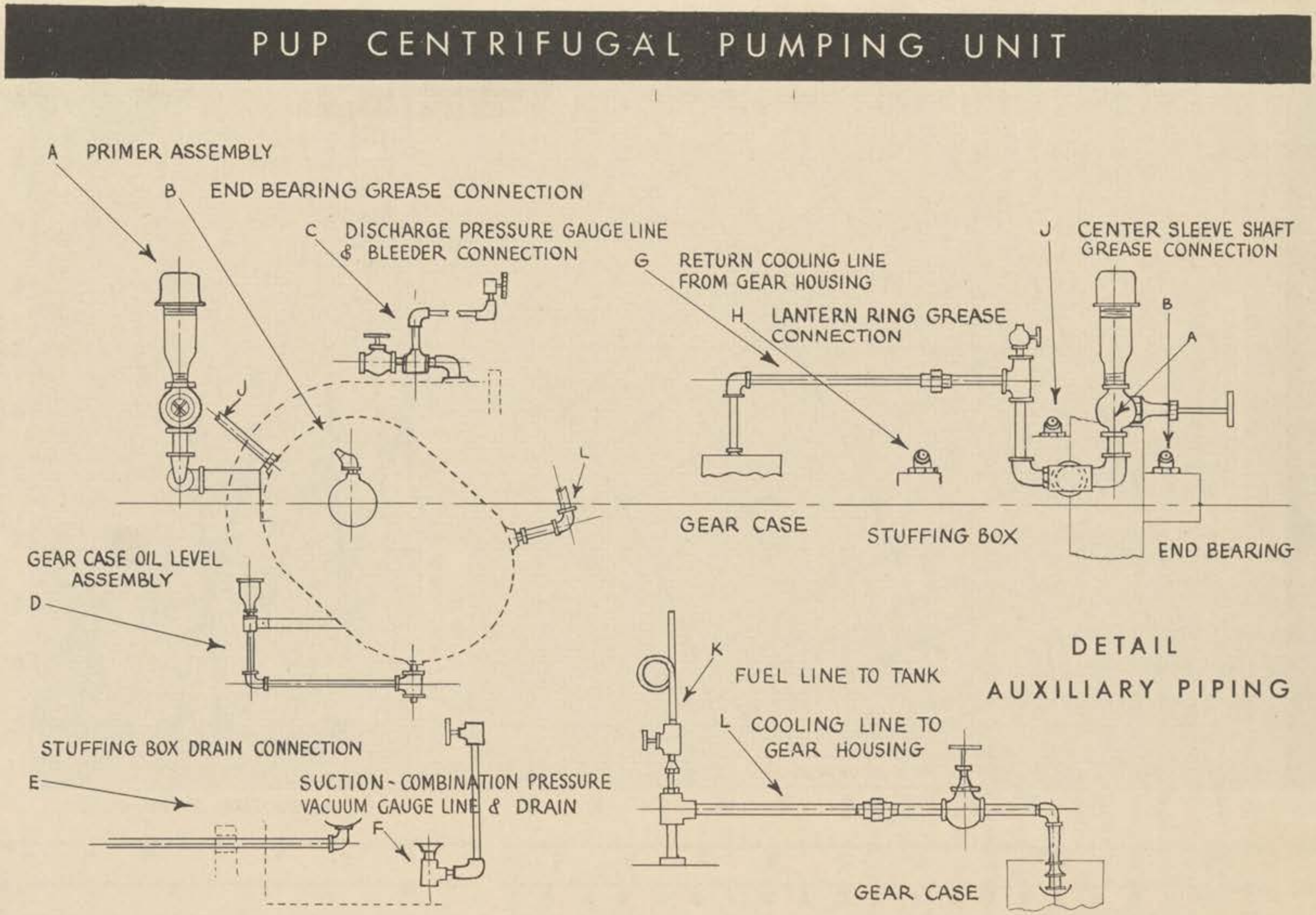


Figure 136. Detail of pup pump auxiliary piping.

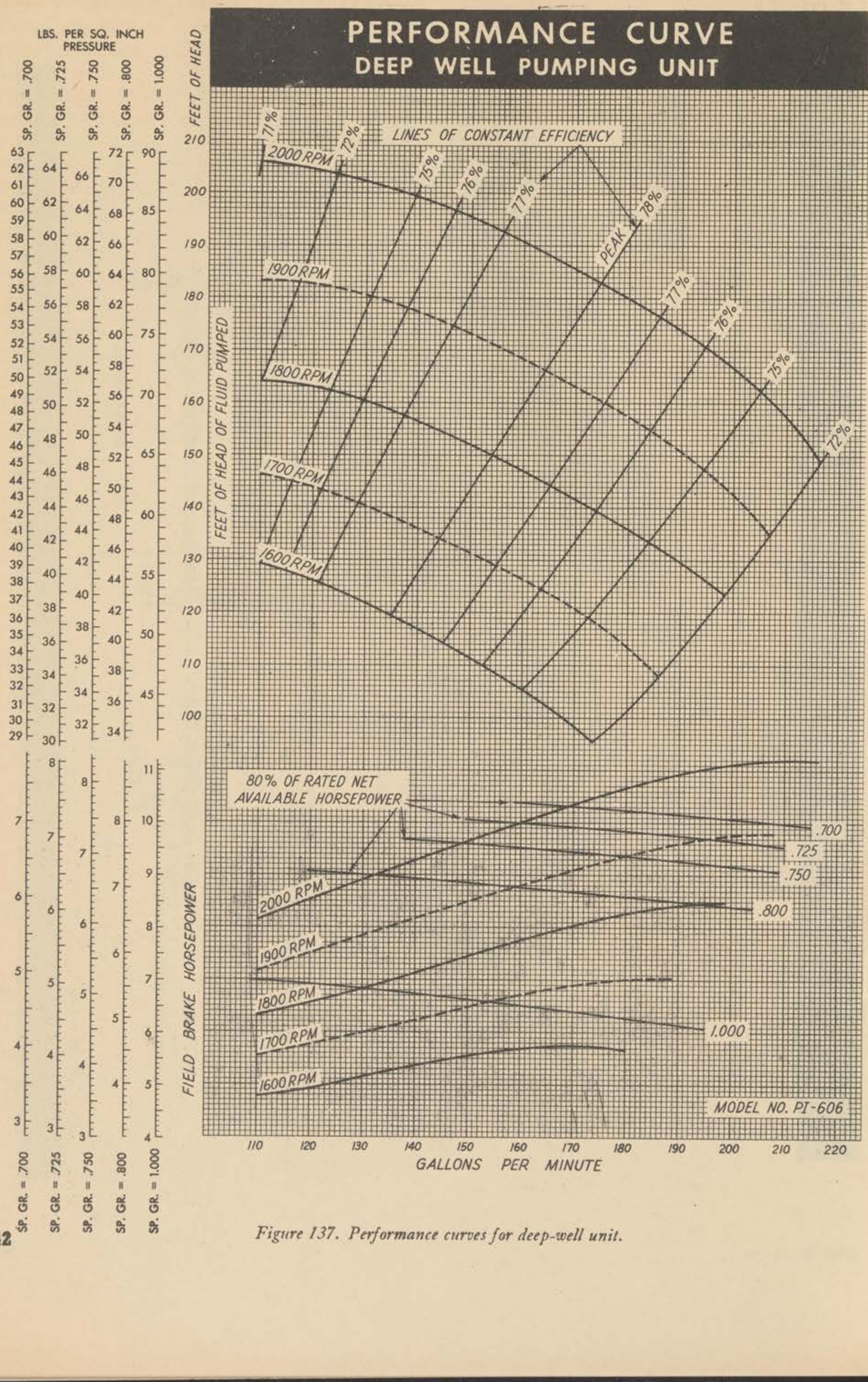


Figure 137. Performance curves for deep-well unit.

over a period of months. Operating conditions should be compared with other units as an additional means of isolating this trouble. Wearing rings can only be replaced at a machine shop.

(3) *Worn packing.* Pump packing will normally be replaced during periodic overhauls. If replacement is necessary at other times new packing can be installed with the regular tools supplied with the unit. Packing gland adjustment which causes excessive friction between packing and shaft will be reflected in high power requirement and heating of packing case.

(4) *High discharge pressures.* High discharge pressures indicate that there is either a restriction in the pipe line downstream or that one or more of the downstream stations are out of service.

(5) *Failure of pump to start.* When a pump fails to maintain its prime and pump liquid it is probable that an impeller is clogged, that air enters the suction line, or that the liquid supply is exhausted.

42. DEEP-WELL CENTRIFUGAL PUMP. Deep-well centrifugal pump performance curves relating pump speed, liquid capacities, horsepower requirements, and feet of head or pressure are shown on figure 136. Use of these curves may be illustrated with the example of a pump moving 0.75 specific gravity gasoline, with a discharge pressure of 49.5 pounds per square inch and a pump speed of 1,800 revolutions per minute. The abscissa of pressure intercepts the upper line of constant 1,800 revolutions per minute at 150 gallons per minute ordinate. This ordinate of 150 gallons per minute intercepts the lower curve of constant 1,800 revolutions per minute at the 5.5 brake horsepower abscissa. Maximum power available is 7.2 horsepower, as determined by the intercept of the 150 gallons per minute ordinate, with the curve of constant 80 percent of rated net available horsepower for 0.75 specific gravity liquid.

CHAPTER 8
PIPE-LINE PERSONNEL AND ORGANIZATION

43. COMMISSIONED OFFICER PERSONNEL FOR CONSTRUCTION AND OPERATION.

a. As a general rule, an Engineer Petroleum Distribution Unit will operate under the command of a commissioned officer of the rank of captain, who will be an engineer and will have had extensive experience in petroleum pipe-line construction and operation. The additional commissioned officer personnel will usually consist of two first lieutenants and four second lieutenants, with responsibility and stations assigned as uniformly along the entire pipe-line system as circumstances permit. It is desirable that all commissioned officers be engineers with previous experience in petroleum pipe-line construction and operation.

b. It is essential that the second lieutenant in direct charge of a beach head or port terminal be familiar with oil refinery laboratory procedure, and it is desirable that he be a chemical engineer. This officer will supervise work carried out by the portable laboratory unit. At least one of the second lieutenants should be a man with considerable experience in safety engineering work as applied to oil fields and refineries. This officer will supervise the activities of two noncommissioned officer assistants. Another second lieutenant should be sufficiently familiar with camouflage work to be able to supervise such activity for the entire pipe-line system.

44. ENLISTED PERSONNEL FOR CONSTRUCTION AND OPERATION.

a. General. Construction and operation personnel of military pipe lines should be divided into groups or crews and the several phases of the work to be done assigned to these crews. These crews should be organized in a military manner. An outline of the operations for all phases of this work and the suggested size, organization, and specific duties of each crew follow:

b. Construction.

(1) Reconnaissance layout, planning, and design are conducted by the commissioned officer personnel with the assistance of their technical staff. These operations do not require crew unit organization. After the design of a system has been completed, construction crew units are organized.

(2) Terminal construction work will be conducted by earth-moving, tank-construction, pipe-coupling, pump-installation, and welding crews.

(*a*) An earth-moving crew may include both hand labor and mechanical equipment operators.

(*b*) A tank-construction crew normally consists of five men under the direction of a noncommissioned officer who must be thoroughly experienced in tank erection.

(*c*) Pipe-coupling crews each consist of four or five men under the direction of a noncommissioned officer. The duties of individual members in this crew and the operation of the crew as a whole are described in detail elsewhere in this manual.

(*d*) Pump-station installation crews normally consist of five men under the direction of a noncommissioned officer designated as "terminal supervisor." Each crew should include two terminal operator assistants who are competent to install and operate the pumping equipment, two machinist helpers from a warehouse depot repair shop trained in the installation and operation of pumping units, and one or more additional men to assist in the installation work.

(*e*) The welding crew consists of four or five men under the direction of a noncommissioned officer experienced in oil field welding, or who has been an oil field foreman. He should have a thorough knowledge of welding standards and requirements. The crew should include experienced welders from one of the warehouse depot shops or portable shop, a machinist's helper from the portable shop, and two or more helpers recruited from either the patrol crew or the technical grade 5th, station operation group.

(3) Pipe-line construction groups will include pipe stringing crews, coupling crews, and pump-station installation crews.

(*a*) Where motor trucks and pipe trailers are used, stringing crews consist of a truck driver, a truck driver helper, and two men to unload the pipe as the truck moves along the pipe-line right of way. Normally, a noncommissioned officer will direct the pipe stringing by walking along the right-of-way with the pipe-stringing truck. Should it be necessary to string the pipe by hand by carrying it from the pipe depots established along the pipe-line right-of-way, larger crews will be required.

(*b*) Where motor transportation is available, a coupling stringing crew will consist of a truck driver, a truck driver helper, and two basics. These men will be under the supervision of the noncommissioned officer in charge of stringing the pipe. If motor transportation along the right-of-way cannot be used, the coupling crew must be augmented by additional labor, the amount depending on the distance the material has to be carried from supply depots.

(*c*) The coupling crew when using the grasshopper method will include four crews of five men each and one tie-in crew of five or more men, each under the direction of a noncommissioned officer. Duties of each crew and of the individual members in the crews are described in detail elsewhere in this manual.

(*d*) Pump-station installation crews will normally consist of five men under the direction of a noncommissioned officer designated as operating and pipe-line construction foreman. Each five-man crew includes three pump-station operators and two men from the patrol crew who have had training in the installation of the pumping units. All pump-station operators and operator assistants should be thoroughly competent to handle the entire installation job as well as to operate the units. The pipe-line construction and operating foreman will be qualified to properly install and adjust the automatic pump-control system if such control equipment is included.

c. Operation.

(1) *Beach head or port terminal.* Beach head or port terminals will be operated by a minimum crew of seven men. Under the noncommissioned officer designated as terminal supervisor, there should be two laboratory assistants, two terminal operator assistants, and two gagers. Large terminals may require additional personnel. Security troops will be assigned to the terminal officer to protect the installations, as required.

(2) A pump station operating crew will normally consist of ten men under the direct supervision of a noncommissioned officer designated as the operating and pipe-line construction foreman. Each pump station operating crew will be required to operate independently, and will consist of four pump station operators, one cook, one cook's helper, and four men for pipe-line patrol duty. This crew will maintain the pump station and make all routine and other minor adjustments to equipment. Major repairs and replacements will be made by the depot or motorized shops.

(*a*) Operating reports relative to pump station activities should be made daily and forwarded to the proper authorities.

(*b*) The pipe line should be patrolled each day by men walking in pairs along the line itself. This is not a security patrol, but rather one to check for leaks which may develop at any time.

(3) Bulk distribution terminal crews normally consist of four men; one, a noncommissioned officer designated as the terminal operator assistant, two gagers, and one basic.

(4) Crew for the warehouse depot shop should consist of nine men under the immediate supervision of a master sergeant designated as master mechanic. The crew includes one mechanic repairman, one communication repairman, one dispatcher (materials and equipment), one combination welder, one truck driver, two machinist helpers, one basic, and one clerk.

(5) The motorized shop will have a crew of five men under the supervision of a sergeant designated as master mechanic. The crew will be made up of one mechanic repairman, one combination welder, one truck driver, and one basic.

CHAPTER 9
PETROLEUM PRODUCTS TESTING LABORATORY

45. GENERAL.

a. Each engineer petroleum distribution company is equipped with a petroleum products testing laboratory set, which includes sufficient apparatus, equipment, and supplies to provide a base laboratory and a portable laboratory unit. The portable laboratory equipment is transported and housed in a collapsible trailer which can be pulled by a 2½-ton 6 by 6, cargo truck over average roads. The equipment supplied with petroleum products testing laboratories is sufficiently complete to permit the units to conduct testing without the use of additional facilities in the field such as electric power, gas for heating, ice, and distilled water.

b. The four laboratory assistants included in the Table of Organization of engineer petroleum distribution companies are skilled technicians and are qualified by experience and training to carry out all routine testing of petroleum products as well as octane rating determinations on gasoline.

46. TESTS WHICH CAN BE MADE WITH PETROLEUM PRODUCTS TESTING LABORATORY SETS.

Gasoline

Gravity.	Octane number.
Color.	Gum, ASTM.
Vapor pressure.	Gum, C. D.
Distillation.	Gum, Army accelerated.
Tetraethyl lead content.	Corrosion.
Sulfur (lamp).	Stability.

Kerosene

Smoke point.	Distillation.
Flash.	Sulfur (lamp).
Color.	Gravity.

Fuels

Gravity.	Viscosity.
Flash.	Pour.
Ash.	Diesel index.
Distillation.	Carbon residue.
Water.	Asphalt.
B. S. & W.	Sediment.

Lubricating oil

Viscosity.	Viscosity index.
Pour.	Flash.
Ash.	Gravity.
Carbon residue.	Corrosion.
Neutralization number.	Color.

Gear oil

Viscosity.	Viscosity index.
Stability.	Corrosion.
Turbidity.	Gravity.

Grease

Penetration.	Water.
Ash.	Alkali content.
Corrosion.	Dropping point.
Viscosity and flash of oil component.	

47. BASE LABORATORY.

a. The base laboratory will normally be expected to conduct routine testing on all petroleum products in theaters of operation, and, in addition, will make octane rating determinations on aviation gasoline up to an octane value of 100. In most cases the base laboratory will be set up at a port, beach head, or tank farm terminal where suitable housing facilities can be made available for properly installing the special equipment such as precision analytical balances, octane rating engine, and heavy duty electric generating plant.

b. The base laboratory will be equipped with a 15-kilowatt, 60-cycle, 3-phase, 220/115-volt Diesel engine-driven electric generator. This unit will provide electric power for the octane rating engine sychronous induction motor and suitable current for all laboratory apparatus and equipment requiring electric energy. A bottled gas system is furnished to provide fuel for bunsen burners and blow pipes. The laboratory is also equipped with a mechanical ice-making and refrigerating machine, which is capable of reaching a temperature as low as 20° below zero Fahrenheit and can be used to provide low temperature baths for cloud and pour tests. Water distillation apparatus of ample capacity is also provided.

48. PORTABLE LABORATORY.

a. As it is anticipated that the portable laboratory unit will be shifted from place to place in a theater as operations require, a limited amount of apparatus and equipment will be provided. Determinations requiring the use of highly sensitive analytical balances or heavy and bulky equipment must necessarily be carried out at a base laboratory. As previously mentioned, the portable laboratory equipment is transported and housed in a collapsible trailer which can be pulled by a 2½-ton, 6 by 6 cargo truck over average roads.

b. The 2½-ton cargo tractor-truck will transport a 5-kilowatt, 60-cycle, 3-phase, 115-volt, skid-mounted, gasoline engine-driven electric generator, which will provide the necessary current for all apparatus and equipment requiring electric power. A bottled gas system is built into the laboratory trailer to supply necessary fuel for bunsen burners and other gas-burning devices. The portable laboratory will also be provided with water distillation apparatus of ample capacity for all normal requirements, and an ice-making and refrigerating machine of the same size and capacity as the one for the base laboratory.

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. a. Section 1.

Item	Unit	Quantity
Octane rating engine (C. F. R.-1C) equipped motor and aviation method complete with 3-phase, 60-cycle, 220-volt, synchronous induction motor (manufactured only by Waukesha Motor Company, Waukesha, Wisconsin).	Each	1
Spare parts and accessories, 6 months' maintenance, octane rating engine as listed below, plus such other spare parts as may be considered necessary by supplier to provide 6 months' supply of maintenance items:		
Piston	Each	1
Pin, piston	Each	1
Rings, piston (set of 3 compression and 2 oil).	Set	10
Bushing, connecting rod pin	Each	1
Cylinder	Each	1
Valve (intake and exhaust same).	Each	12
Inserts, valve seat	Each	6
Bolts, manifold stud (with nuts and washers).	Each	6
Bushings, rocker arm	Set	2
Petcock, radiator drain	Each	1
Breaker points, ignition	Pair	4
Gasket, condenser body	Each	12
Gasket, condenser water pipe	Each	12
Cap screw, water inlet pipe (with washers).	Each	6
Bolts, condenser body (with lock washers).	Each	4
Gasket, condenser gage	Each	6
Gage glass, condenser	Each	2
Waste, cotton for oil filter	Pounds	2
Tubing, rubber, for carburetor connections (¼").	Feet	10
Float valve seal assembly, carburetor.	Each	2
Gasket, carburetor, thin	Each	6
Gasket, carburetor, thick	Each	1
Fuse, panel, plug, 3 amp	Each	6
Rheostat, carbon pile	Each	1

Item	Unit	Quantity
Spare parts and accessories—Con.		
Manifold, exhaust	Each	2
Gasket, manifold, exhaust	Each	12
Galvanometer suspension, potentiometer.	Each	2
Fuse, potentiometer, 45/100 amp.	Each	2
Gasket, thermal plug	Each	12
Thermometer, intake manifold	Each	3
Thermometer, water jacket	Each	3
Grease, worm wheel	Pounds	2
Oil, motor, SAE 50	Gallons	25
Pressure gage assembly, compression.	Each	1
Chamois for carburetor bowl filters.	Each	4
Plug, spark, 18-mm	Each	20
Graph paper, operating curve	Each	150
Data sheet, engine	Each	400
Calibration charts, reference fuel.	Set	1
Compound, valve-grinding	Can	1
Plug, thermal	Each	2
Colorimeter, Tag Robinson, with N. P. A. color scale, complete with 3 color standards, wooden carrying case and color table, but without Tag Standard Daylight Lamp, Tag No. 55300.	Each	1
Spare parts for above:		
Tube, oil immersion, complete, Tag No. 55300F.	Each	2
Color standards, full	Each	4
Color standard one-half	Each	3
Headpiece	Each	1
Chromometer, Saybolt, Standard Universal, A. S. T. M., complete with 3 color standards, wooden carrying case and color table, but without daylight lamp, Tag No. 55350.	Each	1
Spare parts for above:		
Tube, plain, with connection, Tag No. 55350B.	Each	2

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. a. Section 1.—Continued.

Item	Unit	Quantity
Spare parts for above—Con.		
Tube, graduated, with connection, Tag No. 55350D.	Each	2
Glass, plain, for bottom of graduated tube.	Each	2
Gasket, drain spout (package of 24).	Each	1
Headpiece, complete with hinges.	Each	1
Viscosimeter, Saybolt thermostatic, constant temperature bath, motor stirrer, heater, cooling coil, receiving flask guide, Tag No. 55470.	Each	4
Spare parts and accessories for above:		
Tube, viscosity, Saybolt Universal, Tag No. 55411.	Each	8
Tube, viscosity, Saybolt Furol, Tag No. 55426.	Each	3
Wrench, orifice, Tag No. 55400X.	Each	2
Flask, viscosity, Saybolt, Tag No. 55417 (case of 24).	Case	1
Pipette, Tag No. 55418	Each	3
Strainer, 55400Q	Each	4
Pan, with lip, Tag No. 55400T	Each	4
Bulb, pilot, Tag No. 55461	Each	4
Coil, heating, for 2-tube, Tag 55460A.	Each	3
Points, Tungsten, Tag 55464	Set	2
Rheostat (variable heater) Tag No. 55465.	Each	1
Motor, for 1-tube and 2-tube bath, 110-volt, 60 cycle a-c, Tag No. 55465B.	Each	2
Coil, cooling, for 1 and 2 tube	Each	1
Thermometer, viscosimeter, etched stem, range 66° to 80° F., Tag No. 55443.	Each	4
Range 94° to 108° F., Tag 55444.	Each	18
Range 120° to 134° F., Tag 55445.	Each	12
Range 204° to 218° F., Tag 55447.	Each	8
Standard Oil for 100° F	Quart	1
Standard Oil for 122° F	Quart	1
Standard Oil for 210° F	Quart	1
Guard, thermometer, metal, Tag No. 55400G.	Each	12
Tester, Standard Pensky-Martens, closed, A. S. T. M. Tag No. 55952.	Each	1
Spare parts and accessories for above:		
Thermometer, A. S. T. M., range 20° to 230° F., Tag No. 55960.	Each	6
Thermometer, A. S. T. M., range 200° to 700° F., Tag No. 55970.	Each	6
Cup, with handle, Tag No. 55950F.	Each	1
Top, complete with steering mechanism and cup, Tag No. 55950E.	Each	1
Tester, closed, A. S. T. M., Tag No. 56050.	Each	1
Spare parts and accessories for above:		
Burner, alcohol, Tag No. 56100B	Each	1
Thermometer, closed tester, range 20° to 230° F., Tag No. 56070.	Each	4
Thermometer, closed tester, range 0° to 120° F., Tag No. 56085.	Each	6
Thermo-Viscosimeter, aybolt, Tag No. 55500.	Each	1
Spare parts and accessories for above:		
Tube, capillary, Tag No. 55510	Each	2
Bulb, rubber, Tag No. 55500P	Each	2
Thermometer, etched stem, extreme precision grade, range 60° to 110° F., Tag No. 55520.	Each	3
Jar, glass, Tag No. 55500V	Each	2
Apparatus, carbon residue, A. S. T. M., complete with asbestos block, Tag No. 55900.	Each	2
Spare parts and accessories for above:		
Hood, Monel metal, Tag No. 55900B.	Each	1
Crucible, outer, Monel metal, with cover, Tag No. 55900C.	Each	2
Crucible, Skidmore, Tag No. 55900D.	Each	2
Crucible, porcelain, Coors, Size 1.	Each	12
Triangle, chromel, Tag No. 55900K.	Each	4
Apparatus, sediment, A. S. T. M., complete, Tag No. 55595.	Each	3
Spare parts and accessories for above:		
Support, thimble, Tag No. 55595C.	Each	4
Condenser, extraction, Tag No. 55595B.	Each	4
Tubing, rubber, for condenser connection.	Feet	25
Thimble, alundum, Tag No. 55595A.	Each	24
Apparatus, water determination, A. S. T. M., with bunsen burner and supports, Tag No. 56233.	Each	2
Spare parts and accessories for above:		
Tubing, rubber (condenser connection).	Feet	40
Receiver, Pyrex, Tag No. 56238A.	Each	3
Flask, Pyrex (500 ml)	Each	6
Condenser, Pyrex, Tag No. 56236A.	Each	4
Apparatus, cloud and pour test, A. S. T. M., Tag No. 55550; complete with 10 No. 55560 thermometers, range −36° to +120° F., and two Tag No. 55561 thermometers, range −70° to +70° F.	Each	2

Item	Unit	Quantity
Spare parts and accessories for above:		
Thermometer, range −36° to +120° F., Tag No. 55560.	Each	12
Jar, test, Tag No. 55570	Each	24
Bath, insulated, cooling, Tag No. 55550J.	Each	4
Cover, wooden, Tag No. 55550E.	Each	4
Penetrometer, Universal model, with adjustible head, Tag No. 55849 complete with two Tag No. 55841 needles and two Tag No. 55843 A. S. T. M. grease cones.	Each	1
Grease worker, A. S. T. M., Tag No. 55844.	Each	1
Apparatus, grease dropping point, A. S. T. M., complete with all accessories including two A. S. T. M. thermometers, Tag No. 51140 range 20° to 580° F., one 400-ml beaker, stand with rod, and clamp holder for thermometers, and special 4″ test tube, grease cup, electric heater stirrer, and special rod for working grease in cup.	Each	1
Apparatus, preformed gum, single unit, A. S. T. M., complete with beaker, condenser, flowmeter, and air reducing valve, Tag No. 55925.	Each	1
Spare parts and accessories for above:		
Beaker, Pyrex, No. 1040, 100-ml capacity, without spout, Tag No. 55927.	Each	6
Apparatus, distillation, A. S. T. M. (gasoline) complete, to include 100-ml Engler distilling flask, condenser system shield, ring and ring stand, asbestos board 6″ x 6″ x 1¼″ hole, battery jar, 4⅝″ diameter by 9″ to hold receiver, 100-ml graduate, 10-ml graduate, electric heater fitted with asbestos board top ¼″ thick and having 1¼″ hole. Tag No. 55852.	Each	2
Spare parts and accessories for above:		
Jar, battery, 4⅝″ diameter by 9″ high.	Each	4
Board, asbestos, 4″ hole 8″ x 10″ x ¼″.	Each	2
Board, asbestos, 2¾″ hole, 6″ x 6″ x ¼″.	Each	4
Board, asbestos, 1½″ hole 6″ x 6″ x ¼″.	Each	6
Board, asbestos, 1¼″ hole, 6″ x 6″ x ¼″.	Each	6
Thermometer, range 30° to 580° F., Tag No. 55870.	Each	12
Thermometer, range 30° to 760° F., Tag No. 55872.	Each	8
Washer (rubber or plastic)	Each	12
Cylinder, single graduated, 10-ml Cenco No. 16120.	Each	6
Cylinder, single graduated, 100-ml Cenco No. 16120.	Each	12
Cylinder, single graduated, 200-ml Cenco No. 16120.	Each	12
Spare parts and accessories for above—Continued.		
Heater, electric, for 110 volts a-c, Tag No. 55853.	Each	2
Flask, distilling, 100-cc	Each	24
Flask, distilling, 250-cc	Each	12
Cork, for 100 cc, distilling flask	Dozen	12
Cork, for 250 cc, distilling flask	Dozen	6
Shield, ice, for graduate	Each	4
Bomb, vapor pressure, Reid, immersion type, consisting of gasoline chamber, air chamber, gage bushing, complete with one pressure gage 0 to 15 lb., and one pressure gage 0 to 45 lb. (gasoline chamber to have female connection), Curtin 16513 (W. H. Curtin and Company, Houston, Texas).	Each	4
Spare parts and accessories for above:		
Bath, thermostatically controlled, for 4 bombs.	Each	1
Thermometer, range 94° to 108° F., Curtin No. 16633.	Each	4
Thermometer, range −30° to +120° F., Curtin No. 16525.	Each	6
Gage, pressure, range 0 to 15 lb., ¼″ standard pipe thread, 4½″ dial, Curtin No. 16520.	Each	3
Gage, pressure, range 0 to 45 lb., 1¼″ standard pipe thread, 4½″ dial, Curtin No. 16521.	Each	1
Apparatus, gum stability (motor gasoline bomb method), complete apparatus to include bomb, glass liner, bomb accessories, pressure gage (200 psi maximum), water bath (4½-gal.), gaskets and wrench. Tag. No. 55980.	Each	2
Spare parts and accessories for above:		
Clamp, bench, Tag No. 55980C	Each	1
Liner, glass, only Tag No. 55981.	Each	6
Gage, pressure, 200 psi maximum, Tag No. 6632.	Each	2
Thermometer, range 204° to 218° F., Tag No. 55447.	Each	4
Washer, Neoprene, Tag No. 55980A.	Each	12
Apparatus, sulfur in petroleum oils (lamp method) complete apparatus to consist of: lamp, chimney, absorber, spray, trap, cotton wicking, suction pump, cylinder, glass beads, ground glass joints with glass connections interchangeable, Tag No. 56214.	Each	2
Spare parts and accessories for above:		
Chimney, Pyrex, Tag No. 56215B.	Each	4
Absorber, Pyrex, Tag No. 56215A.	Each	3
Spray trap, Pyrex, Tag No. 56215C.	Each	4
Burner, Tag No. 56215E	Each	3

Item	Unit	Quantity
Spare parts and accessories for above—Continued.		
Wicks, Tag No. 56212H	Gross	2
Beads, glass	Set	4
Apparatus, tetraethyl, lead extraction, A. S. T. M., complete apparatus of Pyrex glass to consist of heating tube with chimney, 500-ml boiling flask Hoskins reflux condenser, 70-ml thistle tube, support stand and slide wire rheostat, Cenco No. 27640.	Set	2
Spare parts for above:		
Apparatus, Pyrex, two-piece construction, T-joint similar to B. K. H. 51975.	Set	4
Apparatus, acid heat, A. S. T. M., apparatus to include thermos bottle (calibrated), molded rubber stopper, pressure release tube and stopcock, acid heat thermometer, 30° to 220° F., 6″ immersion, metal retaining cap and 100-ml graduate, Tag No. 55810.	Set	2
Spare parts and accessories for above:		
Bottle, thermos, calibrated, Tag No. 55812.	Each	2
Pressure release tube and stopcock, Tag No. 55814.	Each	6
Stopper, molded, rubber, Tag No. 55816.	Each	6
Thermometer acid heat, 30° to 220° F., 6″ immersion, Tag No. 51131.	Each	6
Tester, flash point Cleveland, A. S. T. M., complete with thermometer, Tag No. 56008.	Each	2
Spare parts for above:		
Thermometer, range 20° to 760° F., Tag No. 56010.	Each	6
Cup, with handle, flash, Cleveland, Tag No. 56003C.	Each	4
Apparatus, aniline point, complete	Each	1
Spare parts and accessories for above:		
Test tube	Each	6
Stirring rod	Each	2
Thermometer, for aniline point determination.	Each	2
Apparatus, gum content of gasoline, copper dish method, 6-opening, complete with 6 copper dishes and steam bath, B. K. H. No. 51912.	Set	2
Spare parts for above:		
Copper dishes	Each	12
Apparatus, smoke, I. P. T	Each	1
Spare parts for above:		
Wicks	Package	6
Wick holder, stainless steel	Each	2
Oil container for wick holder, stainless steel with connection.	Each	2
Centrifuge, electric, 110-volt a-c for 100-ml pear-shaped tubes, Tag No. 57910.	Each	2

Item	Unit	Quantity
Centrifuge, hand powered, 15-ml tubes, Tag No. 57805.	Each	2
Spare parts for above:		
Tube, centrifuge, 15-ml, cone-shaped.	Each	24
Hydrometer, certified, double gravity scale, solid metal ballast streamline tip, 10½″:		
Tag No. C 32031, range 0° to 10°.	Each	4
Tag No. C 32033, range 10° to 20°.	Each	6
Tag No. C 32036, range 20° to 30°.	Each	6
Tag No. C 32039, range 30° to 40°.	Each	6
Tag No. C 32042, range 40° to 50°.	Each	6
Tag No. C 32045, range 50° to 60°.	Each	6
Tag No. C 32048, range 60° to 70°.	Each	6
Tag No. C 32051, range 70° to 80°.	Each	4
Tag No. C 32054, range 80° to 90°.	Each	2
Balance, pulp, enclosed type, No. "B" Cenco No. 2620.	Each	2
Weights, set, precision, lacquered, Class S Cenco No. 8121.	Set	2
Balance, torsion, Fisher 2–080	Each	2
Weights, balance, Fisher 2–300	Each	2
Balance, analytical, E&A model, Fisher 1–918.	Each	1
Weights, Fisher No. 2–216 (For Fisher 1–918 analytical balance).	Set	1
Bath, test, corrosion, 6-place electric, Cenco No. 27809.	Each	2
Bath, thermostatically controlled with rheostat and stirrer, 110-volt a-c, Cenco No. 97000.	Each	2
Gas system, Pyrofax, or similar	Each	2
Bottles, for Pyrofax gas system	Each	10
Heater, Ful-Kontrol-Electric, 750 watts, P&S No. 1600.	Each	6
Spare parts for above:		
Heating element, P&S 1856	Each	4
Element, replacement coil, P&S 1876.	Each	4
Refractory top, reversible, porcelain with opening 3⅛″ diameter, P&S 1820.	Each	4
Hot Plate, 8″ diameter, 110-volt a-c, Fisher No. 11–464.	Each	6
Spare parts for above:		
Heating element	Each	2
Switch	Each	3
Ice making machine, York Ice Corporation, approximately 42 lb. ice per 24 hours capacity, minimum temperature −20° F., 115-volt, 60-cycle, approximate dimensions 18″ x 23″ x 58″.	Each	2
Heater, immersion style A, 115-volt, Fisher No. 13–580.	Each	4
Furnace, muffle Cooley electric, type M. P., Serial A, 110-volt, 60-cycle.	Each	1

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. a. Section 1—Continued.

Item	Unit	Quantity
Spare parts for above:		
Rheostat, for type M. P., Serial A Cooley electric muffle furnace.	Each	2
Heating unit for type M. P. furnace, Curtin No. 8720.	Each	2
Lamp "Daylite", A. S. T. M., Tag MacBeth with 60-watt, 110-volt bulb, 6-ft extension cord, adjustable base, Tag No. 55373.	Each	2
Spare parts for above:		
Bulb, light, A-21, 60-watt, 110-volt for Tag 55373 Daylite lamp.	Each	12
Lens, for Daylite lamp	Each	2
Oven, electric, high temperature, 110-volt a-c, maximum not less than 220° C., Cenco No. 95200.	Each	2
Pump, vacuum, "Hyvac", iron base, Serial A, complete with motor for 101-volt a-c, 60-cycle, Curtin No. 18155.	Each	3
Spare parts and accessories for above:		
Oil, Curtin No. 18160	Gallons	2
Belt	Each	2
Pump, air, rotary, Serial B, 8 P. S. I., vacuum and pressure, 110-volt a-c, 60-cycle, Curtin No. 18135.	Each	2
Spare parts for above:		
Belt	Each	4
Apparatus, distilling, precision, all metal, electrically heated, capacity 1 gal per hour, for 110 volts, Curtin No. 7208.	Each	2
Spare parts for above:		
Heating elements for 110 volts	Each	2

b. Section 2.

Item	Unit	Quantity
Apron, rubber, Fisher No. 1-350	Each	4
Cord, asbestos, diameter 1/16", Fisher No. 1-455.	Pounds	3
Gloves, asbestos, Fisher No. 1-460	Pair	2
Cup, asphalt sample, A. S. T. M., Fisher 1-520.	Dozen	6
Airejector, Fisher 9-956	Each	3
Bottles, reagent with glass stoppers, clear glass, wide-mouth stopper, 16 oz, A. H. T. No. 6285.	Each	48
Bottles, clear glass, stoppered, narrow-mouth, 16 oz. A. H. T. 2207-K.	Each	48
Bottles, brown glass, stoppered, narrow-mouth 16-oz.	Each	24
Bottles, clear glass, stoppered, narrow-mouth 8-oz, A. H. T. 2207-K.	Each	48
Bottles, narrow-mouth, Bakelite screw cap, 1-qt capacity.	Each	24
Bottles, narrow-mouth, Bakelite screw top, amber, 32-oz.	Each	144
Bottles, pressure, for saponification numbers.	Each	4
Bottles, wide-mouth, brown glass, 16-oz.	Each	12
Bottles, wide-mouth, clear glass, stoppered, 4-oz, A. H. T. number 6285-A.	Each	72
Bottles, narrow-mouth, 4-oz, Cenco No. 10305.	Each	24
Bottles, washing, 500-ml capacity, Curtin No. 2520.	Each	12
Bottles, for testing aviation fuel, 8-oz.	Each	144
Bottles, narrow-mouth, 5-gal capacity.	Each	12
Bottles, reagent, with chemically resistant resin caps:		
Narrow-mouth, clear glass, 2-oz, A. H. T. No. 2207K.	Each	24
Narrow-mouth, brown glass, 2-oz.	Each	24
Wide-mouth, clear glass, 1-oz, A. H. T. 6285.	Each	24
Wide-mouth, brown glass, 1-oz, A. H. T. 6285A.	Each	24
Bottles, reagent, with chemically resistant resin dropper caps:		
Narrow-mouth, clear glass, 2-oz, A. H. T. 2248B.	Each	24
Narrow-mouth, brown glass, A. H. T. 2248-B.	Each	24
Bottles, reagent, Fisher No. 3-120:		
Acetic acid	Each	2
Alcohol ethyl	Each	2
Ammonium, hydroxide, concentrated.	Each	2
Ammonium hydroxide diluted	Each	2
Hydrochloric acid, concentrated	Each	2
Hydrochloric acid diluted	Each	2
Sulfuric acid, concentrated	Each	2
Sulfuric acid diluted	Each	2
Nitric acid, concentrated	Each	2
Nitric acid, diluted	Each	2
Beakers, Griffin, with spout, Pyrex glass, Fisher No. 2-540:		
20-ml capacity	Each	24
50-ml capacity	Each	24
100-ml capacity	Each	24
250-ml capacity	Each	24
400-ml capacity	Each	24
600-ml capacity	Each	24
1000-ml capacity	Each	12
Beaker, 1-qt capacity with 3/4" opening, Tag. No. 56428.	Each	12
Borer, cork, set Fisher 7-850	Each	3
Sharpener, borer, Fisher 7-865	Each	2
Burette, 50-ml capacity with stopcock, blue line, "Exax", retested, Fisher No. 3-699.	Each	4
Burette, automatic zero, with central filling tube, 10-ml capacity.	Each	6
Burette, Fisher automatic, clear glass with pincock and rubber connection, Fisher No. 3-843.	Each	4
Burner, Fisher No. 3-900	Each	6
Burner, Fletcher for natural gas, Fisher No. 3-952.	Each	3
Burner, acetylene, Bunsen type, Fisher 3-970.	Each	3
Box, wood, Hercules, style 16 to hold 6 acid bottles (manufactured by National Box and Lumber Co., Newark, New Jersey).	Each	2

Item	Unit	Quantity
Brushes:		
Beaker, Fisher No. 3–540	Each	3
Beaker, Fisher No. 3–565	Each	3
Large test tube, Fisher 3–572	Dozen	1
Small test tube, Fisher No. 3–574.	Dozen	1
Burette, Fisher 3–614	Each	3
Pipette, Fisher No. 3–625	Each	3
Paint, 1" wide, Fisher 3–645	Each	2
Paint 2" wide, Fisher 3–645	Each	4
Paint, 4" wide, Fisher 3–645	Each	2
Balance, size B, Fisher No. 3–654.	Each	12
Scrub, Fisher 3–675	Each	3
Table, Fisher, No. 3–680	Each	3
Single, Fisher No. 3–682	Each	2
Wire, Fisher No. 3–685	Each	2
Broom, mill, fiber	Each	6
Burner, alcohol, Fisher 4–245	Each	3
Wick, burner, Fisher No. 4–250 (package of 12).	Package	4
Tongs, beaker, Fisher No. 2–620	Each	3
Burner, blast, gasoline, Fisher 4–295.	Each	4
Barometer, aneroid, Fisher 2–405	Each	2
Cement, DeKhostisky, 1-oz packages:		
Soft	Package	6
Medium	Package	6
Hard	Package	6
Cement, tube, 1-oz Fisher No. 4–752 (box of 12).	Box	2
Clamp, beaker, Cenco No. 12090	Each	4
Clamp, double, burette holder, Fisher No. 5–779.	Each	3
Clamp, pinchcock, Fisher No. 5–849	Each	6
Clamp holder, Castaloy, Fisher No. 5–756.	Each	12
Clamp, Castaloy, Fisher No. 5–734	Each	6
Clamp, Castaloy, Fisher No. 5–742	Each	6
Clamp, Castaloy, hosecock, Fisher No. 5–847.	Each	6
Clamp, for rubber tubing, Fisher No. 14–197:		
3/8" size	Each	6
1/2" size	Each	12
5/8" size	Each	6
3/4" size	Each	6
Clock and interval timer, electric, Fisher No. 6–661.	Each	2
Cloth, cheese, rolls of 100 yd, Fisher 6–665.	Each	4
Crucible, Coors Curtin No. 5932:		
Size 2	Each	12
Size 4	Each	12
Crucible, Gooch, Coors, porcelain, size 3, Curtin No. 5947.	Each	12
Perforated disks, size 3, Curtin No. 5949.	Each	6
Crucible holder, Walker's, for size 3 Gooch Crucible, Curtin No. 6026.	Each	3
Crucible, porcelain, hign form, Coors, ml capacity (30) complete with covers, Cenco No. 18535–1.	Each	12
Cylinder, Pyrex glass, lifetime red, graduated, Fisher No. 8–552R:		
5-ml capacity	Each	6
10-ml capacity	Each	6
Cylinder, Pyrex glass, lifetime red, graduated—Continued.		
25-ml capacity	Each	12
100-ml capacity	Each	24
200 (graduated in percent to 100 percent).	Each	24
Cylinders, Pyrex glass, plain:		
500-ml capacity	Each	24
1,000-ml capacity	Each	24
Cloth, emery, No. 1 (package of 12)	Package	6
Cloth, emery, No. 0	Package	6
Cloth, emery, No. 00	Package	6
Cotton, absorbent, 12" wide (1-lb package).	Package	6
Chamois, 2 ft square (for filtering gasoline).	Each	12
Can, screw top, gasoline:		
1-gal. capacity	Each	144
2-gal. capacity	Each	24
5-gal. capacity	Each	24
Corks, regular length, XXXX quality in bags of 100, Fisher No. 7–795:		
No. 2	Bag	1
No. 3	Bag	1
No. 4	Bag	1
No. 5	Bag	1
No. 6	Bag	1
No. 7	Bag	1
No. 8	Bag	1
No. 9	Bag	1
No. 10	Bag	1
Corks, regular length, quadruple quality, assorted No. 6 to 15, bags of 100, Fisher 7–795.	Each	5
Cork press, rotary, Fisher No. 7–880	Each	2
Corkscrew, Fisher No. 7–885	Each	2
Dispenser, P–Hydrion paper (manufactured by Cargille and Company, 118 Liberty Street, New York City).	Set	12
Dish, evaporating, porcelain, 100-ml capacity.	Each	12
Desiccator, 250-mm diameter, with porcelain place, Cenco No. 14550E.	Each	6
Dish, evaporating, opaque, 45-ml capacity, fused silica.	Each	6
Dish, evaporating, opaque, 80-ml capacity, fused silica.	Each	6
Diamonds, for writing on glass, Fisher No. 8–675.	Each	1
Funnel, separatory, Curtin No. 8446:		
125-ml capacity	Each	6
250-ml capacity	Each	12
500-ml capacity	Each	6
Funnel, glass, extra long stem, 50-mm, Curtin No. 8274B.	Each	6
Funnel, glass, ribbed, Serial A, 4½", Curtin No. 8298.	Each	6
Funnel, glass, extra long stem, 75-mm, Curtin No. 8274D.	Each	6
Funnel, glass, ribbed, Serial C, 7", Curtin No. 8298.	Each	6
Flexaframe, set No. 1, complete, Fisher 14–661–1.	Set	2

Item	Unit	Quantity
Cots, finger:		
Style A for fingers, Fisher 9–998.	Each	12
Style B for thumbs, Fisher 9–998.	Each	4
Flask, Erlenmeyer, narrow-mouth, Pyrex brand, 250-ml, Cenco No. 14905.	Each	12
Flask, Erlenmeyer, narrow-mouth, Pyrex brand, 500-ml, Cenco No. 14905.	Each	12
Flask, Erlenmeyer, narrow-mouth, Pyrex brand, 1000-ml, Cenco No. 14905.	Each	12
Burner, flame test, with base, Curtin No. 16242.	Each	4
Flask, distilling, Hemple, Pyrex, Curtin No. 8004.	Each	6
Flask, Erlenmeyer, Pyrex, wide mouth, Curtin No. 7952:		
250-ml capacity	Each	12
500-ml capacity	Each	12
Flask, glass, Pyrex, Curtin No. 7944:		
500-ml capacity	Each	4
1000-ml capacity	Each	3
2000-ml capacity	Each	2
File, rat tail, 5″	Each	6
File, 3-cornered, 6″, papered	Each	6
Flask, volumetric, glass stoppered, Cenco No. 16230:		
1 liter capacity	Each	6
500-ml capacity	Each	6
250-ml capacity	Each	6
Flask, filter, heavy wall, 1000-ml, Curtin 8054.	Each	4
Gloves, rubber, lightweight, size 9, Fisher 14–094.	Pair	8
Gloves, rubber, heavy weight, size 9, Fisher 14–097.	Pair	3
Cutter, glass tubing, Griffin form, Curtin No. 9416.	Each	3
Cutting wheels, glass cutter, Curtin No. 9416A.	Dozen	2
Glass blower, shaper, Fisher No. 11–348–25.	Each	1
Labels, E&A Catalog No. 223	Box	24
Lighter, or gas, Fisher 12005	Each	6
Tips, for No. 12–005 lighter, Fisher 12–010.	Dozen	2
Measure, meterstick, Fisher 12–095	Each	3
Manometer, "U-tube" type, low pressure, Serial D, 30″ long, Curtin No. 13006.	Each	2
Mortar, porcelain, Coors, size E with pestle, Cenco No. 17381.	Each	2
Mop, floor, with handle	Each	3
Paper, filter (Whatman No. 40) 110-mm diameter, Curtin No. 7806.	Package	12
Paper, filter (Whatman No. 40) 150-mm diameter, Curtin No. 7806.	Package	12
Paper, filter (Whatman No. 12) 240-mm diameter, Curtin No. 7818.	Package	24
Plate, cast iron, 2³⁄₁₆″ hole test flame, bead-covered Heat-Rock board, P. S. 1840.	Each	4
Pencil, carborundum, Curtin No. 17178.	Each	2
Pencil, wax, red, Curtin No. 17180	Each	2
Pipette, transfer, precision:		
100-ml, Cenco No. 16360	Each	6
50-ml, Cenco No. 16360	Each	12
25-ml, Cenco No. 16360	Each	6
10-ml, Cenco No. 16360	Each	6
1-ml, Cenco No. 16360	Each	6
Pen, round, writing single point, assorted.	Box	2
Pen holder, writing ordinary	Each	12
Pails, wood, 14-qt	Each	6
Pan, dust	Each	2
Bulb, red rubber, Curtin No. 18672	Each	6
Policeman, rubber, diagonal form, complete with rod, Curtin No. 18716.	Dozen	1
Stretcher, rubber tubing, Fisher 14–195.	Each	2
Stool, laboratory, wood, about 30″ tall.	Each	4
Speed indicator, Curtin No. 19979	Each	2
Splashgon, Fisher 9–959	Each	3
Grease, stopcock, Curtin No. 20088 (1-oz tube).	Tube	24
Sponge, Fisher 14–415	Pound	1
Stopcock, laboratory, Fisher No. 14540.	Each	12
Watch, stop, 60-second dial, Curtin No. 20140.	Each	12
Stirrer, electric, variable speed, worm drive, universal motor, propeller type stirrer with two metal stirrers, Fisher 14–498.	Each	4
Sheet, copper, 12″ wide by 10′ long, 22-gage.	Each	2
Steel strips, for apparatus for determining gum in gasoline, P. S. No. 4737 (100 strips per package).	Package	2
Stopcock, Pyrex, 2-way straight bore, Cenco No. 15406.	Each	6
Shears, 6″, general utility, Curtin 19031.	Each	2
Shears, 11″, Curtin No. 19039	Each	1
Scissors, 2″, trimming	Each	2
Spatula, 4″ blade, Curtin No. 19247.	Each	4
Slide rule, polyphase (Mannheim)	Each	3
Stands, tripod, with concentric rings, Curtin No. 21833:		
Serial A	Each	3
Serial C	Each	2
Stoppers, rubber, 2-hole, 4 sizes:		
Size No. 3	Dozen	1
Size No. 4	Dozen	1
Size No. 5	Dozen	1
Size No. 6	Dozen	1
Stand, supported, Cenco 13825	Each	12
Support, burette, wood, Chaddock, double, Cenco 19010.	Each	4
Tube, test, Pyrex, thick wall, Serial D, 18 x 150 mm, Curtin No. 20555.	Dozen	12
Tubing, glass, Pyrex, standard wall, in factory lengths of 5 ft, Curtin No. 9402:		
6-mm outside diameter	Pound	1
8-mm outside diameter	Pound	2
10-mm outside diameter	Pound	2
12-mm outside diameter	Pound	2

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. b. Section 2—Continued.

Item	Unit	Quantity
Tubing, rubber, "Scimatco", thin-wall, Fisher No. 14–150:		
1/8'' bore	Foot	25
3/16'' bore	Foot	50
1/4'' bore	Foot	50
Tubing, rubber, "Scimatco", thick-wall, Fisher No. 14–155:		
1/8'' bore	Foot	20
3/16'' bore	Foot	20
1/4'' bore	Foot	50
5/16'' bore	Foot	20
Tubing, pressure and vacuum, red, Fisher 14–173:		
1/8'' inside diameter	Foot	20
3/16'' inside diameter	Foot	20
1/4'' inside diameter	Foot	40
Hook, thermometer, suspension, P. S. No. 4560.	Each	6
Thermometer, general purpose, −5° to +300° F., Curtin No. 20730.	Each	12
Thermometer, general purpose, −20° to +150° C. Curtin No. 20736.	Each	12
Pigment, thermometer (1-oz. bottle)	Each	2
Tag, shipping, cloth with wire fasteners.	Each	1,000
Tape, adhesive, 3'' wide, 10-ft roll	Rolls	6
Tongs, 8'' long, Curtin No. 21690	Each	6
Tongs, 16'' long, Curtin No. 21690	Each	1
Triangle, iron wire, Curtin 21780	Each	12
Twine, Belfast cord, in balls:		
Heavy size	Ball	12
Medium size	Ball	12
Light size	Ball	12
Thermo-regulator, red top mercury, range 0° to 500° F., complete with protecting armor, P. S. No. 5910–15.	Each	4

Item	Unit	Quantity
Charts, viscosity, conversion, Tag No. 55469.	Each	6
Charts, viscosity blending, A. S. T. M., Tag 55467.	Each	6
Charts, viscosity temperature, pads of 25 each, Tag No. 55468–A.	Pad	3
Ringer, mop	Each	2
Wire, round, iron:		
18-gage, 25-ft spool	Each	2
22-gage, 25-ft spool	Each	2
26-gage, 25-ft spool	Each	2
Burner, wing tip, Cenco No. 11205	Each	2
Wool, steel, triple O, Fisher 15–595	Pound	6
Watch, glass, well-annealed glass, concave, with edges ground, laboratory grade, Curtin No. 22326:		
40-mm diameter	Each	12
65-mm diameter	Each	12
100-mm diameter	Each	12
Pipette, 1-cc, graduated in 0.01-cc increments	Each	1
Pipette, 5-cc, graduated in 0.10-cc increments.	Each	1
Paper, filter, 330-mm, heavy white creped surface.	Package	2
Funnel, porcelain, diameter at top, 115 mm.	Each	2
Wire, resistance, rated as follows:		
4 ohms per ft	Foot	50
2 ohms per ft	Foot	50
Valve, needle, Cenco No. 13820	Each	12
Tester, gage (dead weight) 1,000 pounds maximum range, complete with weights and carrying case (manufactured by Crosby Gage and Valve Company).	Each	1

c. Section 3.

Item	Unit	Quantity
Acetone, tech. in 1-gal bottles	Each	6
Acid, acetic, glacial, C. P. in 1-lb bottles.	Each	6
Acid, hydrochloric, C. P. specific gravity Sp. Gr. 1.18–1.19 in 6-lb bottles.	Each	3
Acid, nitric, specific Sp. Gr. 1.415–1.42 in 7-lb bottles.	Each	2
Acid, sulfuric, specific Sp. Gr. 1.835–1.84 in 9-lb bottles.	Each	6
Acid, tannic, C. P. in 1-lb bottles	Each	2
Acid, benzoic, U. S. Bureau of Standards.	Grams	300
Ammonium hydroxide in 4-lb bottles.	Each	3
Ammonium molybdate, C. P. in 1-lb bottles.	Each	2
Aniline, high grade, in 1-lb bottles	Each	2
Alcohol, ethyl, C. P. in 2-gal cans	Each	4
Benzene, C. P. in 1-lb bottles	Each	12
Benzene, C. P. in 1-gal containers	Each	20
Benzol, 90 percent in 5-gal can	Each	6
Bromine, C. P. in 1-oz bottles	Each	4
Calcium chloride, purified anhydrous in 1-lb bottles.	Each	2

Item	Unit	Quantity
Calcium, chloride, tech. anhydrous for desiccator in 5-gal cans.	Each	2
Carbon tetrachloride, tech., in 5-gal cans.	Each	2
Chromic oxide, C. P. in 1-lb container.	Each	4
Glycerine, tech., in 1-gal cans	Each	2
Hydrogen peroxide, U. S. P. in 1-lb bottles.	Each	3
Iodine, C. P. resublimed, A. C. S. 1/4-lb bottles.	Each	4
Lead nitrate, C. P., A. C. S., in 1-lb bottles	Each	4
Indicator, powder, methyl orange, 1/4-lb bottles.	Each	2
Indicator, methyl red, 1/4-lb bottles	Each	2
Indicator, phenolphthalein, A. P. H.	Each	12
Methylene blue, U. S. P., 1/4-lb bottles.	Each	1
Mercury metal, triple distilled in 1-lb bottles.	Each	6
Potassium chromate, C. P. in 1-lb bottles.	Each	6
Potassium dichromate, C. P. in 1-lb bottles.	Each	2
Potassium dichromate, tech., powdered in 5-lb containers.	Each	2

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. c. Section 3—Continued.

Item	Unit	Quantity
Potassium sodium tartrate, C. P. in 1-lb bottles.	Each	2
Potassium hydroxide, pellets, C. P. in 1-lb bottles.	Each	4
Potassium, acid, phthalate, in 100-gram bottles.	Each	3
Para Nitro Phenol, Ph., range 5–7, 25-gram bottle.	Each	2
Barium Chloride in 1-lb bottles	Each	2
Barium hydroxide, in 1-lb bottles	Each	2
Sulfur, flowers, in 5-lb packages	Each	6
Pumice stone, lump in 1-lb cans	Each	4
Sodium chloride, C. P. in 1-lb bottles.	Each	2
Sodium carbonate in 1-lb bottles	Each	2
Sodium sulfate, anhydrous, C. P. in 1-lb bottles.	Each	2
Sodium hydroxide, C. P., pellets in 1-lb bottles.	Each	9
Sodium oxalate, C. P. in 1-lb bottles	Each	1
Silver nitrate, C. P. in ¼-lb bottles	Each	4
Solvent, stoddard in 1-gal container	Each	4
Xylene, C. P. in 1-lb bottles	Each	2
Powder, tripoli in 1-lb packages	Each	6
Tetraethyl lead, fluid, 1–T mix in 918 cc cans.	Each	2
Ethylene glycol in 1-gal cans	Each	3
Octane rating engine, reference fuel M–3, 55-gal drums.	Each	2
Octane rating engine, reference fuel F–4, 55-gal drums.	Each	7
Wool, glass in ¼-lb cans	Each	4

d. Section 4.

Item	Unit	Quantity
Tape, gaging, Lufkin type, 50-ft, locking handle, chrome-face or white enamel, graduated in ⅛'' (zero at intersection of snap and bob) Curtin No. 16708.	Each	9
Spare parts for above:		
Tape only, extra, for replacement, Curtin No. 16709.	Each	6
Bob, gaging, plain, 6'', Bakelite insert (manufactured by Standard Inspection Supply).	Each	6
Bob, gaging, deep cut, 6'', Bakelite insert (manufactured by Standard Inspection Supply).	Each	6
Thermometer, tank, cup case, Tag No. 57216SS.	Each	12
Tube, thermometer, graduated and numbered 0° to 180° F. Tag No. 57217SS.	Each	24
Paste, water indicating, gage 0, 3-oz tube, Curtin No. 16718 in carton of 12 tubes.	Carton	2
Thief, drum, glass, Curtin No. 16732	Each	6
Thief, sampling, figure H–386–B, Tulsa type, 12''.	Each	3
Dies, letters a to z and a period, height of letters ⅛'', Fisher No. 8–680.	Set	1
Dies, numbers, height of letters ⅛'', Fisher 8–685.	Set	1
Extinguisher, fire, Pyrene, 1-qt capacity.	Each	2
Extinguisher, foam type, 2½-gal	Each	2
Hammer, claw	Each	2
Extractor, nail	Each	2
Screw driver:		
2''	Each	2
6''	Each	4
8''	Each	4
Goggles, safety chemical, Curtin No. 9424.	Pair	6
Motor, Universal (DC–AC), Fisher No. 9–522.	Each	1
Pliers, side cutting, 8'', Curtin No. 17665.	Each	2
Relay, precision, Model "A," 110-volt, 60-cycle a-c, Curtin No. 21620.	Each	2
Relay, precision, Model "B," 110-volt, 60-cycle a-c, Curtin No. 21622.	Each	4
Rectifier, transformer, Curtin No. 21624.	Each	2
Soldering lead, with resin center in spools of 10 ft.	Each	12
Soldering lead, with acid center, in spools of 10 ft.	Each	12
Iron, soldering, electric, with extra hot point, 110-volt.	Each	2
Vise, bench, 4'' jaw	Each	2
Wire, nichrome, 1-mm diameter (approximately 16 B&S gage).	Feet	20
Wrench, pipe, adjustable:		
6''	Each	2
8''	Each	4
10''	Each	4
12''	Each	2
14''	Each	2
18''	Each	1
Wrench, crescent, adjustable:		
6''	Each	2
8''	Each	2
10''	Each	2
12''	Each	2
Wrench, end, thin, alloy steel, set to handle hex nuts for U. S. Standard bolts ¼'' to 1½'', inclusive (steps to be by eighths).	Set	1
Oiler, ½-pt. capacity	Each	2
Generator, electric, 15-kw, 220-volt, 60-cycle a-c, Diesel engine driven, specification number GS 1209.	Each	1
Trailer, type K–19, Signal Corps, converted to collapsible chemical laboratory trailer.	Each	1

49. PETROLEUM PRODUCTS TESTING LABORATORY APPARATUS, EQUIPMENT, AND SUPPLIES. e. Laboratory Reference Library.

Item	Unit	Quantity
Library, reference, regimental	Each	1
Scott's Standard Methods of Chemical Analysis (2 volumes).	Each	1
*A. S. T. M., Standards on Petroleum Products and Lubricants.	Each	2
*The Significance of Tests of Petroleum Products.	Each	2
*Evaluation of Petroleum Products.	Each	2
New and revised Tag Manual for Inspectors of Petroleum, available from C. J. Tagliabue Manufacturing Company, Brooklyn, New York.	Each	4
Federal Standard Stock Catalogue, Section 4, Part 2, W-L 791b, dated February 19, 1942.	Each	2
Handbook of Chemistry and Physics, 26th Edition.	Each	2
Instructions for Measuring, Sampling and Testing Petroleum Shipments (available from Standard Oil Development Company, 26 Broadway, New York City).	Each	6
Standard Methods for Testing Petroleum and its Products, I. P. T., 3rd Edition (Amil and Griner Co., New York City).	Each	2

*Available from American Society of Testing Materials, 260 South Broad Street, Philadelphia, Pennsylvania.

APPENDIX I
SPECIFICATIONS

CORPS OF ENGINEERS
PRELIMINARY SPECIFICATION

PL–1701 B
17 SEPTEMBER 1942
Superseding PL–1701A

MILITARY 4-INCH PIPE-LINE SECTION

1. GENERAL. This specification shall cover a 4-inch, No. 14 gage, welded steel tubing, with a nipple or sleeve welded on each end for use with a Victaulic coupling. The couplings themselves shall not be furnished but the section shall be complete and ready for field erection. The over-all length of the section shall be 20 feet, 0 inch ± ¼-inch.

2. PROCESS. Tubing shall be straight butt-welded, straight seam lap-welded, spiral butt-welded, spiral lap-welded, or lock joint spiral-welded. The steel for the tubing shall be of good weldable quality. The tubing may be either hot or cold finished, depending on the process necessary to assure compliance with the hydrostatic test in paragraph 4.

3. SECTION ENDS. Each end of the tubing shall be fitted with a 4-inch long nipple or sleeve grooved for use with a standard 4-inch diameter Victaulic coupling. All dimensions and tolerances shall be those recommended by the Victaulic Coupling Co. of America, 30 Rockfeller Plaza, New York, N. Y. If a sleeve is used, it shall protrude past the end of the tube at least $\frac{1}{16}$-inch, and the space between the end of the tubing and the inside of the sleeve shall be fillet-welded. If a nipple is used, it shall be butt-welded to the tubing, and the inside flash must be cleaned off if the burr exceeds a height of $\frac{3}{64}$-inch.

4. HYDROSTATIC TESTS. Each completed section shall be given a hydrostatic test of not less than 900 pounds per square inch.

5. FINISH. The finished section shall be reasonably straight and free from injurious defects.

6. WEIGHT AND DIMENSIONS. The tubing may be 4 inches inside diameter or 4 inches outside diameter. Any slight deviation in the contractor's nominal wall thickness, still guaranteeing the working pressure of 650 pounds and complying with the hydrostatic test of 900 pounds per square inch, will be acceptable. Tolerances and dimensions conforming with standard mill practice will be acceptable.

7. MARKING. One nipple of each section shall be stamped, rolled or the completed section shall be stenciled with the manufacturer's name or trade-mark and the inside diameter.

8. INSPECTION. Each completed section of tubing will be inspected to insure compliance with paragraph 4. Any obvious defects such as slag inclusions will be cause for rejection. All tests and inspections shall be made at the place of manufacture prior to shipment and at the contractor's expense.

9. COATING. Prior to coating, the tubing shall be thoroughly cleaned of all oil, grease, dirt, loose scale, and foreign matter. After cleaning, the tubing shall be given one coat of paint in accordance with the latest revision of Corps of Engineers Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers Tentative Specification T–1213, Supplement B, color card, No. 9, olive-drab.

552517 O - 43 - 11

10. SHIPMENT. The finished sections shall be crated or bundled for export in bundles not exceeding 3 tons in weight. The bundles or crates shall be suitable for handling by shipboard and dock booms. Details of the crate the contractor proposes to furnish shall be submitted to the contracting officer for approval.

11. SHORT LENGTHS. Short lengths of the 4-inch, 14-gage tubing may be butt-welded, end to end, to form a finished section, provided the butt weld flush does not exceed $\frac{3}{64}$ inch on the inside and outside, and provided the finished section thus formed complies with all the requirements listed above.

PL–1702 A
8 OCTOBER 1942
Superseding PL–1702
13 May 1942

MILITARY 4-INCH PIPE-LINE VALVE SECTIONS

1. GENERAL. This specification covers two types of valve sections:

a. A gate valve section, consisting of a gate valve mounted in the center of a 20-foot length of 4-inch pipe, and

b. A check valve section consisting of a check valve and one gate valve mounted in the center of a 20-foot section of 4-inch pipe.

2. VALVES. The gate valves shall be flanged, 4-inch, cast iron, bronze trim, full opening, nonrising stem, double disk, and conforming with the American Petroleum Institute standard, No. 5–G–1, 500-pound work pressure, ASA–B16b Cast Iron 250-pound. The check valve shall be full opening, 4-inch, flanged, bronze trim, of the swing type, and conforming to the American Petroleum Institute standard, No. 5–G–1 500-pound working pressure, ASA–B16b–(American 250-pound standard) Wheatley Bros. Pump & Valve Manufacturers. Twin Gate and Check Valves will be acceptable if they conform generally with the above requirements.

3. GATE VALVE SECTION. The gate valve section shall consist of a 20-foot length of standard 4-inch steel pipe with a gate valve set in the center. The pipe shall be connected to the valve by means of a companion flange with a welding neck. The ends of the pipe shall be grooved for a 4-inch, standard, Victaulic coupling. All dimensions and tolerances shall be those recommended by the Victaulic Co. of America, 30 Rockefeller Plaza, New York, N. Y. The over-all length of the section shall be 20–0″ ± ⅛″. The couplings themselves shall not be furnished but the section shall be complete and ready for field erection.

4. CHECK VALVE SECTION. The check valve section shall consist of a 20-foot length of standard, 4-inch, steel pipe with a check valve and a gate valve set in the center. The gate valve shall be connected to the pipe by means of a companion flange with a welding neck. Both ends of the section shall be grooved for use with a standard 4-inch Victaulic coupling. All dimensions and tolerances shall be those recommended by the Victaulic Co. of America, 30 Rockefeller Plaza, New York, N. Y. The over-all length of the section shall be 20–0″ ± ⅛″. The couplings themselves shall not be furnished but the section shall be complete and ready for field erection.

5. TEST. The pipe and fittings shall be capable of withstanding a hydrostatic test of 1,000 pounds per square inch.

6. COATING. Prior to coating, the pipe shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and other foreign matter. After cleaning, the pipe shall be given one coat of paint in accordance with the latest revisions of Corps of Engineers Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers Tentative Specification T–1213, Supplement B, color card, No. 9 olive drab.

7. SHIPMENT. Both the check-valve section and the gate-valve section shall be boxed for export.

MILITARY 4-INCH PIPE-LINE PUMPING STATION

200 barrels per hour, 200 pounds per square inch

SMALL UNIT

1. GENERAL. This specification is intended to provide a complete portable pipe-line pumping station. The station shall be furnished in five sections for easy erection in the field. These sections shall be the pump and engine mounted on a common base, the sand-trap section, the discharge section, the main line header section, and the suction section. The main line header section shall be interchangeable with the pipe-line sections and shall be fitted with two nipples leading to the suction and discharge of the pump. The sand-trap section shall take the gasoline out of the main line pumping section and introduce it to the suction header. There shall be a sand trap and a gate valve in this section. The suction header shall connect the sand-trap section and the suction flange on the pump. The discharge header shall connect the discharge piping of the pump and the discharge section. The station shall be complete with all piping, valves, and controls, and shall be ready for field operation. Each pumping station manifold shall be equipped with sufficient 90° Victaulic elbows to permit location of the station to the right or left of the main line gate valve within the limits of a parallelogram defined by the main line header section, the sand-trap section, the station manifold, and the station discharge line.

2. PUMPING UNIT.

a. Pump. The pump shall be a V-belt driven 4½-inch diameter bore, 6-inch stroke, double acting, duplex piston power pump capable of delivering 200 barrels per hour at a pressure of 625 pounds per square inch, and shall be a Wheatley Bros. Pump & Valve Manufacturer's figure 2050 or a Gaso Pump and Burner Manufacturer's figure 1740, cr equal. Pump cylinders, stuffing boxes, and flanges shall be constructed to withstand "closed in" pressures up to 900 pounds per square inch, and normal working pressure up to 625 pounds per square inch.

b. Engine. The engine shall be a 4-cycle, spark-ignition, water-cooled industrial type gasoline engine of at least 800-cubic-inch displacement. The engine shall be equipped with an oil bath type air filter, an oil-pressure gage, an oil filter, muffler, water temperature indicator, and a fuel filter. Starting shall be accomplished by an electric starting motor. A generator, a voltage controller, battery and ammeter shall be provided. The cooling system shall include a circulating pump, fan, and a tubular type radiator, and shall limit the jacket water temperature to 200° F. while operating at full load with an ambient temperature of 130° F. The engine shall be equipped with a suitable hand operated friction clutch, and shall be totally enclosed in a steel housing with removable side panels.

A warning plate reading as follows shall be installed adjacent to the gasoline tank fill pipe: "Do not fill the gasoline tank while the engine is in operation."

The engine shall be equipped with a light receptacle mounted on the engine dash. The receptacle shall be of the type to accommodate a two-prong bayonet-type plug.

The engine shall be equipped with an electrically operated fuel pump. The fuel pump shall be piped in a manner which will permit pumping to the fuel tank or directly from storage to the carburetor by the operation of a single valve.

The engine shall be equipped with a Model G–1 combination governor as manufactured by the Syncro-Start Corporation, Chicago, Ill.

c. Skid. The pump and engine shall be mounted on a skid fabricated from heavy 6-inch I-beams, extra heavy 3-inch steel pipe, and structural channels. The mounting shall be sturdy enough to permit lifting on and off of a truck or a trailer and movement by skidding.

d. Controls. The assembled unit shall constitute a complete pipe-line pumping station capable of receiving and delivering 200 barrels per hour. The controlling equipment shall be built into the pumping unit and shall be capable of the following functions:

(1) Control the pumping rate to match the incoming stream so as to maintain a suction pressure of approximately 15 pounds per square inch.

(2) Control the discharge pressure so that upon closure of a downstream valve at any point on the line, the discharge pressure shall not exceed 625 pounds per square inch.

(3) Control the working pressure of the pump so that when a valve is closed downstream or the discharge pressure exceeds 625 pounds per square inch, the pump shall automatically bypass and lower the discharge pressure to equal the suction pressure.

(4) Control the engine so that when the suction pressure exceeds 400 pounds per square inch, the speed shall be reduced to idling.

(5) Control the engine speed so that when the quantity of the income stream is reduced, the corresponding pressure rise shall be distributed over two or three stations upstream. The discharge pressure shall be controlled at some value below 625 pounds per square inch.

(6) Provide two methods by which the discharge pressure of the pump shall be maintained at a value lower than 625 pounds per square inch.

(7) Control the maximum pumping rate when the discharge pressure is below 625 pounds and the suction pressure is below 15 pounds.

e. Finish. The pumping unit shall be painted in accordance with United States Army Corps of Engineers Tentative Specification No. T–1184, class A, type 1.

f. Tool box. Each pumping unit shall be equipped with a tool box for carrying the tools and spare parts necessary for the maintenance and operation of the pump and engine. The box shall be made of sheet steel and shall be bolted to the frame of the unit in some convenient location. The box shall have a hinged cover and shall be provided with a hasp and padlock. Two keys shall be provided per unit and shall be interchangeable with keys of other units.

g. Tools, spare parts, and accessories. Sufficient tools for operation and maintenance of the pumping station in the field shall be furnished. Sufficient spare parts for 6 months continuous operation shall also be furnished. An extra positive displacement pump for the hydraulic control system shall be furnished with each pumping unit. The bidder shall submit with his bid a list of the tools and spare parts he proposes to furnish.

3. SAND-TRAP SECTION. The sand-trap section shall consist of a sand trap manifold, a gate valve, nipples at each end of the section grooved for Victaulic couplings, a drain plug, and an inspection plug not less than 4 inches in diameter. It shall be the function of the sand-trap section to take gasoline out of the upstream nipple on the main line pipe section, settle out the solid matter, and deliver it to the section header. The sand trap shall be constructed of 57-pound seamless 12-inch steel pipe, or equal, and shall be fitted with a drain plug at the pipe-line end, and an inspection plug at the top and center of the sand trap. The drain plug shall be welded into the bottom of the pipe line of the sand trap in such a manner that it does not retard movement by skidding. Both the drain plug and the inspection plug shall be fitted with Victaulic coupling plug ends. The sand trap shall be divided into two parts and shall be connected by a 12-inch Victaulic coupling. One extra gasket shall be packed in the tool box. There shall be furnished with each sand-trap section a suitable sand-trap cleaning device. This device shall be of such a size that it can be inserted in the 4-inch clean-out pipe of the sand trap. The handle of the clean-out shall be sectionalized. The device shall be fastened to the base of the pumping unit when not in use.

4. MAIN-LINE PIPE SECTION. The main-line pipe section shall consist of a 20-foot length of standard 4-inch steel pipe with two gate valves and a check valve mounted in the center and with two nipples grooved for Victaulic couplings for connection to the suction and discharge piping of the pump. The check valve shall be set in the center of the section with the two gate valves on each side.

The main-line pipe section shall be in accordance with Hanlon-Waters, Inc., drawing HW–3793. The dimensions shall be approximately as follows:

Over-all length of section	20′0″ ±¼
Discharge nipple to suction nipple (C to C)	9′10″
Suction nipple center to section center	6′7″
Discharge nipple center to section center	6′7″

5. DISCHARGE SECTION. The discharge section shall connect the discharge header and the discharge nipple on the main-line pipe section, and shall be a standard gate valve section conforming to Corps of Engineers, Preliminary Specification No. PL–1702.

6. SUCTION AND DISCHARGE HEADERS. It shall be the function of the suction header to connect the suction flange on the pump and the sand-trap section. It shall be the function of the discharge header to connect the discharge piping of the pump and the discharge section. The suction and discharge headers shall be interchangeable and shall be fabricated out of a short length of standard 4-inch pipe and the necessary Victaulic elbow fittings to effect the above-mentioned functions.

7. FLEXIBLE COUPLINGS. All flexible couplings on the pumping station shall be the standard 4-inch coupling as manufactured by the Victaulic Co. of America, 30 Rockefeller Plaza, New York, N. Y. Dimensions and grooves shall be as recommended by the Victaulic Co.

8. VALVES. Gate valves and check vales on the pumping station shall conform to the following description.

a. Gate valve. The gate valves shall be flanged, 4-inch, cast iron, bronze trim, full pipe line opening, nonrising stem, double disk, and conforming to the American Petroleum Institute standard, No. 5–G–1, 500-pound working pressure, ASA–B1b–Cast Iron 250-pound.

b. Check valve. The check valve shall be full pipe line opening, flanged, bronze trim, of the swing type, and conforming to the American Petroleum Institute standard, No. 5–G–1, 500-pound working pressure, ASA–B16b–(American, 500-pound, standard). A Wheatley twin check and gate will be accepted if it is in general accordance with the above-mentioned standard in the 500-pound class.

9. COATING. Prior to coating, the above-mentioned sections shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and other foreign matter. After cleaning, these sections shall be given one coat of paint in accordance with the latest revisions of Corps of Engineers, Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers, Tentative Specification T–1213, Supplement B, color card, No. 9, olive-drab.

10. TESTS. The sand-trap section, the suction header, the discharge header, the discharge section, the discharge section and the main line pipe section shall be given a hydrostatic test of not less than 900 pounds per square inch. The pump and the discharge piping shall also be given a hydrostatic test of not less than 900 pounds per square inch. The complete pumping station shall be given sufficient operating tests to satisfy representative of the Office, Chief of Engineers, that the unit is capable of satisfactorily performing all the functions listed in paragraph 2*d* of this specification.

11. WORKMANSHIP. All parts of the complete unit shall be designed, manufactured, and finished in a thoroughly workmanlike manner. All dimensions shall be held as close as is consistent with good shop practice.

12. DESIGN. The pumping station shall be in accordance with Hanlon-Waters, Inc., drawing No. B–222.

13. SHIPMENT. The pumping station shall be boxed for export.

14. CLOSURE NIPPLES. There shall be furnished with each pumping station four-foot lengths of standard pipe grooved for Victaulic couplings and five Victaulic couplings and gaskets. These lengths of pipe and couplings shall be boxed together and the box shall be designated MS "Make-up Section."

MILITARY 4-INCH PRESSURE-REDUCTION STATION

1. GENERAL. The pressure-reduction station covered in this specification shall consist of a 20-foot section of standard, 4-inch, pipe with a gate valve in the center, bypassed with a section of 4-inch standard pipe containing two gate valves and a pressure reduction valve.

2. VALVES. The gate valves shall be flanged, 4-inch, cast iron, bronze trim, full pipe-line opening, nonrising stem, double disk, and conforming with the American Petroleum Institute standard No. 5-G-1, 500-pound working pressure, ASA B16b (American 250-lb. standard).

The pressure reduction valve shall be a Hanlon-Waters Type 120-four inches.

3. PIPING. One gate valve shall be placed in the exact center of the 20-foot length of pipe. This valve shall be bypassed with two gate valves and a pressure reduction valve. The two gate valves shall be bolted to each side of the pressure reduction valve. The pipe shall be standard, 4-inch, black, and wrought steel. The piping and valves shall be able to withstand a hydrostatic test of 1,000 pounds per square inch. It shall be the function of this station to prevent excessive line pressures on downgrades. The valve shall be suitable for field adjustment for maximum pressures of 300 to 600 pounds per square inch. The two ends of the pipe shall be grooved for a standard, 4-inch, Victaulic Coupling. All dimensions and tolerances shall be as recommended by the Victaulic Company of America, 30 Rockefeller Plaza, New York, N. Y.

4. COATING. Prior to coating, the pipe shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and other foreign matter. After cleaning, the pipe shall be given one coat of paint in accordance with the latest revisions of Corps of Engineers, Preliminary Specification No. PL-1712. The dried film shall match approximately Corps of Engineers Tentative Specification T-1213, Supplement B, color card, No. 9, olive-drab.

5. TEST. The pipe and valves shall be able to withstand a hydrostatic test pressure of 1,000 pounds per square inch.

6. SHIPMENT. The pressure-reduction station shall be boxed for export shipment.

MILITARY 6-INCH PIPE-LINE SECTION

1. GENERAL. This specification shall cover a 6-inch number 12 gage, welded steel tubing with a nipple or sleeve welded on each end for use with Victaulic coupling. The couplings themselves shall not be furnished, but the section shall be complete and ready for field erection. The overall length shall be 20 feet—plus or minus ¼ inch.

2. PROCESS. The tubing shall be straight seam butt-welded, straight seam lap-welded, spiral butt-welded, spiral lap-welded, or lock joint spiral-welded. The steel for the tubing shall be of good weldable quality. The tubing may be either hot or cold finished, depending on the process necessary to assure compliance with the hydrostatic test in paragraph 4.

3. SECTION ENDS. Each end of the tubing shall be fitted with a 5-inch long nipple or sleeve grooved for use with a standard 6-inch diameter Victaulic coupling. All dimensions and tolerance shall be those recommended by the Victaulic Coupling Company of America, 30 Rockefeller Plaza, New York, N. Y.

If a sleeve is used, it shall protrude past the end of the tube at least 1/16 inch, and the space between the end of the tubing and the inside of the sleeve shall be fillet-welded. If a nipple is used, it shall be butt-welded to the tubing and the inside circumferential flash shall be cleaned off if the burr exceeds a height of 3/64 inch.

4. HYDROSTATIC TESTS. Each completed section shall be given a hydrostatic test of not less than 900 pounds per square inch.

5. FINISH. The completed section shall be reasonably straight and free from injurious defects.

6. WEIGHT AND DIMENSIONS. The tubing may be 6-inch inside diameter or 6-inch outside diameter. Any slight deviation in the contractor's nominal wall thickness still guaranteeing the working pressure of 650 pounds and complying with the hydrostatic test of 900 pounds per square inch will be acceptable. Tolerances and dimensions conforming with standard mill practice will be acceptable.

7. MARKING. One nipple of each section shall be stamped, rolled, or the completed section shall be stenciled with the manufacturer's name or trade mark and the inside diameter.

8. INSPECTION. Each completed section of the tubing will be inspected to insure compliance with paragraph 4. Any obvious defects such as slag inclusions will be cause for rejection. All tests and inspections shall be at the place of manufacture prior to shipment and at the contractor's expense.

9. COATING. Prior to painting, the tubing shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and other foreign matter. After cleaning, the tubing shall be given one coat of paint in accordance with the latest revisions of Corps of Engineers Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers Tentative Specification T–1213, Supplement B, color card, No. 9, olive-drab.

10. SHIPMENT. The finished sections shall be crated or bundled for export in bundles not exceeding 5 tons in weight. The bundles or crates shall be suitable for handling by shipboard and dock booms. Details of the crate the contractor proposes to furnish shall be submitted to the contracting officer for approval.

11. SHORT LENGTHS. Short lengths of the 6-inch 12-gage tubing may be butt welded end-to-end to form a finished section, provided the finished section thus formed complies with all the requirements listed above.

MILITARY 6-INCH PIPE-LINE VALVE SECTIONS

1. GENERAL. This specification covers two types of valve sections:

a. Valve section, gate, 6-inch, for a portable pipe line.

b. Valve section, check, 6-inch, for a portable pipe line.

2. VALVES. The gate valves shall be flanged, 6-inch, cast iron, bronze trim, full opening, non-rising stem, double disk, and conforming with the American Petroleum Institute standard, No. 5-G-1, 500-pound working pressure, ASA-B16b-Cast Iron, 250-pound. The check valve shall be full opening, 6-inch, flanged bronze trim, of the swing type, and conforming to the American Petroleum Institute standard, No. 5-G-1, 500-pound working pressure, ASA-B16b (American 250-pound standard). Wheatley Brothers Pump and Valve Manufacturers twin gate and check valves will be acceptable if they conform generally with the above requirements.

3. GATE-VALVE SECTION. The gate-valve section shall consist of an assembly of two lengths of standard 6-inch pipe and a gate valve. The gate valve shall be fitted with two short nipples each grooved for Victaulic 6-inch couplings. The two lengths of standard pipe grooved for Victaulic couplings on each end shall be of equal length and shall be of such length that the assembled section will be 20 feet plus or minus ¼ inch long. Two couplings shall be furnished with the unit. All dimensions and tolerances shall be those recommended by the Victaulic Co. of America, 30 Rockefeller Plaza, New York, N. Y.

4. CHECK-VALVE SECTION. The check-valve section shall consist of an assembly of two lengths of standard 6-inch pipe, one check valve, and one gate valve. The gate valve and check valve shall be flanged together and shall be fitted with nipples grooved for Victaulic coupling. The two lengths of pipe shall be of equal length, shall be grooved for Victaulic 6-inch couplings, and shall be of such length that the assembled section is 20 feet plus or minus ¼ inch long. Two couplings shall be furnished with the assembly. All dimensions and tolerances shall be those recommended by the Victaulic Co. of America, 30 Rockefeller Plaza, New York, N. Y.

MILITARY 6-INCH PRESSURE-REDUCTION STATION

1. GENERAL. The pressure reduction station covered in this specification shall consist of a 20-foot section of standard 6-inch pipe with a gate valve in the center, bypassed with a section of 6-inch standard pipe containing two gate valves and a pressure reduction valve.

2. VALVE. The gate valves shall be flanged, 6-inch, cast-iron, bronze trim full pipe-line opening, nonrising stem, double disk, and conforming with the American Petroleum Institute Standard No. 5–G–1, 500-pound working pressure, ASA B16b (American 250-pound standard). The pressure reduction valve shall be a Hanlon-Waters, Inc., or equal.

3. PIPING. One gate valve shall be placed in the approximate center of the 20-foot length of pipe. This valve shall be bypassed with two gate valves and a pressure reduction valve. The two gate valves shall be bolted to each side of the pressure reduction valve. All other connections shall be Victaulic. The pipe shall be standard, 6-inch, black, and steel. The piping and valves shall be able to withstand a hydrostatic test of 1,000 pounds per square inch. It shall be the function of this station to prevent excessive line pressures on down grades. The valve shall be suitable for field adjustment for maximum pressures of 300 to 600 pounds per square inch. The two ends of the pipe shall be grooved for a standard, 6-inch Victaulic coupling. All dimensions and tolerances shall be as recommended by the Victaulic Company of America, 30 Rockefeller Plaza, New York, New York.

4. COATING. Prior to painting, the unit shall be thoroughly cleaned of all oil, dirt, grease, loose scale, and other foreign matter. The unit shall be given one coat of paint in accordance with the latest revisions of the Corps of Engineers, Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers, Tentative Specification T–1213, Supplement B, color card No. 9, olive drab.

5. TEST. The pipe and valves shall be able to withstand a hydrostatic test pressure of 1,000 pounds per square inch.

6. SHIPMENT. The pressure reduction station shall be boxed for export shipment.

7. COUPLINGS. Ten couplings shall be provided for each station.

MANIFOLD, TWO-UNIT, FOR 6-INCH MILITARY PIPE LINE

1. GENERAL. This specification covers a pipe manifold which will permit the operation of two "Pup" pumping units (Corps of Engineers, Preliminary Specification P-724) in series, parallel, individually; or will allow the pumps to stand by idle to the main pipe line which is connected to the pump manifolds. The general arrangements of the manifold shall be in accordance with Hanlon-Waters, Inc., Drawing No. B 322-S, except the discharge branch from each pump shall include a swing check valve.

2. FITTING. The following fittings shall be furnished as a part of each manifold:

- 10 elbows, 90°, 4-inch, grooved for Victaulic couplings.
- 5 elbows, 90°, 6-inch, grooved for Victaulic couplings.
- 4 tees, 4-inch, grooved for Victaulic couplings.
- 2 tees, 6-inch, grooved for Victaulic couplings.
- 2 reducers, 6-inch by 4-inch, grooved for Victaulic couplings.
- 2 plugs, 6-inch, grooved for Victaulic couplings.

Fittings shall be malleable iron, wrought iron, or fusion welded from standard pipe. For all types of fittings the dimensions and tolerances shall be identical with those used with Victaulic grooved type fittings and shall be suitable for a working pressure of 600 pounds per square inch.

3. COUPLINGS. The following couplings, complete with gaskets and bolts, shall be provided as a part of each manifold:

- 35, each, couplings, 4-inch, grooved type.
- 20, each, couplings, 6-inch, grooved type.

The dimensions and tolerances shall be those recommended by the Victaulic Company of America, 30 Rockefeller Plaza, New York, New York. The gasket material shall be suitable for use in a pipe line which will be required to handle 100-octane gasoline containing 40 percent aromatics. If any grooved type coupling, other than that manufactured by the Victaulic Company of America, is supplied, the gaskets, bolts, and both halves of the coupling shall be interchangeable, part for part, with the Victaulic couplings. In addition to the above requirements, the following spare gaskets and bolts shall be furnished:

- 10 gaskets, 4-inch for Victaulic grooved type coupling.
- 5, each, gaskets, 6-inch for Victaulic grooved type coupling.
- 20, each, bolts and nuts for 4-inch Victaulic couplings.
- 10, each, bolts and nuts for 6-inch Victaulic couplings.

4. FLANGES. Companion flanges shall be cast iron, A. S. A. Standard B 16-e-1939, 300-pound drilling, 1/16-inch raised face.

5. VALVES. The gate valves shall be of cast iron or semisteel, bronze trim, full pipe-line opening, inside screw, wedge or double disk type, flanged with raised face. Check valves shall have cast iron or semisteel bodies, bronze trim, and shall be of the swing type with full pipe openings. Check valves shall have flanged ends with raised faces. A Wheatley Brothers Pump and Valve Company's combination gate and check valve will be considered as a substitute for one gate valve and one check valve in the main line header, if it meets the remainder of the valve specifications. All gate valves, check valves, and combination gate and check valves shall conform with A. P. I. Standard No. 5-G-1, latest revision, 500 pounds per square inch working pressure; and shall have flanged ends conforming with A. S. A. Standard B-16-E 1939, 300-pound drilling, raised faces. Ring gaskets of gasoline-resistant material, suitable for an operating pressure of 600 pounds per square inch, shall be furnished for all valves. Carbon steel bolts with square heads and washer faced nuts conforming to A. S. T. M. Specification A 107-42, minimum tensile strength 65,000 pounds per square inch, shall be furnished with the valves for assembling in pipe manifold.

6. CONNECTIONS. All pipe connections, except where valves are fitted into pipe manifolds, shall be with Victaulic couplings. Valve connections are to be made with bolted flange joints. All bolts, gaskets, flanges, and split couplings necessary for assembling a liquid-tight manifold for 650 pounds per square inch working pressure shall be furnished under this specification. The sand trap, discharge section, and main line gate valve and check valve header shall also be furnished.

7. SAND TRAP. The sand trap shall consist of a 12-foot length of 16-inch O. D., 73 pounds per foot, seamless line pipe with four 6-inch standard weight pipe nipples welded on in locations shown on Drawing No. B322–S, for flow connections, clean-out, and inspection. The over-all length of the sand trap, including pipe nipples, shall be 20 feet, plus or minus ¼-inch. The nipple adjacent to the main line shall consist of a 6-foot length of standard weight 6-inch line pipe with a 6-inch Wheatley self-cleaning rack, flanged gate valve fitted in the center. The 14-foot section containing the 12-foot length of 16-inch pipe shall have welded joints. Sand traps shall be fitted with a 6-inch inspection plug and a 6-inch drain plug. Inspection plug shall be placed on the top center of the 16-inch pipe. The drain plug shall be located near the bottom of the 16-inch pipe in such a position as not to retard movement by skidding. Both of the openings shall be grooved for Victaulic couplings and shall be fitted with Victaulic plugs.

8. CONTROLS. The following control equipment shall be provided for each manifold:

a. Temperature control. Two each Mercoid Figure DR–38 temperature control switches with a range of 100° F. to 200° F., 20-foot capillary, No. 2 bulb, ¾-inch I. P. S. union connection shall be provided. Capillary shall be armored full length. The instrument shall be equipped with a manual reset; and 12 feet of two-conductor cable shall be furnished for connecting the Mercoid switch in series with the low-voltage primary feeder to the ignition distributor. The circuit is to be broken by an increase in temperature beyond that of the instrument setting. The instruments shall be furnished with steel bushings to screw into ¾-inch I. P. S. couplings.

b. Low suction pressure control. One each Mercoid Figure 23R103, range 0–800 pounds per square inch with manual reset shall be provided. The instrument shall be factory set to break the circuit at 5 pounds per square inch and to close the circuit when the suction pressure reaches approximately 15 pounds per square inch. The instrument shall be furnished with 20 feet of two-conductor armored cable for connecting the Mercoid switch in series with the low voltage primary feeder to the ignition distributor. The instrument shall be adjustable upward. The instrument shall be furnished with a steel bushing to screw into a ¾-inch I. P. S. coupling.

c. High discharge pressure control. Two each Mercoid Figure 23R, range 0–1500 pounds per square inch with manual reset, high discharge pressure protection instruments shall be provided. The instruments shall be factory set to open the circuits at 700 pounds per square inch and to close the circuits at approximately 30 pounds per square inch. The instruments shall be furnished with 29 feet of two-conductor armored cable each for connecting in series with the low voltage primary feeders to the ignition distributors. The instruments shall be furnished with steel bushings to screw into ¾-inch I. P. S. couplings.

9. MAINLINE HEADER SECTION. A main-line header section for connecting both the discharge section and the sand trap into the main line shall be furnished, and shall consist of a gate valve and a check valve or a twin check and gate valve, mounted in the center of a 6-foot length of standard 6-inch line pipe, two 6-inch Victaulic grooved type tees, and two short lengths of standard 6-inch line pipe to make up an over-all length of 20 feet, plus or minus ¼-inch. The valves shall meet the requirements of paragraph 5 and the pipe joints and fittings shall be made up with Victaulic couplings.

10. COATING. All of the pipe shall be given one coat of paint conforming to the latest revision of Corps of Engineers, Preliminary Specification PL–1712. The color shall be olive-drab conforming to color card, Supplement B to No. T–12B, No. 9.

11. SHIPMENT.

a. Packaging and Packing. Manifolds required for oversea shipment shall be packaged and packed in accordance with the requirements of Army-Navy General Specification for Packaging and Packing for Oversea Shipment, No. 100–14A.

Manifolds required for domestic shipment shall be shipped in such manner as to insure arrival at destination in an undamaged condition, and shall be acceptable to the freight agent in compliance with the current issue of the Consolidated Freight Classification. All equipment and parts shall be suitably protected to insure against damage during transit. The hardware, accessories, nuts, and bolts shall be coated with a suitable rust preventive and wrapped in oil paper. The hardware and accessories shall be packed in separate boxes from the gaskets, nuts, and bolts.

b. Marking. Shall be in accordance with Corps of Engineers Tentative Specification T-1729, Standard Requirements for Marking Corps of Engineers Shipments.

PUMP, CENTRIFUGAL, TWO-STAGE, SERIES-PARALLEL OPERATION, GASOLINE-ENGINE DRIVEN

(Series Operation, 0.68 Specific Gravity Gasoline, 200 Barrels per Hour at 200 Pounds per Square Inch; Parallel Operation, 400 Barrels per Hour at 100 Pounds per Square Inch)

1. GENERAL. This specification is intended to cover a gasoline-engine-driven, two-stage, skid-mounted pump for handling gasoline and fuel oil.

2. PUMP. The pumping unit shall be a Byron Jackson Co. "Pup" and shall be equipped with a built-in increaser gear and complete manifolding which will allow the two stages of the pump to be operated either in series or parallel. All pump parts shall be designed for a working pressure of 700 pounds per square inch. The increaser gear shall be fully inclosed for an oil bath and shall be jacketed so that a small amount of the fluid to be pumped can be circulated through the jacket and returned to the suction of the pump. A suitable coupling shall connect the pump and the engine. The suction and the discharge flanges shall be fitted with a companion flange and a short nipple grooved for a standard, 4-inch, Victaulic coupling. The suction and discharge of the pump shall be fitted with suitable pressure gages.

3. RATING. For parallel operation at a speed not to exceed 2,400 rpm and a head of 147 pounds, the pumping unit shall be capable of delivering 420 gallons of .68 specific gravity gasoline per minute.

For series operation at a speed not to exceed 2,400 rpm and a head of 294 pounds, the pumping unit shall be capable of delivering 210 gallons of .68 specific gravity gasoline per minute.

4. ENGINE. The engine shall be a standard, General Motors model 270 engine. The cooling system shall include radiator, fan, and circulating pump, and shall provide sufficient cooling to maintain a temperature not to exceed 200° when the engine is operating at full load with an ambient temperature of 120°. The engine shall be equipped with an oil-bath type air filter, an oil-pressure gage, and oil filter, electric starting equipment (including battery, generator starting motor, and ammeter), governor, tachometer, muffler, gasoline sediment bulb, and all other accessories necessary to make a complete pumping unit. The fuel tank shall have a capacity of at least 25 gallons. To facilitate the filling of the fuel tank when pumping gasoline, a small gasoline line with a petcock shall connect the fuel tank and some point in the pump piping—the suction flange, the discharge flange, or the manifolding. The engine shall be completely inclosed in a suitable sheet steel housing with removable side panels. The pumping unit shall be equipped with a suitable lifting bail to facilitate loading and unloading from trucks.

5. SHIPMENT. The pumping unit shall be boxed for export shipment.

6. PAINT. The pumping unit shall be painted in accordance with the U. S. Army Quartermaster Tentative Specification ES No. 680.

7. SPARES. All tools and spare parts necessary for successful field operation and maintenance shall be provided. The contractor shall furnish a list of the spares and tools which he proposes to furnish, with his quotation. This list shall include such items as pump packing, wearing rings, gaskets, and any other items necessary for 6-month continuous duty in the field.

TANKS: STEEL, GASOLINE, VERTICAL, BOLTED
(Aboveground Type)

A. APPLICABLE SPECIFICATIONS.

A-1. The following specifications and drawings, of the issue in effect on the date of the invitation to bid, form a part of this specification:

A-1*a*. *Federal Specifications*.

ZZ-R-601—Rubber Goods; General Specifications (Methods of Physical Tests and Chemical Analysis).

A-1*b*. *Army and Navy Specifications*.

AN-813—Aviation Fuel.

A-1*c*. *U. S. Army Specifications*.

100-14—Army-Navy General Specification for Packaging and Packing for Oversea Shipment.

A-1*d*. *Corps of Engineers Specifications*.

PL-1712—Enamel, Lusterless, Sand.

T-1213—Supplement B, Color Card.

T-1739—Standard Requirements for Marking Corps of Engineers Shipments.

A-1*e*. *American Petroleum Institute Specification*.

12-B—Bolted Tanks.

A-1*f*. *O. C. E. Drawing*.

GE-500-501—Details of Connections for Bolted Steel Gasoline Storage Tanks.

B. TYPE.

B-1. This specification covers vertical aboveground bolted steel gasoline storage tanks of the following sizes:

100 barrel	1,000 barrel low	5,000 barrel
250 barrel	1,000 barrel high	10,000 barrel
500 barrel low		

C. MATERIAL AND WORKMANSHIP.

C-1. *Material*. Shall be as specified hereinafter.

C-2. *Workmanship*. Shall be first class.

D. GENERAL REQUIREMENTS.

D-1. See section E.

E. DETAIL REQUIREMENTS.

E-1. *Tanks*.

Material, fabrication and design of the tanks shall comply with American Petroleum Institute Specification No. 12-B (third edition, dated September 1940) except that the thickness of the plates shall conform to the following:

THICKNESS OF PLATES IN DECIMAL PARTS OF AN INCH

(Commercial tolerance will be permitted)

Tank size in barrels	Bottom plates	First ring plates	Second ring plates	Third ring plates	Top plates
100	.1406	.1406			.1094
250	.1406	.1406			.1094
500 low	.1406	.1406			.1094
1,000 low	.1406	.1406			.1406
1,000 high	.1406	.1406	.1406		.1406
5,000	.1406	.1875	.1406	.1406	.1406
10,000	.1406	.1875	.1406	.1406	.1406

E-1*a*. *Tank equipment*.

E-1*a*(1). *Pressure and vacuum relief valves*. Each tank shall be equipped with a pressure and vacuum relief valve set at 1 ounce internal pressure and one ½ ounce internal vacuum. The valve shall be 8-inch nominal size with adequate capacity for the rates of filling and emptying indicated below. The bolt punching of the flange shall be as shown on the attached Drawing No. GE-500-501. The make and type of the pressure and vacuum relief valve shall be approved by the contracting officer. No flame arrester is required.

Size of tanks, in barrels	5,000 10,000	100, 250 500, 1,000
Rate of filling, in barrels per hour	4,000	500
Rate of emptying, in barrels per hour	600	600

E–1*a*(2). ***Thief hatch.*** Each tank shall be equipped with an 8-inch vapor tight thief hatch. The bolt pattern on the thief hatch shall be in accordance with the attached drawing No. GE–500–501. The tanks will be gaged by hand and no mechanical gaging devices will be required.

E–1*a*(3). ***Tank ladders.*** Each tank shall be equipped with an outside steel ladder. The ladder shall slope approximately 1 foot in 8 feet, and shall be securely braced against the tank. The sides of the ladder shall extend 3 feet above the roof and curve inward in accordance with standard practice. No inside ladder is required; however, a ladder may be incorporated as part of the roof support.

E–1*a*(4). ***Gasket material, cement, bolts, nuts, and washers.*** The necessary amount of gasket material, standard square nuts, recessed or counter sunk steel washers, Neoprene ring washers and sealing cement required for proper erection of the tanks, plus 10 percent additional, shall be furnished with each tank. The bolts and nuts used in the tank shall be ½ inch. Recessed or countersunk washers with accompanying Neoprene ring washers shall be supplied in sufficient quantities for installation with the standard bolts and nuts in the tank bottom seams and in all vertical seams. Standard bolts and nuts only shall be supplied for all other seams.

E–1*b*. ***Tank connections.*** The tank will be filled and will deliver gasoline through the same connection. Each tank shall be provided with fill and delivery connections, a water draw-off connection, and a clean-out. Sizes of the fill and delivery connections and the sizes of the water draw-off are tabulated below. One connection of each size will be required as listed.

E–1*b*(1) ***Fill and delivery connections.*** The fill and delivery connections shall be fitted with flanges faced or ground with drilled holes, in accordance with American Standards Association and shall be guaranteed liquid tight by the manufacturer. Blind flanges shall be provided for all tank connections. The location details and sizes of the fill and delivery connections shall be as shown on attached drawing No. GE–500–501.

E–1*b*(2). ***Water draw-off connection.*** Each water draw-off shall be equipped with a suitable valve. Sizes of the water draw-off are tabulated below. Installation details are shown on attached drawing No. GE–500–501.

E–1*b*(3). ***Tank clean-out.*** The clean-out shall be 24 inches by 24 inches and shall be located flush with the bottom of the tank.

Size of tanks, in barrels	10,000	5,000	1,000 High	1,000 Low	500 Low	250	100
Size, in inches, of fill and delivery connections	8 6 4	8 6 4	6 4	6 4	6 4	6 4	6 4
Size, in inches, of water draw-off connections	4	4	2	2	2	2	2

E–2. ***Gasket material.*** Shall be synthetic rubber suitable for use with 100-octane gasoline containing 40 percent aromatics, or 130-octane aviation gasoline, and shall be approved by the Naval Research Laboratory, Anacostia Station, Washington, D. C. The gasket material shall be free from defects in material and workmanship and shall have smooth surfaces; however, a slight fabric imprint on the surface of the material is permissible. The material shall be 0.090 inch thick plus 0.016 inch or minus 0.008 inch. The gasket material shall have the following physical requirements:

Shore hardness	75+5
Tensile strength	900 psi minimum
Elongation	200 percent minimum
Aging: tensile strength	75 percent of normal

Aviation Fuel Immersion (Army-Navy Specifications AN–813)

Volume increase	70 percent of normal-maximum
Tensile strength	75 percent of normal-minimum
Elongation	65 percent of normal-minimum
Compression set	25 percent-maximum
Ply separation	None

Aviation Fuel Immersion (100 octane-zero percent aromatics)

Volume increase	5 percent minimum
Brittle point	40° C.

E–3. ***Sealing cement.*** Shall be approved by the Naval Research Laboratory for use with 100-

octane gasoline containing 40 percent aromatics or 130-octane gasoline and shall be furnished in sufficient quantities to seal all the overlaps in the chimes and along the chimes for the distance of 4 inches on either side of the overlap and on all bottom overlaps. The quantity of sealing cement furnished with each size of tank shall be as follows:

Size of tank, in barrels	*Sealing cement, in gallons*	*Thinner, in gallons*
100	1/2	1/4
250	1	1/4
500 low	1	1/4
1,000 low	1 1/2	1/4
1,000 high	2	1/2
5,000	3	1/2
10,000	6	1

E–4. *Painting, and protection.* Before shipment the inside of the tanks shall be thoroughly cleaned of any traces of paint and shall be given a coating of suitable flushing oil. The outside surface of the tanks, fittings and accessories shall be given one coat of paint in accordance with the latest revisions of Corps of Engineers, Preliminary Specification No. PL–1712. The dried film shall match approximately Corps of Engineers, Tentative Specification T–1213, Supplement B, color card, No. 9, olive-drab.

E–5. *Erection brackets.* Shall be furnished with each tank more than one ring high. The number of brackets to be furnished shall be as follows:

Tank size in barrels	*Number of erection brackets*
1,000 high	14
5,000	26
10,000	37

E–6. *Field erection tools.* Shall be furnished with each tank. Each set of field erection tools shall consist of the following:

3	Speed wrenches
5	1/2-inch short sockets
4	1/2-inch long sockets
3	5/8-inch by 12-inch driftpins
3	5/8-inch by 18-inch driftpins
3	8-inch crescent type adjustable wrenches
2	Deck rope hooks
2	5/8-inch by 6-inch flat cold chisels
2	5/8-inch by 6-inch diamond point chisels
2	1 1/4-pound ball peen hammers
24	Patch bolts
2	3-inch flat paint brushes
1	Ampco metal No. C–3 flat calking tool
1	Ampco metal No. H–3 ball peen hammer

One set of field erection tools shall be furnished with each 100 and 250-barrel tank, and two sets for each tank of all other sizes.

E–7. *Wiping cloths.* Suitable washed wiping cloths for wiping the flushing oil off the inside of the tanks shall be provided with each tank. The quantities of cloths to be furnished with each type of tank are tabulated below.

Size of tank, in barrels	100	250	500, 1,000 high, 1,000 low	5,000	10,000
Wiping cloths, pounds per tank	5	15	25	50	100

E–8. *Instruction manual.* An instruction manual shall be furnished with each tank. The manual shall include instructions for the proper preparation of the tank foundation.

F. METHODS OF INSPECTION AND TESTS.

F–1. *Inspection.* Equipment furnished under this specification will be subject to inspection during and after the process of manufacture by authorized Government inspectors who shall be afforded proper facilities for determining compliance with this specification.

F–2. *Tests for gasket material.* The methods of test for the gasket material shall be as follows:

F–2a. *Hardness.* Hardness shall be determined with a shore durometer, type A. Three plies, superimposed, shall be used for test.

F–2b. *Tensile and aging tests.* Tensile and aging tests shall be made in accordance with Federal Specification No. ZZ–R–601A.

F–2c. *Aging test.* Aging specimens shall be exposed for 168 hours to circulating air in a Geer oven at 158° F.

F–2d. *Aviation fuel immersion.* Test specimens for immersion test shall conform to Figure No. 2 of Federal Specification No. ZZ–R–601a. They shall be immersed in aviation fuel AN–813 at a temperature of 21° to 27° C. for 48 hours. Within 10 minutes after removal from the fuel the tensile strength shall be determined, calculations being based on dimensions just before load application.

F–2e. *Volume increase.* Volume increase shall be measured in accordance with Federal Specification No. ZZ–R–601a.

F–2f. *Water immersion test.* A sample approximately 1 inch by 2 inches shall be immersed in distilled water and boiled for 1 hour. The specimen shall show no surface tackiness, softening, or other indication of solubility and shall retain 90 percent of its original tensile strength.

F–2*g*. *Brittle point*. After cooling at −40° C. in an air bath for 48 hours, a strip of the gasket material 1 inch by 5 inches shall not crack when folded double so that the opposing plane surfaces are in contact with each other to within ½ inch from the fold.

F–2*h*. *Ply separation*. A sample approximately 1 inch by 2 inches shall be immersed in AN–813 fuel for 8 hours. After removal the sample shall be examined to determine evidence of separation into distinct layers or laminations.

F–2*i*. *Compression set*. The method described in A. S. T. M. D.–395–40 T, Method "B," shall be used to determine the compression set.

G. PACKAGING, PACKING, AND MARKING FOR SHIPMENT.

G–1. *Packaging and packing*. Tanks required for oversea shipment shall be packaged and packed in accordance with the requirements of Army-Navy General Specification for Packaging and Packing for Oversea Shipment, No. 100–14A. Tanks required for domestic shipment shall be shipped in such manner as to insure arrival at destination in an undamaged condition, and shall be acceptable to the freight agent in compliance with the current issue of the Consolidated Freight Classification. All equipment and parts shall be suitably protected to insure against damage during transit. The hardware, accessories, nuts, and bolts shall be coated with a suitable rust preventive and wrapped in oil paper. The hardware and acessories shall be packed in separate boxes from the gaskets, nuts, bolts and cement.

G–2. *Marking*. Shall be in accordance with Corps of Engineers, Tentative Specification T–1739, Standard Requirements for Marking Corps of Engineers Shipments.

H. NOTES.

H–1. Copies of this specification may be obtained from the Office, Chief of Engineers, U. S. Army, Washington, D. C.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility or obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Section I

ORGANIZATION

Designation: †------Engineer Petroleum Distribution Company

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			Headquarters platoon					Operating platoon									
	Unit	Technician grade	Company headquarters	Safety section	Laboratory section	Camouflage section	Total Platoon	Platoon headquarters	Far terminal section	Near terminal section	12 pipe line operating section (each)	Maintenance and transportation section	Total platoon	Total company	Attached medical [a]	Aggregate	Enlisted cadre
2	Captain		1				1							1		1	
3	First lieutenant							1		1			2	2		2	
4	Second lieutenant		1	1		1	3					1	1	4		4	
5	Total commissioned		2	1		1	4	1		1		1	3	7		7	
6	Master sergeant, including							1				2	3	3		3	2
7	Master mechanic (342)											(2)	(3)	(2)		(2)	(1)
8	Operating and pipe-line construction foreman (059)							(1)					(1)	(1)		(1)	(1)
9	First sergeant (585)		1				1							1		1	1
10	Technical sergeant, including					1	1			1			1	2		2	1
11	Camouflage supervisor (804)					(1)	(1)							(1)		(1)	
12	Terminal supervisor (485)									(1)			(1)	(1)		(1)	(1)
13	Staff sergeant, including		2	2	2		6				1	1	13	19	1	20	5
14	Assistant safety engineer (486)			(2)			(2)							(2)		(2)	(1)
15	Laboratory assistant (411)				(2)		(2)							(2)		(2)	(1)
16	Medical (673)														(1)	(1)	
17	Mess (824)		(1)				(1)							(1)		(1)	(1)
18	Motor (813)											(1)	(1)	(1)		(1)	(1)
19	Operating and pipe-line construction foreman (059)										(1)		(12)	(12)		(12)	
20	Supply (821)		(1)				(1)							(1)		(1)	(1)
21	Sergeant, including		2				2		1	2		1	4	6		6	
22	Communications (542)		(1)				(1)							(1)		(1)	
23	Dispatcher (materials and equipment) (769)		(1)				(1)							(1)		(1)	
24	Master mechanic (342)											(1)	(1)	(1)		(1)	
25	Terminal operator, assistant (081)								(1)	(2)			(3)	(3)		(3)	
26	Corporal, including		3				3							3		3	1
27	Communications (542)		(1)				(1)							(1)		(1)	
28	Warehouseman (769)		(1)				(1)							(1)		(1)	
29	Clerk, company (405)		(1)				(1)							(1)		(1)	(1)
30 31 32 33	Technician, grade 4 Technician, grade 5 Private, first class Private } including		32		2		34		2	3	9	35	148	36 57 37 52	1 1 1 1	37 58 38 53	1 1
34	Clerk, general (055)	5	(1)				(1)			(1)			(1)	(2)		(2)	
35	Clerk, general (055)		(1)				(1)							(1)		(1)	
36	Cook (060)	4	[b](7)				(7)							(7)		(7)	(1)
37	Cook (060)	5	[b](7)				(7)							(7)		(7)	(1)
38	Cook's helper (062)		[b](12)				(12)							(12)		(12)	
39	Gauger (488)	5							(2)	(2)			(4)	(4)		(4)	
40	Laboratory assistant (411)	5			(2)		(2)							(2)		(2)	
41	Machinist helper (431)	5										[c](4)	(4)	(4)		(4)	
42	Mechanic, repairman (487)	4										(1)	(1)	(1)		(1)	
43	Mechanic, repairman (487)	5										(2)	(2)	(2)		(2)	
44	Operator, air compressor (467)	5										(1)	(1)	(1)		(1)	
45	Patrolman, pipe-line (489)										(4)		(48)	(48)		(48)	
46	Pump station operator (081)	4									(2)		(24)	(24)		(24)	
47	Pump station operator (081)	5									(2)		(24)	(24)		(24)	
48	Repairman, communications (646)	4	(1)				(1)							(1)		(1)	
49	Repairman, communications (646)	5	(1)				(1)							(1)		(1)	
50	Surgical technician (861)	4													(1)	(1)	
51	Surgical technician (861)	5													(1)	(1)	
52	Surgical technician (861)														(2)	(2)	
53	Tractor operator (359)	5										(1)	(1)	(1)		(1)	
54	Truck, driver, heavy (245)	5										(1)	(1)	(1)		(1)	
55	Truck driver, light (345)	5										(8)	(8)	(8)		(8)	
56	Truck driver, light (345)											(13)	(13)	(13)		(13)	
57	Welder, combination (256)	4										(3)	(3)	(3)		(3)	
58	Basic (521)		(2)				(2)				(1)	(1)	(13)	(15)		(15)	
59	Total enlisted		40	2	4	1	47	1	3	6	10	39	169	216	5	221	12
60	Aggregate		42	3	4	2	51	2	3	7	10	40	172	223	5	228	12
61	E Compressor, air, motorized											1	1	1		1	
62	E Shop, motorized, general purpose repair											1	1	1		1	
63	E Tractor, crawler type, gasoline engine driven, w/bulldozer, 35 DBHP.											1	1	1		1	
64	E Trailer, full flat bed, 8 ton											1	1	1		1	
65	E Trailer, 2 wheel, utility pole type, 2½ ton, type I											2	2	2		2	
66	O Carbine, cal. .30, M1A2													175		175	
67	O Gun, machine, cal. .50, HB, flexible										2		24	24		24	
68	O Launcher, grenade, M1													48		48	
69	O Rifle, U. S. cal. .30, M1903													48		48	
70	O Launcher, rocket, AT										1		12	12		12	
71	O Trailer, 1-ton, 2-wheel, water tank, 250-gallon											2	2	2		2	
72	O Truck, ¼-ton											6	6	6		6	
73	O Truck, ¾-ton, weapons carrier											3	3	3		3	
74	O Truck, 2½-ton, cargo											6	6	6		6	
75	O Truck, 2½-ton, cargo, w/winch											6	6	6		6	
76	O Truck, 4-ton, cargo, ponton											1	1	1		1	

18 — Remarks

† Insert number of company.

[a] 1 captain or first lieutenant, Medical Corps; 1 ambulance, ¾-ton, 4 x 4; 1 ambulance driver (699) and 1 ambulance orderly (696) may be provided when two or more petroleum distribution companies are operating independently and no other medical facilities are available, when authorized by the War Department. The medical officer to be authorized only when required and available within the continental United States, will be authorized prior to overseas departure.

[b] Mess personnel provided to operate 12 separate messes (one at each pumping station).

[c] Drives truck (1).

This unit is capable of constructing and operating 120 miles of pipe-line system composed of 12 pumping stations, 2 tank terminals and 2 warehouses. 1 engineer general service company is required when the construction of the pipe line must be completed within a short time.

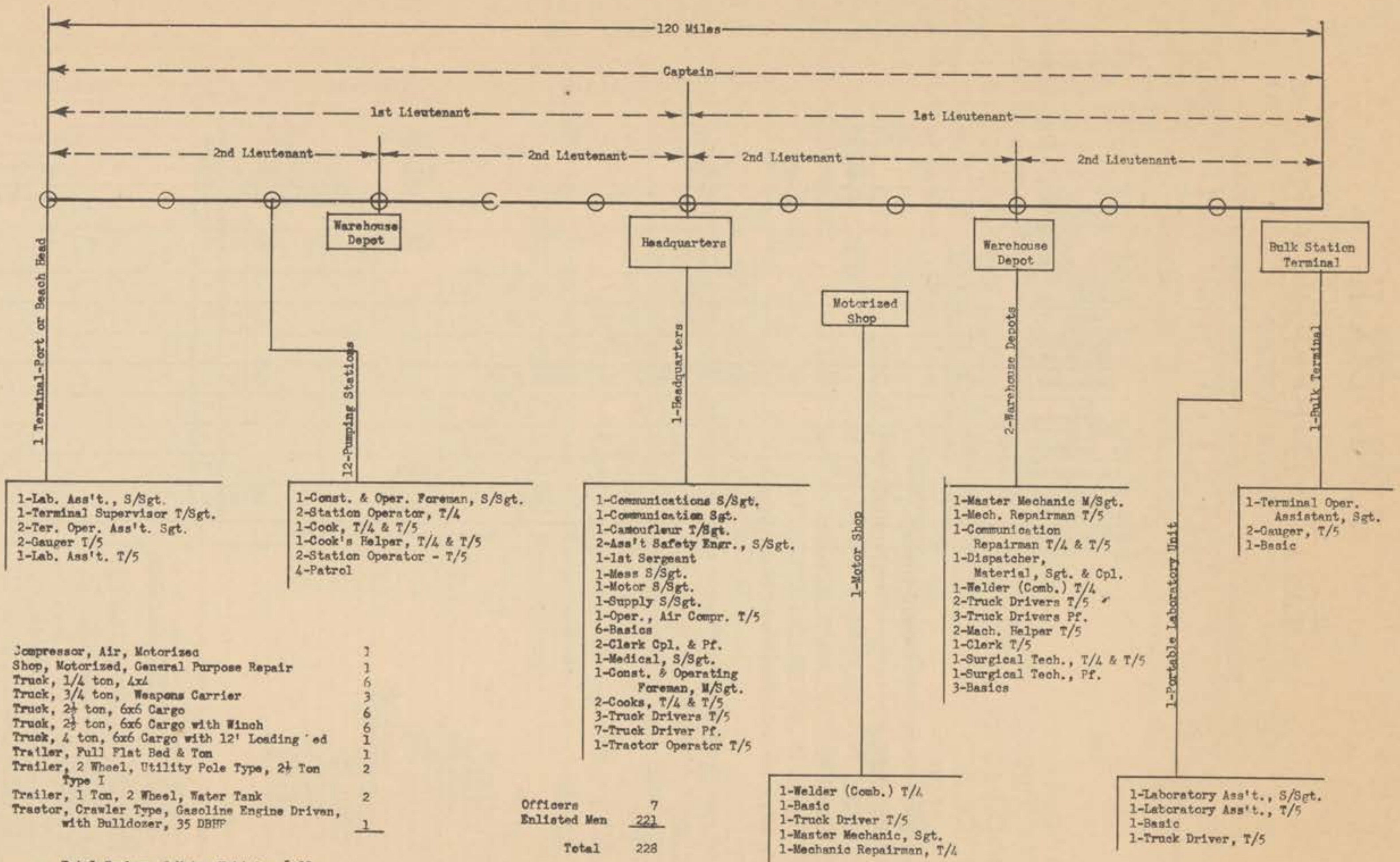
The serial number symbol shown in parentheses is an inseparable part of the specialist designation. See AR 615-26.

Figure 138.

PERSONNEL CHART

FOR

120 MILE LONG, 12 PUMP STATION, ENGINEER PETROLEUM DISTRIBUTION COMPANY



Compressor, Air, Motorized	1
Shop, Motorized, General Purpose Repair	1
Truck, 1/4 ton, 4x4	6
Truck, 3/4 ton, Weapons Carrier	3
Truck, 2½ ton, 6x6 Cargo	6
Truck, 2½ ton, 6x6 Cargo with Winch	6
Truck, 4 ton, 6x6 Cargo with 12' Loading ed	1
Trailer, Full Flat Bed & Ton	1
Trailer, 2 Wheel, Utility Pole Type, 2½ Ton Type I	2
Trailer, 1 Ton, 2 Wheel, Water Tank	2
Tractor, Crawler Type, Gasoline Engine Driven, with Bulldozer, 35 DBHP	1

Total Number of Motor Vehicles - 25

Officers	7
Enlisted Men	221
Total	228

Figure 139.

APPENDIX II
SELECTED REFERENCES

FM 5-10 Communications, Construction, and Utilities.
FM 5-20 Camouflage.
FM 5-21 Camouflage Painting of Vehicles and Equipment.
FM 5-25 Explosives and Demolitions.
FM 21-45 Protective Measures, Individuals and Small Units.
FM 21-105 Engineer Soldier's Handbook.
FM 24-5 Signal Communication.
TM 5-225 Rigging and Engineer Hand Tools.
TM 5-230 Topographic Drafting.
TM 5-235 Surveying.
TM 5-236 Surveying Tables.
TM 5-240 Aerial Phototopography.
TM 5-269 Materials for Protective Concealment.
TM 5-280 Construction in the Theater of Operations.
TM 5-281 Construction in the Theater of Operations.

U. S. GOVERNMENT PRINTING OFFICE : 1943