RESTORING WET PIC CABLE USING AIR DRYING

CONTENTS PAGE

1. GENERAL

1.01 This section covers the methods to be used for removal of water from buried or underground ***pressurized PIC cable***, using the Forced Air Restoration Method (FARM).

1.02 This section is revised to include the use of liquid nitrogen cylinders as the recommended air source for the FARM system. Since this is a general revision, arrows normally used to indicate changes have been omitted.

1.03 The FARM system will restore wet PIC cable, but it does not in any way prevent the re-entry of water into the cable sheath. The water entry points ***must be located and repaired*** if FARM is to be effective over a long term.

1.04 The air drying method of restoring wet PIC cable is a two-step process which consists of:

- Injecting high-pressure air into the air core cable, thereby forcing the bulk of the water out of the cable at selected vent points.
- Forcing massive amounts of dry air through the air spaces in the cable core to evaporate the residual water. This step is continued until the moisture level of the air exiting from the cable vent points is reduced below a specified humidity value.

1.05 The drying time for this process is directly related to the rate at which the dry air is forced through the cable. The pressure at the inlet should be as high as the cable or splice case will withstand safely (see Precautions, Part 2).

1.06 Water in the core of a cable with insulation defects can cause defective pairs because of low insulation resistance and/or foreign voltages. Generally, if there are conductor insulation defects, water in the cable core will cause insulation resistances less than 1 megohm.

1.07 If a wet condition is detected early, buried or underground pressurized PIC cables that are giving unsatisfactory service may be restored by the air drying method to their prior condition rather than replaced. However, opens resulting from long-term electrolytic reactions cannot be restored. Measurements of insulation resistance (IR) and foreign voltages on conductors may determine if cable restoration is needed.

1.08 Since the PIC cable is restored to its prior condition, FARM is considered a restoration rather than a reclamation process. Methods for reclaiming wet nonpressurized PIC cable using reclamation compounds are covered in Section 629-295-312 of the Bell System Practices.

2. PRECAUTIONS

2.01 If the air pressure is injected through a splice case, the inlet splice case as well as the exit splice cases should be flash tested (Section 633-400-200) after closing and sealing.

2.02 The cable at the high-pressure inlet should not be exposed to direct sunlight or other heat sources. Heat from these sources may weaken the polyethylene sheath and may result in ruptured sheaths from the restoration pressures.

2.03 The maximum allowable pressure limits when air is injected through a splice case or directly into the cable are as follows:

POUNDS PER SQUARE INCH (PSI)	INLET POINT ARRANGEMENT
25	Plastic splice case
25	Lead sleeve closure
35	Cast iron splice case
50	Through F pressure flange directly into cable core.

2.04 Follow the procedures outlined in Section 620-140-501 when it is necessary to enter a manhole.

DANGER: When the liquid nitrogen method is used, refer to Section 620-140-501 for manhole venting procedures. Nitrogen escaping from the exit opening will displace normal air without warning and can cause asphyxiation in a confined area without adequate ventilation.

2.05 Even with the maximum pressure limits observed, there is still a remote possibility of rupturing a splice case when high-pressure air is injected. Therefore, ***the following precautions should be observed:***

(1) Prior to pressurization, splice case bolts should be replaced with new bolts.

(2) A length of 1/2-inch construction chain (Section 081-020-100) should be wrapped around the splice case and hooked to contain the case if the bolts fail.

(3) Workers ***must not*** be in the manhole or splice pit during the period the splice case is under high pressure. If it is necessary to enter the manhole during the drying process, the pressure should be reduced to 10 psi.

(4) Transducers and contactors used to monitor the pressure should be pneumatically disconnected during restoration.

3. SELECTION OF CABLE FOR RESTORATION

3.01 The requirements that must be met before using the air drying method for restoring wet PIC cable are as follows:

- Pressurized buried double sheath or underground cable
- Water entry—probably a singular occurrence
- Water entry point is or has been repaired
- Air drying should be used on nonpressurized cable only when the added capacitance of reclamation compound is detrimental to circuit performance (eg, cable with special service circuits).

3.02 Factors that should be taken into account in selecting the most favorable length of cable for restoration are:

- The length of cable suspected of containing water
- Slope of the terrain
- Location of splice cases in the section
- Pneumatic resistance of the section.

3.03 If the length of cable suspected of containing water is such that the resulting distance between an air inlet and exit would be greater than 1000 feet, the section should be subdivided.

3.04 When the suspected wet cable section is on a downgrade, the dry air should be introduced at a point above the wet section. This takes advantage of the effect of gravity on the bulk water.

3.05 The length of a cable section for restoration should be chosen so the moist air will not be forced through a splice. The distance between any two splices defines the maximum length of a section to be restored, provided the length of the section does not exceed 1000 ft.

3.06 Sections of suspected wet cable having a total pneumatic resistance value larger than 0.4 should be subdivided. (Refer to Section 637-020-020.) The restoration process then should be applied to each subdivided section.

4. RESTORATION EQUIPMENT AND ARRANGEMENTS

4.01 The FARM system for removal of water from buried or underground pressurized cable consists of the following two methods:

- Liquid nitrogen method (recommended)
- Compressor and air dryer method.

A. Liquid Nitrogen Method

4.02 Liquid nitrogen cylinders contain approximately 18 times as much nitrogen as the conventional 224 cubic foot nitrogen tank and are intended for use when large amounts of nitrogen or dry air are required. Refer to Section 637-300-102 for the description, precautions, and use of liquid nitrogen cylinders.

4.03 Arrangements must be made with the supplier of liquid nitrogen to deliver the cylinders to the exact placing location. This location must have a firm and level surface and be situated adjacent to a support for securing the cylinder.

4.04 The recommended equipment and arrangement of connections for restoration by vaporization using liquid nitrogen cylinders is shown in Fig. 1.

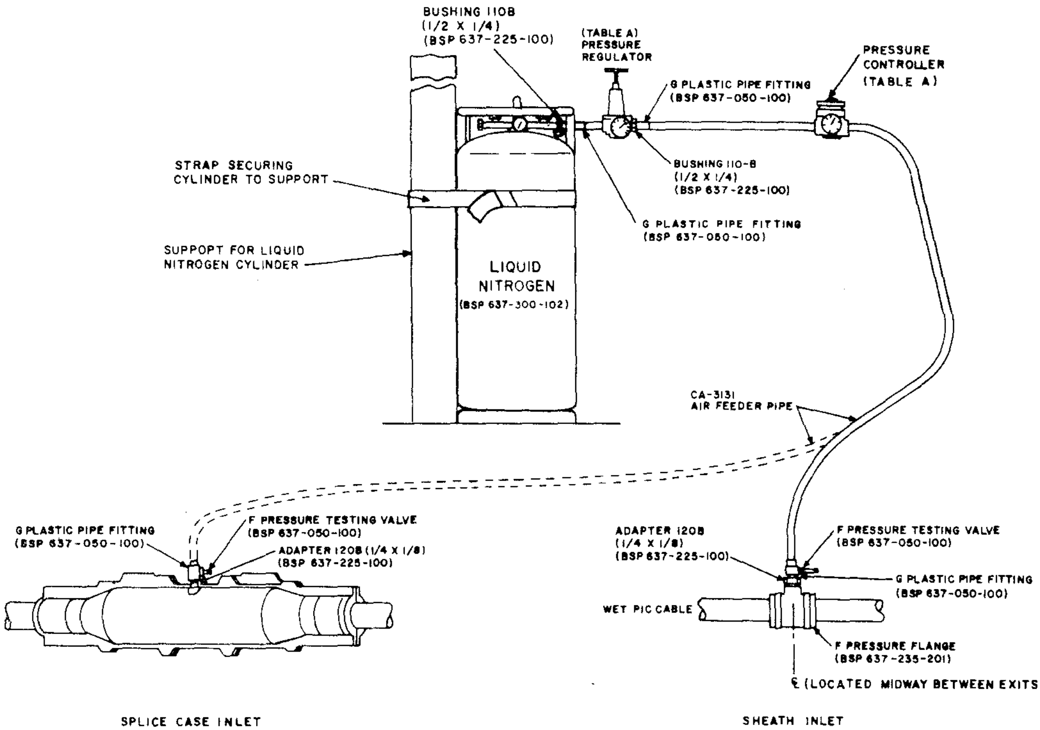

Fig. 1—Equipment Arrangement for Water Removal From PIC Cable (Liquid Nitrogen Method)

4.05 Equipment required for this method of cable restoration is listed in Table A. The listing of specific equipment in Table A does not imply that other equipment that meets the generic requirements is not equally suitable.

TABLE A

EQUIPMENT MANUFACTURERS AND SPECIFICATIONS (NOTE 1)--LIQUID NITROGEN METHOD

	(NOTE 2) CODE	(NOTE 3) MODEL NO.	DESCRIPTION	SPECIFICATIONS	ADDRESS
Liquid Nitrogen Cylinders	LN1	ARGL-45	AIRCO Liquid Nitrogen Cylinder	325 Scfh Storage Capacity 3630 Dry (Cu/Ft) Full Weight 524 lbs.	AIRCO 70 Diamond Road Springfield, NJ 07081
	LN2	PGS-45	LINDE Liquid Nitrogen Cylinder	250 Scfh Storage Capacity 3640 Dry (Cu/Ft) Full Weight 524 lbs.	LINDE Union Carbide Corp. Linde Division 270 Park Ave., NY, NY 10017
	LN3	VGL-160-L	AIR PRODUCTS Liquid Nitrogen Cylinder	325 Scfh Storage Capacity 3630 Dry (Cu/Ft) Full Weight 524 lbs.	AIR PRODUCTS 407 7th Street, NW New Prague, Minnesota, 56071
Pressure Regulators	PRI	11-002-067	Norgren General Purpose Industrial Regulator	1/2" NPT I/O, 2-125 Psi	C.A. Norgren Co. 5400 S. Delaware Littleton, Col 80120
	PR2	2001-4G	Wilkerson Pressure Regulator (with gauge	1/2" NPT I/O, 3-125 Psi	Wilkerson Corp. P. O. Box 1237 Englewood, Col 80110
	PR3	8804G	Rego Airline Regulator (with gauge)	1/2" NPT I/O,	REGO 1201 W. Patterson Ave. Chicago, Ill 60646
Pressure Controller	DC1	2302-1	Wilkerson Dial Air Pressure Controller (with gauge)	1/2" NPT I/O, 3-160 Psig	Same as PR2

Notes:

1. The equipment listed in this table is not to imply that other equipment that meet the requirements are not equally suitable.

2. The codes listed in this column are for reference only and are not associated with the manufacturers identification.

3; When ordering equipment, specify both the model number and the complete description.

4.06 The setting of equipment components is shown in Table B.

TABLE B

EQUIPMENT COMPONENT SETTINGS
(LIQUID NITROGEN METHOD)

LIQUID NITROGEN CYLINDER LN*	DIAL AIR PRESSURE CONTROLLER DC1*	PRESSURE REGULATOR PR*
Refer to Section 637-300-102 for control settings	Splice Case Inlet – 37 Psi Sheath Inlet – 52 Psi	Adjust to maintain a minimum of 60 psi

* Refer to Table A

4.07 A graph of approximate flow rates for various pneumatic resistance units of PIC cables is shown in Fig. 2. ***When air flows away from the inlet in two directions, the required capacity is the sum of the flow rates obtained using the total pneumatic resistance in each direction.***

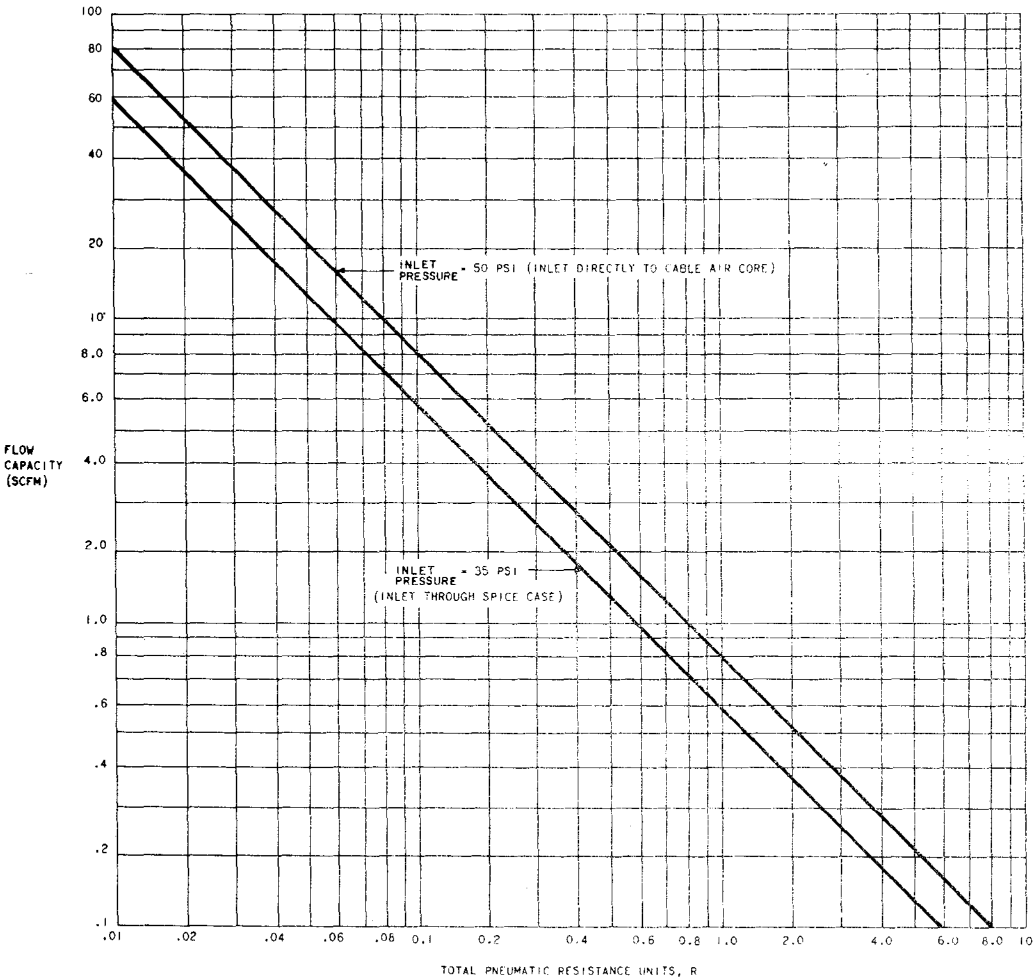

Fig. 2—Airflow Rates as a Function of Pneumatic Resistance Units for Given Inlet Pressures

4.08 By manifolding (as shown in Fig. 3), a second cylinder can be used to accelerate the completion of a particular restoration project. Even when the additional capacity is not required, the second cylinder is recommended to be on-line to ensure continuous service.

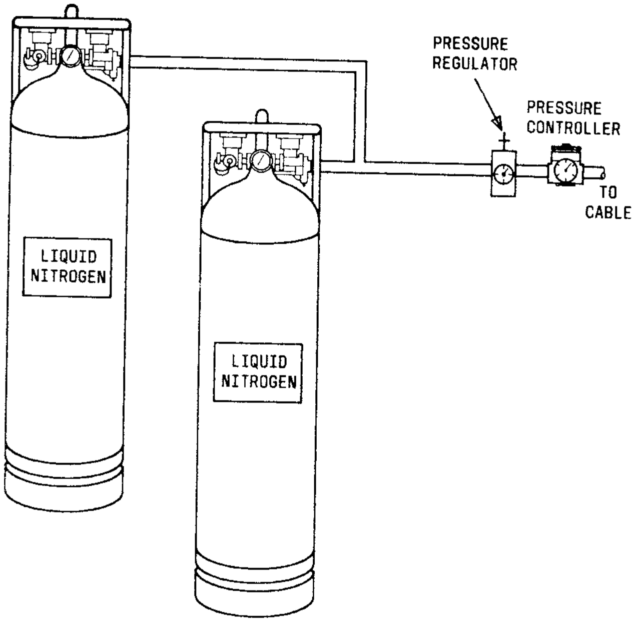

Fig. 3—Manifolding Arrangement to Provide Increased Flow Capacity (Liquid Nitrogen Method)

B. Compressor and Air Dryer Method

4.09 The recommended equipment and arrangement of connections for restoration by vaporization using the compressor and air dryer method is shown in Fig. 4.

4.10 Equipment required for this method of cable restoration is listed in Table C. ***The listing of equipment in this table does not imply that other equipment that meets the generic requirements is not equally suitable.***

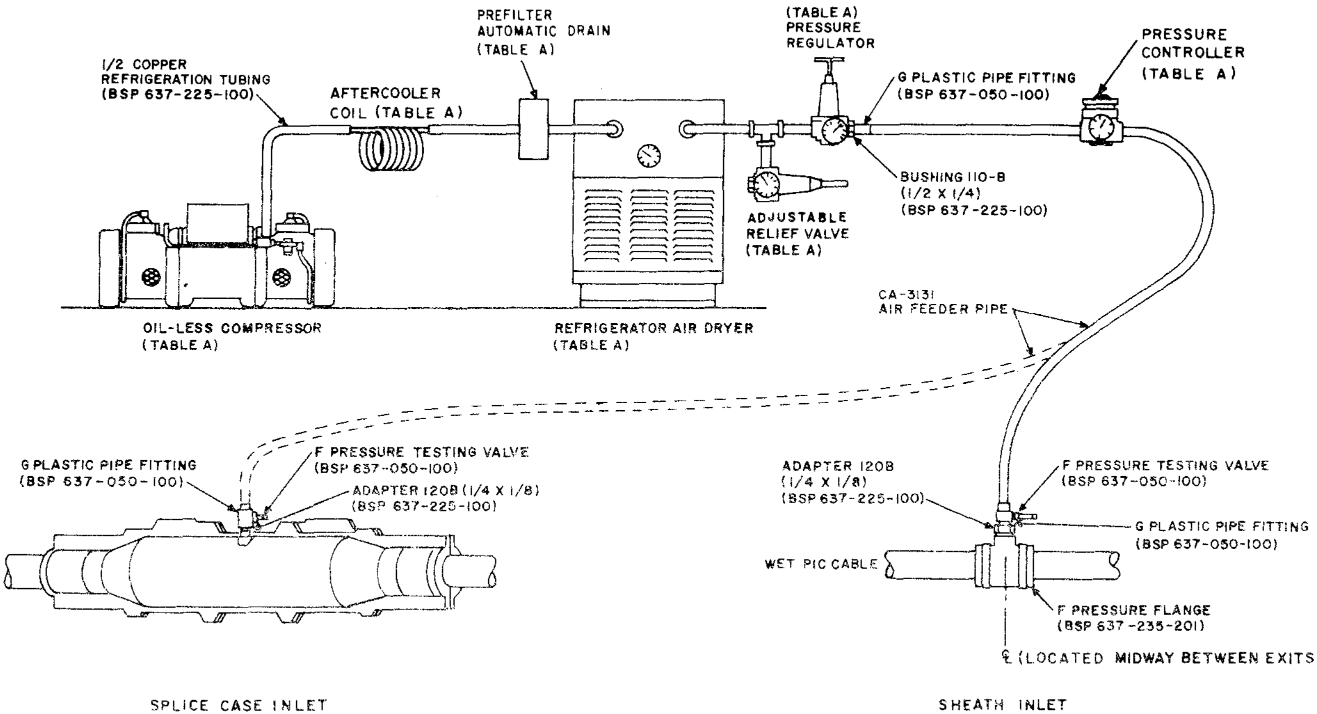

Fig. 4—Equipment Arrangement for Water Removal From PIC Cable (Compressor and Air Dryer Method)

TABLE C

EQUIPMENT MANUFACTURERS AND SPECIFICATIONS (NOTE 1)–COMPRESSOR AND AIR DRYER METHOD

	(NOTE 2) CODE	(NOTE 3) MODEL NO.	DESCRIPTION	SPECIFICATIONS	ADDRESS
Oil-less Compressor (Note 4)	C1	7HDD	GAST Tankless Motor Compressor (with thermal protection, check valve, and safety valve)	9.1 Scfm 1-1/2 HP, 115-230V, Single Phase, Single Stage—100 psi, 65 lbs.	Gast Manufacturing Corporation P. O. Box 97 Benton Harbor, Mich 49022
Refrigeration Air Dryers	R1	25 Scfm	Rego Refrigeration Air Dryer (with low ambient control)	25 Scfm, 1/4 HP, 115V/60 85 lbs, 17" × 17" × 15"	REGO 4201 W. Patterson Ave. Chicago, Ill 60646
	R2	25 Scfm	Kellogg-American Compressed Air Dryer with: 1. Refrigerant Analyzer 2. Air Pressure Gauge 3. Amber Running Light 4. High Temperature warning Light 5. Automatic Condensate Trap 6. Inlet Temperature Gauge 7. Low Ambient Control 8. Dryer Stand	25 Scfm, 1/4 HP 115V/60 Hz/1 PH, 190 lbs, 20" × 21" × 15"	Kellogg-American, Inc. 565 Cedar Way Oakmont, Pa 15139
Pressure Regulators	PR1	11-002-067	Norgren General Purpose Industrial Regulator	1/2" NPT I/O, 2-125 Psi	C.A. Norgren Co. 5400 S. Delaware Littleton, Col 80120
	PR2	2001-4G	Wilkerson Pressure Regulator (with gauge	1/2" NPT I/O, 3-125 Psi	Wilkerson Corp. P. O. Box 1237 Englewood, Col 80110
	PR3	8804G	Rego Airline Regulator (with gauge)	1/2" NPT I/O	Same as R1

TABLE C (Contd)

EQUIPMENT MANUFACTURERS AND SPECIFICATIONS (NOTE 1)—COMPRESSOR AND AIR DRYER METHOD

	(NOTE 2) CODE	(NOTE 3) MODEL NO.	DESCRIPTION	SPECIFICATIONS	ADDRESS
Adjustable Bleed Regulator	B1	16-001-034 Gauge No. 18-013-203	Norgren Diaphragm Type Spring Adjustable Relief Valve	1/2" NPT I/O, 2-125 Psi	Same as PR1
Humidity Indicator	H1	15-9315	Minireader Kit	10% to 100% Relative Humidity ±3% RH, 5" × 4-5/8" × 2-7/8"	Hygrodynamics, Inc. 949 Selim Rd. Silver Springs, Md. 20910
After-cooler			A suitable aftercooler can be constructed locally by forming several turns of 1/2-inch id copper tubing into a helix approximately 1 foot in diameter. At least six turns should be used to provide adequate cooling.		
Pressure Controller	DC1	2302-1	Wilkerson Dial Air Pressure Controller (with gauge)	1/2" NPT I/O, 3-160 Psig	Same as PR2
Prefilter (Note 5)	P1	F02-400-A3 A3T	Norgren Industrial Airline Filter (with Automatic Drain)	1/2" NPT I/O, 2-215 Psi	Same as PR1

Notes:

1. The equipment listed in this table is not to imply that other equipment that meet the requirements are not equally suitable.
2. The codes listed in this column are for reference only and are not associated with the manufacturer's identification.
3. When ordering equipment, specify both the model number and the complete description.
4. Adequate capacity for 500-foot cable length and one-direction airflow.
5. Do not confuse this filter with the automatic condensate trap and drain used with dryer.

4.11 Arrangements must be made to provide power source at site. The equipment operates from 120-volt, single-phase, 60-Hz power, with a current capability of 50 amperes.

4.12 More detailed generic specifications for the equipment required for this method of cable restoration are described in Part 9. Also outlined in Part 9 are instructions and settings of equipment components.

4.13 By manifolding (as shown in Fig. 5), a second compressor can be used to accelerate the completion of a particular restoration project. Even when the additional capacity is not required, the second compressor is recommended to be on-line to ensure continuous service in case one compressor malfunctions.

> ***Note:*** The air dryer must be capable of this increased capacity.

5. LIMITATIONS

5.01 When outside ambient temperatures are expected to drop below freezing (+32°F), the air delivery line between the air dryer or cylinder and the cable should be wrapped with a suitable insulating material to preclude the possibility of the moisture condensate freezing in the air line. A variety of insulating tapes may be obtained locally from refrigeration equipment dealers for this purpose.

5.02 The equipment shown in Fig. 3 and Fig. 5 should not be subjected to temperatures below 40°F or above 110°F.

5.03 The air drying method should not be used when cable temperature, ie, the ground temperature at cable depth, is lower than 35°F.

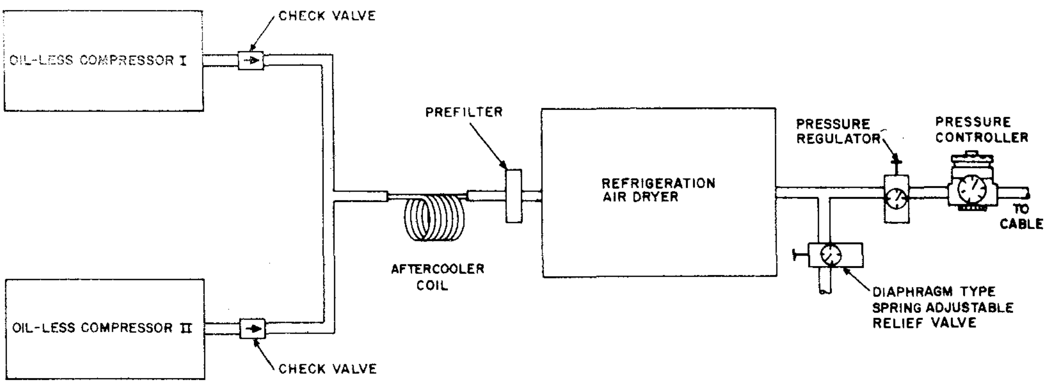

Fig. 5—Manifolding Arrangement to Provide Increased Flow Capacity (Compressor and Air Dryer Method)

6. RESTORATION PROCEDURES (BURIED CABLE)

6.01 A recommended water removal arrangement for wet buried cable is illustrated in Fig. 6.

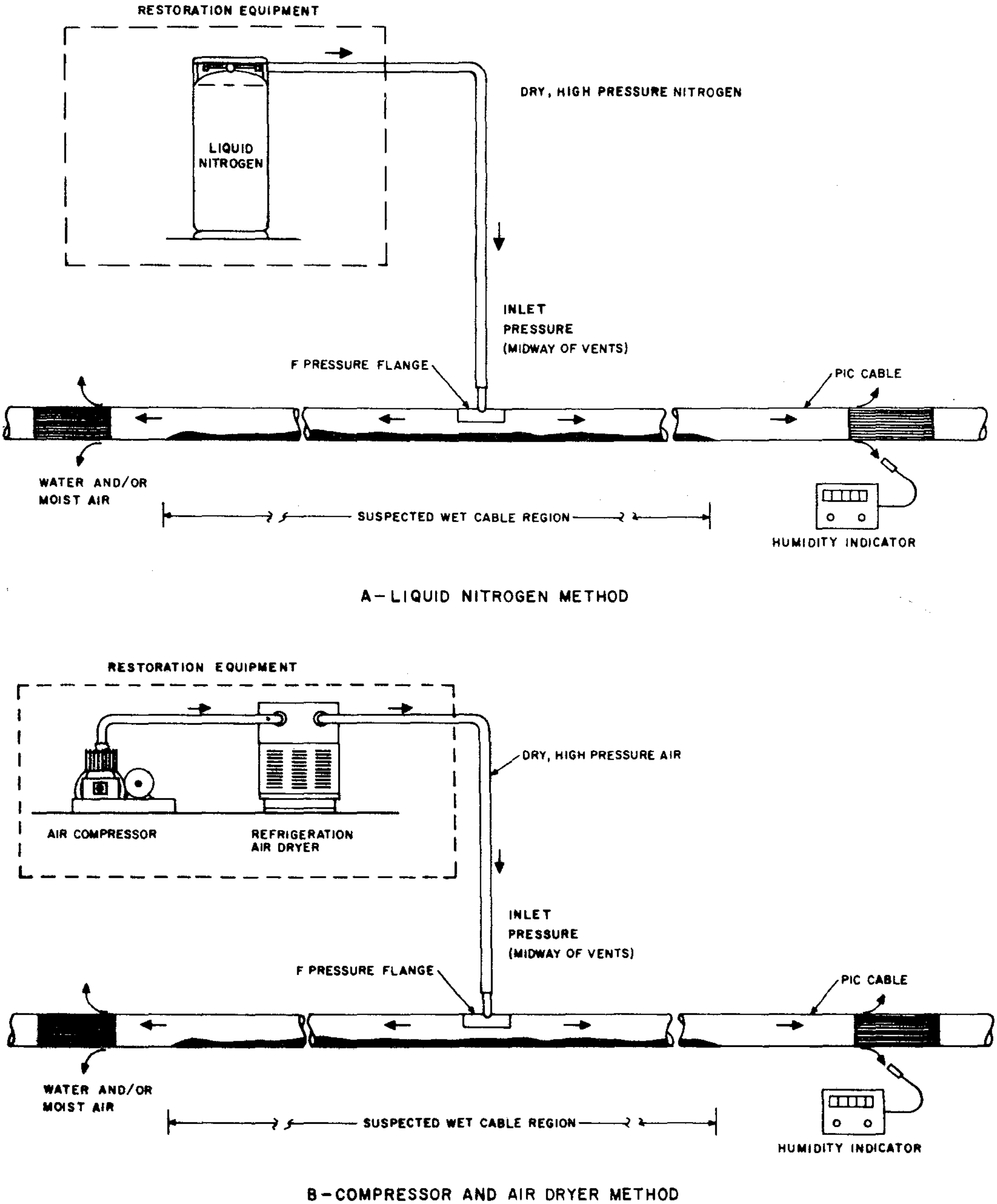

Fig. 6—Water Removal Arrangement for Wet Buried Cable

A. Preparation of Cable

6.02 Proper preparation of the cable is essential for successful restoration. Before restoration procedures are initiated, the following should be considered:

- Any cable sheath damage that will affect the ability of a cable section to hold pressure must be repaired.
- *Circuit Testing:* A sample of any bad pairs that have water-related circuit problems (low insulation resistance) should be identified and tested. These circuits should be tested again as indicated in paragraph 6.10, and periodically during the subsequent vaporization tests.
- Resistance and capacitance measurements should be made on several good cable pairs in the suspected cable section to determine an approximation of the amount of water in the cable. (Refer to Part 8 for details of these measurements.) This is important for planning considerations because cables containing small quantities of water normally can be restored in less time than cables containing large quantities of water.

6.03 Where possible, air should be injected at the middle of the cable section.

6.04 In instances where it is not feasible to select existing access points, an F pressure flange should be installed at the position of forced air inlet. (Installation procedures for the F pressure flange are outlined in Section 637-235-201.) The cable core should be exposed at the exit points either by removing an existing splice case or opening the sheath. After purging, existing or new splice cases should be closed and vented (for moist air to exit) before being left unattended.

> ***Note:*** On cable having PAP or similar sheath, the pressure flange should be placed over the inner polyethylene jacket. No attempt should be made to remove the water trapped between the inner and outer jackets.

6.05 If the wet cable section is pressurized from a single source, a buffer must be incorporated. The buffer is formed by placing a tank of dry nitrogen on the field side of the wet cable section with respect to the pressure source. The tank should be positioned at a distance far enough from the restoration vent to prevent excessive use of nitrogen.

B. Initial Bulk Water Purge

6.06 To remove the bulk of water from the cable, the setup shown in Fig. 1 and 3 or 4 and 5 may be used.

> ***Warning: Do not exceed pressure limits established for splice cases (see Precautions, paragraph 2.03).***

6.07 Connections from the liquid nitrogen cylinder or compressor and air dryer to the inlet point on the cable are made using the pipe and fittings shown in Fig. 1 and 4, respectively.

6.08 When the compressor and air dryer method is used, apply power to the restoration equipment and refer to paragraph 9.04 for details on the proper settings for the pressure regulator relief valves. When the liquid nitrogen method is used, refer to Section 637-300-102 for cylinder control settings and to paragraph 9.04 for pressure regulator and pressure controller settings.

6.09 The initial bulk water purge should be continued until the flow exiting from the cable is in the form of a light mist. At this point, approximately 85 percent of the air core space should be free of water.

6.10 Pairs that were known to have low insulation resistance should be checked from the central office after the first phase of restoration (initial purge). If their electrical integrity has been restored at this point, service also can be restored.

C. Vaporization of Residual Water

6.11 Dry air absorbs most of the remaining water in the cable by vaporization. The moist air transports the water out of the cable, where it exits at the vent points.

When the compressor and air dryer method is used, the air dryer drain must be checked periodically to ensure proper drainage to prevent dryer "freeze-up."

6.12 Dry air is forced into the cable until the moisture level of the air exiting from the cable is reduced below a specified acceptable value.

6.13 If low insulation tested pairs do not test clear after the bulk purge, periodically test for change in insulation resistance.

D. Cable Moisture Level Check

6.14 The moisture level of the air exiting from the cable should be checked periodically to determine if an acceptable moisture level has been reached. The humidity indicator specified in Table C or its equivalent may be used for this check.

DANGER: When the liquid nitrogen method is used, refer to Section 620-140-501 for manhole venting procedures. Nitrogen escaping from the exit opening will displace normal air without warning and can cause asphyxiation in a confined area without adequate ventilation.

6.15 Air exiting from the cable should be directed into a container that houses the humidity sensor. (This is done to prevent moisture from diffusing into or being absorbed from surrounding air.) This container may be a clean 1-gallon can with small air-outlet holes punched in the bottom or lower portion of the sides. The sensor should be positioned near the bottom of the container and several minutes of purge time allowed before readings are made.

Note: Humidity monitoring should not be initiated as long as the moistened air exits from the cable in the form of a mist.

6.16 When the humidity monitor indicates the outcoming air has a moisture level of less than 40 percent relative humidity (rh), a more accurate check is necessary. The inlet pressure must be reduced to 10 psi and, after 15 minutes, another reading taken. ***When the relative humidity of the outlet air at this lower flow rate (10 psi) drops to less than 35 percent rh, the cable is considered dry.***

E. Electrical Testing to Confirm Restoration

6.17 When acceptable moisture levels have been reached (paragraph 6.16), all the known problem pairs are to be rechecked. If no pairs are found to have less than 10 megohms insulation resistance (conductor to ground), the restoration is completed. If suspected water-related problems still exist in the cable section being restored, forced air drying should be continued until the testing indicates that the pairs have cleared.

F. Closing Sheath Openings

6.18 After acceptable moisture levels have been reached and electrical tests have been made to confirm restoration, the sheath openings should be closed and flash tested.

7. RESTORATION PROCEDURES (UNDERGROUND CABLE)

7.01 A recommended water removal arrangement for wet underground cable is illustrated in Fig. 7.

7.02 The restoral procedures for a wet section of underground PIC cable are different from buried PIC in that the section length for restoration is fixed by the manhole-to-manhole spacing. The maximum allowable injection pressure is restricted to 35 psi for cast iron splice cases (paragraph 2.02) and consequently results in a proportionately longer drying time.

7.03 Consider slope of terrain when selecting the air inlet and exit of a section so that the water is forced toward the lower elevations. The dry air should be introduced directly into the splice case on the higher elevation side of the water sections.

A. Preparation of Cable

7.04 Before restoration procedures are initiated, any sheath opening that will affect the ability of a cable section to hold pressure must be repaired, and the considerations outlined in paragraph 6.02 for wet buried cable should be observed.

7.05 In preparation for the initial water purge, the splice cases of the affected cable sheath should be removed in the nearest manhole on each side of the inlet manhole. After purging, these splice cases should be replaced and vented (for the moist air to exit) before being left unattended. This results in a two-direction flow of dry forced air, as achieved in the recommended buried cable arrangement.

> ***DANGER: When the liquid nitrogen method is used, refer to Section 620-140-501 for manhole venting procedures. Nitrogen escaping from the exit opening will displace normal air without warning and can cause asphyxiation in a confined area without adequate ventilation.***

7.06 Plastic splice cases should be replaced with cast iron cases, since the former can only be subjected to pressures up to 25 psi. This replacement also should be made for large lead sleeves when used in lieu of cast iron splice cases.

7.07 If the wet cable section is pressurized by only a single source, a buffer must be incorporated (paragraph 6.05, buried cable preparation).

B. Procedures

7.08 The following procedures are the same for underground cable restoration as are outlined in Part 6 for buried cable restoration:

(1) Initial bulk water purge (paragraphs 6.06 through 6.10)

> ***Warning: Do not exceed pressure limits established for splice cases (Precautions, paragraph 2.02).***

(2) Vaporization of residual water (paragraphs 6.11 through 6.13)

(3) Cable moisture level check (paragraphs 6.14 through 6.16)

(4) Electrical testing to confirm restoration (paragraph 6.17).

8. ELECTRICAL TEST TO DETERMINE MOISTURE CONTENT

8.01 The quantity of moisture contained in a wet cable, as a percentage of the air volume, can be determined by comparing the apparent capacitive length of pairs in the cable section to the resistive length of these pairs.

8.02 A PIC cable full of water will experience a mutual capacitance increase on the pairs of approximately 120 to 140 percent. A pair in a completely wet cable thus will appear to be approximately 2.3 times its normal length when measured with a capacitive length meter such as the Delcon 4910F or equivalent open fault locator. The resistive length of the pairs can be determined by measurement with a Wheatstone bridge or an automatic bridge test set such as the Dynatel 710A, Delcon 4912, or equivalent.

8.03 The problem in this test comes when trying to determine the presence of small percentages of water. Manufacturer variations and measurement error tend to require a ±15 percent tolerance on mutual pair capacitance of individual cables. Therefore, cable moisture content below approximately

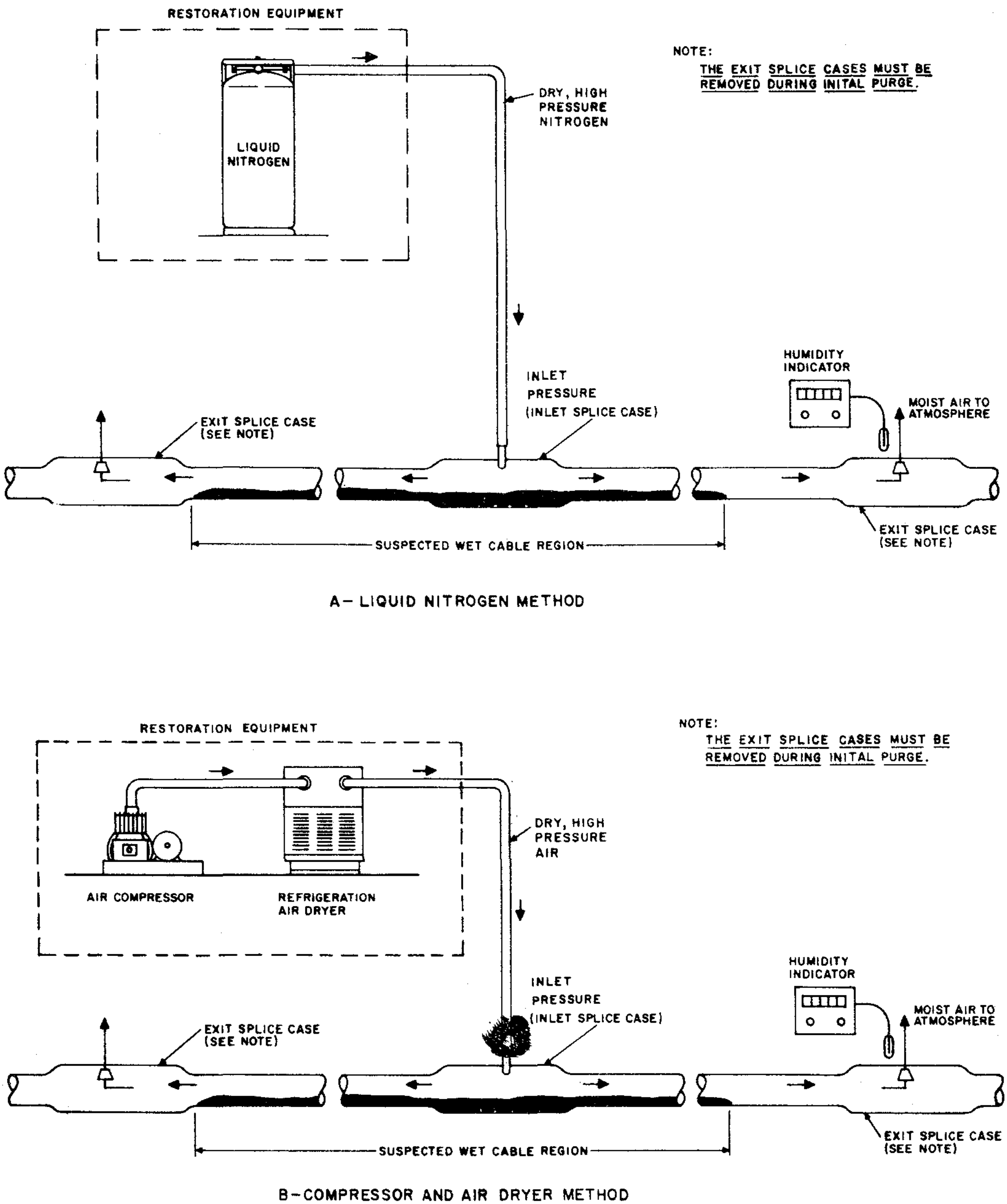

Fig. 7—Water Removal Arrangement for Wet Underground Cable

12 percent may not be readily detectable. However, if the cable contains another section from the same production run as the wet section, it is possible to nearly eliminate the capacitance variation effect from the measurement. This can be achieved by measuring the resistive length of the known dry section and then adjusting the "D FACTOR" control so the 4910F reads exactly the same as the resistive length when connected to the same dry section. When this is done, the 4910F probably can detect moisture content as low as 5 percent (on this cable for which it is calibrated) so long as the "D FACTOR" control is not moved.

8.04 For the purpose of determining the effort required to remove the water from a wet section, the graph shown in Fig. 8 can be used to estimate the percentage water fill. The technique is as follows:

(1) Measure the resistive length of a pair or pairs with an accurate bridge instrument. (Dynatel 710A or equivalent).

(2) Measure the capacitive length of the pair or pairs with a Delcon 4910F open fault locator.

(3) Compare the capacitive length to the resistive length and refer to Fig. 8 to estimate the amount of water in the section.

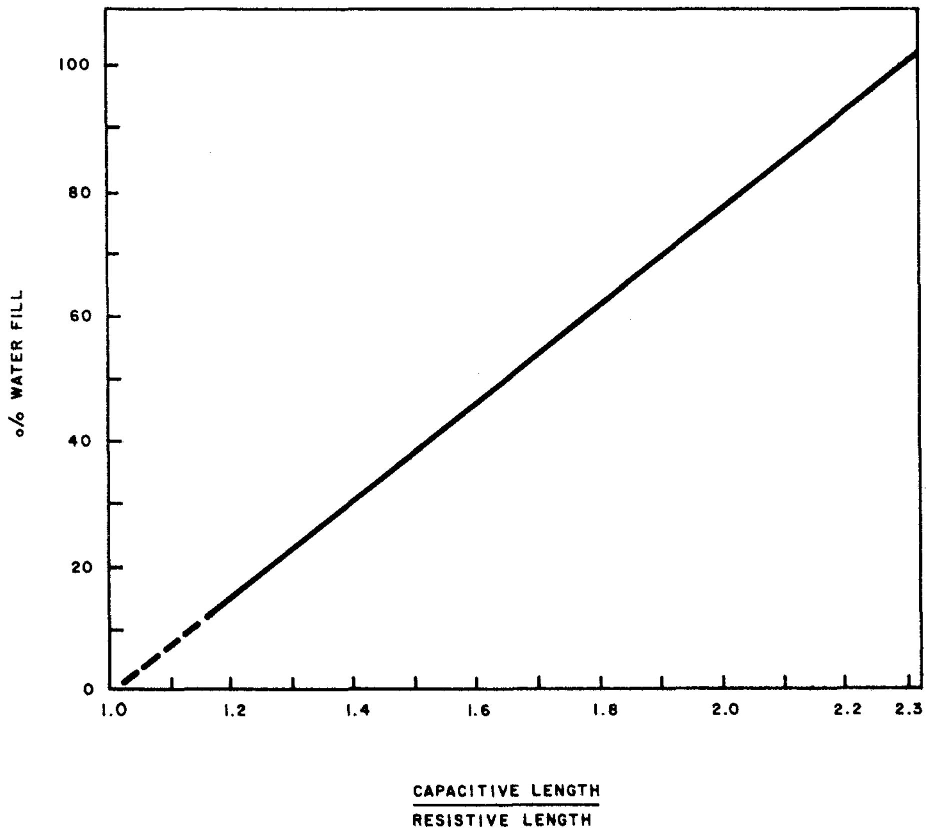

Fig. 8—Graph for Determination of Water Content in Wet PIC Cable

9. DETAILED EQUIPMENT SPECIFICATIONS AND INSTRUCTIONS (COMPRESSOR AND AIR DRYER METHOD)

9.01 The detailed equipment specifications and instructions for equipment settings are covered in this part to aid in selecting components other than those listed in Table A without compromising the functional requirements of the restoration arrangement.

9.02 Equipment mounting is left to the discretion of the operating company. However, if the equipment is placed inside a van during restoration (compressor and air dryer method), adequate ventilation must be ensured to prevent the heat dissipated by the equipment from causing excessive ambient temperatures (eg, leave windows and doors open). When the equipment is used on warm, sunny days, it should be shaded from direct sunlight.

9.03 Positions for quick-disconnects are indicated to simplify on-site assembly if this approach is chosen over permanent mounting to a baseplate, trailer, or van.

A. Dual-Compressor System

9.04 The dual-compressor restoration system is shown in Fig. 9, with recommended component numbers that refer to Table C. The relative dryness of the air delivered by the system depends primarily on the back pressure maintained in the dryer and the pressure at which air is delivered to the cable. Instructions and settings of equipment components are shown in Table D and explained as follows:

(a) ***High Pneumatic Resistance Section:*** The functional requirements imposed upon the regulators and relief valves are different, depending on whether the wet section has a high or low total pneumatic resistance. A high pneumatic resistance section is defined as a section in which the compressor capacity is sufficient to create an inlet pressure greater than the allowable inlet pressure for restoration (eg, greater than 35 psi for splice case entry). For this case the dial air pressure controller should be set to provide the allowable pressure at the inlet to the cable air core. The bleed relief valve should be set at a 75 psi pressure or higher if continuous compressor operation can be maintained (ie, slightly below the upper pressure cutoff). This setup maintains higher pressure at the inlet of the air dryer (higher inlet pressure results in more efficient dryer operation). In a high pneumatic resistance section, the intermediate regulator does not come into play and should be set wide open. This setup should always be used during the bulk purge.

(b) ***Low Pneumatic Resistance Section:*** A low pneumatic resistance section is defined as a section having such a low pneumatic resistance that the available compressor capacity is not capable of creating the objective pressure at the air core inlet. For this case, the pressure controller is set to the inlet pressure merely to prevent unsafe pressures if the flow is obstructed. The intermediate pressure regulator is closed until ***at least a 60 psi pressure is created at the inlet to the air dryer.*** The flow will be restricted somewhat under these conditions, but the higher pressure results in more efficient drying. This is particularly important under cold environmental conditions because the dew point temperature is lowered following expansion through the regulator. The bleed relief valve does not come into play with a low pneumatic resistance section because the compressors are not capable of flow rates necessary to cause pressure relief conditions.

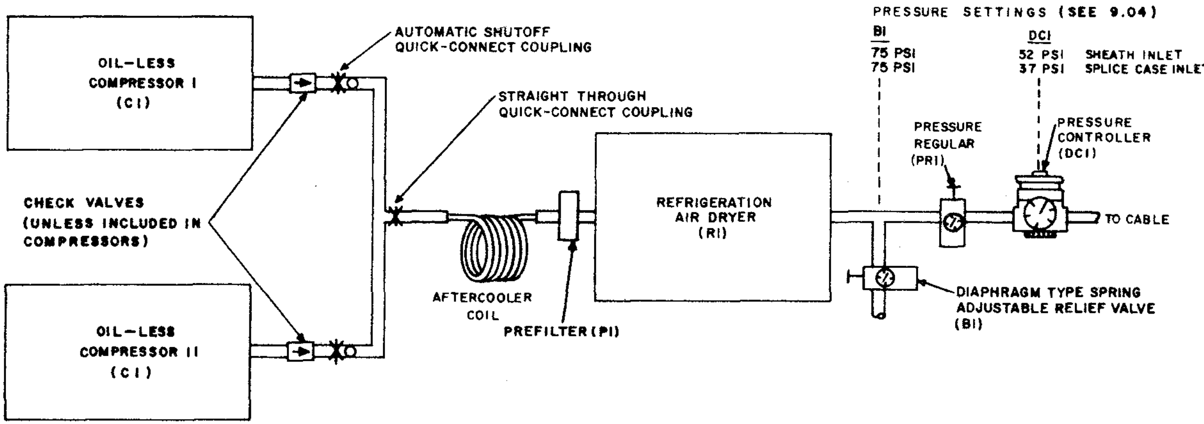

Fig. 9—Restoration Equipment (Compressor and Air Dryer Method)

TABLE D

EQUIPMENT COMPONENT SETTINGS
(COMPRESSOR AND AIR DRYER METHOD)

BLEED VALVE B1*	DIAL AIR PRESSURE CONTROLLER DC1*	PRESSURE REGULATOR PR*
75 Psi	Splice Case Inlet } 37 Psi Sheath Inlet } 52 Psi	Adjust to maintain a minimum of 60 psi at air dryer gauge

* Refer to Fig. 8

9.05 Manifolding of two compressors has the following two advantages:

(1) The flow capacity is increased above 15 scfm, which will provide optimum drying conditions for essentially all cases.

(2) Drying will continue if one compressor malfunctions.

9.06 For cases where one compressor will provide the maximum flow rate needed (eg, flow rate less than 8.2 scfm), the other unit may be unplugged when the equipment is attended.

9.07 Additional flexibility is gained by using self-closing quick disconnects at the compressor outlet. This allows two units to be included only when conditions require the added capacity.

9.08 The aftercooler is necessary to dissipate thermal energy generated during compression so that the temperature of the air entering the dryer does not exceed the specified level.

B. Generic Specifications

9.09 ***Compressor:*** The oil-less compressors should be capable of delivering at least 7.5 scfm at 75 psi, with an output temperature less than 200°F. Compressors should have automatic check valves to prevent reverse airflow.

9.10 ***Air Dryer:*** The refrigeration air dryer should be capable of 15 scfm, 75 psi air at a dew point not greater than 0°F at 14.7 psi when the inlet temperature is 150°F. The air dryer also should have an automatic temperature bypass so the cooling chamber will not freeze at very low flow rates.

9.11 ***Aftercooler:*** The aftercooler must be capable of dissipating enough energy to reduce the outlet temperature of the air from the compressor to the specified inlet temperature of the air dryer (preferably less than 130°F).

9.12 ***Adjustable Relief Valve:*** The adjustable relief valve should be capable of bleed flows up to 15 scfm at 5 to 125 psi. A pressure gauge having the same range also is required (1/2-inch NPT Inlet and Outlet).

9.13 ***Pressure Controller:*** The pressure controller should have an associated gauge and be capable of operating at 150 psi (up to 200°F) and 15 scfm (1/2-inch NPT Inlet and Outlet).

9.14 ***Pressure Regulator:*** The pressure regulator should be industrial quality, having a compatible pressure gauge. The operating range should be 5 to 125 psi at a flow rate of 15 scfm (1/2-inch NPT Inlet and Outlet).

9.15 ***Prefilter:*** The prefilter should be industrial quality, have an automatic drain, and be capable of operating at 150 psi at 200°F and 15 scfm airflow (1/2-inch NPT Inlet and Outlet).