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SHELTER PACKAGE VENTILATION KIT

by

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REVIEW NOTICE

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

FOREWORD

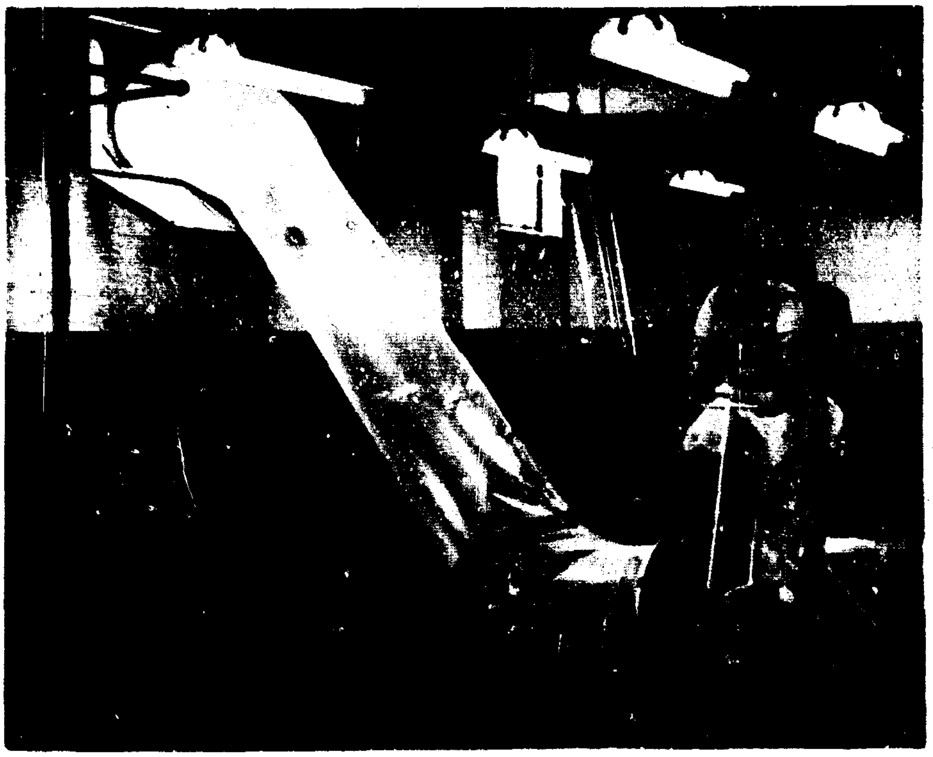
A portable ventilation system for fallout shelters has been developed for the Office of Civil Defense under Contract OCD-PS-64-22. Military Specification MIL-V-40645 (Army-OCD), "PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR DRIVE (CIVIL DEFENSE)", was prepared and issued on 16 August 1965. Additional development work and tests are continuing under Stanford Research Institute Subcontract B-70925(4949A-28)-US.

The authors wish to thank the project monitor, Mr. Robert G. Hahl, Engineering Development Division, Office of Civil Defense, for his guidance during this development program.

ABSTRACT

A portable ventilation system that can be driven manually or by an electric motor was developed for use in Civil Defense fallout shelters. This Package Ventilation Kit includes a Fan Assembly and Drive Modules which can be assembled and operated by untrained personnel.

Specification MIL-V-40645 (Army-OCD), "PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR DRIVE (CIVIL DEFENSE)" dated 16 August 1965 was prepared for possible large volume procurement of this system. The cost of the Fan Assembly and Drive Module is estimated to be $89 and $65 respectively. This estimate is based on one hundred thousand Kits, and does not include freight and warehousing.



Package Ventilation Kit in Operation

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SECTION 1

INTRODUCTION

Certain fallout shelters in the United States require ventilation systems capable of supplying from 5 to about 30 cubic feet per minute of outside air per person sheltered in order to achieve a high confidence of maintaining tolerable conditions of temperature and humidity during hot weather (Ref. 1).

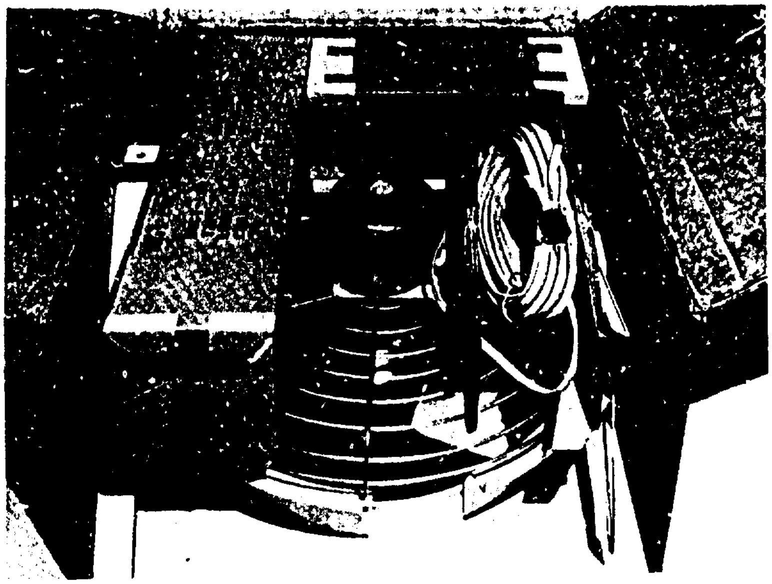
Many shelters with better protection factors, that have been identified in the National Fallout Shelter Survey, are in belowground areas and are not ventilated at all. Since the Office of Civil Defense does not own identified shelters, and since many shelters may be replaced by better shelters as the system is upgraded, the installation of conventional permanent ventilation systems is undesirable. Therefore, OCD required a study of the problems of shelter ventilation and the development of novel ventilation techniques tailored specifically to identified fallout shelters. The goals of this development program are portability, low cost, manual and electric drive, ease and universality of application.

The resulting Package Ventilation Kit (PVK) is a complete packaged mechanical ventilation system that is portable, can be assembled and deployed by untrained personnel, and can be driven either electrically or by human power. The PVK (see Figure 1) consists of two basic packages — a Fan Assembly and Drive Module (see Figure 2).

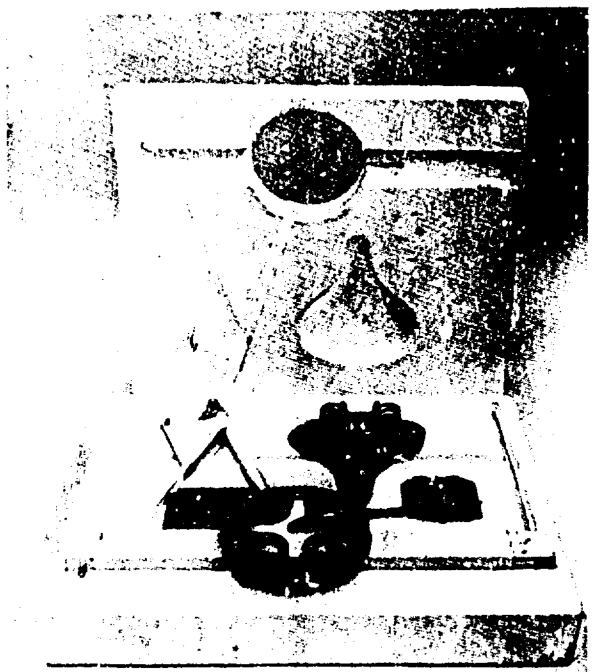
This report discusses the design and the performance of the PVK. The unit has been thoroughly field tested (see Refs. 2 and 3) and no failures occurred

Figure 1 Package Ventilation Kit in Operation

after continuous operation of the unit for two weeks. Specification MIL-V-40645, "PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR DRIVE (CIVIL DEFENSE)", was published by OCD 16 August 1965, based on technical specification data developed by GARD under this contract, and is included as Appendix A. The assembly instructions are presented in Appendix B.



Fan Package



Drive Module Package

Figure 2 PVK Packaging

SECTION 2

DESIGN

2.1 Drive Module

The bicycle-like drive is designed on a modular basis (see Figure 3). The basic dimensions are the same as those of a standard bicycle (see Figure 4). The main structural member of the Drive Module and Fan Assembly is the horizontal "spine". This beam member is fabricated from 2 inch by 3 inch rectangular steel tubing. This configuration was chosen because, in addition to its resistance to bending, it lends itself to a male-female interlocking joint which aligns the Drive Modules and Fan Assembly. Two types of connecting joints, and various methods for locating and locking the spines were designed, fabricated, and evaluated.

2.1.1 Connecting Joint

A flange joint and a swaged-expanded joint, as shown in Figures 5 and 6 respectively, were evaluated.

The flange joint is comprised of flanges welded at each end of the Drive Module and Fan Assembly spines. The separate assemblies are fastened together with threaded studs welded to the flange. The addition of several more parts at each joint - the flanges, studs, nuts, washers and spacers - as well as more welding operations make this joint considerably more expensive than the swaged-expanded joint. Use of the threaded fasteners makes assembly by shelter occupants more difficult and time consuming.

The swaged-expanded joint is fabricated by forming the ends of the spine tubing to size to the correct fit. In production quantities - several thousand

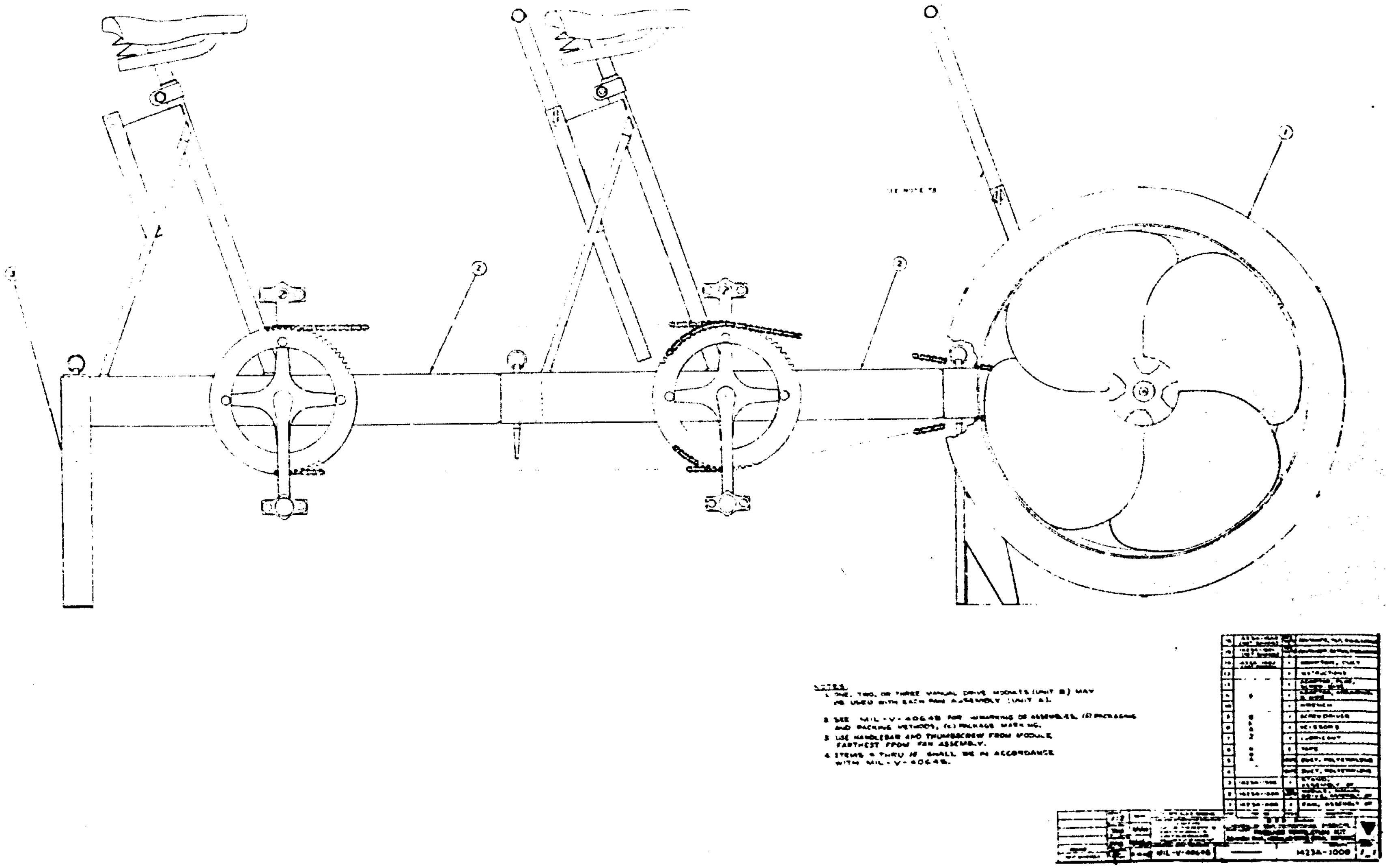


Figure 3 Package Ventilation Kit, 20-Inch Fan, Modular (Civil Defense) (Part No. 1423A-1000)

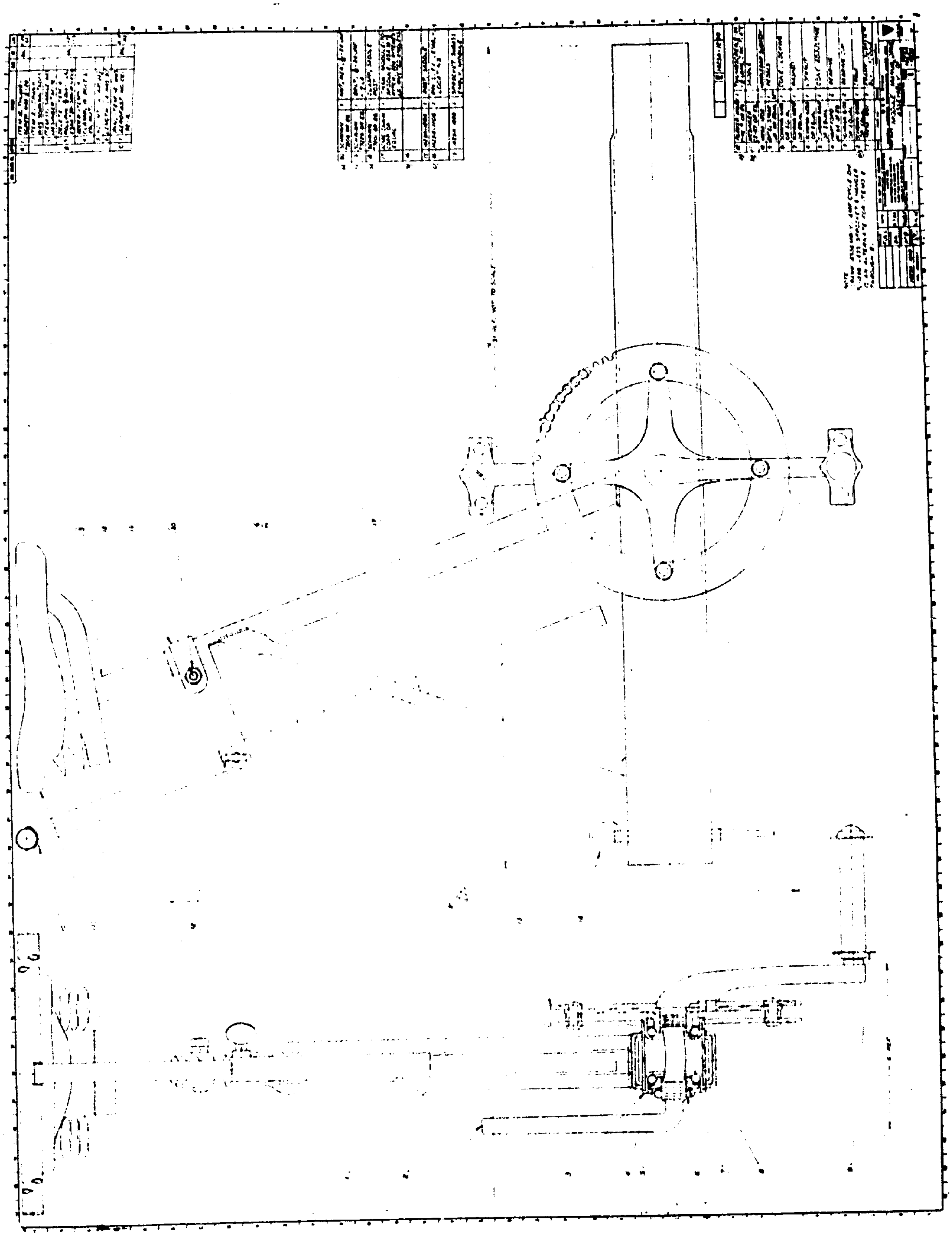


Figure 4 Module Assembly (Part No. 1423A-1200)

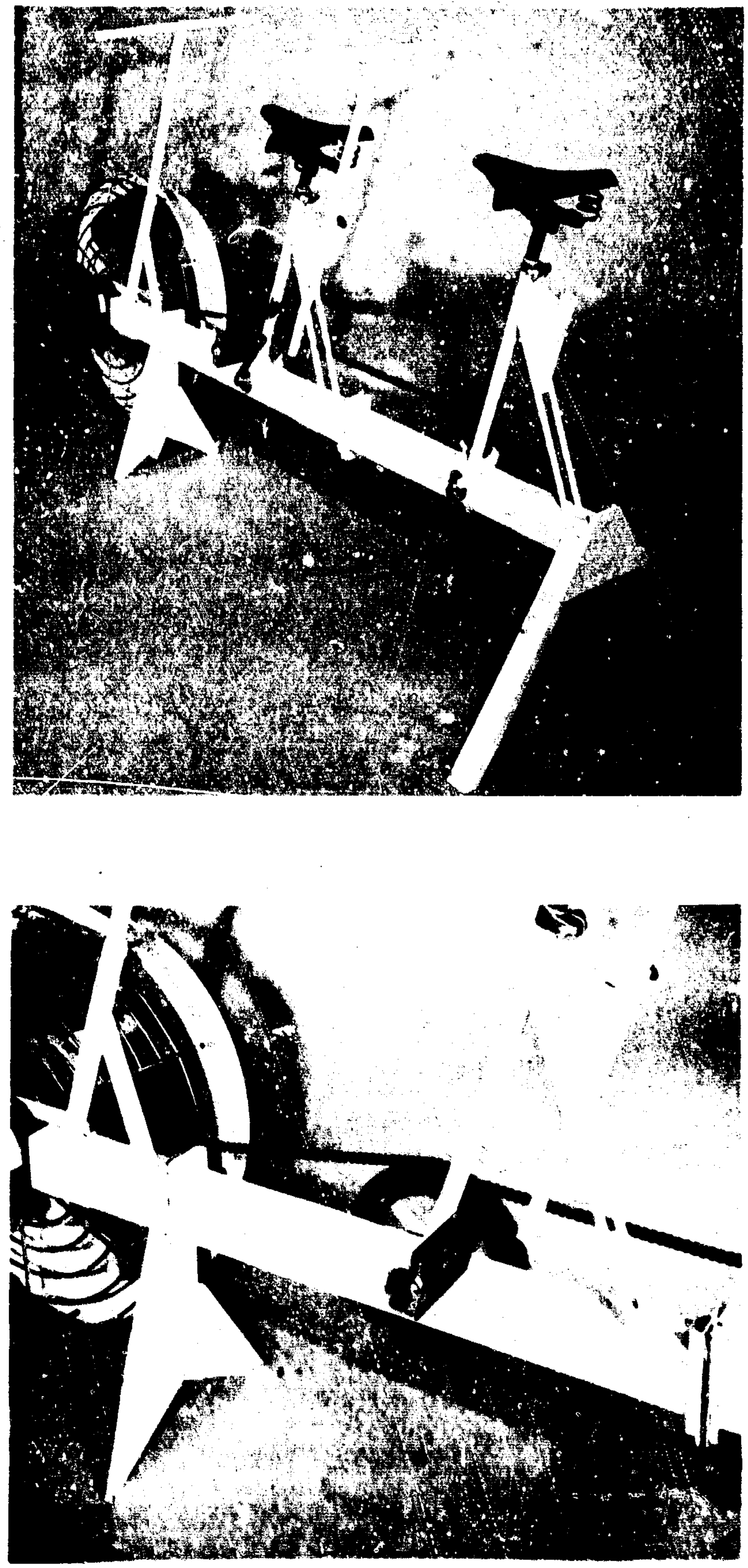


Figure 5 Flange-type Unit

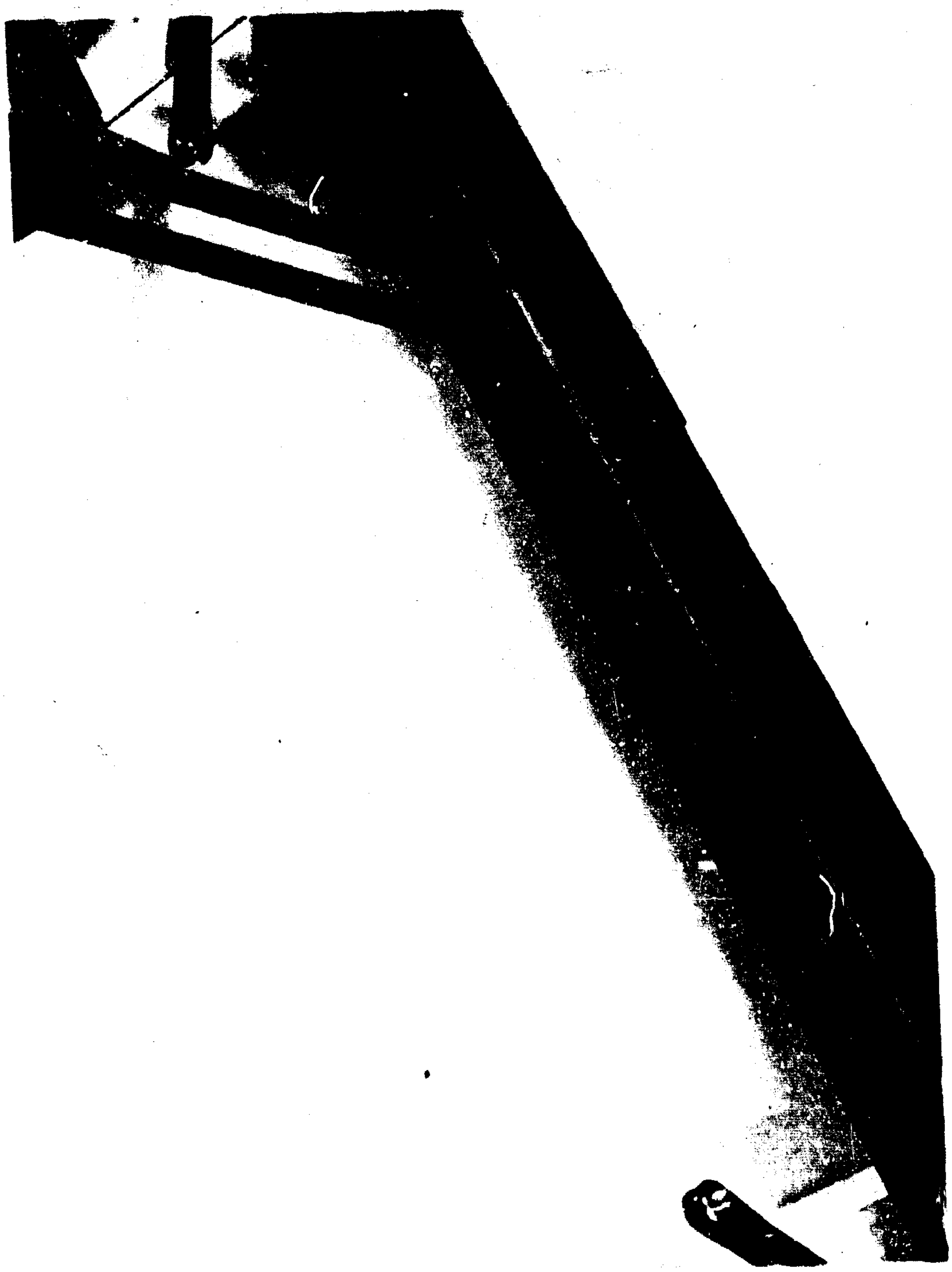


Figure 6 Illustration of Swaged-Expanded Connecting Joint

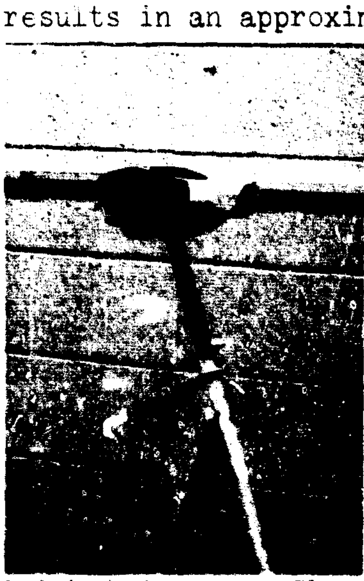
or more to spread the cost of the tooling — this method is the least costly. Production tooling was developed to fabricate the joint parts to permit evaluation. The ease of assembly, alignment and rigidity (Ref. 3, page 16) of the unit is excellent, and therefore the swaged-expanded joint is specified.

2.1.2 Locating and Locking Pin

Of the methods of locating and locking the spines relative to each other (see Figure 7), the tapered pin is best for the PVK application. With this pin the holes in the spines are easily aligned with the tapered end, and the pin is easily inserted because of the long tapered section. The pin is finished with a solid dry-film lubricant to facilitate its insertion in the spine holes.

2.1.3 Saddle Adjustment

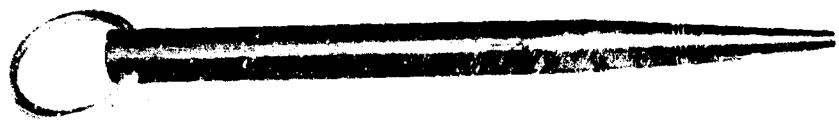
The quick-adjustment clamp (see Figure 8) was included in the preliminary design for rapid height adjustment of the saddles. Tests with people indicated that the rapid adjustment feature was unnecessary (Ref. 4, page 27), and that the standard bicycle saddle mast clamp (see Figure 8) is suitable. This change results in an approximate saving of 83 cents per drive module.



Quick-Adjustment Clamp

Standard Bicycle Clamp

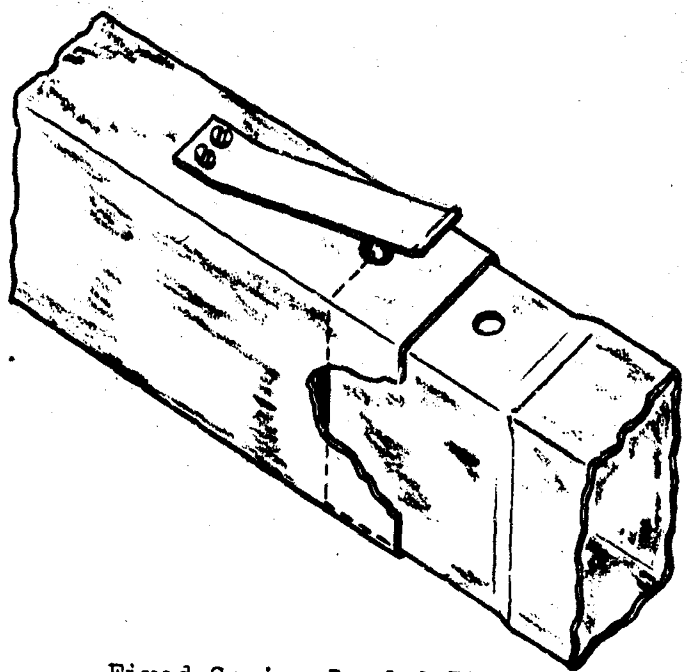
Figure 8 Types of Saddle Adjustment Clamps



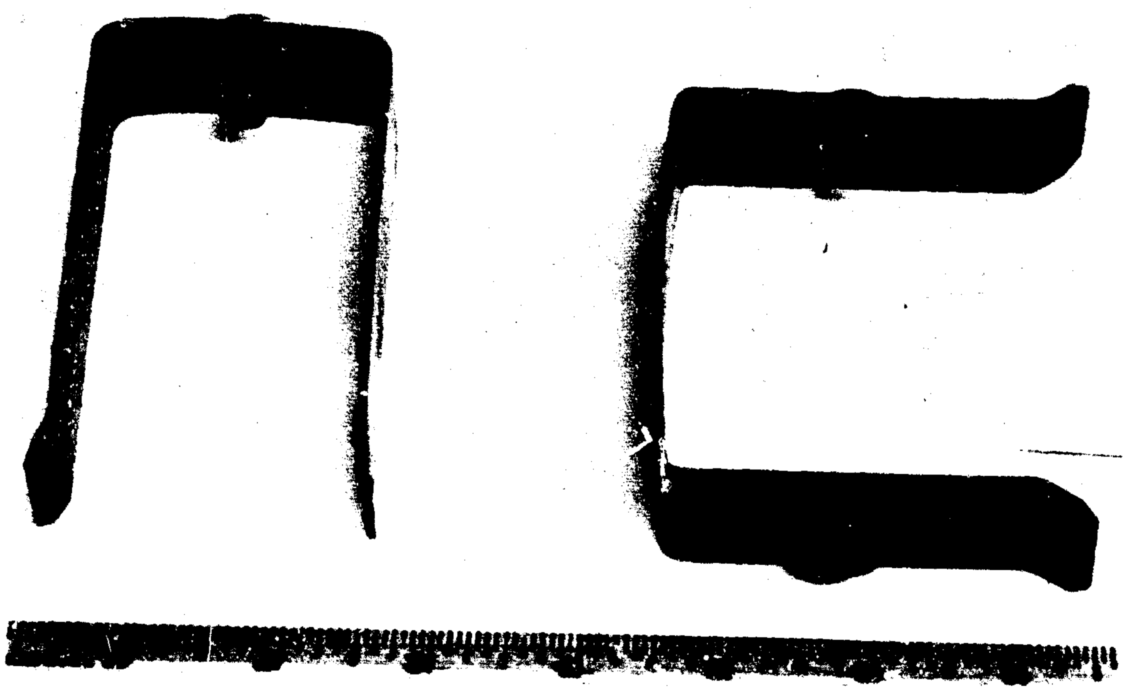
Tapered Pin

Blunt-End Pin With Spring-Loaded Retaining Ball

Figure 7a Types of Locking Devices



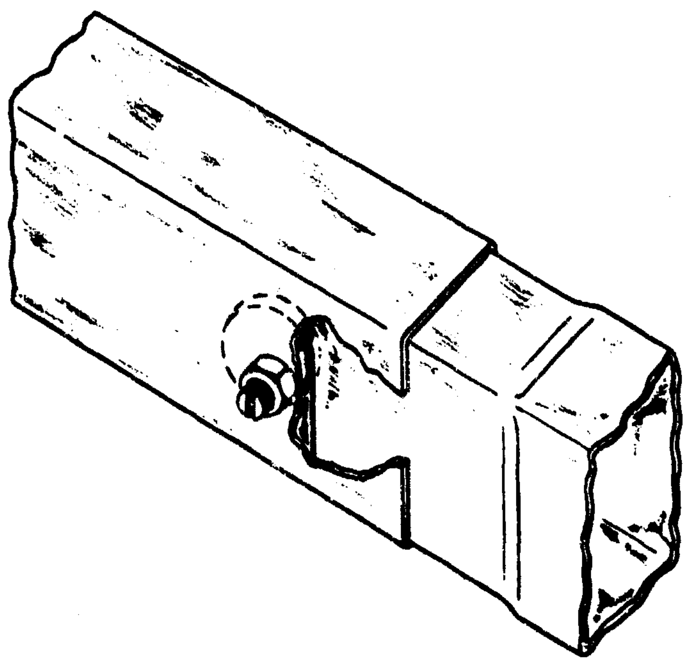
Fixed Spring-Loaded Pin



Removable Pin Clips

Figure 7b Types of Locking Devices (Continued)

Slot and Bolt



Eccentric-Cam

Figure 7. Types of Locking Devices (Continued)

2.1.4 Handlebar

Although the handlebar need not be adjustable (Ref. 4, page 28) this feature has been retained since the handlebar must be removed for packaging (see Figure 9). Other arrangements were developed and evaluated, such as the combination handlebar-saddle (see Figure 10). This arrangement was not suitable as reported by the American Institutes For Research (Ref. 4, page 26).

Figure 9 Illustration of Adjustable Handlebar

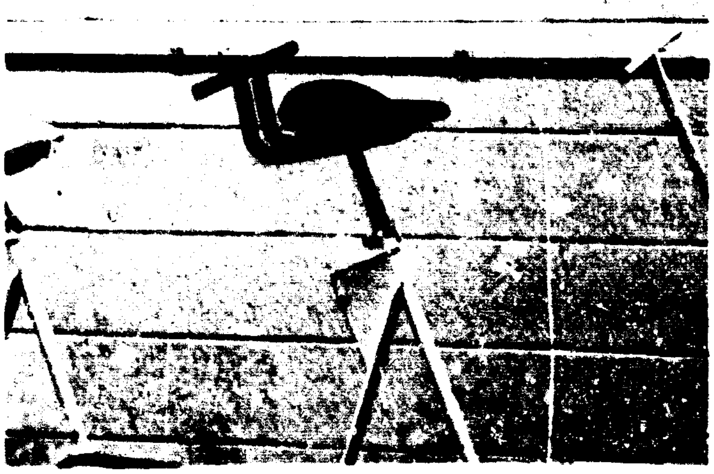


Figure 10 Illustration of Combination Handlebar-Saddle

2.2 Fan Assembly

The components of the Fan Assembly are arranged for use with ducting on the discharge side of the fan-shroud subassembly (see Figure 11). The PVK is thus used to exhaust stale, hot and humid air from the shelter.

2.2.1 Impeller Selection

Specific speed (Equation 1) presents a simple way to determine which type of blower will be most efficient in any application. Each type of impeller, regardless of size, develops its peak static efficiency (Equation 2) at a characteristic specific speed (see Figure 12). In practice it is usually not possible to procure manufactured fans with these efficiencies for particular engineering applications.

$$N_s = \frac{N\sqrt{Q}}{\left[P_s\right]^{3/4}} \qquad (1)$$

$$\eta_s = \frac{Q\,P_s}{63.6\,P} \qquad (2)$$

where:

N_s = specific speed, rpm

N = impeller speed, rpm

Q = air flow rate, cfm

P_s = static pressure, inches of water gauge (w.g.)

η_s = static efficiency, percent

P = shaft input power to the blower unit, horsepower

Investigation of many manufacturers indicated that no standard impeller will develop a static efficiency greater than 53 percent; however, one manufacturer proposed to develop a vaneaxial fan ($158 each in lots of 1000 or more) which would have the following characteristics:

Q	P_s	N	P	N_s	η_s
2250 cfm	0.3" H_2O	750 rpm	0.21 hp	88,000 rpm	50%
1700	0.4	720	0.17	59,000	63%

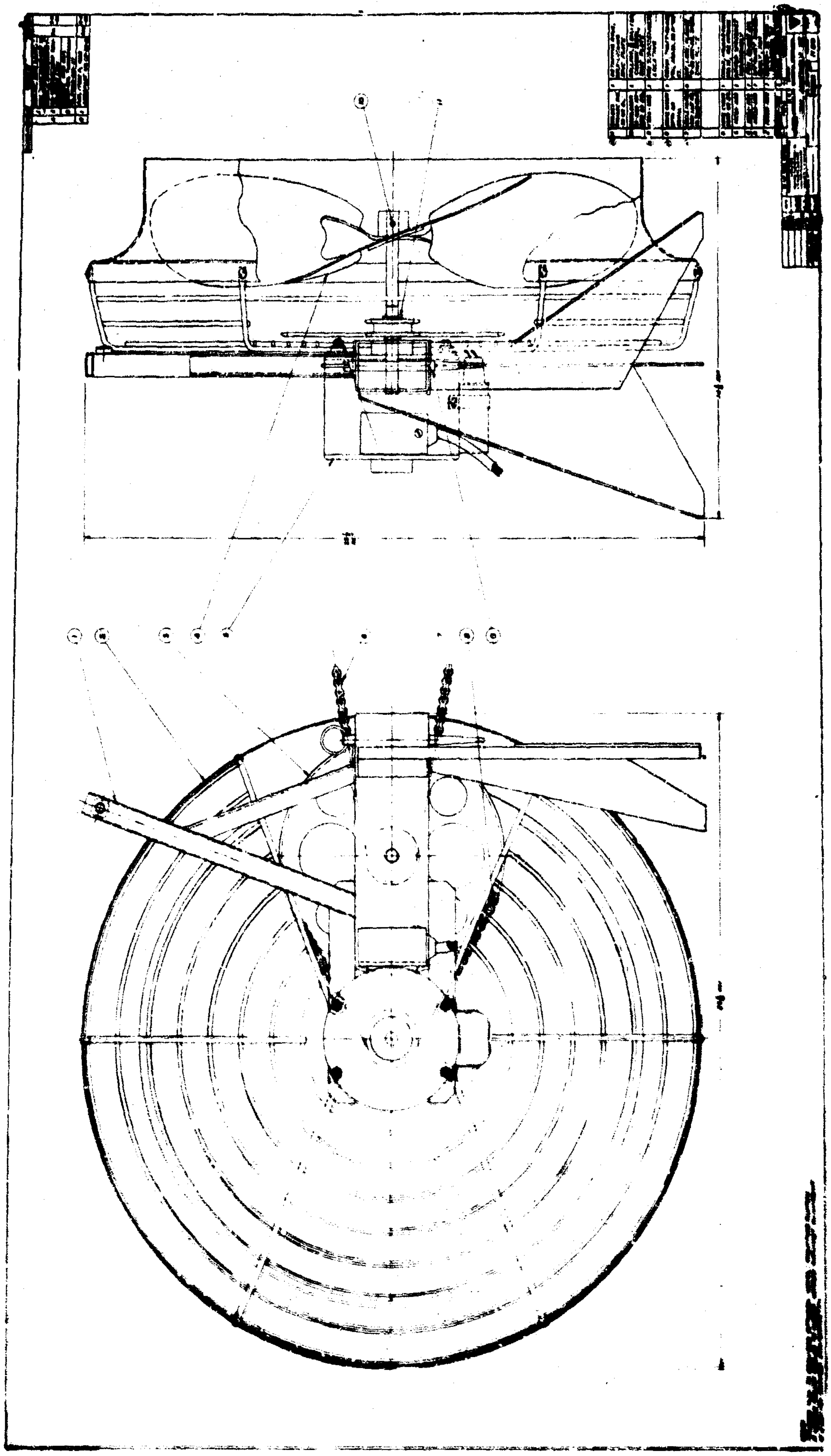


Figure 11 Fan Assembly (Part No. 1423A-1100)

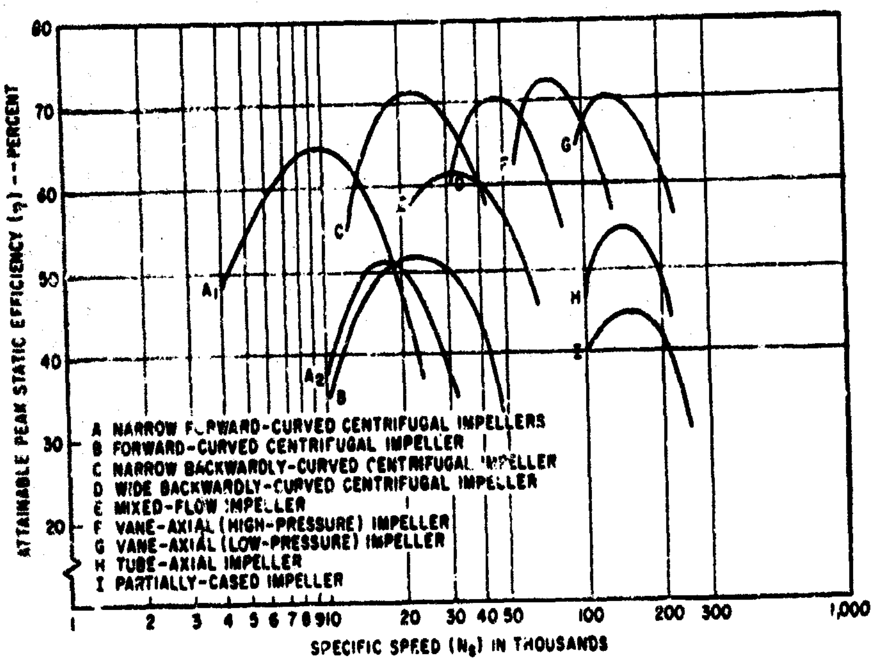
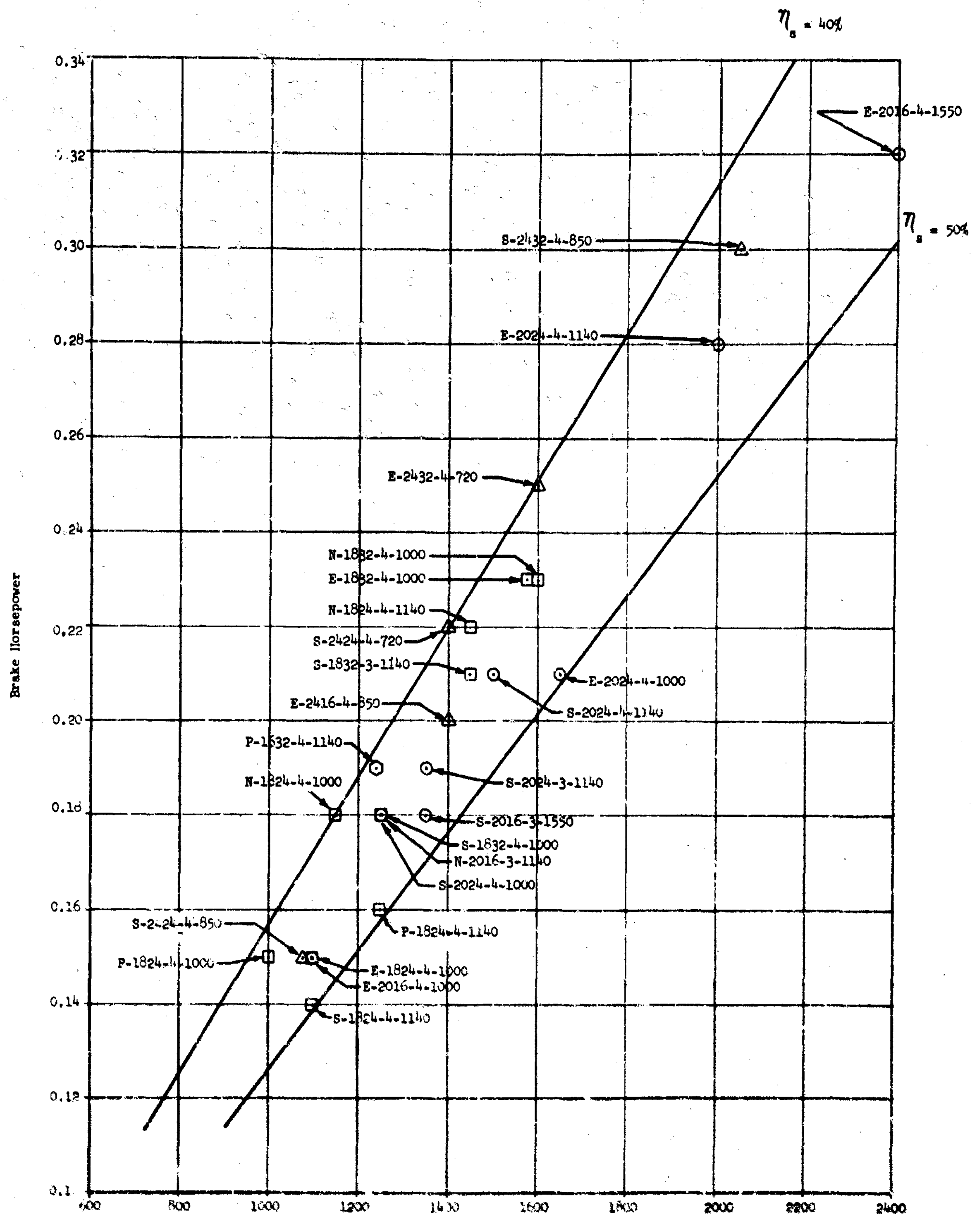


Figure 12 Peak Static Efficiency for Different Impeller Types

Since propeller-type fans are far less expensive ($3.28 each in lots of 50,000 or more) and static efficiencies as high as 47 percent are obtainable, these impellers are selected for the Civil Defense Package Ventilation Kit. Since The Torrington Manufacturing Company has the most complete fan performance data available (brake horsepower), their data were used exclusively for the fan selections. The specification (see 4.7 of MIL-V-40645) permits substitution of a fan which is equal in performance and interchangeable with this manufacturer's product. All comparisons in this section are based on catalogued data and standard air density (ρ = 0.075 lbs/cu ft). See Section 3.1 for the actual PVK fan-shroud performance data.

2.2.1.1 Two-Man PVK

The flow rate versus brake horsepower characteristics of all 16, 18, 20, 22 and 24-inch diameter propeller fans with a static efficiency greater than 40 percent at a static pressure of 0.4 inches are plotted on Figure 13.



NOTES: 1. Data based on The Torrington Mfg. Co. catalog test data (NEMA Code FM1-7.02).

2. Torrington Fan Nomenclature:

Fan Number	Series	Diameter	Pitch	Blades
E-2024-4	E	20"	24°	4

Figure 13 Fan Impellers at 0.4 Inches W.G. Static Pressure

The 20-inch diameter fans develop the greater air flow per unit brake horsepower; therefore, the empirical fan performance characteristics of these fans are further compared in Figure 14. The best fan based on 0.2 pedal horsepower and an overall PVK mechanical efficiency of 92 percent (see Section 3.2) is N-2016-3-1140.* This fan will develop 1250 cfm against a static pressure of 0.4 inches when rotating at 1140 rpm. The brake horsepower is 0.184 and the static efficiency 42.7 percent.

A static pressure of 0.4 inches w.g. will develop when 1250 cfm (N-2016-3-1140 fan characteristic) of air flows through 1670 feet of straight 20-inch sheet-metal duct (0.024 inches/100 feet, see Ref. 5, p. 562). Since the equivalent length of duct systems in most shelters will probably be less than 1670 feet of 20-inch diameter rigid duct, a fan is also selected for a 0.3-inch w.g. static pressure drop application. All 18 and 20-inch diameter fans with a static efficiency greater than 40 percent at a static pressure 0.3 inches w.g. are compared in Figure 15. As can be seen from the fan characteristic curves of Figure 14, the E-2024-4-1000 fan will develop 1800 cfm against a static pressure of 0.3 inches when rotating at 1000 rpm. The brake horsepower is 0.19 and the static efficiency 44.6 percent. At this flow rate and pressure drop (0.048 inches/100 feet), the equivalent length of 20-inch diameter sheet-metal duct is 625 feet.

The fan characteristics for both of the above selected fans (the N-2016-3-1140 rpm at 0.4-inch static pressure, and the E-2024-4-1000 rpm at 0.3-inch static pressure) are superimposed on various sheet-metal duct system characteristic curves in Figure 16. The fans are compared in Table I with various equivalent lengths of 20-inch diameter sheet-metal duct. The E-2024-4 fan,

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*Refer to Figure 13 for fan nomenclature.

NOTES:
1. Static efficiency (η_s) greater than 40% @ 0.4 inches w.g. static pressure.
2. Based on The Torrington Mfg. Co. catalog data (NEMA Coe FM1-7.02).
3. Fan brake horsepower of 0.2 or less .... solid line
   Fan brake horsepower greater than 0.2 .... dashed line.
4. Refer to Figure 13 for fan nomenclature.
5. N-1824-4-1140, N-1832-4-1000, and S-2024-4-1140 not shown.

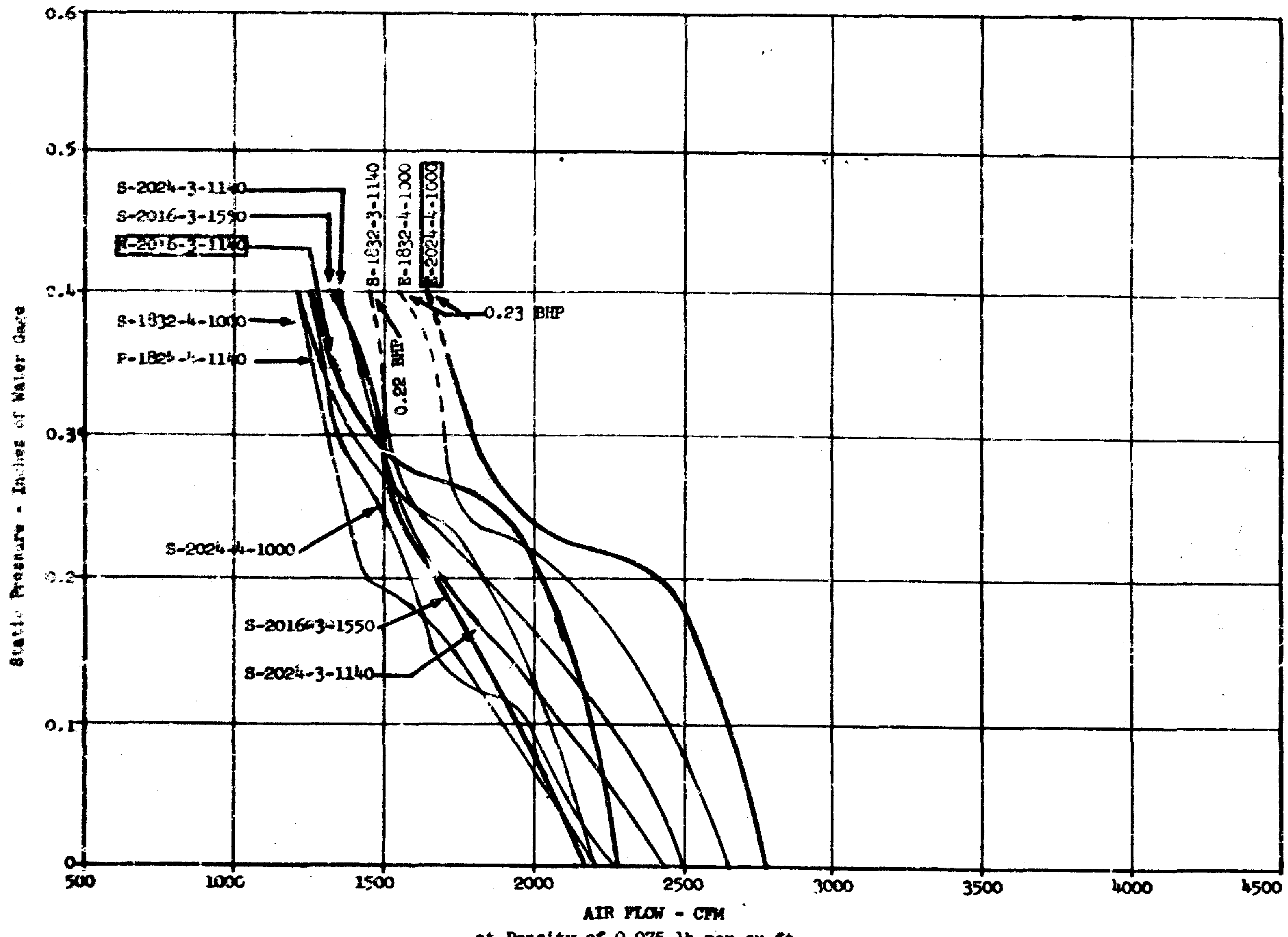
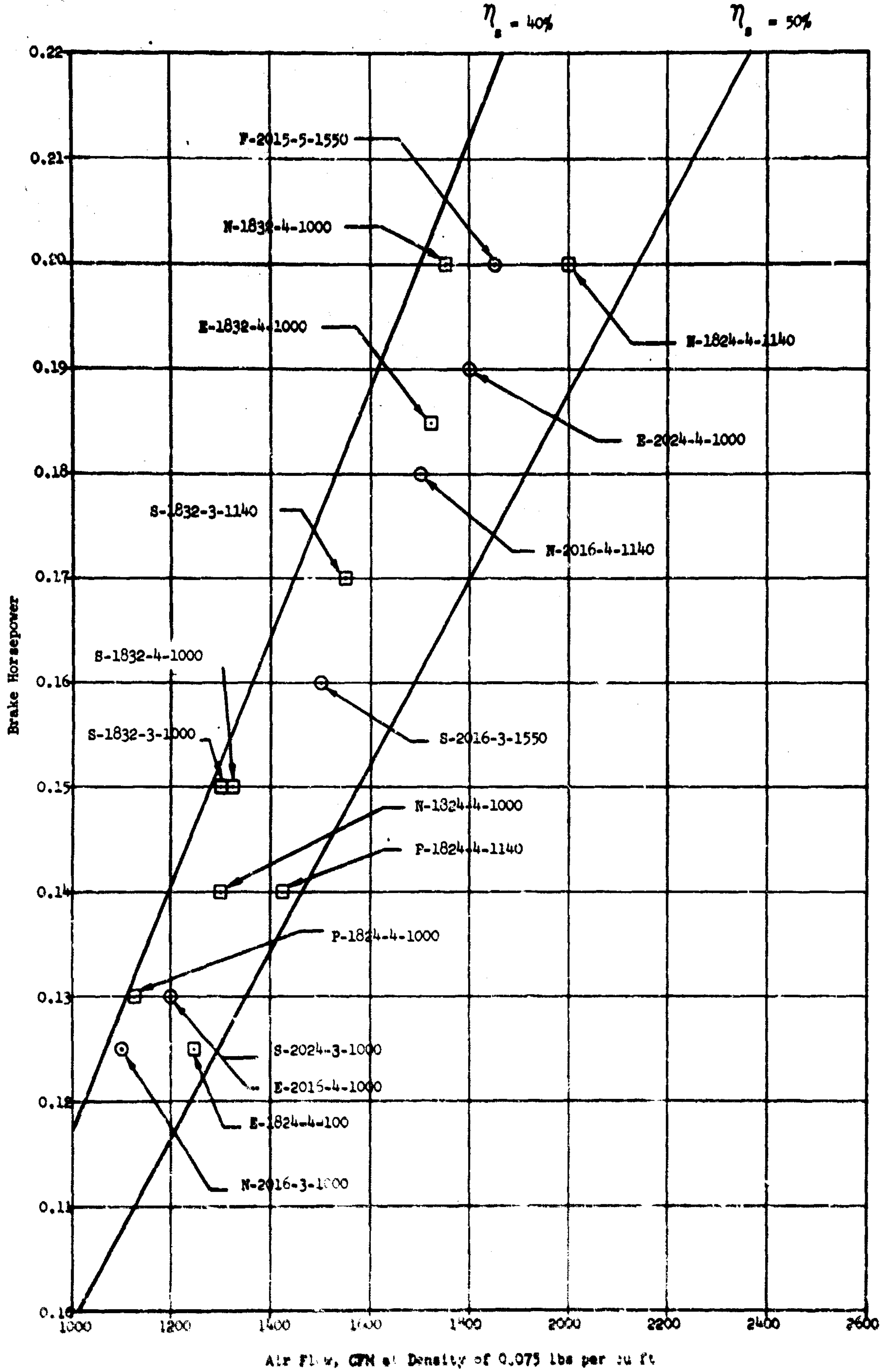


Figure 14 Performance Characteristics of Candidate Fans



NOTES: 1 Data based on The Torrington Mfg. Co. catalog test data (NEMA Code FM1-7.02).
2 Refer to Figure 13 for fan nomenclature.

Figure 15 Fan Impellers at 0.3 Inches W.G. Static Pressure Loss

NOTES:

1. Nomenclature:

Key	Fan No.	Series	Dia. (in.)	Pitch (deg.)	Blades	Speed (rpm)	Number of Operators
N	N-2016-3	N	20	16	3	1140	2
E	E-2024-4	E	20	24	4	1000	2

2. Fan Characteristics shown dotted if brake horsepower exceedr 0.2.
3. Fan Characteristics based on catalog data.

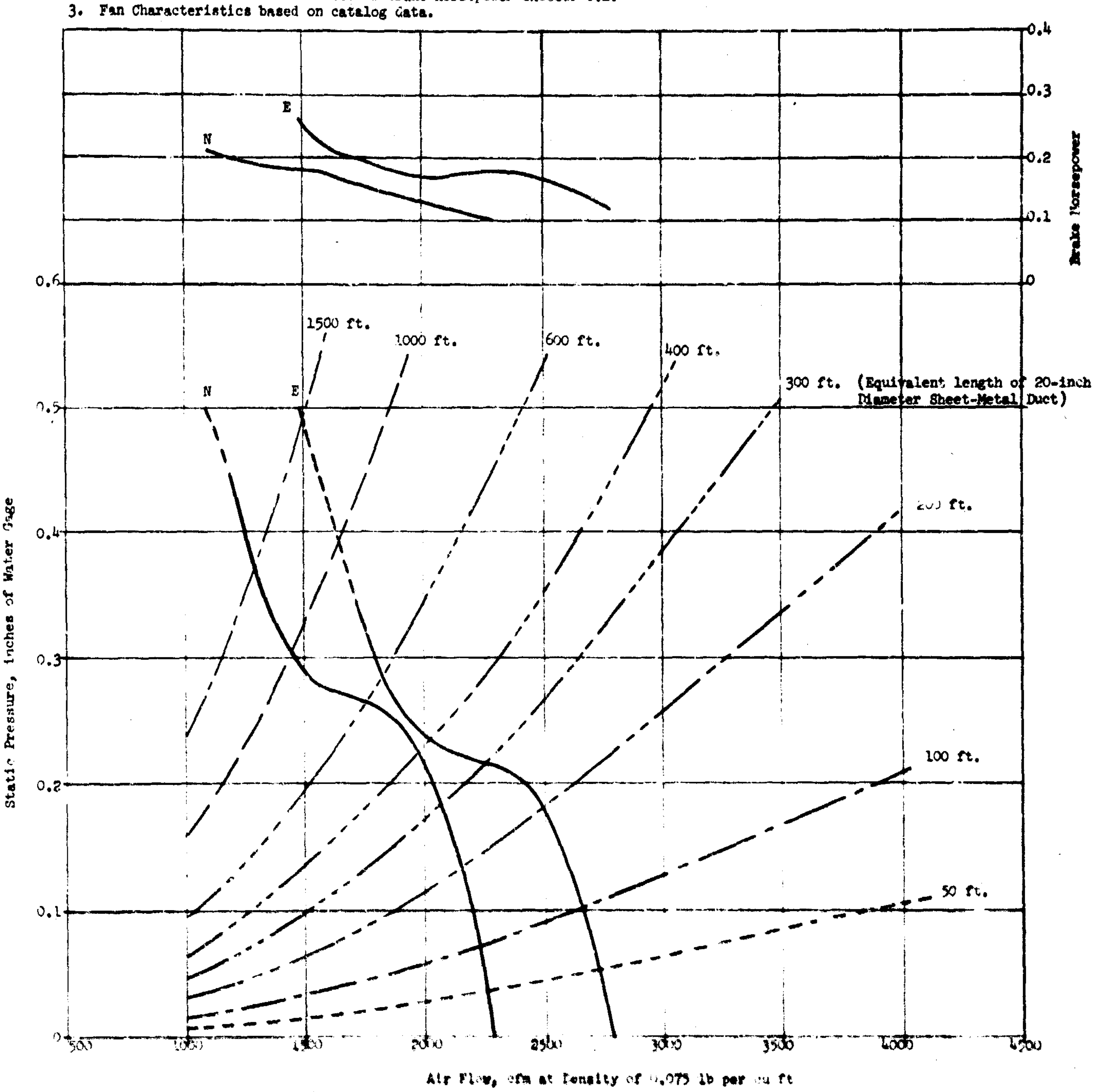


Figure 10 Fan and System Characteristics for a Two-Man PVK

Table I

Comparison of Fans and System Characteristics
For a Two-Man PVK

Equivalent Length of 20" Dia. Sheet Metal Duct, Feet	N-2016-3			E-2024-4		
	1140 RPM			1000 RPM		
	CFM	HP	P_s, inches w.g.	CFM	HP	P_s, inches w.g.
100	2200	0.11	0.07	2650	0.14	0.10
200	2150	0.12	0.13	2500	0.17	0.18
300	2050	0.13	0.18	2250	0.18	0.22
400	1950	0.14	0.23	2000	0.17	0.24
500	1870	0.15	0.25	1900	0.18	0.26
600	1750	0.16	0.27	1800	0.19	0.29
800	1550	0.17	0.28	1700	0.20	0.35
1000	1450	0.18	0.31	1650	0.21	0.39

NOTES: 1. Data from Figure 16.
2. Shaded area indicates fan brake horsepowers exceeding 0.1 per person.

which rotates at 1000 rpm as compared to 1140 rpm for the other fan, will develop more air flow and is therefore selected as the best fan for a shelter ventilation fan with a two-man drive.

2.2.1.2 One-Man PVK

The 18 and 20-inch diameter fans require the minimum brake horsepower per unit air flow. All 18-inch fan characteristics curves with a static efficiency greater than 40 percent at a brake horsepower of 0.1 are compared to the two-man PVK 20-inch diameter fan selection (E-2024-4) in Figure 17. The best 18-inch diameter fan (E-1824-4-1000) is compared to the two-man E-2024-4 fan at 800 rpm in Table II. The E-2024-4 fan can accommodate up to 600 feet of sheet-metal duct (20-inch diameter), while the E-1824-4 fan can be used with 300 feet of duct (18-inch diameter). Both selections are based on approximately 0.1 horsepower. With the same duct system the E-2024-4 fan will develop more air flow; therefore, this fan is also the best fan selection for a one-man PVK.

2.2.1.3 Three-Man PVK

The PVK can be assembled to handle more than two operators if desired. The E-2024-4 fan (the fan also recommended for the two-man and one-man drive PVK's) rotating at 1140 rpm has the best static efficiency (46.5 percent at 0.4 inches w.g.) of all the 20-inch diameter fans (see Figure 13). No attempt was made to determine if a better fan is available in a larger diameter since the PVK is designed around a two-man drive. The E-2024-4 fan rotating at 1140 rpm develops 2850 cfm when operating against 200 feet of 20-inch sheet-metal duct and 2000 cfm at 0.4 inches static pressure (see Figure 18).

2.2.1.4 Summary of Impeller Selection

The fan-system characteristics for the selected E-2024-4 fan operating at constant speeds of 800, 1000, and 1140 rpm for the one, two, and three-man PVK's are presented in Figure 19. Refer to Figure 34, page 55, for the as-tested PVK rating.

NOTES:

1. STATIC EFFICIECY (η_s) GREATER THAN 40%
2. 0.1 BHP (UNLESS OTHERWISE SHOWN AS DOTTED)
3. NOMENCLATURE:

KEY	FAN NO.	SERIES	DIA. (IN.)	PITCH (DEG.)	BLADES	SPEED (RPM)
1	P-1824-4	P	18	24	4	1000
2	S-1824-4	S	18	24	4	1140
3	N-1816-3	N	18	16	3	1140
4	E-1816-4	E	18	16	4	1140
5	S-1824-4	S	18	24	4	1000
6	N-1816-4	N	18	16	4	1000
7	S-1824-3	S	18	24	3	1000

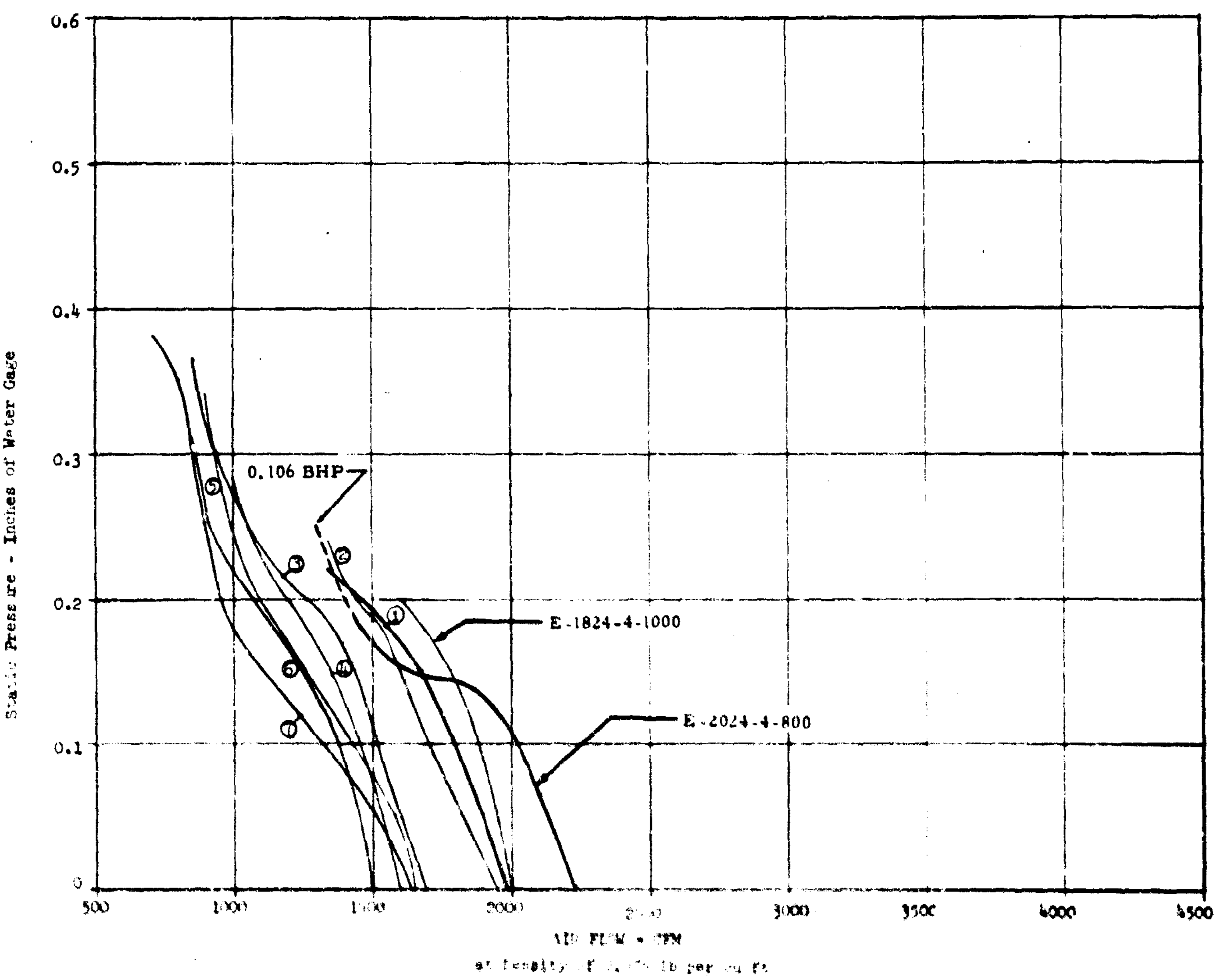


Figure 1[illegible] Fan Characteristics for One-man PVK

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Table II

Comparison of Fans and System Characteristics
For A One-Man PVK

Equivalent Length of 20" Dia. Sheet-Metal Duct, Feet	E-2024-4			E-1824-4		
	800 RPM			1000 RPM		
	CFM	HP	p_s, inches w.g.	CFM	HP	p_s, inches w.g.
100	2100	0.072	0.06	1900	0.075	0.09
200	2000	0.087	0.12	1750	0.08	0.16
300	1750	0.092	0.14	1600	0.10	0.20
400	1600	0.087	0.16	1450	0.105	0.22
500	1500	0.092	0.17	-	-	-
600	1450	0.097	0.19	-	-	-
800	1350	0.102	0.22	-	-	-
1000	1300	0.108	0.25	-	-	-

NOTE: Shaded area indicates fan brake horsepowers exceeding 0.1 per person.

2.2.2 Shroud

The performance of a propeller fan is radically affected by the design and dimensions of the orifice. The four factors in the design of an orifice which affect the performance of a propeller fan are

1. the type of orifice,
2. the clearance between the impeller blade tips and the orifice,
3. the axial depth of the orifice, and
4. the position of the impeller in the orifice.

NOTES:

1. Nomenclature:

Key	Fan No.	Series	Dia. (in.)	Pitch (deg.)	Blades	Speed (rpm)	No. of Operators
E'	E-2024-4	E	20	24	4	800	1
E''	E-2024-4	E	20	24	4	1000	2
E'''	E-2024-4	E	20	24	4	1140	3

2. Fan characteristics shown dotted if brake horsepower per operator exceeds 0.1.
3. Fan characteristics based on catalog data.

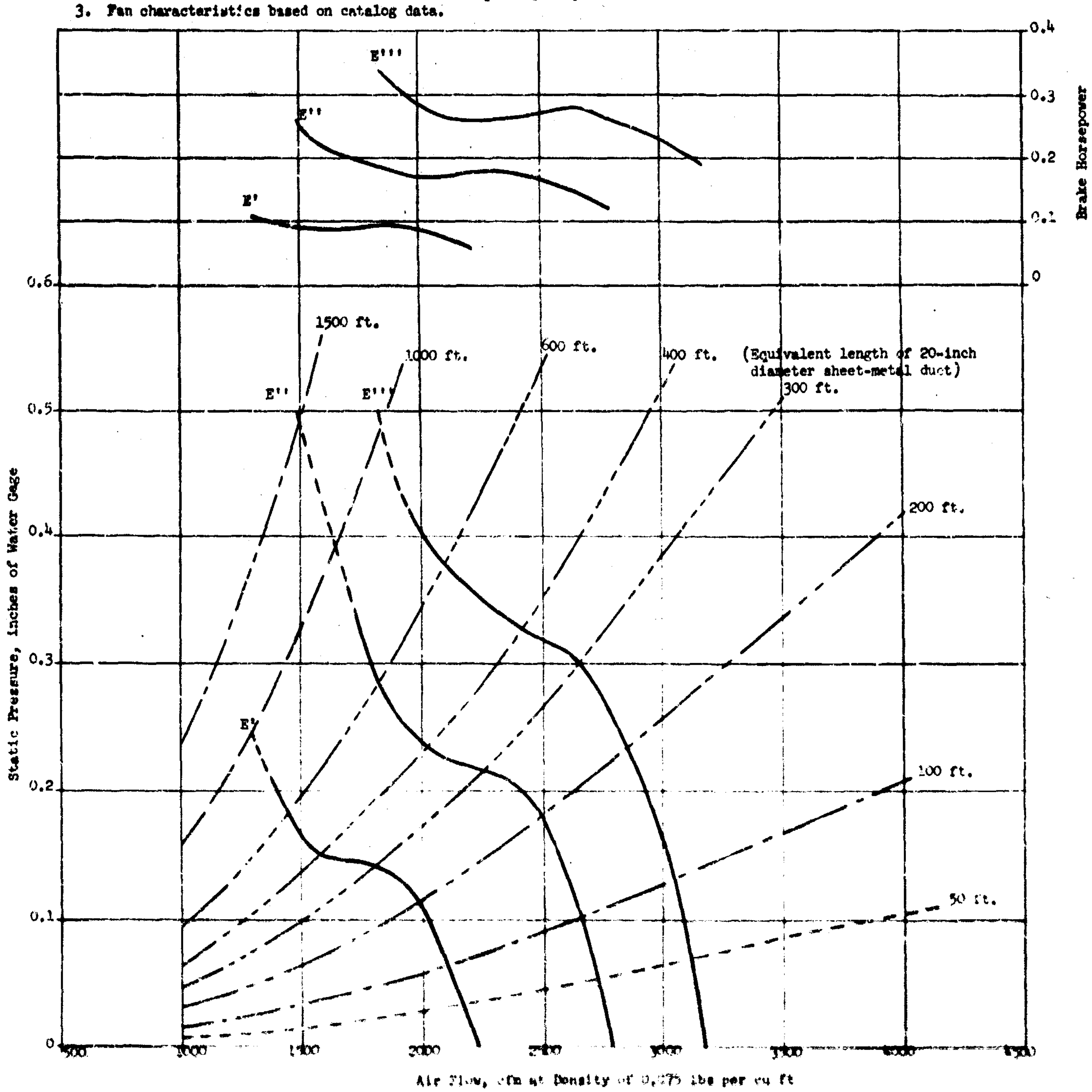


Figure [illegible] Preliminary FVK Fan and System Characteristics (CAUTION: Refer to Figure 31, page 55, for the as-tested FVK rating.)

Of these three basic types of orifices (Figure 19) — sharp edge, cylindrical, and converging (cone or bell-mouth) — the bell-mouth orifice develops higher static pressures in the operating range of the shelter ventilator and requires the least energy to drive the fan (Ref. 6). Therefore, this orifice design was incorporated into the specifications (Figure 20).

The gap between the blade tips and orifice allows leakage of air from the high-pressure intake side of the fan. As the tip clearance becomes larger, there is a drop in flow rate for a given pressure difference between discharge and intake. It has been found (Ref. 6) that a tip clearance of 1.5 - 2.0 percent, as defined in Equation 3, results in an impeller performance very nearly equal to that for zero tip clearance, and yet permits production with commercial tolerances.

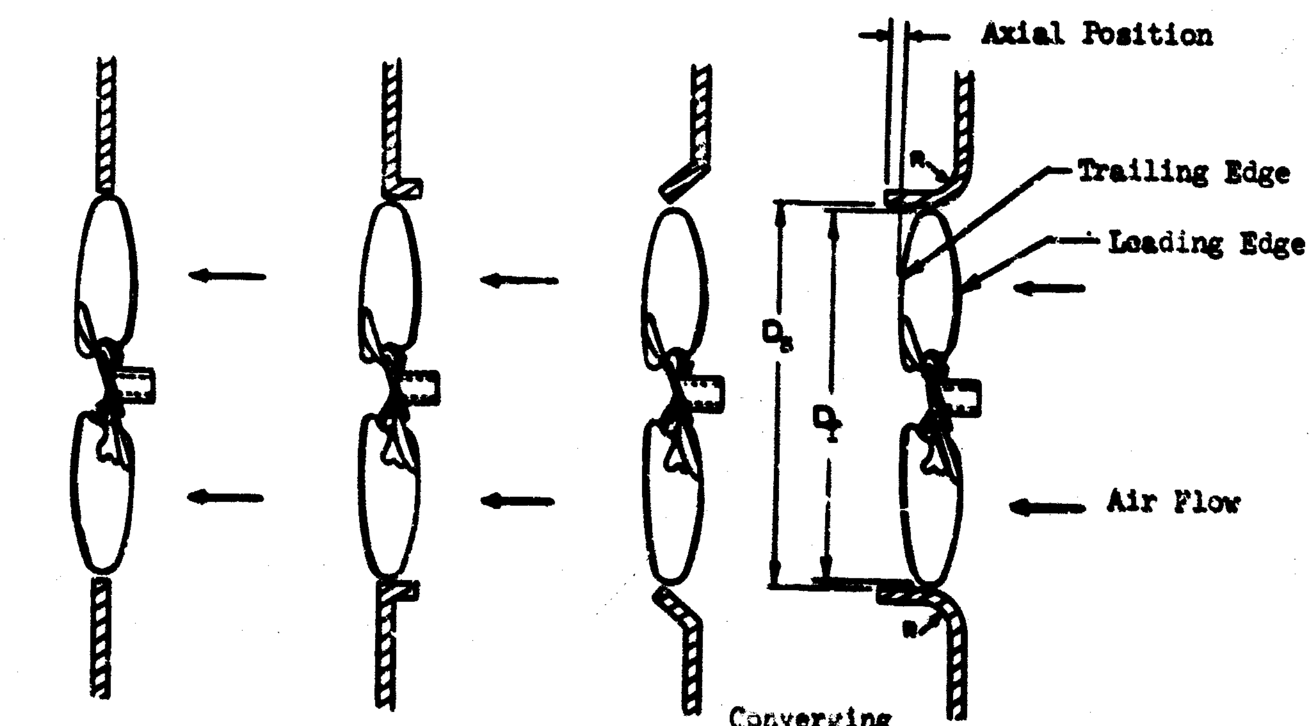


Figure 19 Orifice Types

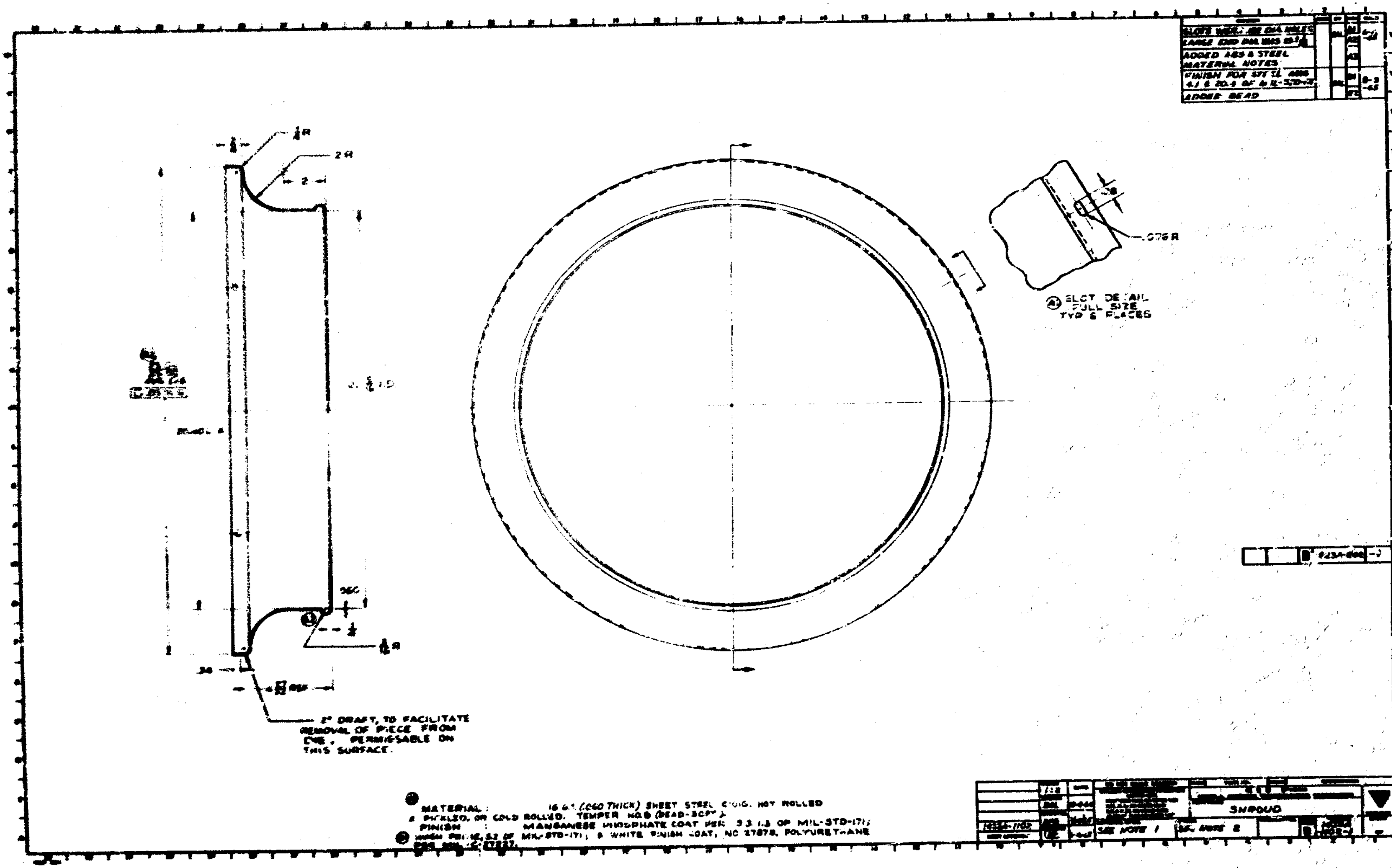


Figure 20 Shroud Design (Part No. 1423A-1102-1)

$$\text{TIP CLEARANCE} = \frac{D_s - D_f}{D_f} \text{ percent} \qquad (3)$$

where:

D_s = inside shroud diameter, inches

D_f = blade tip diameter, inches

The axial depth of a bell-mouth orifice is equal to the radius (R). A radius of 10 percent of the blade tip diameter is generally recommended (Ref. 6), since larger radii produce negligible increases in performance. If the bell-mouth radius is less than 10 percent of the blade tip diameter, the static efficiency drops.

The axial position of the fan in the orifice is the most critical factor affecting the performance of the fan. Based on test results (see Section 3.1) the optimum position of the fan was found to be flush with the discharge end of the shroud. For packaging, the fan is recessed approximately 1/8-inch within the shroud to protect the blades and the motor from damage.

2.2.3 Motor

The motors considered for use in the PVK were the split phase, permanent-split capacitor, capacitor start-induction run, shaded pole, and the capacitor start-capacitor run. The significant characteristics of these motors are shown in Figure 21.

The high start, split phase motor has a high resistance auxiliary winding which is in the circuit during starting, but is disconnected through the action of a centrifugal switch as the motor comes up to approximately 75 percent of the speed at full load. Under running conditions it operates as a single-

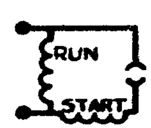
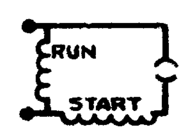
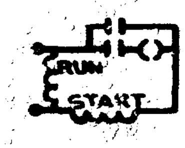
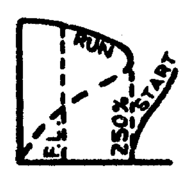
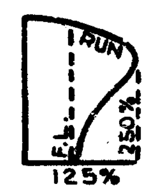
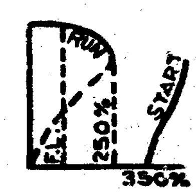
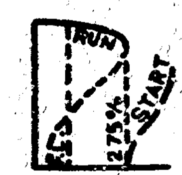
TYPE OF MOTC	Split-Phase General-Purpose	Split-Phase High-Start	Permanent-Split-Capacitor	Capacitor-Start Induction-Run	Shaded-Pole	Capacitor-Start Capacitor-Run
Connecting Diagram						
Speed Torque Curves: ——Combined Windings ---Run Windings						
Starting Method	Relay	Relay	None	Relay	None	Relay
Torque: Locked rotor / Breakdown	Moderate / Moderate	High / High	Low / Moderate	Very High / High	Low / Low	High / High
Full Load Power Factor	Moderate	Moderate	High	Moderate	Moderate	High

Figure 21 Characteristics of Single-Phase A.C. Motors
(from Ref. 5, Table 4, p. 873)

phase induction motor with one winding in the circuit. The starting torque is high, about 250 percent of full load torque. The locked rotor torque of the general purpose motor is 125 percent of full load torque, as compared to 250 percent for the high resistance start motor.

The permanent-split capacitor motor has a low starting torque, about 125 percent of full load torque, and is ideally suited for small fan drives. Operation is similar to the capacitor-start motor, except that the capacitor is not cut out when running. This motor can be used for direct drive only (air over the motor for cooling). It is the quietest and smoothest performing of the single-phase motors.

The capacitor start-induction run motor develops high starting torque (350 percent) in the fractional horsepower sizes. During the starting period a winding with a capacitor in series is connected to the motor circuit, and when the motor comes up to speed a centrifugal switch cuts the capacitor and second winding out of the circuit.

The shaded pole motor has one winding only and a portion of each pole is "shaded" by a low resistance coil to provide the starting torque. The starting torque is low, about 25 percent of full load torque. The speed is fairly constant, but the variation from no-load to full-load is greater than for other types of induction motors. This motor can be used for direct drive only, since air-over the motor is required for cooling.

The capacitor start-capacitor run motor develops high starting torque, about 275 percent of full load torque. This design employs a starting capacitor and a running capacitor. The starting capacitor is cut out by a centrifugal switch.

The permanent-split capacitor and the shaded pole motors are the least expensive, and are generally used where a direct-drive is required, such as fan-coil units. The permanent-split capacitor (PSC) motor is specified because:

1. the air flow rate developed by the PSC motor is 5 percent greater than the shaded pole motor because it operates at a higher speed,
2. the starting torque of the PSC motor is considerably higher, 125 percent of full load torque as compared to 25 percent of full load torque for the shaded pole motor,
3. the mechanical efficiency of the PSC motor is considerably greater, 61 percent as compared to 37 percent for the shaded pole motor,
4. the full load current at 1/3 horsepower for the PSC motor is 4.3 amperes, as compared to 6.8 amperes for the shaded pole motor,
5. the power losses to manually drive the unit are a minimum since this motor (also the shaded pole) does not have an integral cooling fan, and
6. the motor does not have any centrifugal switches, thus minimizing the transmission losses when the unit is manually driven, and increasing the reliability of the motor after long periods of storage. Centrifugal switches can be a constant source of trouble (Ref. 7, page 84). If the mechanism sticks in the running position the motor will not start. On the other hand, if stuck in the closed position the motor will not attain speed and the starting winding will quickly heat up. The motor may also fail to start if the cut-off points of the switch are out of adjustment or coated with an oxide.

2.3 Transmission

The fan is mounted on the motor shaft and thus can be driven when 115 volt single-phase A.C. power is available. The pedal drive is coupled to the fan shaft through an idler-shaft using roller chain and sprockets.

2.3.1 Chain

Roller chain is used in the PVK to transmit power from the operators to the fan while increasing the rotational speed from 55-62 rpm at the crank to 1070-1206 rpm at the fan. Gear, chain, and belt drives were considered for the PVK. Gear and chain drives for the PVK would be about 92 percent efficient, while the efficiency with belts would not exceed 73 percent. Belt drives are too inefficient, and gear drives too expensive for the PVK.

American Standards Association (ASA) No. 35 chain is used throughout the PVK. The pitch of ASA 35 chain is 3/8 inch, as compared to 1/2 inch pitch for bicycle chain, thus resulting in sprockets 1/3 smaller in diameter and reducing the storage volume required. Greater reliability is offered by ASA 35 chain since it has a rated tensile strength of 2100 pounds as compared to 1600 pounds for bicycle chain.

2.3.2 Sprockets

An overall increase in speed from 55-62 rpm at the pedal crank to 1070-1206 rpm at the fan is obtained in two equal ratios. The first step-up (4.41 ratio) occurs between the 75 tooth module sprocket and the 17 tooth sprocket of the idler shaft sprocket subassembly. An identical speed step-up occurs between the 75 tooth sprocket of this subassembly (integral with the 17 tooth sprocket mentioned above) and the 17 tooth motor shaft sprocket. The overall speed ratio is 19.46 to 1. All module sprockets have 75 teeth, hence there is no speed change between modules.

Excessive wear in the teeth of the 17 tooth sprockets in an endurance test (Ref. 4, page 23) pointed out the need for their being hardened. Case hardening the teeth to Rockwell C 40-45 was sufficient to correct this deficiency. No heat treatment was necessary for the large sprockets. The wear was concentrated in the small sprockets only, because the load is transmitted by relatively few teeth.

2.3.3 Clutch

A ratchet and pawl device integral with the dual module sprocket was designed, fabricated and evaluated (see Figures 22 and 23). This device allows an operator to stop pedaling while the others continue, without creating a significant drag or resistance for the remaining operators. This clutch was deleted when tests (Ref. 4, page 29) showed it to be unnecessary.

2.3.4 Bearings

2.3.4.1 Crank Bearings

The crank, crank bearings, locknut and lock washer are standard bicycle components. The bearings are separable angular contact ball bearings. The nine, 5/16-inch diameter bearing balls in each bearing assembly are retained by a pressed steel cage. The stationary outer races or bearing cups are drawn steel, unground, case hardened and cadmium plated. The outer races

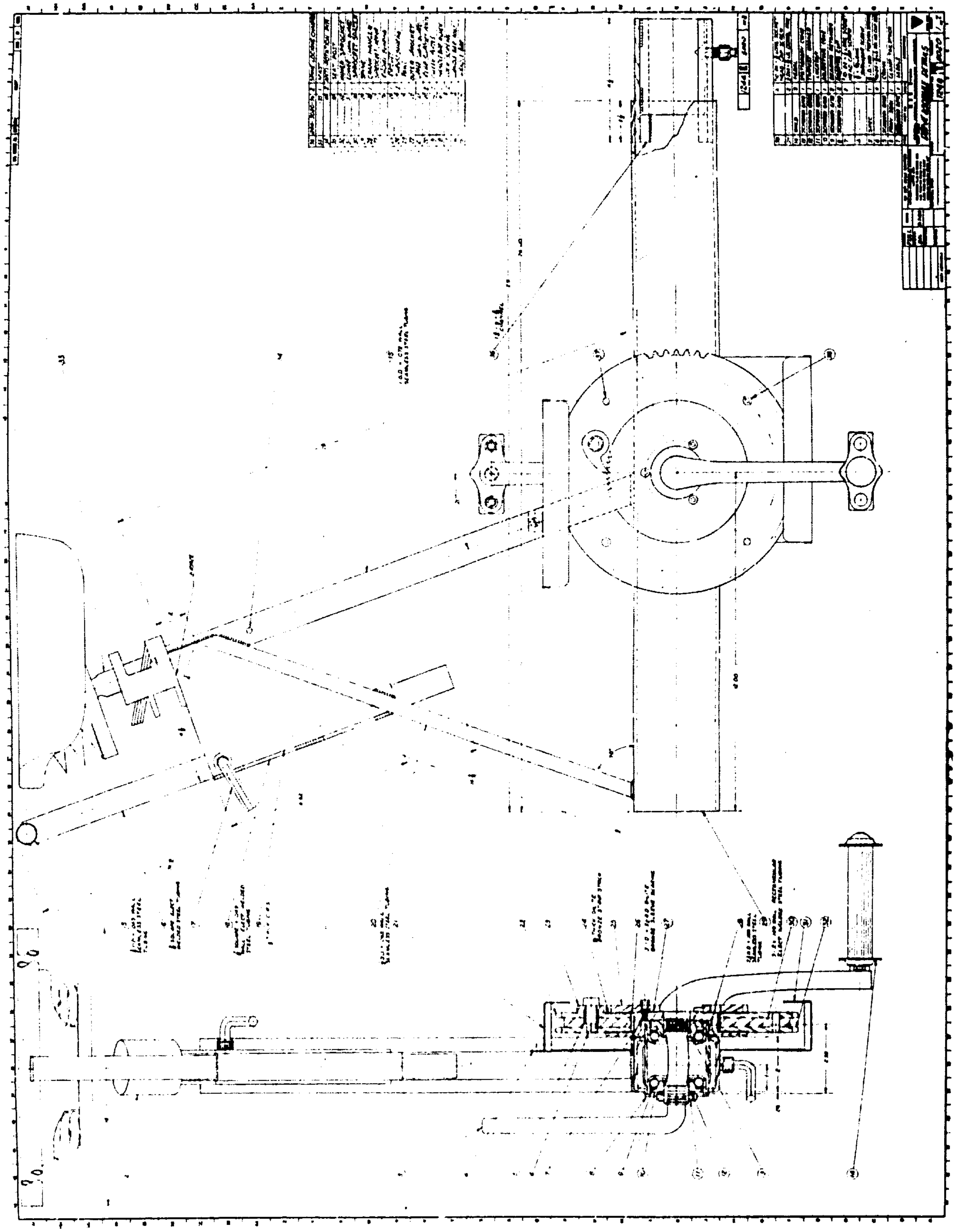


Figure 22 Clutch Design

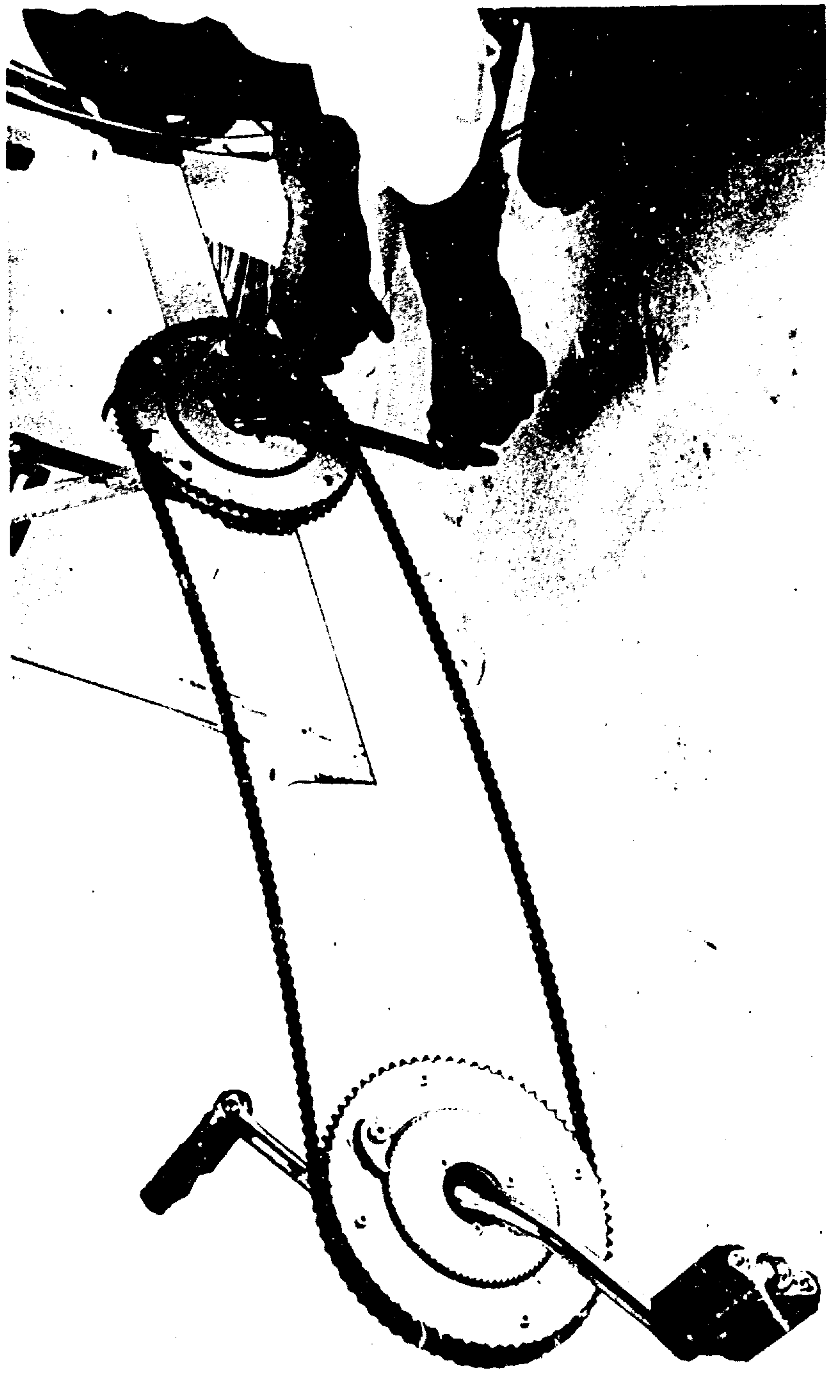


Figure 23 Illustration of the Clutch

are retained in the drive module by a light press fit in the tubular crank hanger. The bearing inner races - designated as the adjusting cone, and the locking cone - are machined, unground, steel and case hardened. While each cone functions as an inner race of these crank bearings, the locking cone also secures the sprocket subassembly on the crank. By changing the axial position of the adjusting cone on the crank threads in assembly, the bearing internal clearances are controlled.

At assembly these bearings are packed with a long term storage, high stability grease. This grease contains an organic gelling agent thickener, rather than the more commonly used metallic soap, thus minimizing bleeding of oil from the grease, and providing a strong positive anti-oxidation protection for the grease.

2.3.4.2 Idler Shaft Bearing

A flanged, sintered bronze, oil impregnated sleeve bearing was selected for the sprocket subassembly (and idler shaft). This bearing has low rotating torque and is economical. The flange takes up any thrust loads, and positively locates the bearing in the sprocket. The idler shaft is protected from corrosion with a solid dry-film lubricant finish.

The bearing is fabricated from metal powders to form a material containing thousands of interconnected pores. With these pores filled with oil, a reservoir is formed that has a volume of approximately 20 percent of the total bearing volume. Oil is drawn to the bearing surface when there is motion of the bearing relative to the shaft. When the bearing is motionless, the oil is reabsorbed into the bearing by capillary action.

The sliding coefficient of friction for sintered bronze sliding on steel, lubricated by oil from within the bearing, ranges from 0.02 to 0.10. The range is great because many variables affect the coefficient of friction — such as bearing unit pressure, lubricant viscosity, velocity of sliding, and the smoothness of the bearing surfaces. The static coefficient of friction ranges from 0.12 to 0.15. The load carrying capacity of plain bearings may be expressed as a PV factor, the load per unit projected bearing area times the surface velocity of the bearing surface in feet per minute. A permissable PV value of 50,000 is used for oil impregnated sintered bronze bearings. In the PVK application the bearing rotates at approximately 275 rpm on a 0.5 inch diameter shaft. At the resulting surface velocity of 36 feet per minute a unit bearing load of 1390 pounds per square inch could be applied without exceeding the 50,000 PV value. This is equivalent to a total permissable load of 870 pounds. With a 0.33 horsepower input at 62 rpm at the crank, a load of 59 pounds is applied at this bearing and the actual PV is only 3360.

2.3.4.3 Motor Bearings

Babbitt-lined, steel-backed sleeve bearings were selected for the PVK motor because of their long storage life (Ref. 7, page 33), good resistance to humidity, resistance to mild dirt infiltration, and low first cost. The motor shaft is also protected with a solid dry-film lubricant finish to increase its reliability of operation after long term storage.

2.4 Finish

The basic finish selected for the PVK is a solid dry-film lubricant (meeting the requirements of MIL-L-8937 and MIL-L-25504A) because (1) this finish system offers excellent protection against corrosion, (2) the thickness does not exceed 0.0007 inches, thus better dimensional control of the mating parts of the connecting joint is obtained, (3) easy assembly of the unit is assured since seizing is reduced, (4) the transmission losses are minimized since the sprockets are dry-filmed, and (5) the ability to adjust the saddle and handlebar is increased. Those parts which do not require dimensional control and lubrication, such as the shroud and module stand, are finished with a polyurethane paint since this method is slightly less costly.

All parts are given a manganese phosphate coating before they are dry-filmed or painted. Phosphated panels, when painted or dry-filmed and then scribed with a sharp instrument so as to expose the base metal, will show no evidence of corrosion, excepting the exposed metal, when subjected to a salt spray for 200 or more hours (Ref. 8). If the finish is accidentally gouged, especially during packaging, any ensuing corrosion will be restricted to that particular area. There will be no creeping of rust under the surface, nor any popping off of the paint or dry-film beyond the damaged area.

2.5 Packaging

The packages developed for the Fan Assembly and the Drive Module are water-vaporproof meeting the requirements of Method IA-14, Specification MIL-P-116. These packages consist of an interior container, a heat sealed bag, and an exterior carton.

2.5.1 Fan Assembly Package

Plywood and triple-wall corrugated fiberboard boxes were considered for the Fan Assembly and PVK accessories. The corrugated fiberboard package, which is less expensive, weather resistant, and has a high stacking strength (up to 30 feet), was developed as illustrated in Figure 24. A water-vaporproof bag is placed over this container and heat sealed. Then a wax and/or resin impregnated corrugated fiberboard container is placed over the bagged interior box, sealed, and strapped with corrosion resistant polypropylene straps (see Figure 25).

All items within this package have been further preserved (see 5.1.1 of MIL-V-40645, Appendix A) by either (1) a direct application of a strippable compound, (2) a sealed greaseproof and waterproof bag, (3) a sealed water-vaporproof bag, or (4) a waterproof bag. These correspond to Methods IB-1, IC-1, IA-8, and IC-3 of Specification MIL-P-116.

2.5.2 Drive Module Package

Plywood, curled hair inserts, foaming-in-place with polyurethane, pre-expanded polystyrene used with an adhesive, and molded polystyrene inserts interior packages were evaluated by develcping a prototype of each and establishing production costs. Based on the cost of material, labor, tooling, and machinery required (such as the blender for the bead-adhesive method) the molded polystyrene package (see Figure 26) was selected for the Drive Module packaging. Over this package is placed a water-vaporproof bag which is then heat sealed. A wax and/or resin impregnated corrugated fiberboard container is then placed over the bagged interior package (see Figure 27), sealed, and strapped with corrosion resistant polypropylene straps.

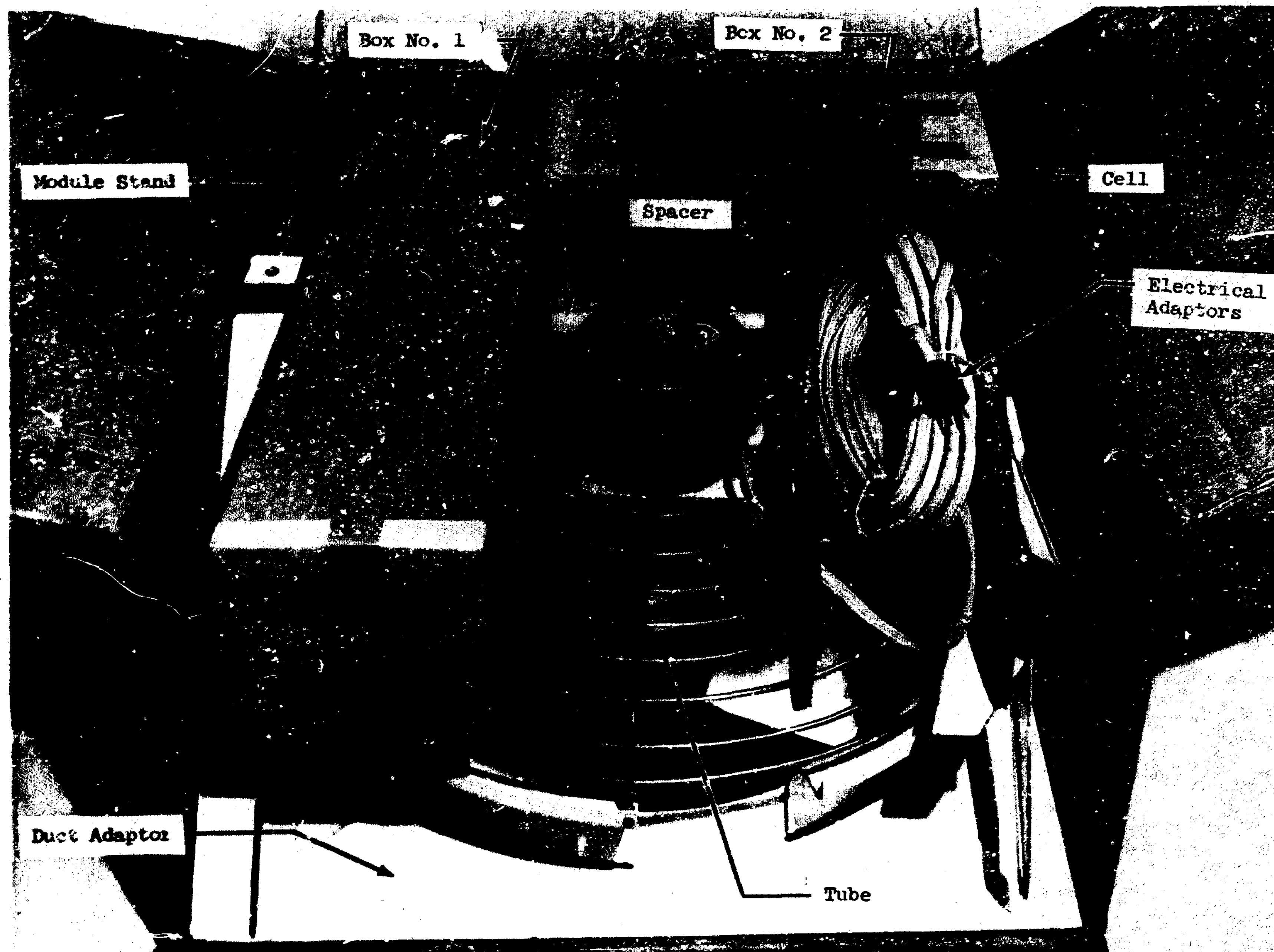
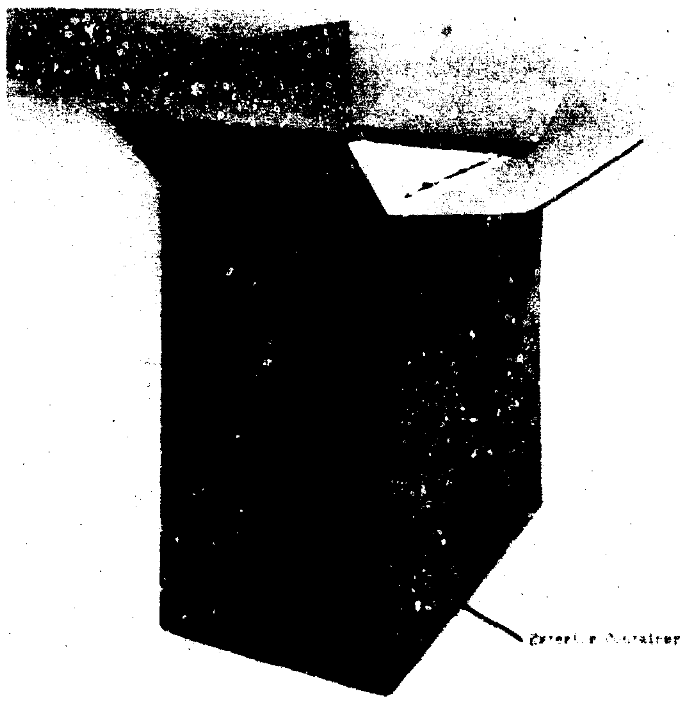


Figure 24 Fan Assembly Package

NOTE: Assembly manual and elbows not shown (see MIL-V-40645, Figure 11, Appendix A).



NOTE: Exterior Container Marking Not Shown (see Figure 12 of MIL-V-40645, Appendix A).

Figure 25 Packaging of Fan Assembly

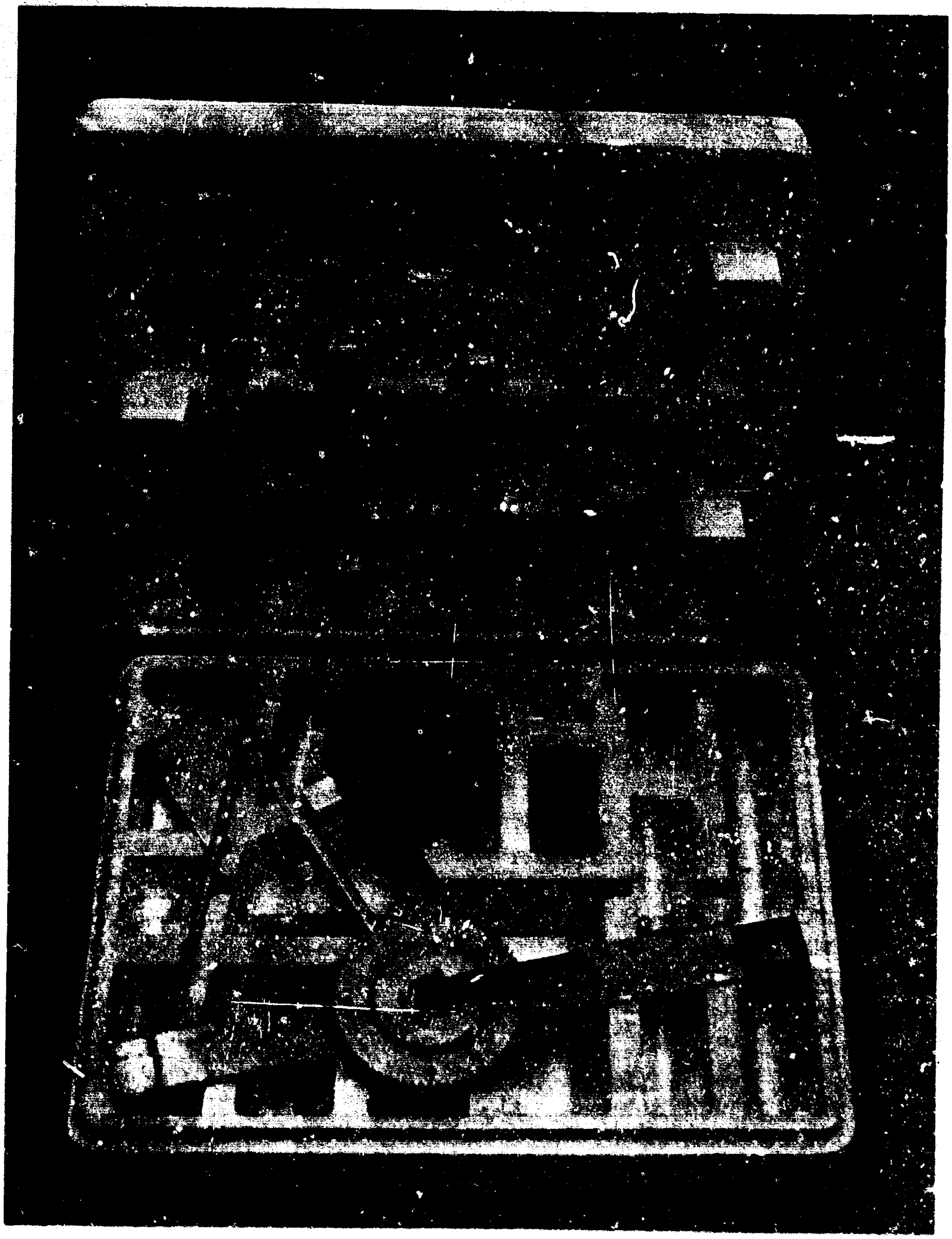
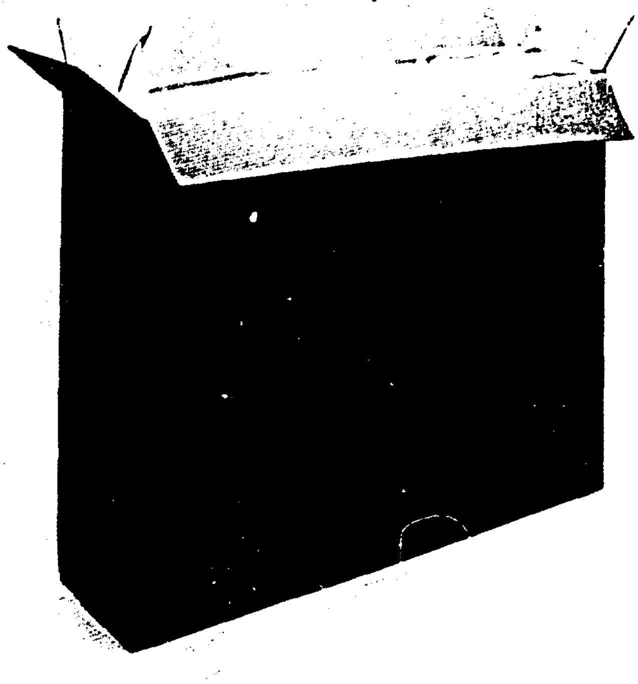


Figure 2(Drive Module Package

NOTE: Clutch-type PVK module shown (see MIL-V-40045, Figure 13, Appendix A).



NOTE: Exterior Container Marking Not Shown (see Figure 14 of MIL-V-40645, Appendix A).

Figure 27 Packaging of Drive Module

All appurtenances within this package have been further preserved (see 5.2.1 of MIL-V-40645, Appendix A) by either a coating with a grease, Type P-1 of MIL-P-116, or a sealed greaseproof and water-vaporproof bag, Method IC-1 of MIL-P-116.

Many difficulties were encountered with the foam-in-place method. The foam would not spread evenly over the bottom of the container because of its high viscosity; thus many voids remained around the irregular shaped drive module. This packaging was estimated to cost more than eight dollars per Drive Module. For these reasons this method of packaging was not considered further.

The bead-adhesive package does not satisfy the requirement for stacking. In this method the pre-expanded polystyrene beads are automatically mixed with an adhesive and drying agent. The formulation then is blown around the product after it has been encased in a polyethylene film bag and set into the corrugated fiberboard container.

2.6 Cost Analysis

The cost of a Package Ventilation Kit based on large production quantities is estimated to be $89 for the Fan Assembly, and $65 for the Drive Module (see Tables III and IV). A complete one-module PVK thus costs $154, and a complete two-module PVK $219.

Ventilation cost per shelteree have been determined based upon (1) the above costs, (2) an assumed minimum ventilation requirement of 15 cfm per shelteree, and (3) shelters with equivalent duct lengths of zero, 200, and 400 feet. These costs are presented as a function of shelter capacity for various stocking procedures including all one-module PVK's, all two-module PVK's, and for the combination of one-module and two-module PVK's that results in the lowest ventilation cost in Figures 28a, b and c. Similar cost curves could be generated for different minimum ventilation rates.

These cost curves provide an insight into the cost savings that are possible if minimum cost combinations of one and two-module PVK's are stocked, rather than stocking only one or two-module PVK's. To do this it is necessary to assume that there is a uniform distribution of shelters by size; that is, that there are just as many 50 man shelters as 51 man shelters, etc., up to 900 man shelters. The areas under the cost curves in Figures 28a, b

TABLE III

Cost Analysis of Fan Assembly Per MIL-V-40645

Purchased Parts & Materials: $41.98

Drawing & Item	Description	Cost
1423A-1100 Item 6	Chain, Module-To-Fan	$2.62
Item 7	Nuts, Lock, Flange	0.038
Item 8	Chain, Shaft-To-Motor	1.56
Item 10	Rollpin	0.007
Item 11	Retaining Ring	0.005
-1101 Item 2	Nut, Weld	0.008
-1102 Item 3	Rivets	0.014
-1102-1	Shroud	2.77
-1102-2	Guard	1.137
-1103	Sprocket Subassembly	1.58
-1104	Fan	3.28
-1105 Item 3	Rollpin	0.007
-1105 Item 4	Cord	1.39
-1105 Item 5	Connectors, Parallel, Insulated	0.033
-1000 Item 11	Adaptor, Grounding	Cost included in -1105 Item 4, Cord
-1105-1	Motor	13.56
-1105-2	Sprocket, Motor Shaft	0.42
-1106	Pin Subassy, Locating	0.22
-1101 (material)	Frame	1.172
-1300 (material)	Stand	
Packaging and Packing:		7.80
Cartons	5.40	
Bag	1.75	
Dunnage	0.65	
Finishing		4.36

Labor: 4.0 hours @ $3.10/hr 12.40

Labor Overhead: (90%) 11.16

Accessories: 13.56

Drawing & Item	Description	Cost
1423A-1000 Item 4	Duct (90 ft.)	2.50
Item 5	Duct (130 ft.)	3.61
Item 6	Tape (1-1/2 inch x 36 yds)	2.64
Item 7	Lubricant	0.030
Item 8	Scissors	0.22
Item 9	Screwdriver	0.10
Item 10	Wrench	1.00
Item 12	Adaptor, Plug	0.108
Item 13	Instructions (Furnished by OCD)	--
-1401	Duct Adaptor	0.788
	Elbows (see 3.7.3 of MIL-V-40645, Appendix A)	2.56

Sub-Total........... 79.10

General & Administrative Services: (8%) 6.33

Sub-Total........... 85.43

Profit: (4%) 3.42

Total...............$88.85

NOTES: 1) Based on 100,000 units.
2) No freight costs included.

TABLE IV

Cost Analysis of Drive Module Per MIL-V-40645

Purchased Parts & Materials: $27.05

Drawing & Item		Description	Cost
1423A-1200	Item 2	Crank	$1.40
	Item 3	Bearing Cups	0.22
	Item 4	Bearings	0.094
	Item 5	Cone, Adjusting	0.128
	Item 6	Locknut	0.048
	Item 7	Washer	0.011
	Item 8	Cone, Locking	0.128
	Item 9	Pedals	0.46
	Item 11	Saddle	0.87
	Item 12	Thumbscrew	0.022
	Item 17	Chain, Module-To-Module	3.86
	Item 18	Clamp, Saddle Post	0.09
	Item 19	Bolt	0.04
	Item 20	Nut	0.02
-1201	Item 3	Nut, Weld	0.008
-1203-1		Sprockets	1.84
-1203	Item 2	Rivets	0.036
-1106		Pin Subassembly, Locating	0.22
-1201 (material)			
-1202 (material)			2.50
-2104 (material)			
-1501 & 1502		Containers (polystyrene)	5.79

Packaging & Packing Materials:		3.50
Carton	1.70	
Bag	1.42	
Dunnage	0.38	
Finishing		5.76

Labor: 5.2 hours @ $3.10/hr 16.12

Labor Overhead: (90%) 14.51

Sub-Total......... 57.68

General & Administrative Services: (8%) 4.61

Sub-Total......... 62.29

Profit: (4%) 2.49

Total............$64.78

NOTES: 1) Based on 100,000 units.
2) No freight costs included.

and c are then directly proportional to the cost of ventilating the country's identified shelters using PVK's. The area under the lowest curve is proportional to the lowest cost (for each equivalent duct length), and the shaded area is proportional to the increase in ventilation costs if only one-module PVK's were stocked. The cost of stocking only one or two-module PVK's exceeds the minimum cost combinations of one and two-module PVK's as follows:

Table V
PVK Cost Analysis

Equivalent Duct Length, feet	Ratio of 1-module PVK Stocking Costs to Minimum Combination of 1 & 2 Module PVK's	Ratio of 2-module PVK Stocking Costs to Minimum Combination of 1 & 2 Module PVK's
0	1.03	1.34
200	1.07	1.22
400	1.06	1.20

GARD is conducting a comprehensive evaluation of the distribution of shelters according to size, ventilation requirement, and equivalent duct length in order to determine what size and design styles of PVK's best meets OCD's needs. If this study (Stanford Research Institute Subcontract B-70925(4949A-28)-US, OCD Work Unit 1423A) confirms that there is a large need for one-module PVK's, it will be possible to modify the present design and reduce the cost of shelter ventilation below those indicated in Figures 28a, b and c.

2.7 Patent

Patent Application S.N. 455,694 was filed in behalf of the Office of Civil Defense under Contract OCD-PS-64-22. This application is based on the unit (see Figure 29) completed and demonstrated at the Pentagon on 5 March 1964, and described in GATC Report MRD 1244, "Package Ventilation Unit For Identified Shelter Spaces", dated February 1964 by E. J. Rollo, et. al.

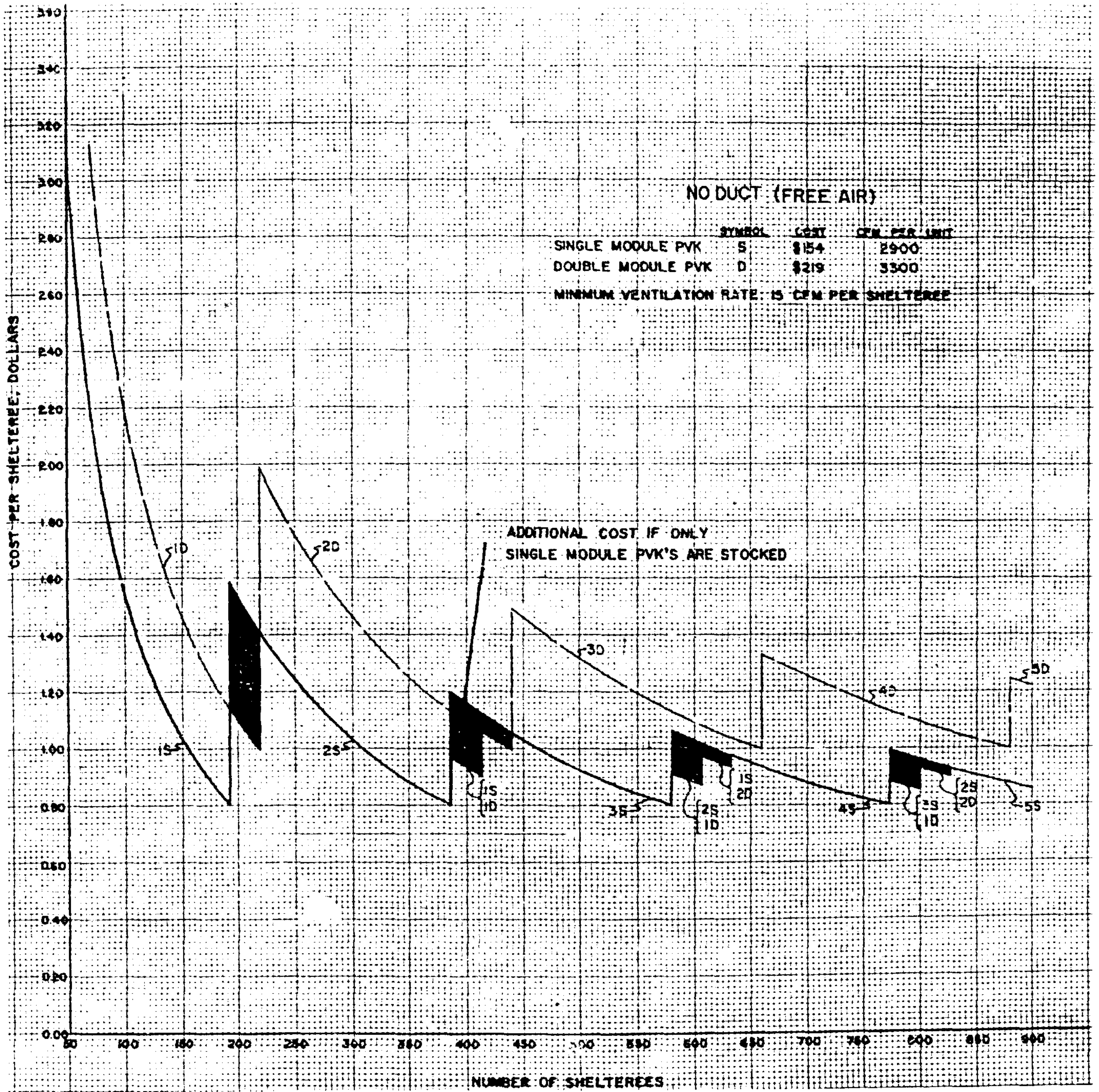


Figure 28a Ventilation Costs for Various PVK Stocking Methods - No Duct (Free Air)

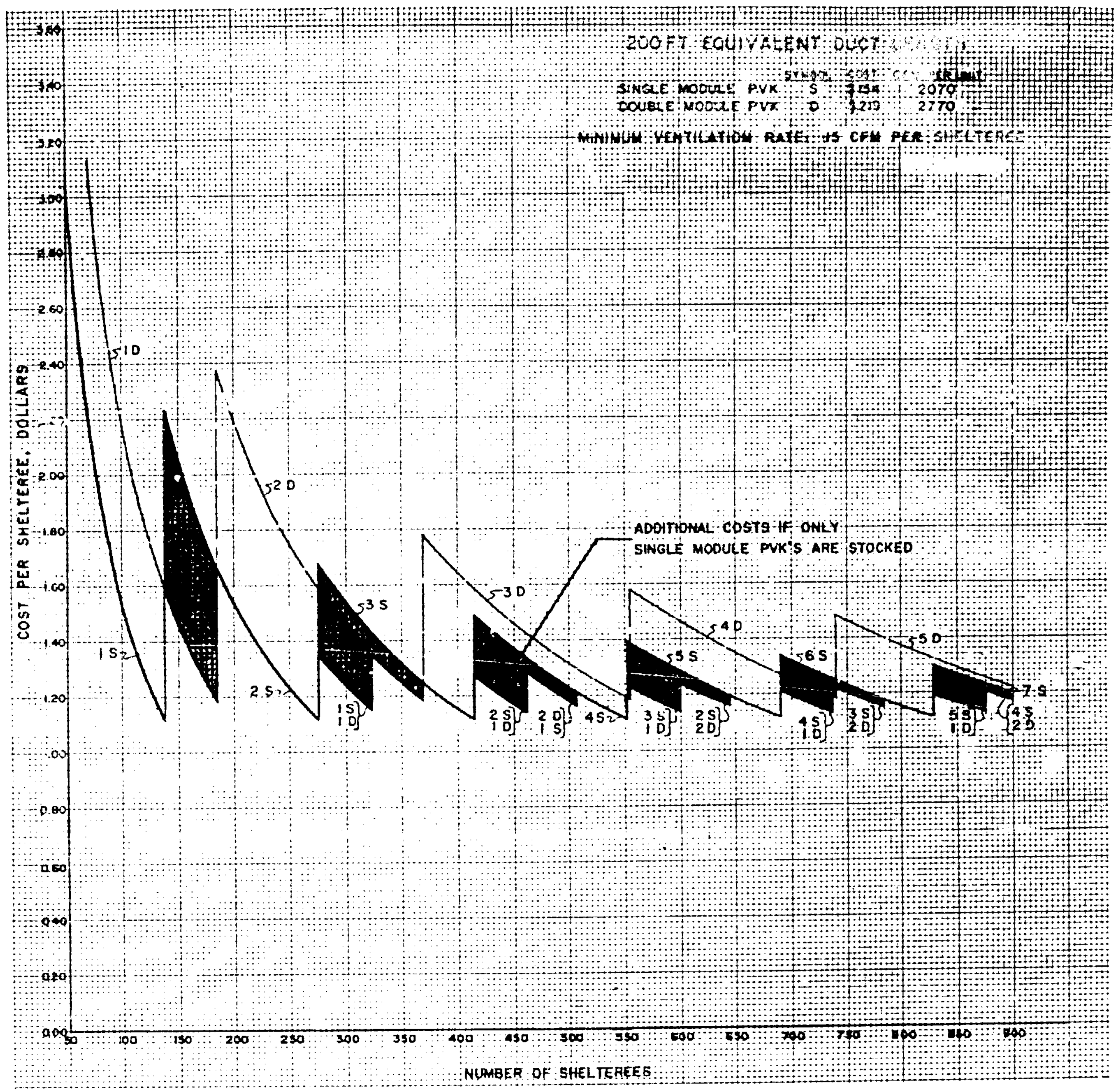


Figure 28b Ventilation Costs for Various PVK Stocking Methods - 200 Feet of Duct

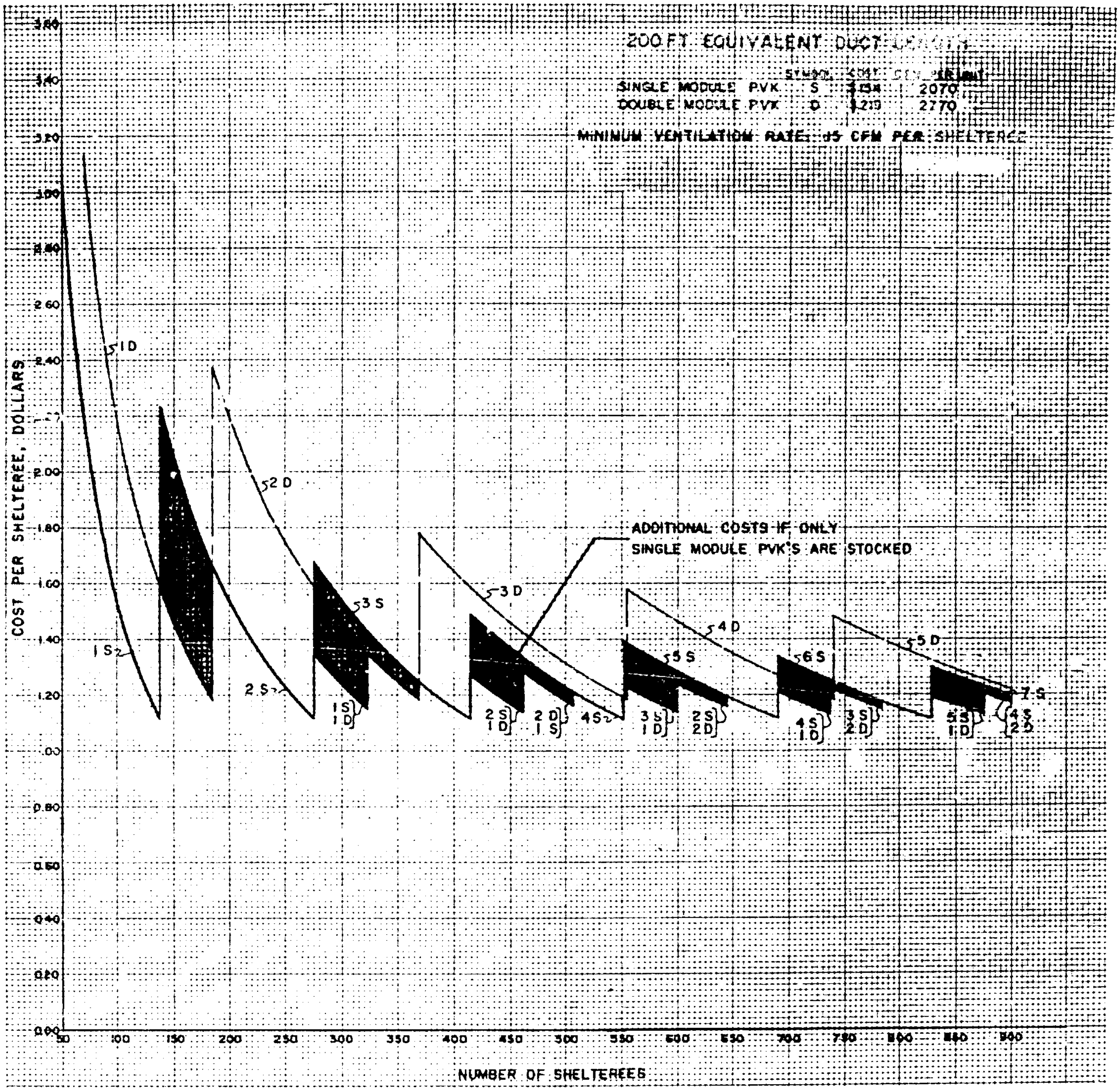


Figure 28b Ventilation Costs for Various PVK Stocking Methods - 200 Feet of Duct

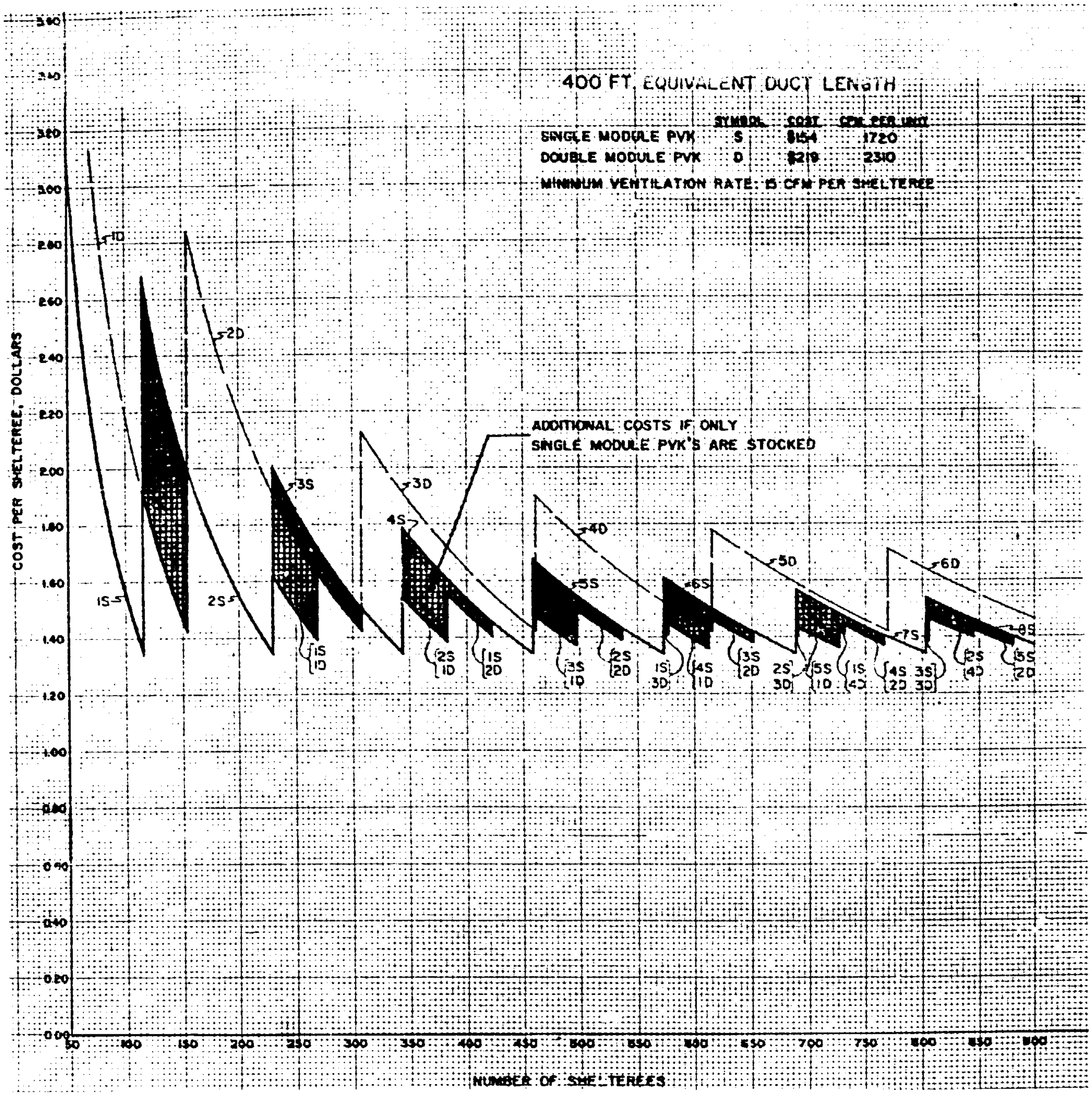


Figure 28c Ventilation Costs for Various PVK Stocking Methods - 400 Feet of Duct

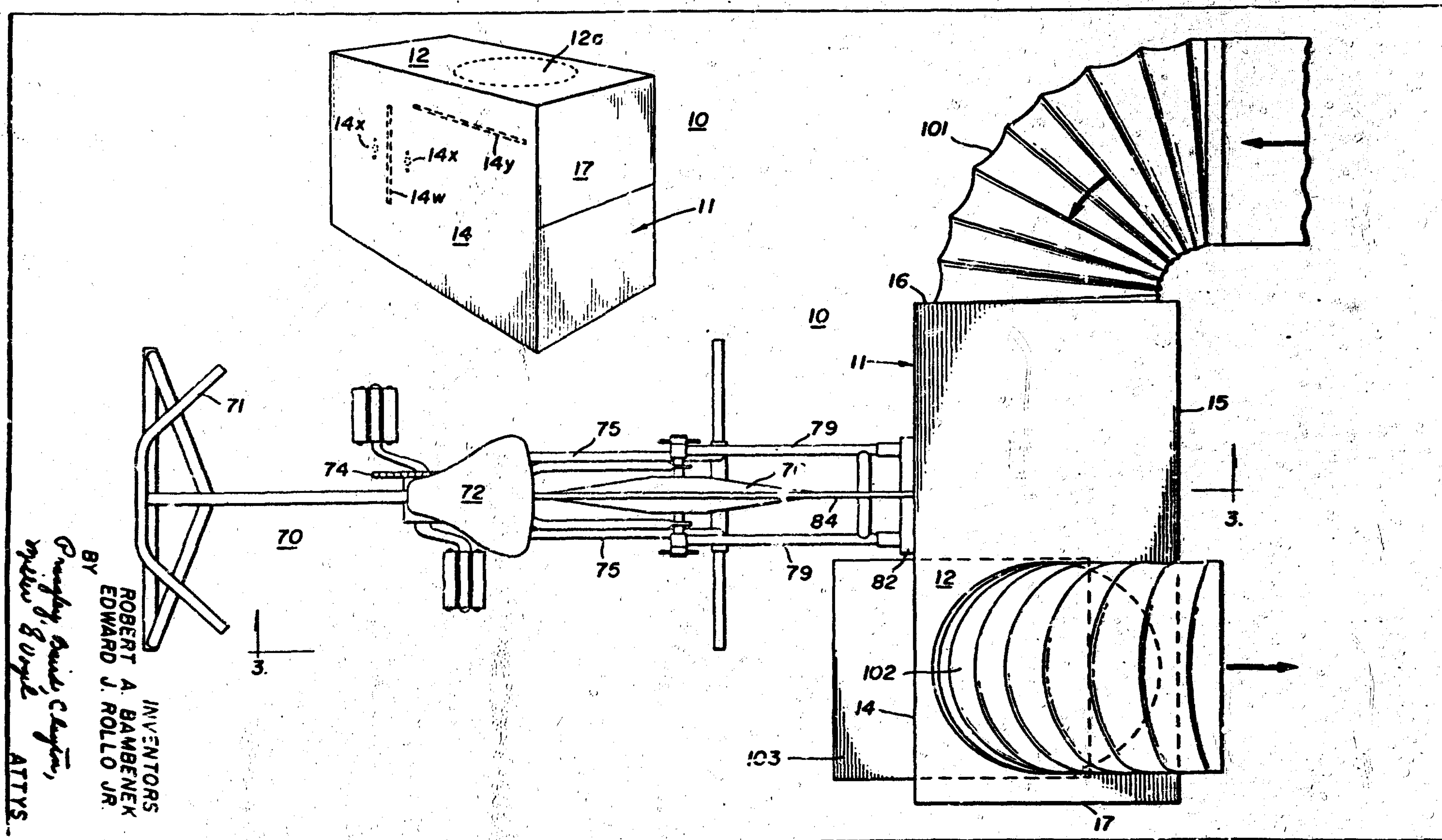


Figure 29 Illustrations from Patent Application S.N. 455,694

SECTION 3

PERFORMANCE

3.1 Fan

As shown in the fan selection analysis (see 2.2.1), The Torrington Mfg. Co. Model E-2024-4 is the best impeller for application to a ventilator driven by 1, 2, or 3 persons at nominal speeds of 800,1000, and 1140 rpm respectively. For these speeds the fan-shroud performance characteristics were established at The Torrington Laboratories per NEMA Code FML-7.02 (see Figure 30).

3.1.1 Standard Air

To obtain the fan speeds of 800, 1000, 1140 rpm for the 1, 2, and 3 man-drive unit respectively the pedal speeds required are approximately 41, 52, and 59 rpm respectively (see 2.3.2). When operating at these constant speeds, the power capability of the operators (1/10th horsepower each) as shown in Figure 30 is not utilized throughout the entire range of duct lengths or system pressure drops; therefore, performance curves (see Figure 31) based on a constant fan brake horsepower of 0.10 per drive position (up to pedal speeds of 62 rpm) were developed using the following fan law (Ref. 5, page 584):

For constant power and variable speed:
(Constant Air Density — Constant System)

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1} \qquad (4)$$

$$\frac{SP_2}{SP_1} = \left(\frac{N_2}{N_1}\right)^2 \qquad (5)$$

$$\frac{HP_2}{HP_1} = \left(\frac{N_2}{N_1}\right)^3 \qquad (6)$$

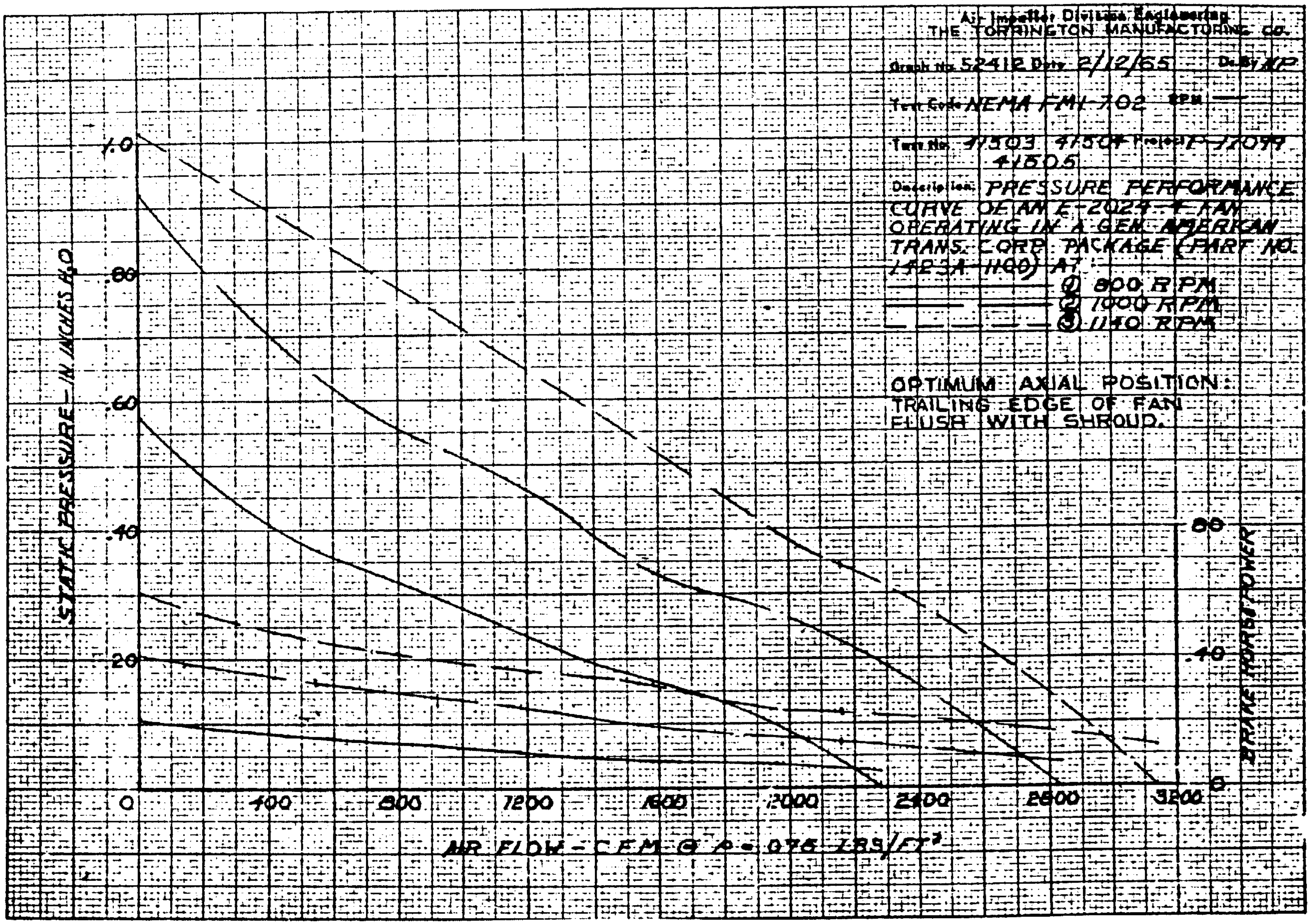


Figure 30 Fan-Shroud Performance Data

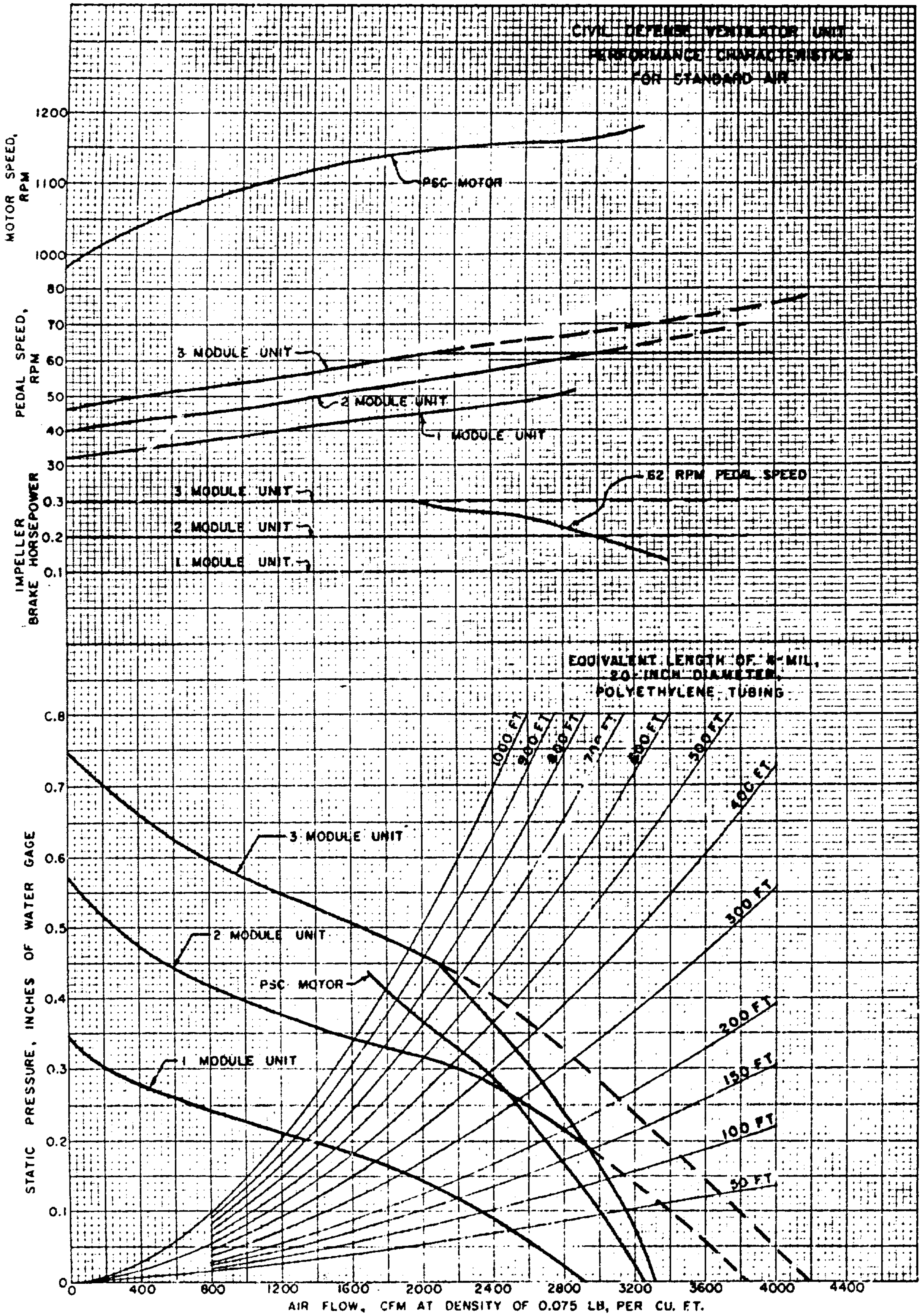


Figure 31 PVK Performance for Standard Air

where:

Q = air flow, cfm

N = fan speed, rpm

SP = static pressure, inches of water gage

HP = brake horsepower

The fan performance curves are superimposed on the system characteristic curves for 4-mil, 20-inch diameter polyethylene tubing (Ref. 9). The constant power curves in Figure 31 which require pedal speeds greater than 62 rpm are shown dotted since it is difficult for people to pedal effectively at these higher speeds. The two and three-man PVKs have the same performance curve from free air to 150 feet of duct because of the pedal speed limitation. For the three-man PVK to be economical the sprocket ratio must be increased and an additional PVK-style must be carried in inventory.

3.1.2 Effect of Elevation and Exhaust Air Conditions

Ventilation rates developed by the PVK fan increases with increasing elevation because of the decreased air density and decreased duct resistance to flow. However, the air density reduction due to altitude reduces the cooling ability of the air more rapidly. The net effect is that the PVK has less cooling ability at increased altitude; therefore, caution must be exercised when finalizing the PVK stocking procedures.

If the shelter ventilation requirements are expressed in terms of the actual shelter air density, that is, in terms of shelter elevation and the psychrometric exhaust air conditions of dry-bulb and wet-bulb temperatures [as GARD is doing on Stanford Research Institute Subcontract B-60421(4949A-4)-US under OCD Work Unit 1215A], then the PVK performance for standard air can be used with the selected logistic program (see Section 2.6). This simplified procedure is conservative in that it underestimates the PVK air handling capacity by as much as 13 percent at an elevation of 5000 feet (see Table VI). NOTE: Any of the stocking programs inherently has excess ventilation above the design ventilation rate since the PVK-system air flow rate remains constant and the number of shelterees per PVK unit varies considerably (see Figure 28). If a more exact and economical procedure is required for use with the selected logistic program, then PVK performance curves must be developed for other elevations, and the shelter elevation, as well as the actual shelter air requirement, must be specified. Included herein (see Figure 32) is the PVK performance for 5000 feet elevation. This PVK performand rating was developed using the following fan law and Equations 4, 5, and 6.

For variation in air density:
(Constant Volume - Constant System - Fixed Fan Size - Constant Fan Speed)

$$Q_2 = Q_1 \tag{7}$$

$$\frac{SP_2}{SP_1} = \frac{\rho_2}{\rho_1} \tag{8}$$

$$\frac{HP_2}{HP_1} = \frac{\rho_2}{\rho_1} \tag{9}$$

where:

Q = air flow, cfm

SP = static pressure, inches of water gage

HP = brake horsepower

ρ = air density, lbs./cu. ft.

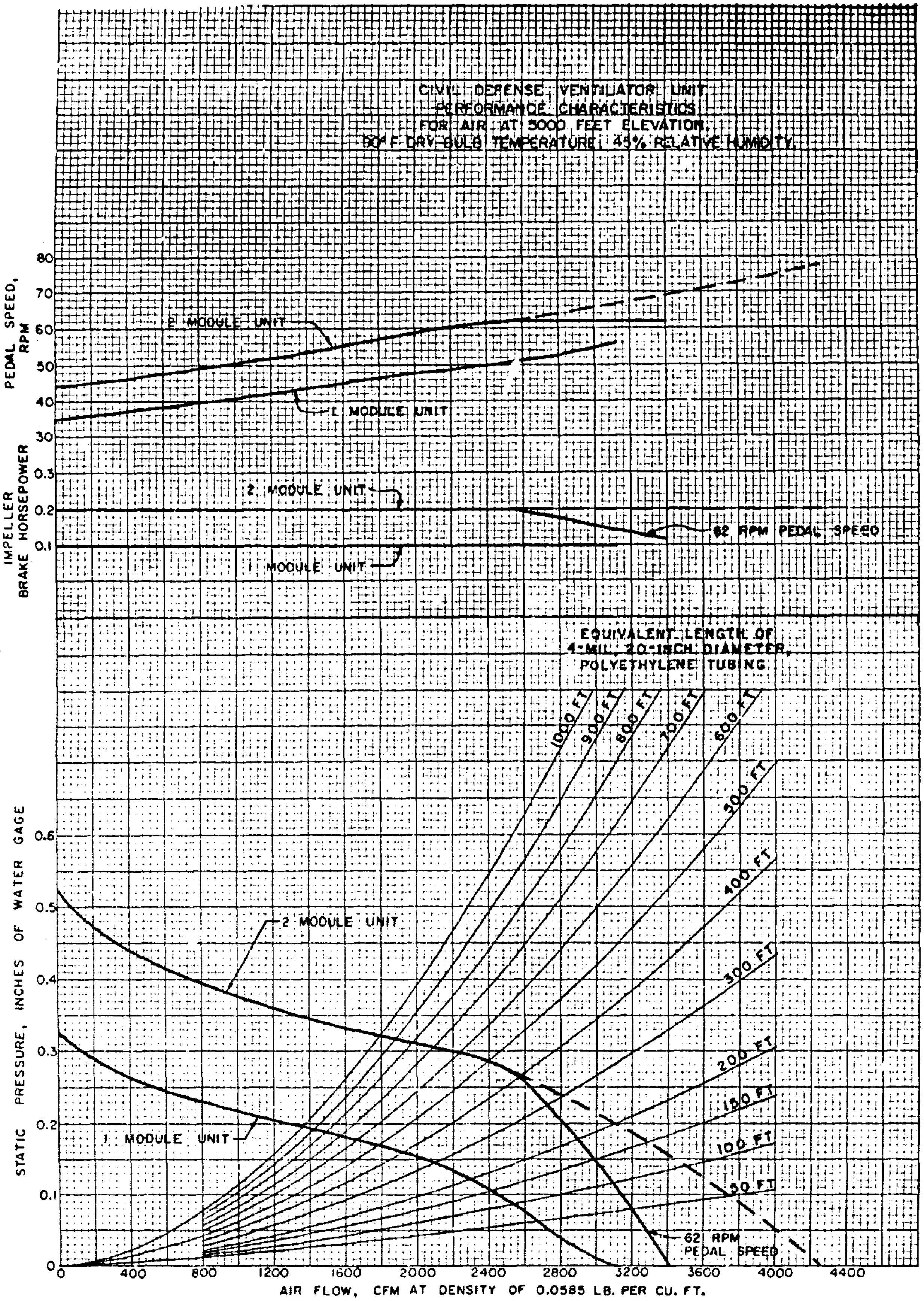


Figure 32 PVK Performance at 5,000 Feet Elevation

TABLE VI

PVK Rating For Standard Air and 5,000 Feet Elevation

Equivalent Length of Duct System, Feet	One Drive-Module PVK			Two Drive-Module PVK			Motor-Fan Rating	
	Air Density, lb per cu ft		% Increase Air Flow Due to Decreased Density	Air Density, lb per cu ft		% Increase Air Flow Due to Decreased Density	Air Density, lb per cu ft	
	0.075 *	0.0585 #		0.075 *	0.0585 #		0.075 *	
	Air Flow, Q_s cfm	Air Flow, Q_a cfm	$\frac{Q_a - Q_s}{Q_s} \times 100$	Air Flow, Q_s cfm	Air Flow, Q_a cfm	$\frac{Q_a - Q_s}{Q_s} \times 100$	Air Flow, Q_m cfm	Speed, RPM
0	2920	3120	6.8	3310	3410	3.0	3250	1180
50	2500	2670	6.8	3160	3200	1.3	3020	1165
100	2340	2540	8.6	3050	3090	1.3	2900	1160
150	2190	2410	10.0	2950	2990	1.4	2790	1158
200	2080	2300	10.6	2800	2900	3.6	2690	1157
300	1890	2100	11.1	2540	2720	7.1	2520	1156
400	1730	1920	11.0	2330	2570	10.3	2370	1154
500	1600	1780	11.2	2150	2400	11.6	2230	1150
600	1510	1660	9.9	2010	2230	10.9	2110	1148
700	1420	1570	10.6	1880	2090	11.2	2010	1145
800	1340	1490	11.2	1780	1970	10.7	1930	1142
900	1280	1420	10.9	1690	1880	11.2	1850	1140
1000	1220	1380	13.1	1610	1790	11.2	1790	1138

* Air density of 0.075 lbs per cu ft (standard air) is at sea level (29.92 inches of Mercury Barometer), 70°F dry-bulb temperature, 0% relative humidity. Data from Figure 31.

\# Air density of 0.0585 lbs per cu ft is at 5,000 feet elevation (24.89 inches of Mercury Barometer), 90°F dry-bulb temperature, 45% relative humidity. Data from Figure 32.

If the ventilations requirements are presented in terms of standard air at sea level [as documented in the 1964 ASHRAE Guide and Data Book, Applications, Figure 12 (from Ref. 10)], the ventilation requirements for shelters at higher elevations must be corrected to actual flow rates. Then the PVK rating for standard air, which results in a conservative and simplified stocking procedure, or the PVK rating at the respective elevation, which results in a more exact and economical stocking method, can be used with the selected logistic method.

3.2 Transmission

The power losses in the transmission were determined by measuring the torque required to drive the assembly at various speeds with the fan removed. The pedal shaft was driven by a compound-wound (d.c.) motor with a Power Instruments Inc. Model 784 Torqmeter located between the motor and the pedal shaft (see Figure 33). The crank was modified to accommodate this direct-drive arrangement. The fan shaft speed was measured with a stroboscope and the power required to drive the system calculated using the following expression.

$$P_L = \frac{T(N/R)}{63,025} \qquad (10)$$

where:

P_L = transmission power losses, horsepower (hp)

T = input torque, lb-in

N = impeller shaft speed, rpm

R = speed ratio from shaft to pedal crank shaft (19.46), dimensionless

The results of these tests are shown in Figure 34. For any of the systems the transmission power losses do not exceed 8 percent of the total input based on 0.1 hp input per drive-position (see Table VII).

Figure 33 Laboratory Set-Up For Determining Transmission Losses

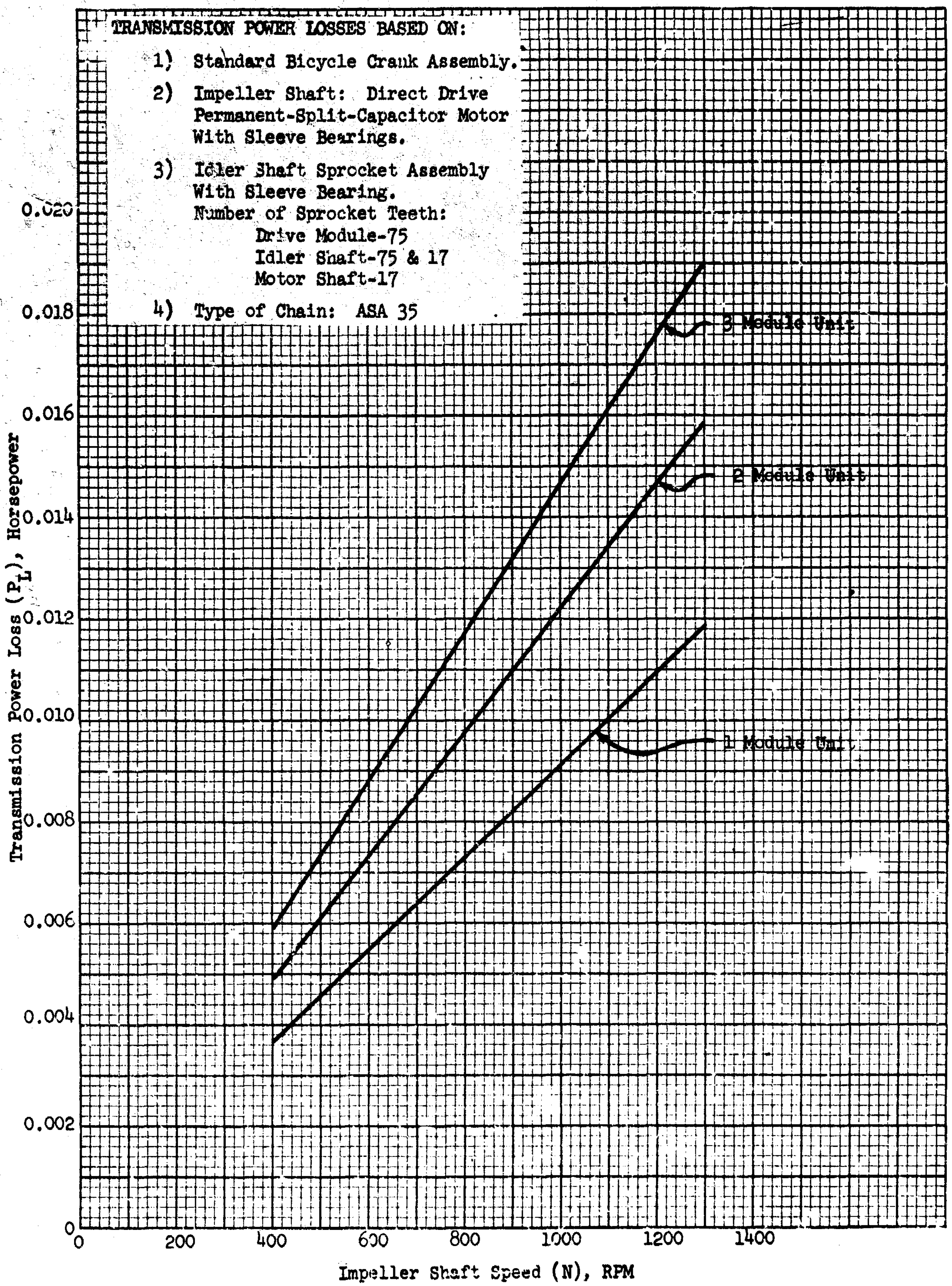


Figure 34 PVK Transmission Power Losses

Table VII

Transmission Power Losses

Number of Drive Modules	Fan Shaft Speed (N), rpm	Power Losses (P_L), hp	Mechanical Efficiency, Percent
1	800	0.0073	92.7
2	1000	0.0122	93.9
3	1140	0.0167	94.4

3.3 Motor

The performance characteristics of the specially wound permanent split-capacitor (PSC) motor, as manufactured by the Emerson Electric Mfg. Co., is presented in Figure 35. This same motor was installed in a PVK, and tested at The Torrington Laboratories per NEMA Code FM1-7.02. The results of this test are shown in Figure 36, and the air flow — static pressure data are also shown in Figure 31, page 55, PVK Performance for Standard Air. This Emerson motor, Model No. K55HXCTD-1916, is certified to meet all the quality assurance provisions of Section 4, Specification MIL-V-40645. This motor also meets the Underwriters Laboratories requirements for approval. The maximum measured temperature rise of the motor windings is 26.5°C when operating at 1/3 horsepower (Ref. 11).

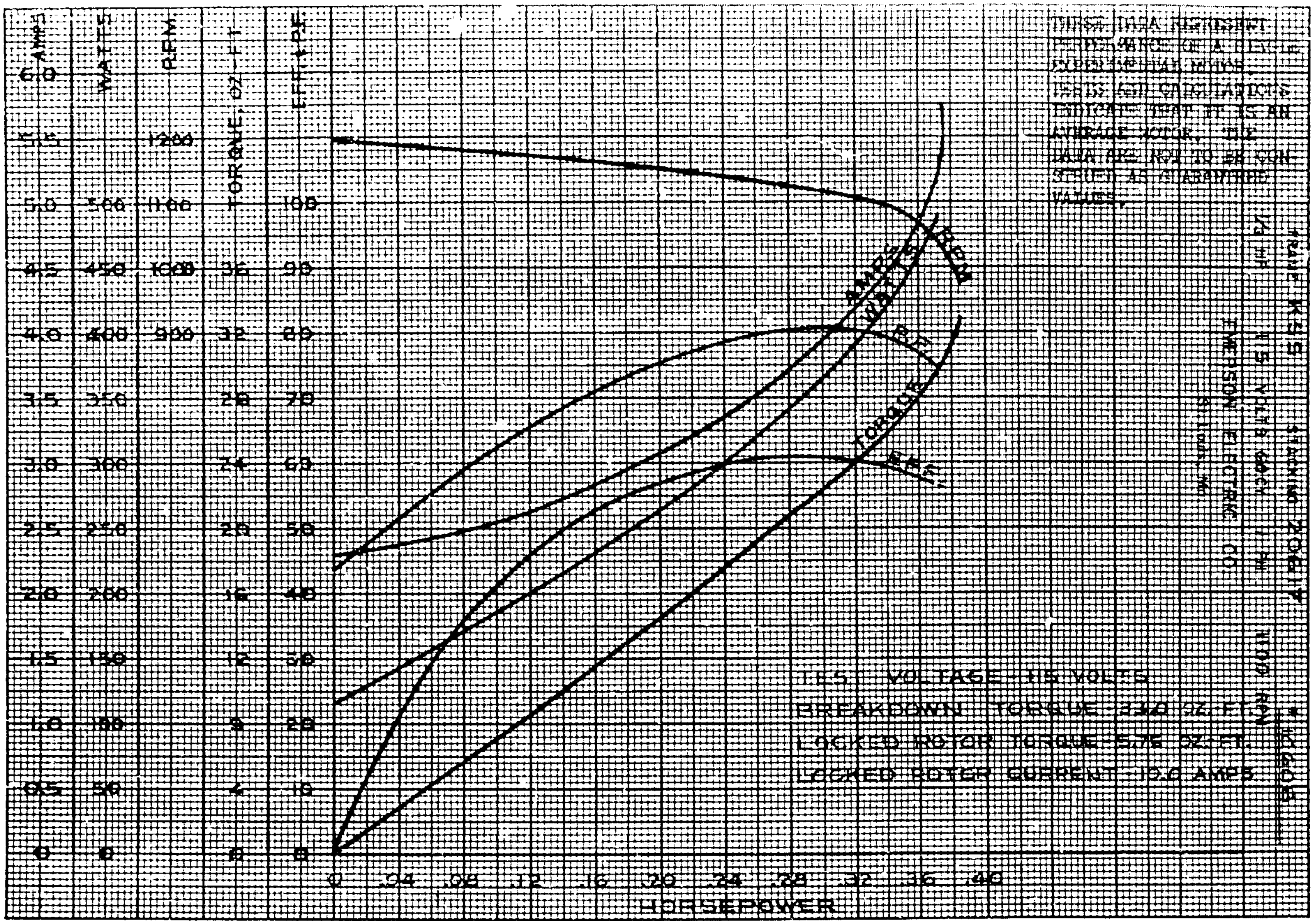


Figure 35 Motor Performance Data — Emerson Electric Mfg. Co.

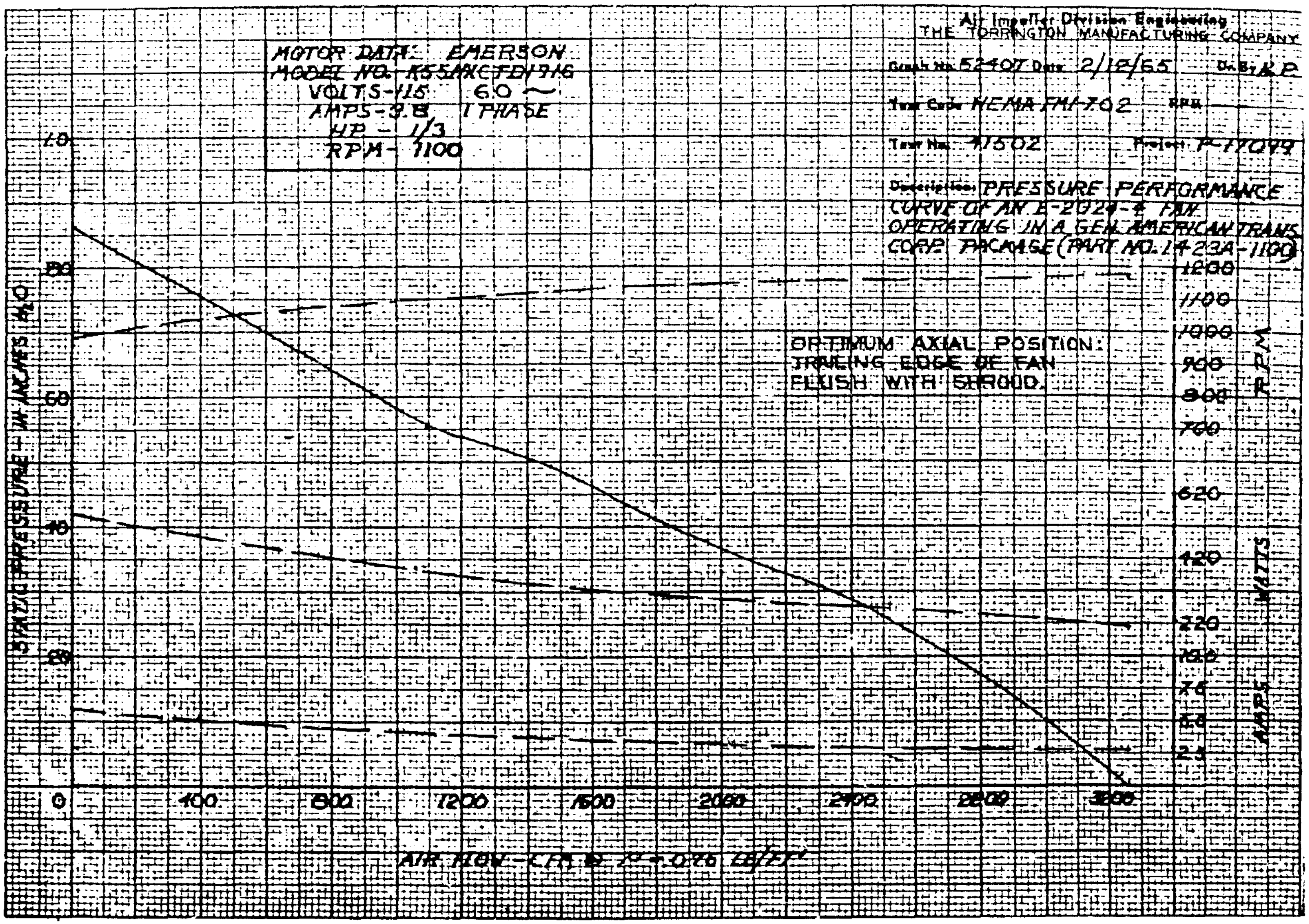


Figure 36 PVK Motor-Fan Performance For Standard Air

REFERENCES

1. G. Engholm, "Physiological And Meteorological Aspects Of Shelter Ventilation", paper presented at Scientific Working Party of NATO Civil Defense Committee, July 1965.

2. B. A. Libovicz and H. F. Behls, "Experimental Prototype Package Ventilation Kit, First Structural and Human Factors Test", prepared for the Office of Civil Defense under Stanford Research Institute Subcontract B-70925(4949A-28)-US, General American Transportation Corporation (GARD Report 1278-4.1), Niles, Illinois, May 1965.

3. B. A. Libovicz, R. B. Neveril, and H. F. Behls, "Preproduction Prototype Ventilation Kit, Second Structural and Human Factors Test", prepared for the Office of Civil Defense under Stanford Research Institute Subcontract B-70925 (4949A-28)-US, General American Transportation Corporation (GARD Report 1278-4.2), Niles, Illinois, August 1965.

4. Op. Cit., Libovicz, GARD Report 1278-4.1, Supplement, "Evaluation of An Experimental Prototype Package Ventilation Kit: First Human Factors Test", prepared by J. F. Hale, R. L. Dueker, D. E. Meagley, and R. L. Davis of the American Institutes For Research (AIR Report E55-5/65-TR), Pittsburgh, Pennsylvania, for the General American Transportation Corporation, Niles, Illinois.

5. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Guide and Data Book, 1965 and 1966, New York.

6. A. A. Atalla, "Propeller Fan Orifice Design", The Torrington Manufacturing Company, Electrical Manufacturing, December 1956.

7. "Fractional Horsepower Motor Handbook", Bodine Electric Company, Chicago, Illinois, 1963, second edition.

8. "Phosphate Coatings", H. A. Henderson Company, Los Angeles, California.

9. R. B. Neveril and H. F. Behls, "Friction Loss In Flexible Plastic Air Duct", prepared for the Office of Civil Defense under Stanford Research Institute Subcontract B-70925(4949A-28)-US, General American Transportation Corporation (GARD Report 1278-2), Niles, Illinois, October 1965.

10. F. C. Allen, "Mechanical Equipment Requirements", ASHRAE Symposium on Survival Shelters, June 1962.

11. Op. Cit., Libovicz, GARD Report 1278-4.2, Supplement II, "Package Ventilation Kit: Motor Test".

APPENDIX A

SPECIFICATION

MIL-V-40645(Army-OCD)
16 August 1965

LIMITED COORDINATION

MILITARY SPECIFICATION
PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR DRIVE (CIVIL DEFENSE)

This limited coordination military specification has been prepared by the Office of Civil Defense based upon currently available technical information, but it has not been approved for promulgation as a coordinated military specification. It is subject to modification. However, pending its promulgation as a coordinated military specification, it may be used in procurement.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers the fabrication, assembly, performance, and packaging of a pedal operated and electrically driven portable ventilation fan and ducting (see Figure 1) for use in fallout shelters.

1.2 Classification. Package Ventilation Kits shall be of one type, size, and style, composed of two(2) units (see 6.1 and 6.2 and Figure 1).

UNIT A - Fan Assembly with stand, duct adaptor and accessories

UNIT B - Drive Module with saddle, pedals, chain and handlebar

2. APPLICABLE SPECIFICATIONS, STANDARDS, DRAWINGS AND OTHER PUBLICATIONS

2.1 Specifications and standards. The following specifications and standards of the issue, in effect on date of invitation for bids, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

L-P-378	Plastic Film (Polyethylene Thin Gage)
PPP-B-636	Box, Fiberboard
PPP-F-00310	Fiberboard, Corrugated, Wax and/or Resin Impregnated
PPP-B-640	Boxes, Fiberboard, Corrugated, Triple-Wall
GGG-S-278	Shears and Scissors
PPP-T-45	Tape, Gummed, Paper, Reinforced
PPP-T-76	Tape, Pressure-Sensitive Adhesive Paper, (For Carton Sealing)

FSC 4140

PPP-S-760	Strapping, Nonmetallic, (and Connectors)
CC-M-636	Motor, Alternating-Current (Fractional Horsepower)
PPP-T-66	Tape: Pressure-Sensitive Adhesive, Vinyl Plastic Film

Military

MIL-C-27227	Coating, Polyurethane, For Aircraft Application
MIL-B-121	Barrier Material, Greaseproofed, Waterproof, Flexible
MIL-P-149	Plastic Coating Compound, Strippable (Hot Dipping)
MIL-A-101	Adhesive, Water-Resistant, For Sealing Fiberboard Boxes
MIL-P-116	Preservation, Methods of
MIL-B-131	Barrier Material; Water Vaporproof, Flexible
MIL-T-7928	Terminals; Lug and Splice, Crimp-Style, Copper
MIL-P-19644	Plastic Foam, Molded Polystyrene (Expanded Bead Type)
MIL-L-8937	Lubricant, Solid Film, Heat Cured

STANDARDS

Military

MIL-STD-171	Finishing of Metal and Wood Surfaces
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes

Federal

FED-STD-595	Colors

(Single copies of this specification and other product specifications required by activities outside the Federal Government for bidding purposes are available without charge at the General Services Administration Regional Office in Boston, New York, Atlanta, Chicago, Kansas City, Mo.; Dallas, Denver, San Francisco, Los Angeles, Seattle and Washington, D. C.)

(Copies of the Military Specifications and Standards required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

2.2 Drawings

1423-1000	PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR DRIVE (CIVIL DEFENSE)
" 1100	Fan, Assembly of
" 1101	Frame Subassembly, Fan
" 1101-1	Guide, Handle Bar, Fan
" 1101-2	Support, Handle Bar Guide
" 1101-3	Spine, Fan
" 1101-4	Angle, Motor Mount
" 1101-5	Leg, Left, Fan
" 1101-6	Leg, Right, Fan
" 1101-7	Shaft
" 1102	Guard-Shroud Subassembly
" 1102-1	Shroud
" 1102-2	Guard
" 1103	Sprocket Subassembly, Fan
" 1103-1	Sprocket, 75 Tooth, Fan
" 1103-2	Sprocket, 17 Tooth
" 1103-3	Bearing, Sleeve, Sprocket
" 1104	Fan, 20-Inch Diameter
" 1105	Motor-Sprocket Subassembly
" 1105-1	Motor
" 1105-2	Sprocket, Motor Shaft
" 1106	Pin Subassembly, Locating
" 1200	Module, Manual Drive, Assembly of
" 1201	Frame Subassembly, Module
" 1201-1	Bracket, Cheek
" 1201-2	Guide, Handle Bar, Module
" 1201-3	Support, Mast, Right
" 1201-4	Support, Mast, Left
" 1201-5	Mast
" 1201-6	Spine, Module
" 1201-7	Hanger, Crank
" 1202	Handle Bar Subassembly
" 1202-1	Crossbar, Handle Bar
" 1202-2	Upright, Handle Bar
" 1203	Sprocket Subassembly, Module
" 1203-1	Sprocket, Module
" 1203-2	Spacer, Sprocket
" 1203-3	Spider
" 1204	Post, Saddle

1423A-1300	Stand, Assembly of
" 1301	Leg, Right, Stand
" 1302	Leg, Left, Stand
" 1303	Channel
" 1401	Adaptor, Duct
" 1501	Container, Bottom, Rigid, Module
" 1502	Container, Top, Rigid, Module

(Copies of drawings required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.3 Other Publications. The following publication, of the issue in effect on date of invitation for bids, forms a part of this specification:

National Electrical Manufacturers Association

Publication FM1-1955 - Electric Fans
Publication MG1-1963 - Motors and Generators

(Copies of NEMA Publications may be obtained from the National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.)

3. REQUIREMENTS

3.1 Drawings. Unless otherwise specified herein, the materials and assembly thereof shall be as shown on the drawings (see 2.2 and Figures 2, 3 and 4); however, minor changes will be allowed. Any minor change or substitute of materials must not affect the rigidity of the unit and the performance requirements specified herein and must be approved by the contracting officer. Drawings are furnished for contractor guidance and informational purposes only, to illustrate details of the required equipment. While every precaution has been taken to assure their accuracy, the contractor is responsible for dimensional adequacy and accurate fits for proper equipment assembly, alignment, and operation.

3.1.1 Metal Fabrication. Metal used in the fabrication of the equipment shall be free from kinks. The straightening of material shall be done by methods that will not cause injury to the metal. Shearing and chipping shall be done neatly and accurately. Corners shall be square and true. The dimensions of the swaged and expanded surfaces shown on drawings 1423A-1101-3 and 1423A-1201-6 may be altered slightly from those shown; however, the fit must be approved by the contracting officer or his authorized representative.

3.1.2 Machine Work. Tolerances and gages for metal fits shall conform to the limitations specified herein and otherwise to the standards of best commercial practice. Finished contact and bearing surfaces shall be true and exact. Adequate gages shall be utilized to assure proper connecting-joint fit, interchangeability, alignment, chain tension, and fan concentricity with respect to the shroud.

3.1.3 Bolted and Riveted Connections. Bolt holes shall be accurately punched or drilled and shall have the burrs removed. All bolts and nuts shall be tight.

3.1.4 Welding. The surfaces of parts to be welded shall be free from rust, scale, paint, grease and other foreign matter. Welds shall develop adequate strength in the parts connected.

3.1.5 Heat treatment shall be as specified on drawings.

3.1.6 Painting. Major units and subassemblies shall be painted as specified herein or on drawings.

3.2 Fan. The fan-shroud assembly shall meet the performance characteristics as shown in Figure 5. The fan diameter shall be 20.00± 0.05 inches, the leading and trailing edges shall be in line within 0.11 inches and shall be statically balanced within 0.16 ounce-inches. The fan rotation shall be clockwise (facing air discharge), and the leading edge shall be from 1/8 to 1/4 inch from the air discharge side of the shroud such that the fan does not project beyond the shroud. (See 4.4.1).

3.3 Motor. The motor shall be permanent-split capacitor, class A insulation, continuous duty, 115 volt, 60 cps, 1 phase, counter-clockwise rotation (facing the end of the motor opposite the drive shaft) conforming to Specification CC-M-636. The torque-speed characteristics shall be as indicated in Figure 6, and the allowable variation in speed is ±3 per cent. The current at 1/3 hp shall not exceed 4.5 amperes, the motor efficiency must exceed 58 per cent in the range from 1/4 to 1/3 horsepower, and the power factor shall exceed 0.75 in this same range. The locked rotor torque shall exceed 5.7 ounce-feet and the locked rotor current shall not exceed 11 amperes. (See 4.4.2.) The motor shall be capable of operating continuously at an elevation of 5,500 feet and shall have an automatic reset thermal overload protector set to allow the motor to operate continuously at a minimum output of 1/3 horsepower. The bearings shall be sleeve, babbited steel, with a felt or wick-type oil reservoir with oiling access. The motor shall be protected (double-dipped) from high humidity conditions and moisture condensation. The motor shall have a terminal box with one (see 3.5) knockout, and shall be finished and painted by the standard methods of the manufacturer except as noted on the drawing. The through-bolts must be used for mounting the motor.

3.4 Transmission. The ratio of fan shaft speed to pedal speed shall be 19.46/1.0. The power losses in the bearings, sprockets, and chains for 1, 2 and 3 drive modules connected to the fan assembly shall not exceed 8 per cent of the power input based on 0.1, 0.2 and 0.3 horsepower respectively (see 4.4.3). The chain shall be American Standards Association No. 35. All chains shall be endless riveted.

3.5 Cord, Electric. The cord shall be type SPT (National Electrical Code Standard), 3-wire, 18 gauge, 50 feet. The male plug shall be molded, U-ground, 15 ampere, 125 volt. The opposite end shall have the wires separated 3 inches, the wires stripped 3/8 inch, and shall have a molded strain relief device suitable for knockout not exceeding 1/2 inch. The ground wire shall have an uninsulated solderless number 8 ring tongue terminal. The cord shall be coiled and tied at two locations.

The cord shall be attached to the motor leads with a solderless insulated parallel connector conforming to MIL-T-7928. The ground terminal shall be attached to the retaining screw of the junction box cover. A tag containing data as indicated in Figure 7 shall be affixed to the cord one to two inches below the male plug.

3.6 Saddle. The seat shall have full three point spring suspension, and shall be a minimum of 9 inches long and 9-3/4 inches wide. The top shall be vinyl covered rubber padded. The seat clamp shall be 7/8 inch and the nut shall be hexagon, 9/16 inch across the flats. The saddle shall be finished by the standard methods of the manufacturer.

3.7 Accessories.

3.7.1 Instructions. Each Unit A shall include assembly and operating instructions. This publication will be furnished by the Office of Civil Defense at time of contract award. (See 5.1.1.6)

3.7.2 Duct, Polyethylene. Two rolls, ninety (90) feet and one hundred and thirty (130) feet, of 4 mil thick polyethylene tubing with a flat dimension of 31 inches gussetted to 15-1/2 inches conforming to type II, grade C, finish 1 of specification L-P-378 shall be supplied with each Unit A. (See 5.1.1.1.)

3.7.3 Elbows. Two (2) elbows shall be supplied with each Unit A. The elbows shall be fabricated from 4 mil thick, type II, grade C. finish 1 polyethylene conforming to Specification L-P-378 with a minimum flat dimension of 31 inches. The elbows shall be 90 degrees, smooth, with one heat sealed seam at the minimum and maximum radii (see Figure 8). The centerline radius shall be 40 inches and each end shall have a straight cuff length of 2 inches. The elbows shall be capable of withstanding an internal pressure of 1.0 inches, water guage pressure. (See 5.1.1.7.)

3.7.4 Tape. One roll of pressure-sensitive tape 1-1/2 inches in width by 36 yards in length shall be furnished with each Unit A. The tape shall conform to Specification PPP-T-66. (See 5.1.1.8.)

3.7.5 Adaptor, Plug, Screw-base. A 660 watt, 125 volt, parallel blade, screw-base adaptor plug, with plug-in receptacle end, for electric power cord attachment to a light socket shall be furnished with each Unit A. (See 5.1.2.2.)

3.7.6 Adaptor, Grounding, 3-Wire. A 3-wire, 15 ampere, 125 volt grounding adaptor with a 3-1/2 inch thermoplastic lead shall be supplied with each Unit A. (See 5.1.2.2.)

3.7.7 Lubricant. One and one-half (1-1/2) ounces of SAE 20 lube oil in a clear plastic container shall be furnished with each Unit A. The container shall be 1 inch by 4-5/8 inches, shall be marked in 5 equal increments by volume, and shall have a blind dispenser tip head.

3.7.8 Screwdriver. The screwdriver shall be suitable for the purpose intended; namely, attaching the power cord grounding adaptor to a standard wall plate or ceiling fixture. A stamping with a blade of 7/32 inch by 1/16 inch and length of 2 inches is acceptable. No stamping or marking of this item is required. (See 5.1.1.3.)

3.7.9 Wrench. A double-headed wrench, open-end at one end and box-socket double hexagon (12 point) at the other end, each with 9/16 inch opening, with a minimum length of at least 6 inches and a head thickness from 11/64 to 1/4 inch, shall be supplied with each Unit A. The wrench shall be hardened carbon steel, milled, and black enameled finish. This wrench is intended for both saddle and pedal tightening. If a pedal or saddle other than as indicated on drawings is furnished and has a different opening size required or thickness at attachment point, a similar appropriate wrench must be furnished. (See 5.1.1.4.)

3.7.10 Scissors. Contractor will furnish one 4 inch, blunt point scissors with each Unit A. Scissors shall be FSN-7340-290-3766 in accordance with Federal Specification GGG-S-278, dated November 27, 1956, Type II, Class 3, Style A and/or Style B, Size 4. (See 5.1.1.5.)

3.8 Lubrication at Assembly. The crank bearings shall be permanently lubricated with a lubricant formulated with a non-soap, organic-type thickner (di-amide-carbonyl) such as American Oil Company "RYKON" Grease No. 2. The grease shall be suitable for long shelf life stability without further lubrication during use. The two motor bearings shall be adequately lubricated with a high grade SAE 20 lubricating oil recommended by the motor manufacturer.

3.9 Finish and Color. All parts shall be free from burrs, roughness, and rust. The subassemblies and assemblies, except the sprockets, fan frame and module frame, shall be finished as follows unless otherwise noted herein or on the drawings. All tubular pieces shall be finished on the inside.

Cleaning - Finish 4.2 of MIL-STD-171.
Surface Treatment - Finish 5.3.1.3 of MIL-STD-171.
Prime - Finish 5.2 of MIL-STD-171.
Finish - One coat, semi-gloss white untinted (Number 27875 of FED-STD-595), polyurethane certified to equal or exceed the performance requirements of MIL-C-27227.

The sprockets, fan frame and module frame shall be finished as follows:

Cleaning - Finish 4.1 of MIL-STD-171.
Surface Treatment - Finish 5.3.1.3 of MIL-STD-171.
Finish - Solid film lubricant qualified under MIL-L-8937.

3.10 Marking. The fan and drive module assemblies shall have a metal plate affixed that is stamped as shown in Figures 9 and 10.

3.11 Workmanship. All materials used in the unit shall be of good commerical quality, entirely suitable for the purpose intended. The units, including all accessories, shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of machining, fitting of parts, welding, riveting and marking of assemblies. Visual defects will be cause for rejection.

3.12 Preproduction Sample. When specified in the contract or order (see 6.2) before production is commenced, a sample machine shall be submitted or made available to the contracting officer or his authorized representative for approval in accordance with 4.2. The approval of the preproduction sample authorizes the commencement of production, but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification. The preproduction sample shall be manufactured in the same facilities to be used for the manufacture of the production items.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Responsibility. The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Preproduction Sample Inspection. When a preproduction sample is required (see 3.12), it shall be examined in accordance with applicable paragraphs of Section 3 and Section 4 (with laboratory tests at the contractor's expense). Tests shall be required for the fan, motor and transmission used in the preproduction model, if these components are different than the proven prototype components suggested for use in 4.7 and 4.8 or on drawings 1423A-1000.

4.3 Production Inspection.

4.3.1 Performance. The inspector shall ascertain that the units meet the performance requirements specified herein.

4.3.2 Workmanship. The units shall be inspected for rigidity, chain tension, alignment, interference of components, interchangeability of fan assemblies and drive modules, finish, color and marking. (see 3.10).

4.3.3 Packing and Marking. The inspector shall ascertain that the packing and marking of the containers conform to this specification.

4.4 Tests. If there is any change or substitution in the fan-shroud assembly, motor, or transmission, other than the proven prototype components suggested for use in 4.7 and 4.8 or on Drawings 1423A-1000, then performance tests for these items covered in 4.4.1, 4.4.2 and 4.4.3 shall be required.

4.4.1 Fan Assembly Performance. The fan-shroud assembly shall be tested per NEMA Code FM1-7.02 at 1000 rpm.

4.4.2 Motor Performance. The motor shall be tested per NEMA Standard Publication MG1-1963, Part 12, and shall meet the performance requirements therein.

4.4.3 Transmission Efficiency. The power loss in the transmission shall be measured with a transmission dynamometer or torque-meter and stroboscope. The unit shall be driven at the drive module by replacing the crank arm with a shaft suitable for adapting to the driving and measuring device. The fan shaft shall be driven at 800, 1000, and 1140 rpm for the 1, 2 and 3 drive module units respectively. The power losses shall be based on 0.1, 0.2 and 0.3 horsepower for 1, 2 and 3 modules respectively.

4.4.4 Packaging. Cleanliness, leakage, heat seal tests are required per Specification MIL-P-116, table 3.

4.5 Quality conformance inspection.

4.5.1 Lot. A lot shall consist of one day's production or all units offered for acceptance at one time.

4.5.2 Sampling.

4.5.2.1 Sampling for Examination. Sampling for examination shall be in accordance with MIL-STD-105. The AQL shall be 2.5 per cent defective for major defects.

4.5.2.2 Sampling for Tests. Sampling for tests shall be in accordance with Standard MIL-STD-105, at inspection level II. The AQL shall be 1.0 per cent defective.

4.5.3 Examination. Each unit selected in accordance with 4.5.2.1 shall be examined for defects listed in Table I. Any sample having one or more defects shall be considered a defective unit.

TABLE I - Classification of Defects

Category	Defect
Major:	
101	Fan not as specified.
102	Guard-shroud subassembly not as specified.
103	Motor not as specified.
104	Transmission not as specified.
105	Materials not as specified.
106	Dimensions not as specified.
107	Metal fabrication, including fit of swaged joint not suitable.
108	Fasteners not as specified.
109	Chain and sprocket alignment defective.
110	Chain tension incorrect.
111	Crank locknut adjustment incorrect.
112	Fan not properly centered.
113	Appurtenances (saddle, pedals, electric cord) not as specified.
114	Workmanship, including welds, not acceptable.
115	Stability of unit not acceptable.
116	Finish not as specified or acceptable.
117	Marking of fan and module not as specified.
118	Accessories not as specified.
119	Preservation not as specified.
120	Packaging not acceptable.
121	Package marking not as specified.
122	Components missing, including technical publicatio.

4.5.4 Tests. Samples selected in accordance with 4.5.2.2 shall be tested as specified herein. Any sample failing to pass any test shall be considered a defective unit.

4.6 Inspection of Preparation for Delivery. The preservation, packaging, packing, and marking shall be inspected to determine compliance with the requirements of Section 5 of this specification.

4.7 Fan. The fan shall be equal to or interchangeable with The Torrington Mfg. Co., Fan Number E-2024-4. Any substitution shall meet or exceed performance requirements stated in 3.2.

4.8 Motor. The motor shall be equal to or interchangeable with Emerson Electric Mfg. Co., Model K55HXCTD-1916. Any substitution shall meet or exceed performance requirements stated in 3.3.

5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging of Fan Assembly and Accessories.

5.1.1 The following preservation procedures in conformance with MIL-P-116 shall be effected.

5.1.1.1 Duct. The gussetted tubing shall be wound on a substantial core with an approximate inside diameter of 3 inches and approximately 16 inches in length, and shall be suitable restrained from unwinding. Diameter of the rolled tubing shall not exceed 6-3/4 and 5-7/8 inches for the 130 and 90 foot rolls, respectively. (See 5.1.2.1)

5.1.1.2 Module-to-Fan Chain. The module-to-fan chain shall be preserved and packaged in conformance with Method IC-1 of MIL-P-116.

5.1.1.3 Screwdriver. The screwdriver shall be preserved and packaged in conformance with Method IB-1 or IC-1 of MIL-P-116 (type 1 material of MIL-P-149).

5.1.1.4 Wrench. The wrench shall be preserved and packaged in conformance with Method IB-1 or IC-1 of MIL-P-116 (type 1 material of MIL-P-149).

5.1.1.5 Scissors. The scissors shall be packaged in conformance with Method IA-8 or Method IB-1 (type 1 material of MIL-P-149) of MIL-P-116.

5.1.1.6 Assembly and Operating Instructions. The assembly and operating instructions shall be preserved and packaged per method IC-3 of MIL-P-116. (See 5.1.2.2).

5.1.1.7 Elbows. The two elbows (see 3.7.3) shall be laid out flat, one of top of the other. The elbows shall then be folded fanwise four times and then folded once across the length, resulting in a folded package approximately 17 inches by 7 inches by 1 inch in thickness. The folded elbows shall then be packaged per Method IC-3 of MIL-P-116. (See 5.1.2.2).

5.1.1.8 Tape. The roll of tape (see 3.7.4) shall be packaged in conformance with Method IA-8 of MIL-P-116.

5.1.2 Packing of Unit A. The fan assembly, components and accessory boxes shall be packed in conformance with Method IA-14 of MIL-P-116. The interior box shall be style E. class 2, grade A, triple-wall, corrugated, in conformance with Specification PPP-B-640, with inside dimensions of approximately 25-1/2 inches in length, 25-1/2 inches in width and 15-3/4 inches in depth. The bottom and the top flaps shall be secured by a center seam strip of 3 inch width of pressure sensitive tape overlapping the end panels a minimum of three (3) inches. The tape shall be in conformance with Specification PPP-T-45 or PPP-T-76.

5.1.2.1 Intermediate Packaging of Accessories. The duct (130 feet), tape, lubricant, module-to-fan chain, screwdriver, wrench and scissors shall be packaged in a style RSC, type CF, domestic class, 125 pound bursting strength, fiberboard box fabricated and closed in conformance with Specification PPP-B-636. Approximate inside dimensions shall be 6-3/4 inches in length, 6-3/4 inches in width, and 24-3/4 inches in depth. The roll of duct shall be inserted into the box, then a pad approximately 6-3/4 inches by 6-3/4 inches of the same material as the box shall be inserted flat against the end of the roll of duct. The packages of tape, lubricant, chain, screwdriver, wrench and scissors shall be placed within the remaining space with sufficient packing material and the box closed.

The ninety (90) foot roll of duct shall be packaged in the same style, type and grade fiberboard box as above with approximate inside dimensions of 5-7/8 inches in length, 5-7/8 inches in width, and 16-1/4 inches in depth.

5.1.2.2 Interior Box Packing. See Figure 11. The duct adaptor shall be placed within the triple-wall box. A paperboard heavy duty tube with approximate dimensions of 1-3/8 inch inside diameter by 2-3/4 inches in length shall be placed over the fan hub, the locating pin inserted in the spine, and the fan assembly placed in the carton with the duct adaptor nested within. The drive module support stand shall be then placed in position, with a pad of cushioning material between the drive module support and the fan guard. A pad of cushioning material shall then be placed on the fan guard and the accessory box containing 130 feet of duct, then placed in position between the drive module support and the motor. Accessory box of 90 feet of duct shall be located as shown with a piece of fiberboard 6 inches by 6 inches by 7/8 inches thick placed between the fan assembly and this box. A triple-wall fiberboard cell approximately 18 inches by 5 inches by 6 inches shall be placed in position in the void space remaining and the electric cord inserted therein and cushioned to prevent abrasion. The electrical adaptors shall be affixed to the male plug of the electric cord (see 3.7.5 and 3.7.6 and 3.5). The packaged elbows shall be placed alongside of the triple-wall fiberboard insert (see 5.1.1.7), and the assembly and operating instructions (see 5.1.1.6) shall be placed in the box.

5.1.2.3 Barrier Bag. The packed interior box shall be enclosed in a close fitting heat sealed bag fabricated from barrier material conforming to Specification MIL-B-131, class 1.

5.1.2.4 Exterior Container. The bagged interior box shall be packed in a style RSC box fabricated and with both top and bottom flaps secured with adhesive in conformance with Specification PPP-B-636. Approximate inside dimensions shall be 27-1/4 inches in length, 18-1/4 inches in width and 27-1/2 inches in depth. The corrugated fiberboard shall be wax and/resin impregnated type SW, 275 pound grade, in conformance with Specification PPP-F-00310. (See 5.1.3.2.)

5.1.2.4.1 Closure. The top and bottom flaps of the box specified in 5.1.2.4 shall be securely sealed with water-resistant adhesive conforming to Specification MIL-A-101. In addition, the top center seam shall be sealed by the application of a strip of minimum width 3 inch pressure sensitive tape in conformance with Specification PPP-T-76. The strip of tape shall overlap the side panels a minimum of 6 inches.

5.1.2.4.2 Strapping of Exterior Fan Assembly Box. The box shall be strapped with two straps, centered girthwise and lengthwise. The straps shall be nylon or polypropylene 1/4 inch nominal width and nominal thickness of 0.025 inches in conformance with Specification PPP-S-760, type II. Sealing of straps shall be with crimped seals as recommended by the manufacturer of the strapping.

5.1.3 Marking of Unit A Containers.

5.1.3.1 Marking of Individual Item Packages and Intermediate Box. The individual item packages need not be marked. The intermediate boxes (see 5.1.2.1) shall be marked on one panel with a listing of the contents.

5.1.3.2 Marking of Exterior Fan Assembly Box. The exterior fan assembly box shall be marked as illustrated in Figure 12. All printing shall be white in color and boxes shall be printed prior to being impregnated. (See 5.1.2.4).

5.2 Preservation and Packaging of Drive Module and Components.

5.2.1 When assembly of the Drive Module unit is completed, the following preservation procedures in conformance with MIL-P-115 shall be effected.

5.2.1.1 Crank. The threaded portion of each end of the pedal crank shall be coated with grease preservative, type P-11 of MIL-P-116. Each end of the pedal crank shall then be enclosed in a wrap or bag of barrier material conforming to MIL-B-121, loosely applied and secured by taping, tying or other suitable means.

5.2.1.2 Pedals. The pedals shall be preserved and packaged in conformance with Method IC-1 of Specification MIL-P-116. The pedals shall be placed flat on top of each other in a bag of maximum outside dimensions to fit in cavity in plastic insert.

5.2.1.3 Saddle. All unpainted surfaces shall be coated with type P-1 preservative in accordance with Method I of Specification MIL-P-116.

5.2.1.4 Module-to-Module Chain. The module-to-module-chain shall be preserved and packaged in conformance with Method IC-1 of Specification MIL-P-116. The chain shall be rolled flat and placed in a bag of maximum outside dimensions to fit in cavity in plastic insert.

5.2.2 Packing of Unit B. The drive module and components shall be packed in conformance with Method IA-14 of Specification MIL-P-116. The interior container shall be two piece (see Figure 13) molded polystyrene plastic foam conforming to MIL-P-19644, type N. The halves shall be nested to prevent slippage of one half with respect to the other half. The minimum allowable material thickness is 1/2 inch, and the material density shall be 1-3/4 ± 1/4 pounds per cubic foot. Cavities for the components (see 5.2.1.2, 5.2.1.3, 5.2.1.4), drive module and handlebar, must be of such proportions to enclose the particular unwrapped or wrapped component. The locating pin shall be inserted in spine at expanded end.

Packing shall not be effected prior to ten days from shipment of the foam inserts from the manufacturer to the assembler contractor.

5.2.2.1 Barrier Bag. The packed plastic foam insert shall be enclosed in a close fitting heat sealed bag fabricated from barrier material conforming to Specification MIL-B-131, class 1.

5.2.2.2 Exterior Container. The bagged foam insert pack shall be packed in a style RSC fiberboard box fabricated in conformance with Specification PPP-B-636. Approximate inside dimensions shall be 26-1/2 inches in length, 8-1/2 inches in width, and 35 inches in depth. The corrugated fiberboard shall be wax and/or resin impregnated type SW, 275 pound grade, in conformance with Specification PPP-F-00310. (See 5.2.3.)

5.2.2.2.1. Closure of Exterior Container. The top and bottom flaps shall be securely sealed by applying a strip of minimum width 3-inch pressure sensitive tape in conformance with Specification PPP-T-76 across the center seam. Tape shall overlap the side panels a minimum of 3 inches.

5.2.2.2.2. Strapping of Exterior Container. The exterior container shall be strapped with 2 nylon or polypropylene straps of 1/4 inch nominal width and 0.025 inch nominal thickness in conformance with Specification PPP-S-760, type II. Sealing of straps shall be with crimped seals as recommended by the manufacturer of the strapping. One strap shall be centered over the top, bottom and front and back panels. One strap shall be centered over the front, back and side panels.

5.2.3 Marking of Drive Module Box. The drive module box shall be marked as illustrated in Figure 14. All printing shall be white in color and boxes shall be printed prior to being impregnated (see 5.2.2.2.).

6. NOTES

6.1 Intended Use. Package ventilation kits are intended for use in identified fallout shelters to provide the necessary ventilation air to maintain thermal and atmospheric control of the shelter's environment during a national emergency. The unit can be pedal operated by the shelterees or by an electric motor of 110-volt alternating current if available. A maximum of three drive modules can be used with the fan assembly. The number of drive units depends on the size (air flow and pressure requirements) and location (air flow requirements as a function of the local weather history) of the shelter.

6.2 Ordering Data. Procurement documents should specify the following:

(a) Title, number and date of this Specification.
(b) Number of Unit A assemblies required. (See 1.2)
(c) Number of Unit B assemblies required. (See 1.2)
(d) Contact point for Instruction Manuals. (See 3.7.1.)
(e) Listing of Serial Numbers for Unit A Assemblies. (See 3.10)
(f) Listing of Serial Numbers for Unit B Assemblies. (See 3.10)
(g) When preproduction sample is required. (See 3.12)

Custodian:

Office of Civil Defense

Preparing Activity:

Office of Civil Defense

FIGURE 1. - ASSEMBLED PACKAGE VENTILATION KIT ILLUSTRATING USE OF TWO (2) UNIT B DRIVE MODULES

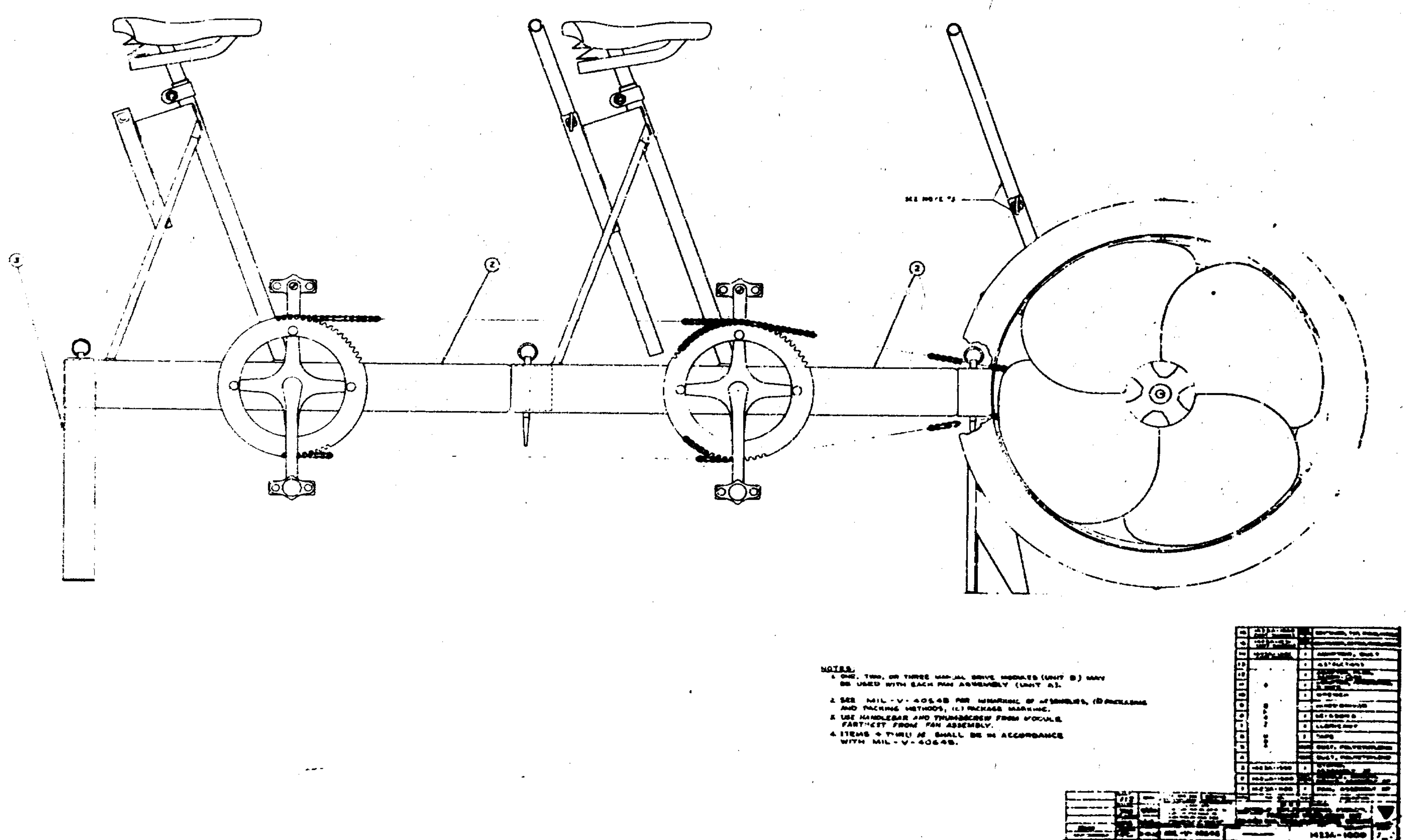


FIGURE 2. - PACKAGE VENTILATION KIT, 20-INCH FAN, MODULAR (CIVIL DEFENSE)
DRAWING NO. 1423-1000

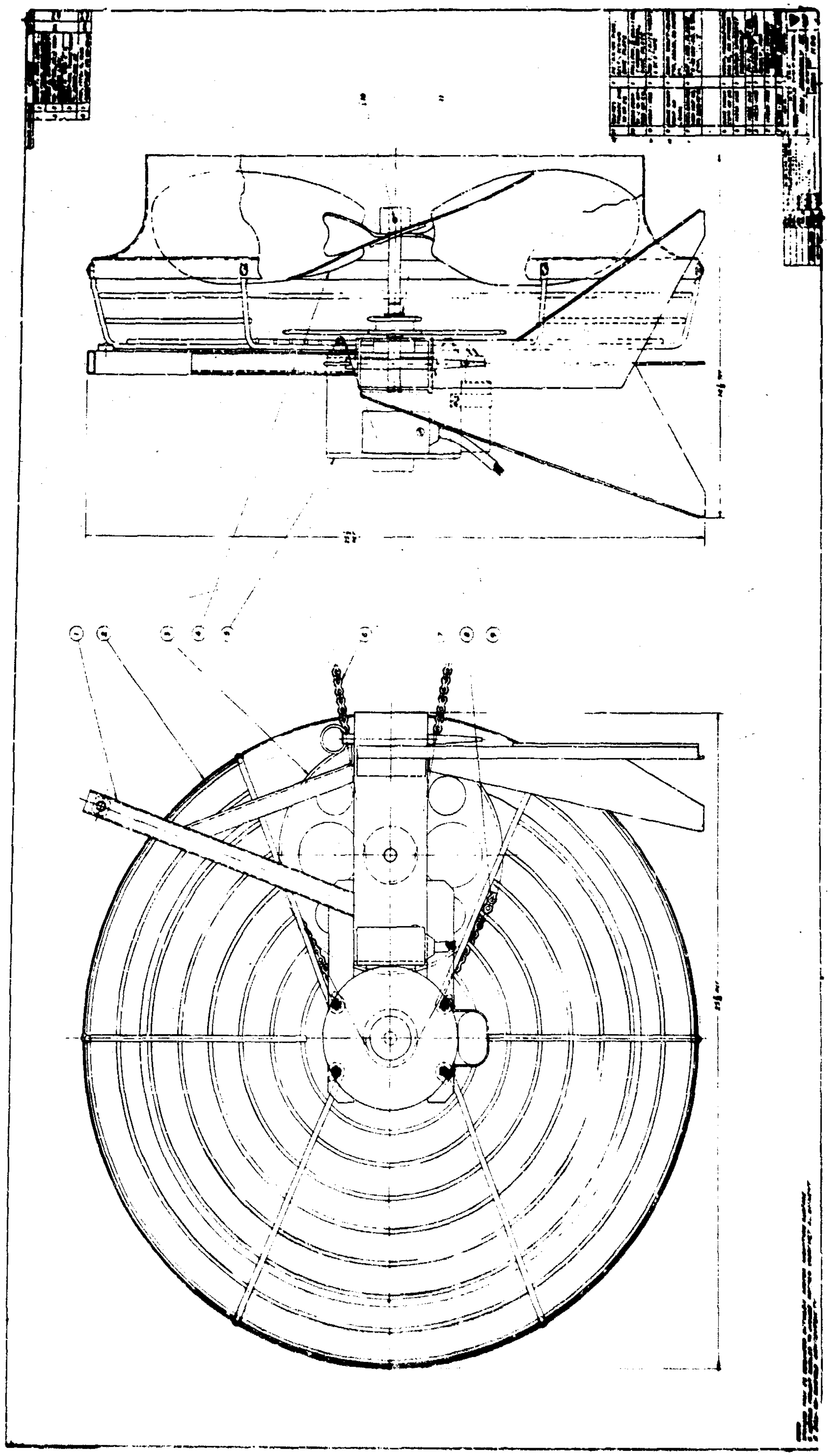


FIGURE 3. - FAN, ASSEMBLY OF (DRAWING NO. 1423A-1100)

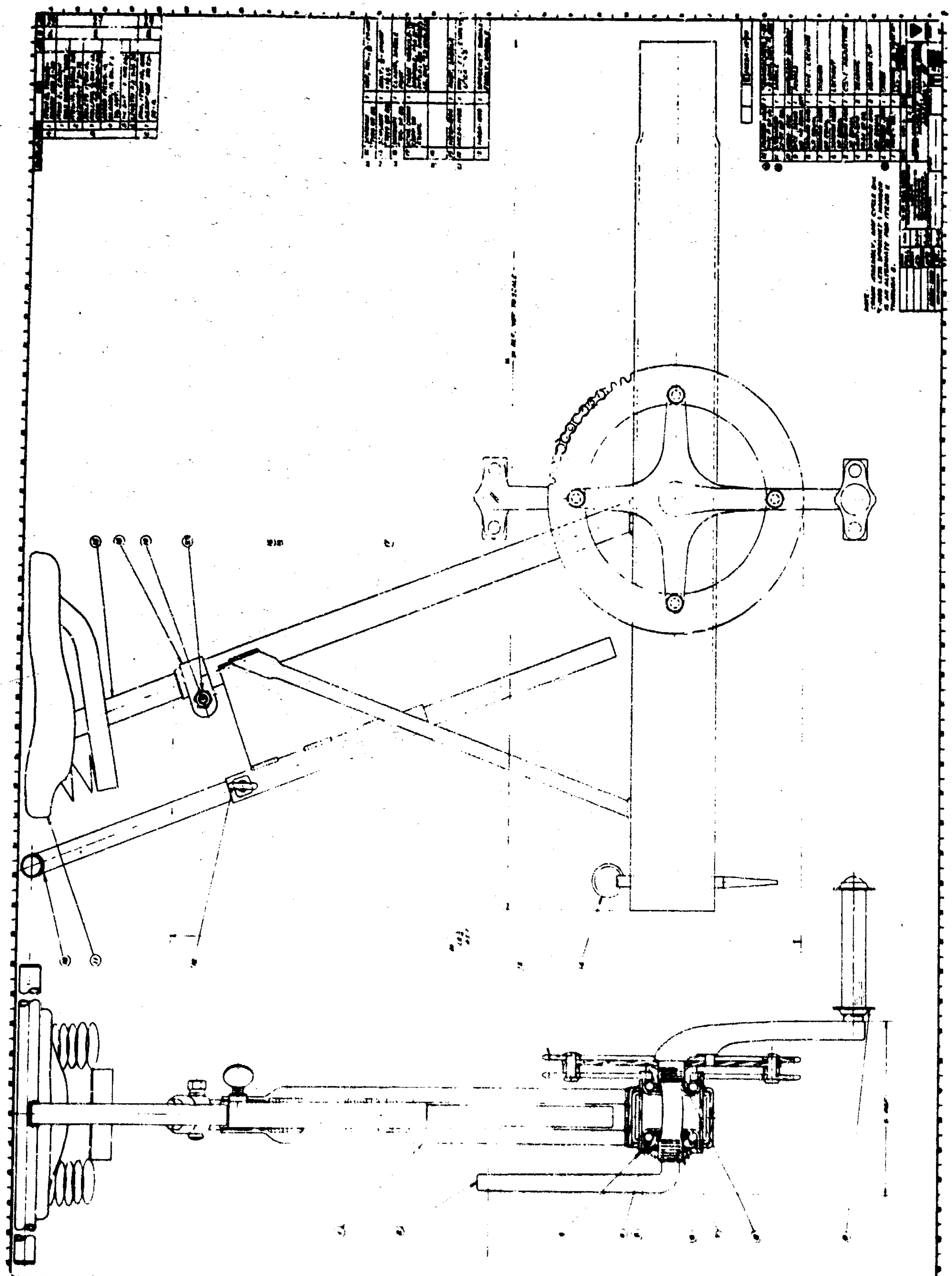


FIGURE 4. - MODULE, MANUAL DRIVE, ASSEMBLY OF (DRAWING NO. - 1423A-1200)

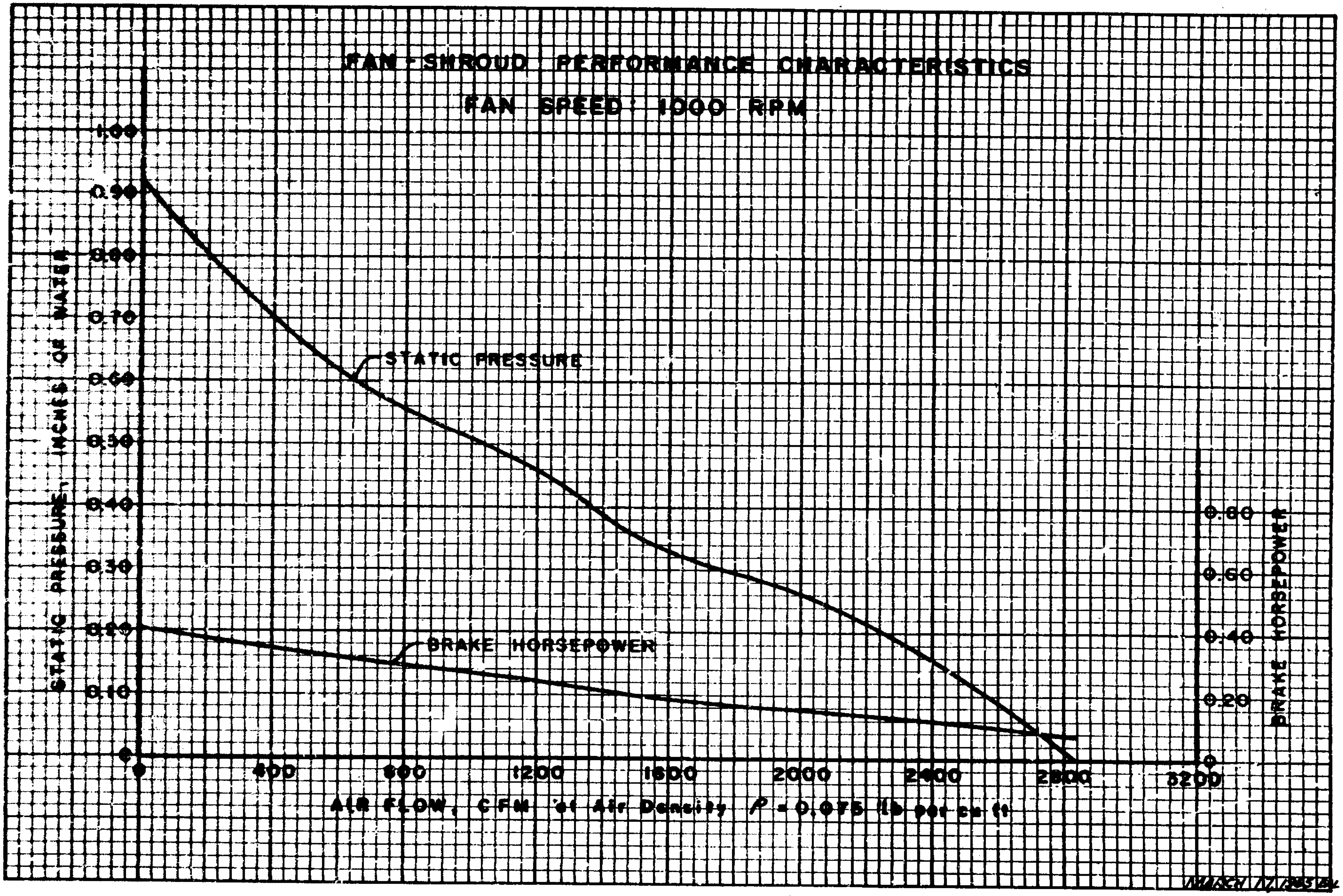


FIGURE 5. - FAN-SHROUD ASSEMBLY PERFORMANCE CHARACTERISTICS

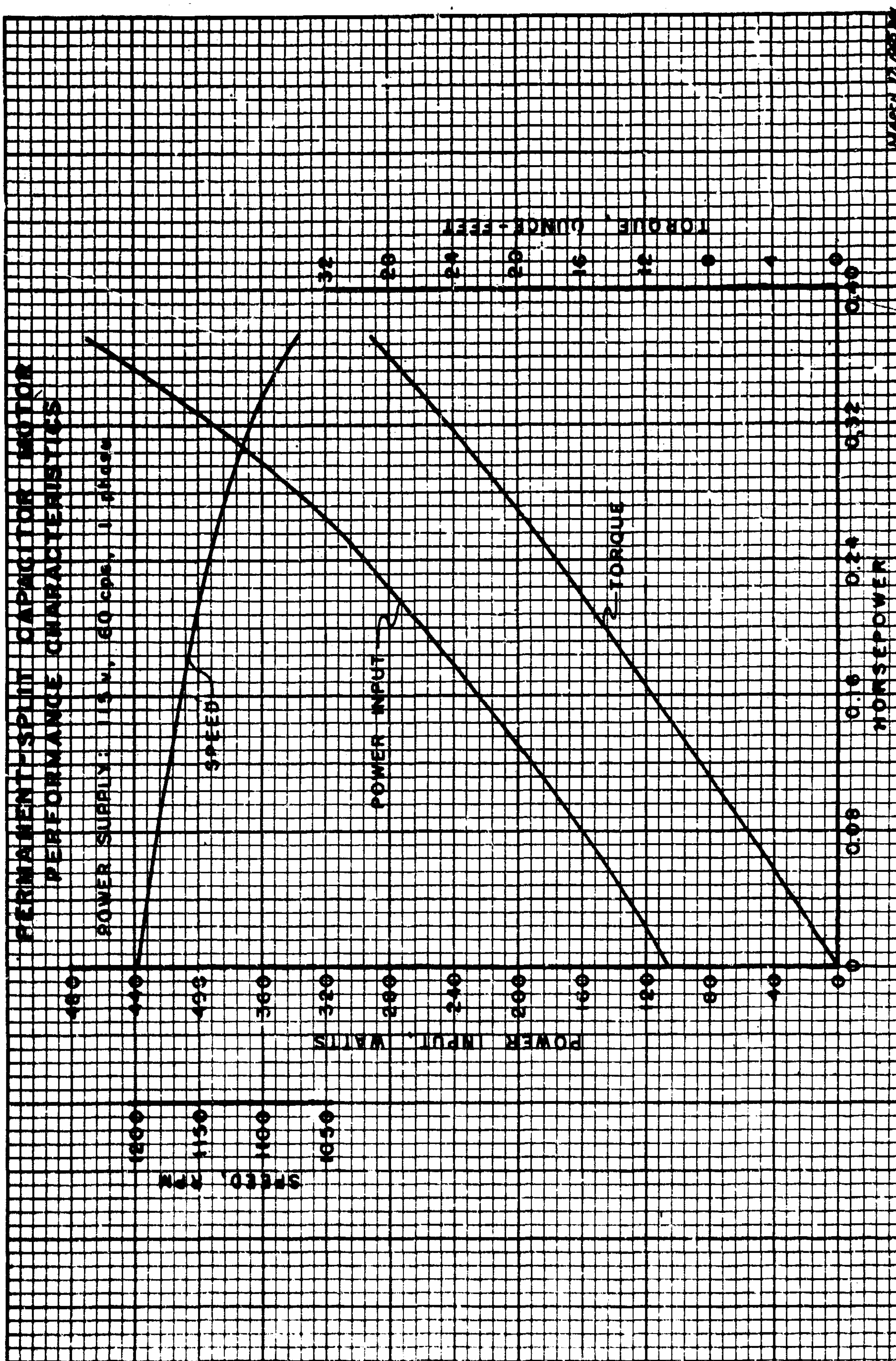
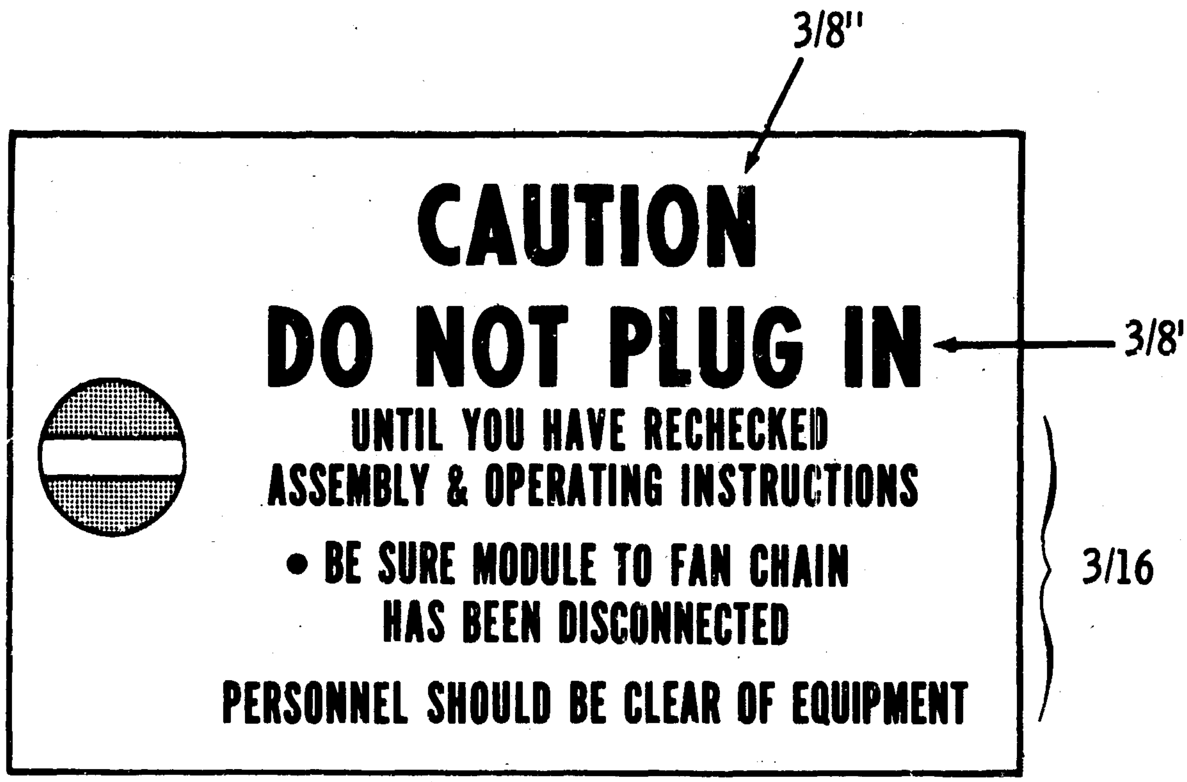


FIGURE 6. - MOTOR PERFORMANCE CHARACTERISTICS



TAG SHALL BE APPROXIMATELY 5 INCHES BY 3 INCHES -

RED IN COLOR - PRINTED IN BLACK BLOCK TYPE.

FIGURE 7 - PACKAGE VENTILATION KIT, ELECTRIC CORD TAG.

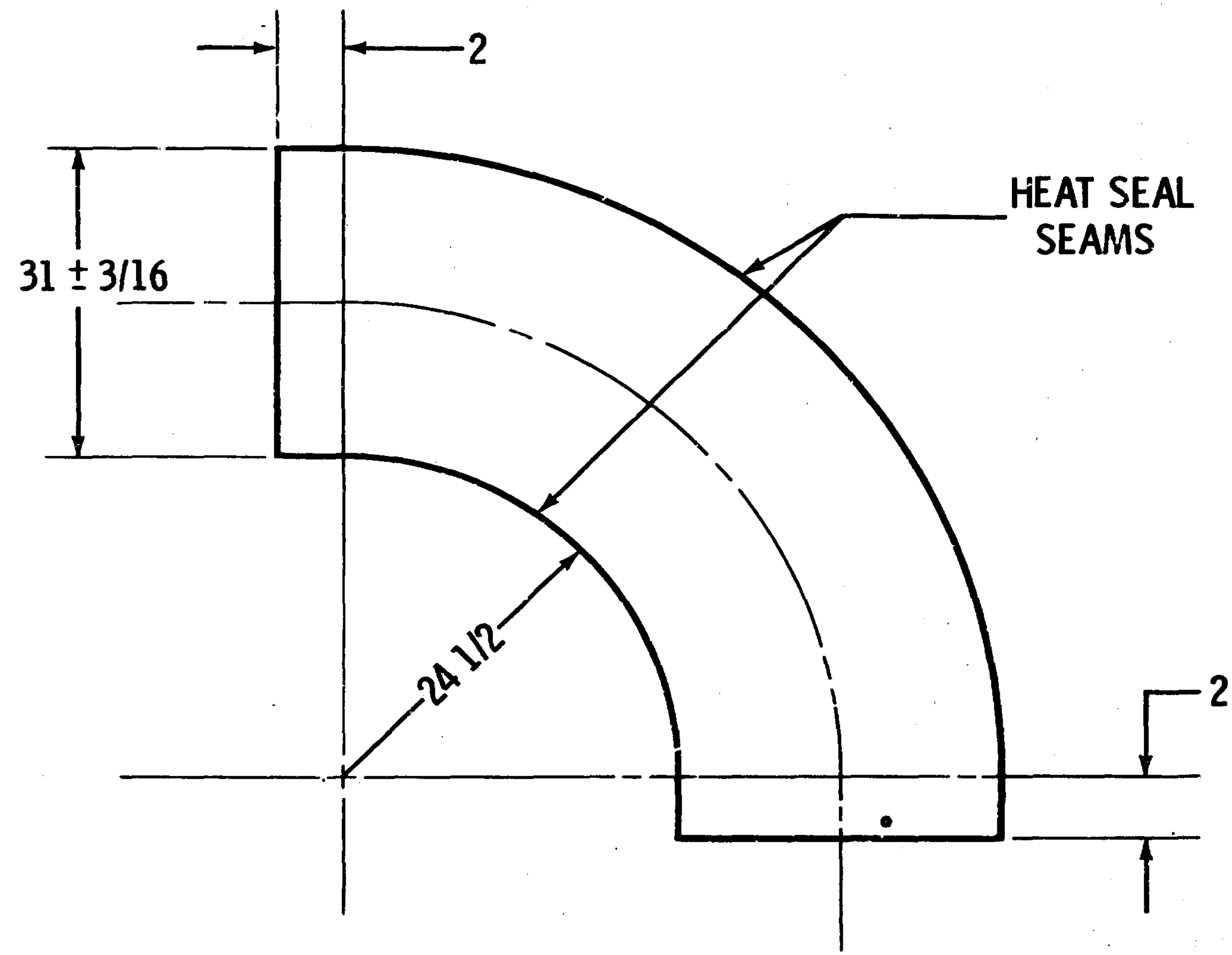


FIGURE 8 - FABRICATED ELBOW - (2 REQ'D)

FAN, PACKAGE VENTILATION KIT
115 V, AC MOTOR--20 INCH FAN
FSN
NAME OF CONTRACTOR
CONTRACT NO.
SERIAL NO.
US

FIGURE 9 - FAN ASSEMBLY IDENTIFICATION PLATE

MODULE, MANUAL DRIVE, PACKAGE VENTILATION KIT
FSN
NAME OF CONTRACTOR
CONTRACT NO.
SERIAL NO.

US

FIGURE 10- DRIVE MODULE IDENTIFICATION PLATE

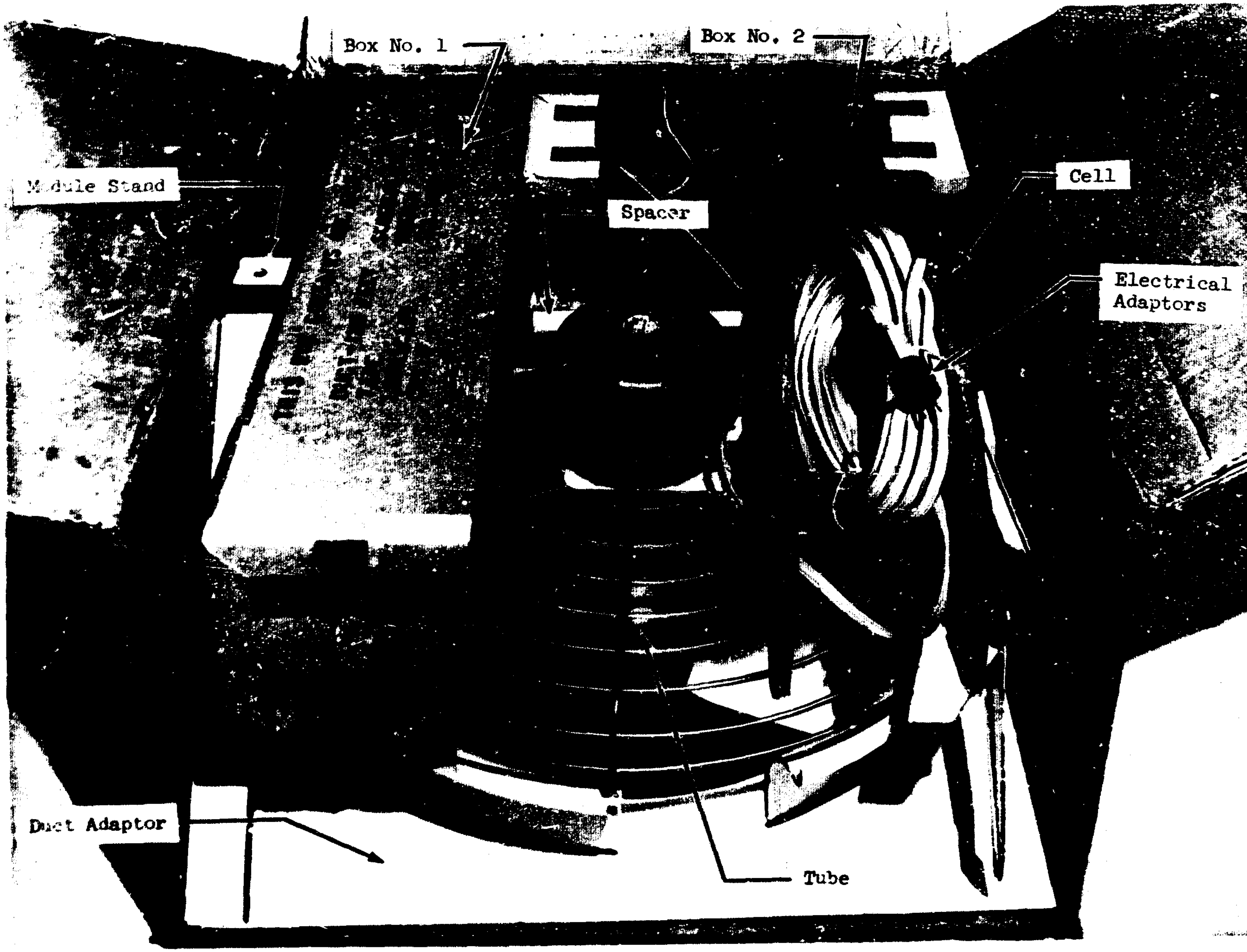


FIGURE 11 - FAN ASSEMBLY - INTERIOR BOX PACKING

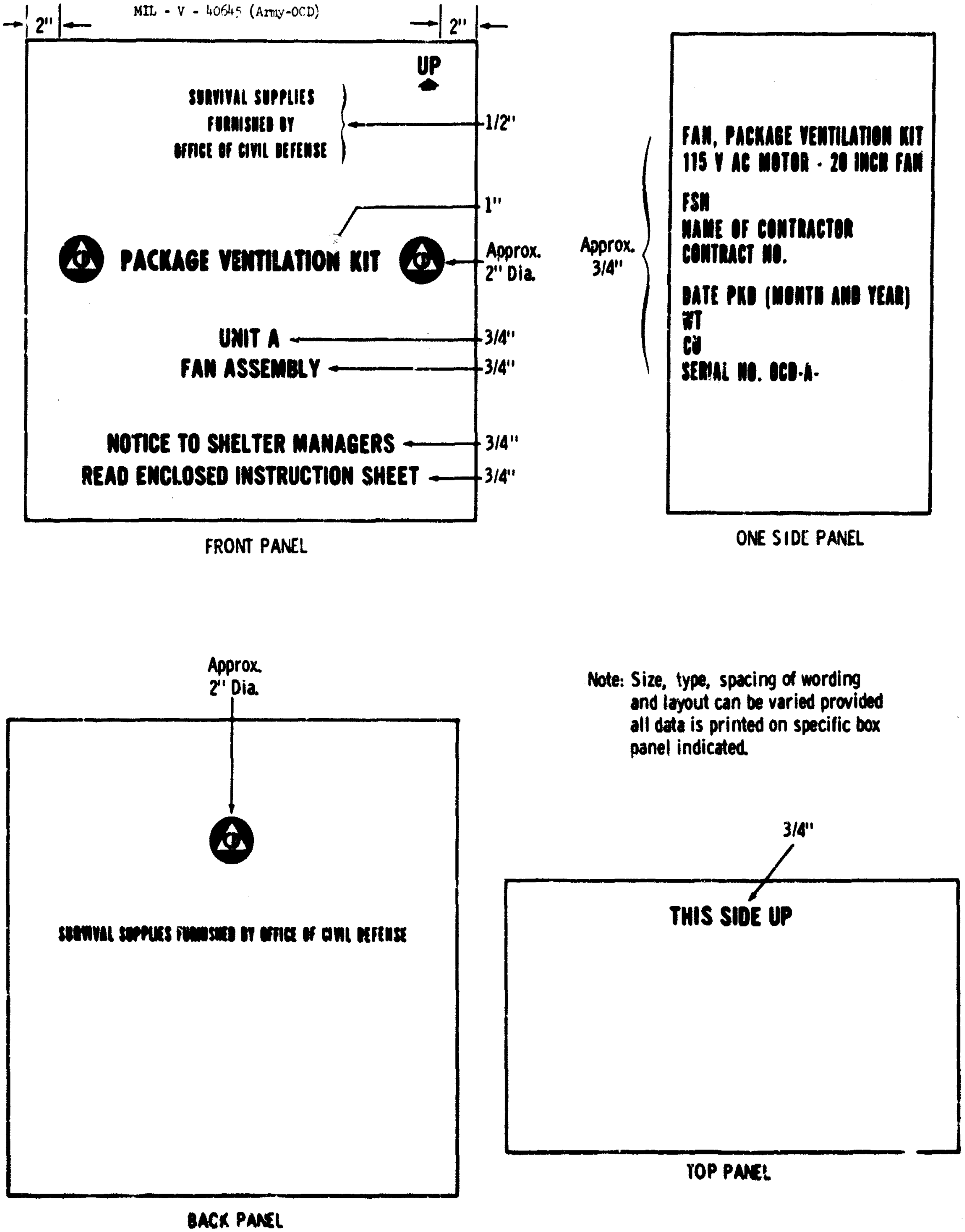


FIGURE 12 - SHIPPING CONTAINER MARKINGS FOR UNIT A - FAN ASSEMBLY

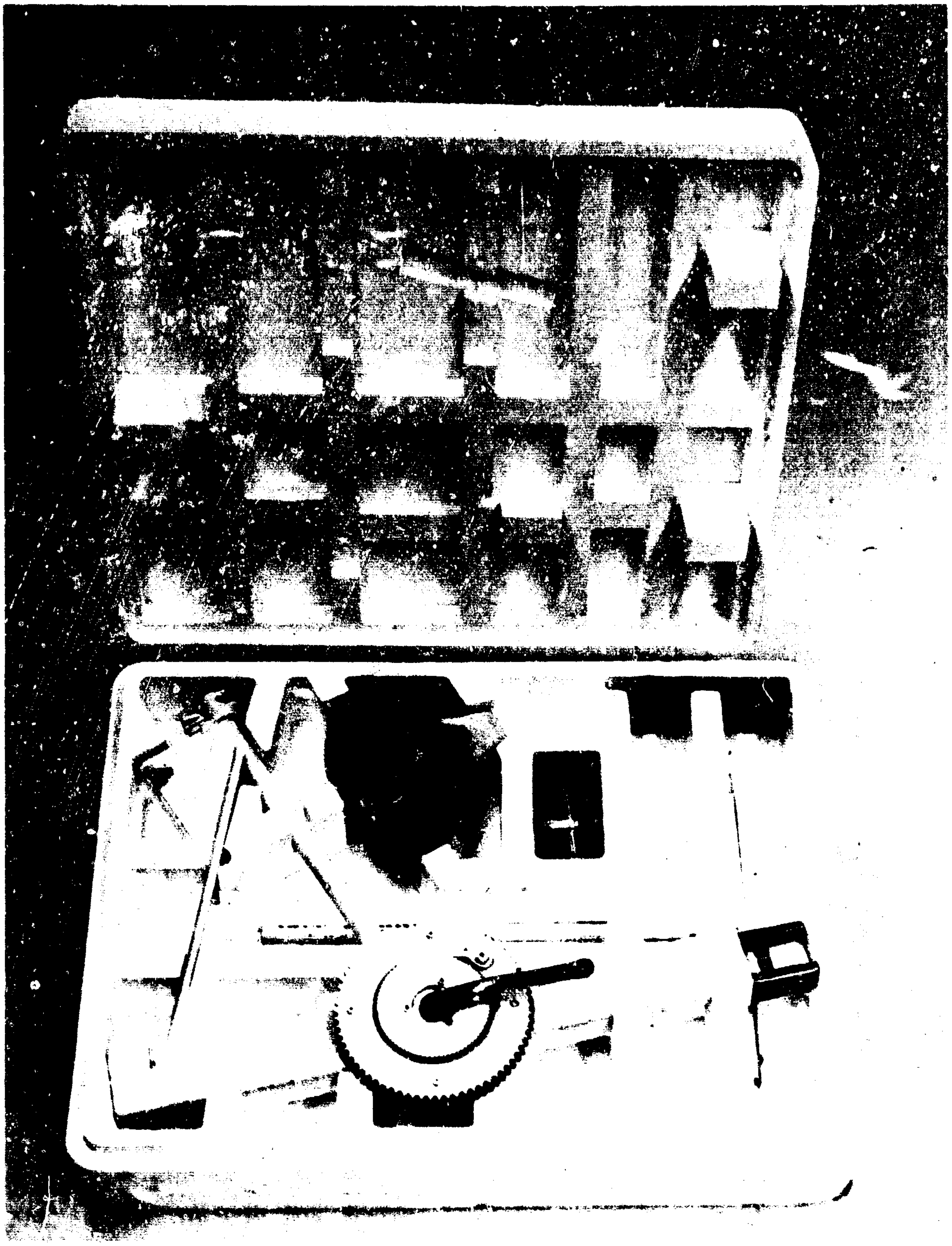


FIGURE 13 - DRIVE MODULE - PACKAGING IN MOLDED POLYSTYRENE INSERT

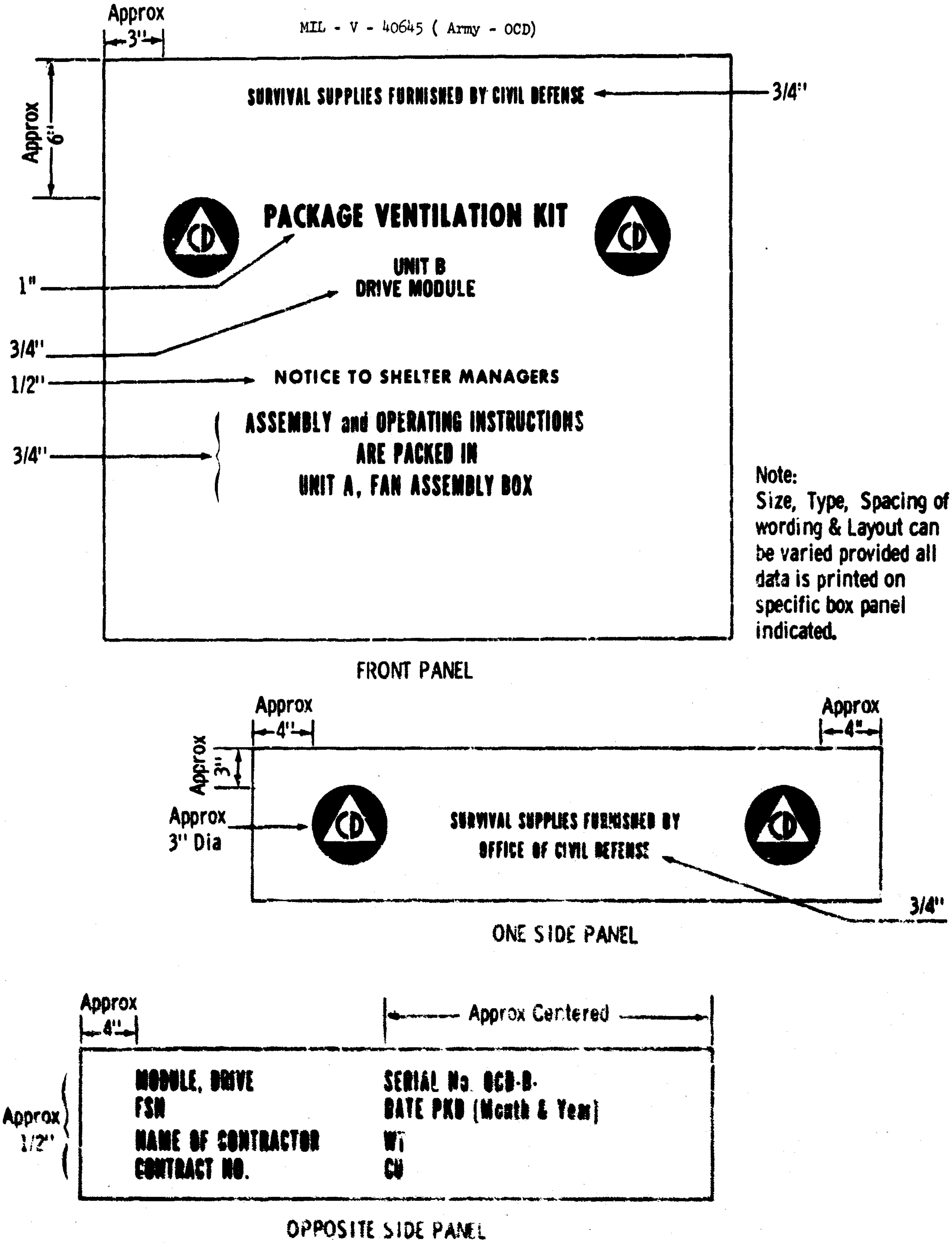


FIGURE 14 - SHIPPING CONTAINER MARKINGS FOR UNIT B- DRIVE MODULE

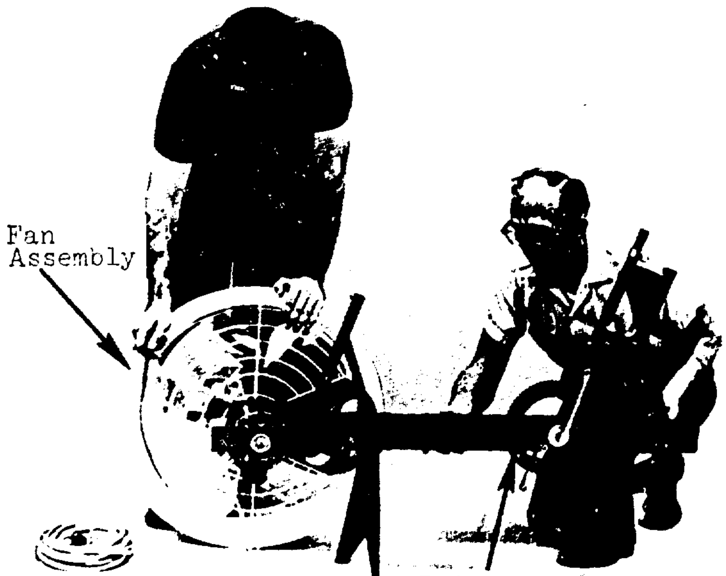
APPENDIX B

ASSEMBLY INSTRUCTIONS

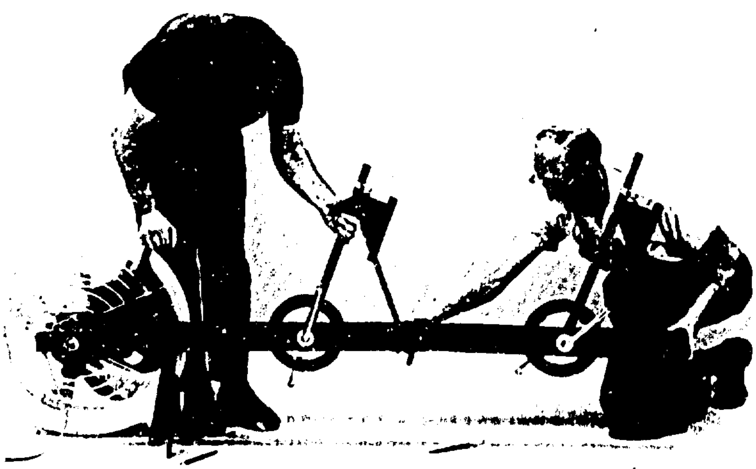
ASSEMBLING THE VENTILATOR:

Remove the contents of the cartons and proceed as follows:

Step 1: Insert a drive module into the fan assembly—do not insert the locking pin yet.

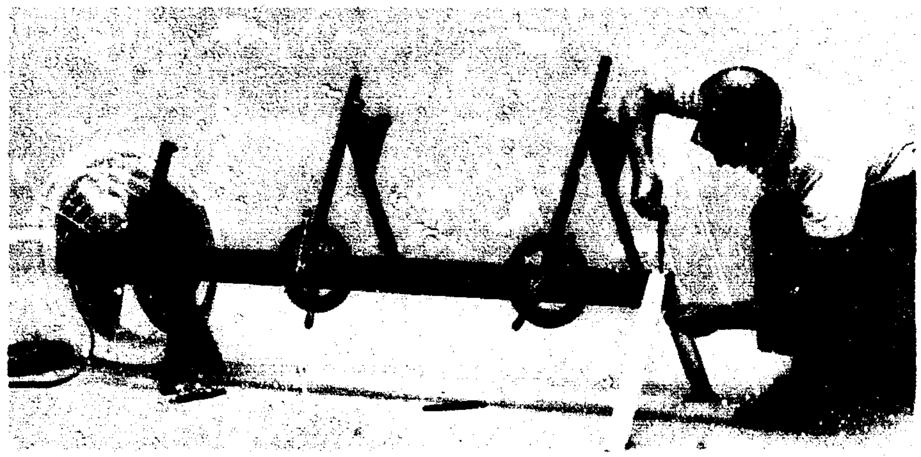


Step 2: If a second drive module is supplied in the kit insert this into the other drive module—do not insert the locking pin yet.



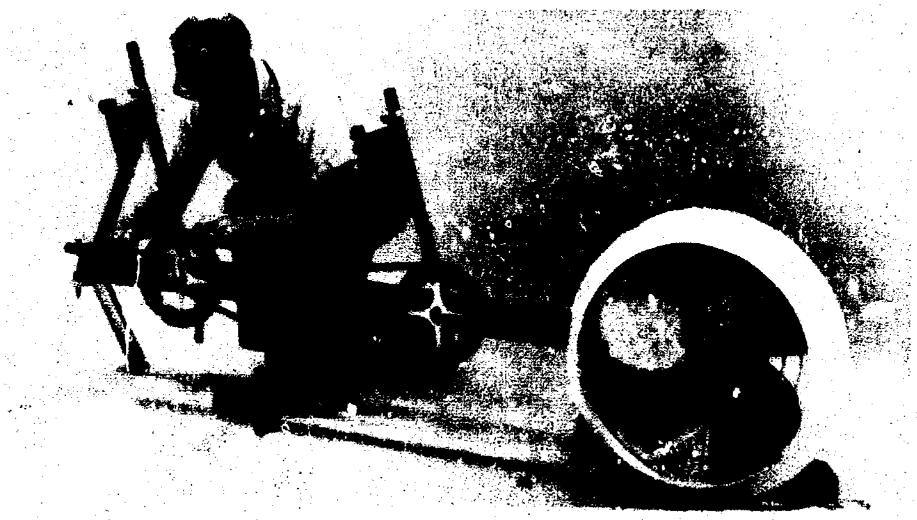
Locking Pin

Step 3: Slip the "v" shaped stand over the end of the last drive module; line up the holes and insert a pin through the holes. This will lock the stand in place.

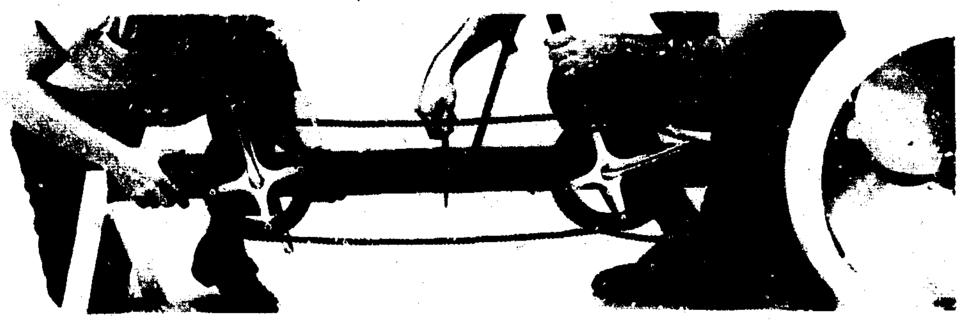


Step 4: If electric power is available, go to Step 14.
If only one drive module is supplied, go to Step 7.
If there are two drive modules, go to Step 5.

Step 5: If two drive modules are supplied—install the LARGEST chain between the drive modules on the INSIDE sprockets. The chain should be installed with one crank pointing vertically and the other pointing horizontally.

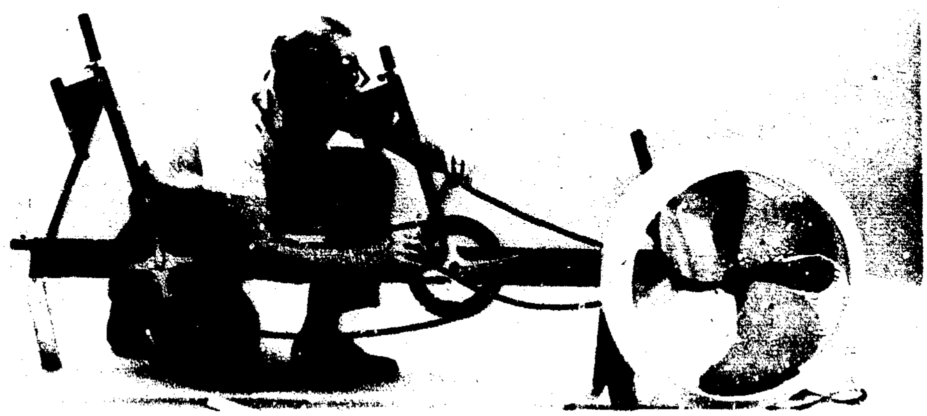


Step 6: Line up the holes at the joint between the two drive modules and insert one of the locking pins. This locks the two modules in place and maintains the proper chain tension.



Step 7: Install the shorter chain between the fan and the first drive module on the OUTSIDE sprocket.

NOTE: THERE WILL ALWAYS BE ONE CHAIN LEFT-OVER.

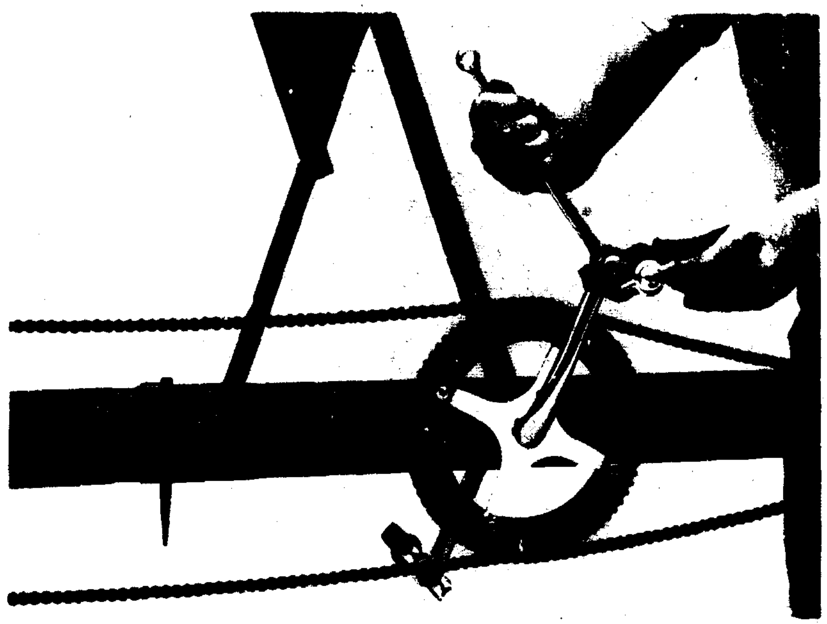


Step 8: Line up the joint between the fan and the drive module and insert the locking pin. This locks the units together and maintains proper chain tension.

Step 9: Using the wrench supplied with the kit install the pedals marked "L" on the left side of the bicycle-fan by threading in a counter-clockwise direction.

Install the pedals marked "R" on the right side of the bicycle by threading in a clockwise direction.

Use the wrench to be sure the peadls are on securely.

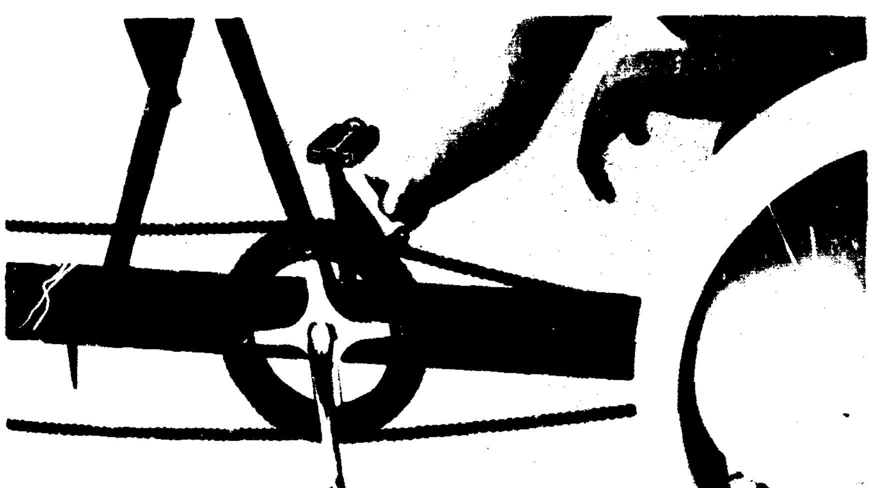


Step 10: Install the bicycle seats on the post and tighten them securely with the wrench.

Step 11: Adjust the seat to the desired height and use the wrench to lock the seat post in that position.

Step 12: Insert the handlebars and lock them into position with the thumbscrews. Use the thumbscrews furthest from the fan on the fan assembly.

Step 13: Lightly oil the chains with the oil supplied in the kit while slowly turning the pedals.



Step 14: Using the tube of oil supplied in the kit, squirt a few drops of oil into each of the two small ports on the top of the motor casing.

THE VENTILATOR IS NOW COMPLETELY ASSEMBLED. CONNECT THE PLASTIC DUCTWORK TO THE FAN SHROUD USING THE TAPE PROVIDED IN THE KIT.

NOTE: THE PLASTIC DUCTING SHOULD BE COMPLETELY LAID OUT AND ASSEMBLED BEFORE IT IS TAPED TO THE FAN SHROUD.

UNCLASSIFIED

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13. ABSTRACT

The design and performance of a manual or electric motor driven fan intended for use in identified fallout shelters. The unit is described in Specification MIL-V-40645 (Army-OCD), "Package Ventilation Kit, 20-Inch Fan, Modular Drive (Civil Defense)" and "Ventilation Kit Assembly and Operating Instructions" published by OCD. (U)

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
CIVIL DEFENSE SYSTEMS						
FALLOUT SHELTERS						
LIFE SUPPORT						
SURVIVAL						
COOLING AND VENTILATING EQUIPMENT						
MACHINES						
PORTABLE						
SPECIFICATIONS						
PROCUREMENT						
INSTRUCTION MANUALS						
DESIGN						
SHELTER IMPROVEMENT						
HOT ENVIRONMENTS						
HUMIDITY						
HIGH ALTITUDE						

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