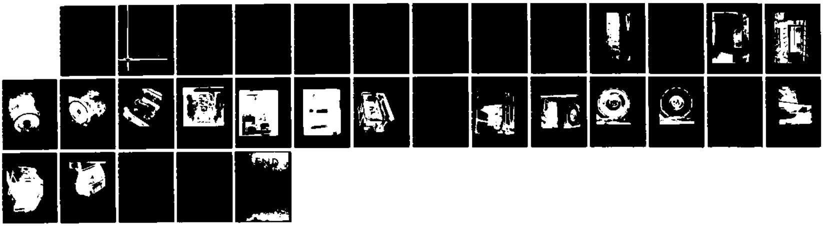
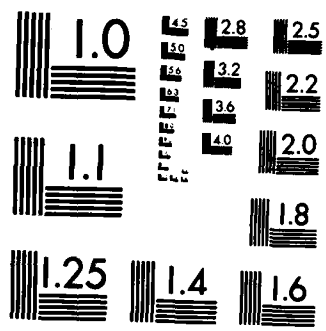
AD-A147 571 COOLING SYSTEM INVESTIGATION OF THE 3-KW MEP MODELS 016A 021A AND 026A (6..(U) ARMY BELVOIR RESEARCH AND DEVELOPMENT CENTER FORT BELVOIR VA.. W A SUMMERSON 1/1

UNCLASSIFIED DEC 83 BRDC-2394 F/G 13/1 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD

AD-A147 571

Report 2394

COOLING SYSTEM INVESTIGATION OF THE 3-kW MEP MODELS 016A, 021A, AND 026A (60-Hz, 400-Hz, AND 28-V d.c.) GASOLINE-ENGINE-DRIVEN GENERATOR SETS

DECEMBER 1983

Approved for public release; distribution unlimited

United States Army
Belvoir Research & Development Center
Fort Belvoir, Virginia 22060

Belvoir R&D Center
U S ARMY TROSCOM

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 2394
2. GOVT ACCESSION NO.: AD-A147571
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): COOLING SYSTEM INVESTIGATION OF THE 3-kW MEP MODELS 016A, 021A, AND 026A (60-Hz, 400-Hz, AND 28-V d.c.) GASOLINE-ENGINE-DRIVEN GENERATOR SETS
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): William A. Summerson
8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Belvoir Research & Development Center, ATTN: STRBE-EM, Fort Belvoir, VA 22060-5606
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Belvoir R&D Center, Tactical Energy Systems Laboratory; Electromechanical Division, Fort Belvoir, VA 22060-5606
12. REPORT DATE: December 1983
13. NUMBER OF PAGES: 30

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

6-hp. Model 4A032 Military Standard Engine
Air-Cooled Engines
Gasoline Engines
Generator Set

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this report is to describe the characteristics of the cooling system on the MIL STD 3-kW, Models MEP 016A (60-Hz), 021A (400-Hz), and 026A (28-V d.c.) gasoline-engine-driven generator sets from the viewpoint of design modifications necessary to alleviate chronic engine overheating problems experienced when the sets are operated in high ambient temperatures and/or operated in revetted (walled) locations. The investigation covers the history of the cooling system on the Model 4A032 6-hp MIL STD engine and how the cooling system was altered and compromised when the engine was applied to the 3-kW generator set. The report describes experimental modifications made to

Item 20. Abstract Continued

the set cooling system which allowed the set to be operated inside an acoustic enclosure without overheating the engine. These improvements to the engine and generator cooling systems could be considered for incorporation into future production 3-kW MIL STD gasoline-engine-driven generator sets.

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (cont'd)

Figure	Title	Page

COOLING SYSTEM INVESTIGATION OF THE 3-kW MEP MODELS 016A, 021A, AND 026A (60-Hz, 400-Hz, AND 28-V d.c.) GASOLINE-ENGINE-DRIVEN GENERATOR SETS

I. INTRODUCTION

The 3-kW gasoline-engine-driven (GED) generator set, powered by the 6-hp, Model 4A032 MIL-STD engine, has been in field use since the early 1960s. MERADCOM (now Belvoir Research and Development Center) research and development and production engineering personnel who are familiar with the set design have been aware for many years that the 6-hp engine/3-kW set does not cool efficiently and runs hot in high ambient environments. The problem was brought to the forefront during the Southeast Asia (SEA) war (circa 1967-71) when many engine failures were attributed, directly or indirectly, to engine overheating which increased oil consumption causing the engines to run out of oil. A massive "get well" program was initiated by MERADCOM in 1969 to solve generator set problems related to operation in SEA. Overheating problems were experienced on all models of the MIL-STD engine-driven generator sets due to operation of the sets in revetments in high ambient temperatures. To solve the overheating problem, the Electrical Power Laboratory launched the "Barkerization" in-house program to develop special housings for each air-cooled set to allow operation in revetments without overheating. The "Barkerization" program (identified with the name of the responsible project engineer) resulted in successful thermal/acoustic housings being developed for the 0.5-, 1.5-, and 5-kW sets. A housing could not be developed for the 3-kW set due to problems encountered with the cooling system on the 6-hp engine. A program to quiet the 3-kW set was conducted by the author during 1969-1970 in response to a requirement from Korea. During the course of this program, a detailed investigation was conducted on the characteristics of the 3-kW/6-hp engine cooling system and how it evolved to its present configuration. Since a final report covering this investigation was never completed, this was prepared to document the findings.

Another incentive to publish this report is the fact that a contract was awarded to Welbilt Electronic Die Corporation (now WEDTECH Corp.) to produce a quantity of 6-hp engines. Since the intended application for the engine is the 3-kW GED generator set, an opportunity exists to correct the design deficiency on the 3-kW cooling system before additional sets are procured.

II. INVESTIGATION

1. 3-kW Noise Attenuation Program. A program to reduce the acoustic signature of the 3-kW, 28-V d.c. MIL-STD generator set by 50 percent (a requirement never clearly defined) was directed by the Army Materiel Command to MERADCOM during 1968. The specific application of the set was to power the jeep-mounted 2.2-kW xenon searchlight. The set was

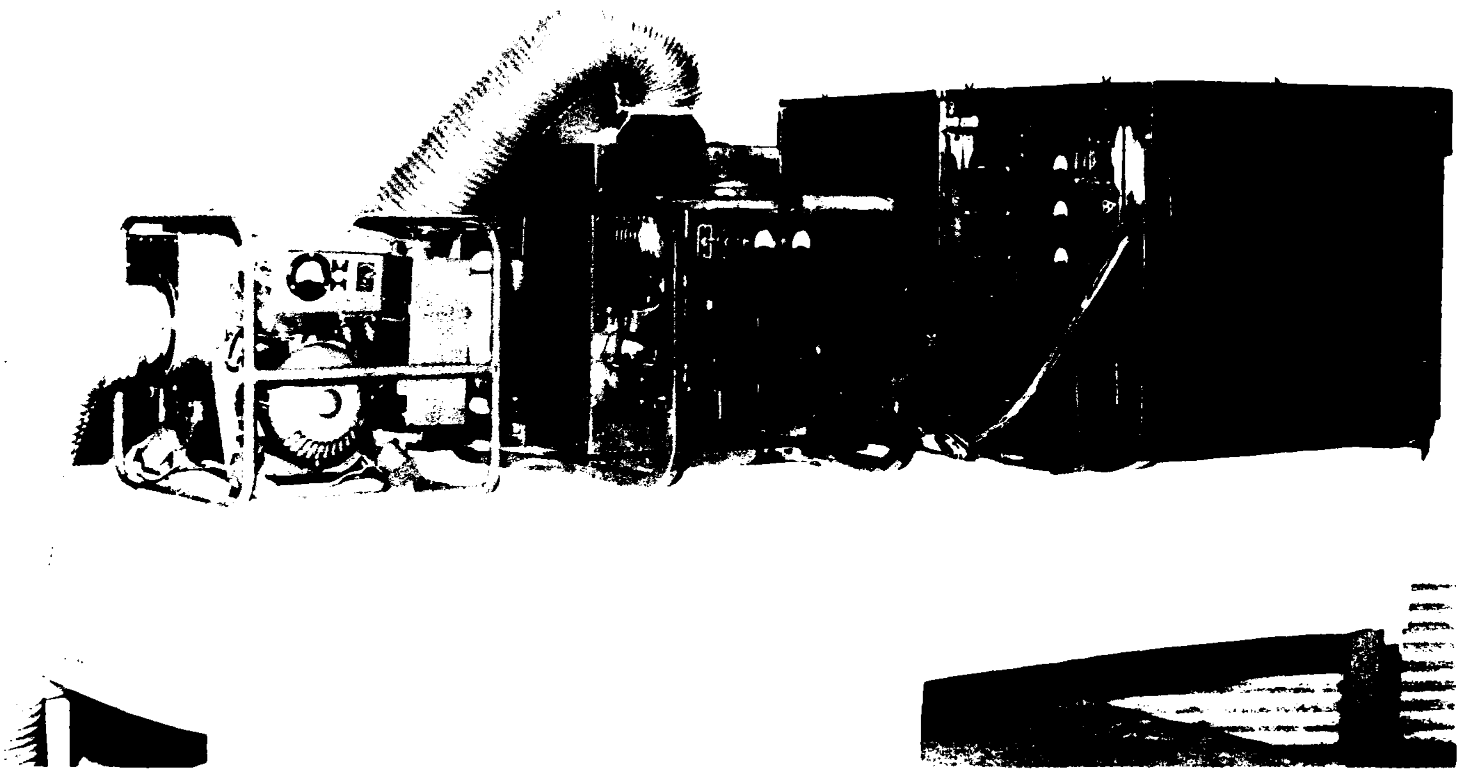


Figure 1. MERDC design "Barkerized" thermal/acoustic kits for 0.5-, 1.5-, and 5-kW gasoline-engine-driven sets, circa 1969.

mounted in a standard 1/4-ton trailer towed by the jeep. The program to suppress the noise signature of the 3-kW set was directed toward the procurement of an improved exhaust muffler system and the development of an acoustic housing around the 3-kW set. Several versions of wooden and metal housings were built and evaluated during the program. Figures 2 and 3 depict the types of housing considered.

2. 6-hp/3-kW Generator Cooling System. It was recognized early in the program that the 6-hp MIL-STD engine and the 3-kW generator cooling system recirculate a large portion of the hot exhaust cooling air into the engine cooling air intake when the set operates in the open, unrestricted configuration. When the set is operated in any type of walled enclosure (housing, trailer, or revetment), the recirculation is greater, and the result is engine overheating and vapor lock. It was determined that engine lubricating oil would approach 300° F when the set was operated inside the standard 1/4-ton trailer (closed tailgate) at 90° F ambient with *no* housing around it. The three-sided wooden housing did not appreciably change the operating temperatures of the set. The following facts were brought to light regarding the cooling system of the 6-hp MIL-STD engine.

The original prototype models of the engine (circa 1959-61) had no restriction or outlet duct around the cooling air exit. The suction type cooling fan could exhaust cooling air radially 360° around the flywheel housing (see Figure 4). These early engines were tested primarily on dynamometer stands which did not block the cooling air exit. The lack of cooling air control on these first prototype engines resulted in subnormal engine operating temperatures during arctic testing. No problems were encountered at + 125° F.

The present thermostatically controlled winterization cooling air outlet duct was added to the top half of the flywheel housing in the first production engines during 1961-1962 (see Figure 5). Note that the lower half of the housing was unrestricted.

In 1962, the engine was applied to the 3-kW MIL-STD generator set which incorporated a fuel tank directly under the engine cooling air lower discharge. It was soon evident that the engine cooling air discharge from the lower half of the flywheel housing was heating the fuel tank and, also, recirculating back into the cooling air inlet. To correct this problem, another plenum with two upward scoops was installed on the lower half of the flywheel housing. Figures 6, 7, 8, and 9 show the prototype 3-kW set as tested in the trailer installation with various modifications to reduce the overheating problem encountered during climatic chamber tests at + 125° F in the summer of 1962. Note the experimental additional upward air scoops on either side of the air discharge duct, the oil cooler (from a 1962 Corvair automobile) and exhaust lines and mufflers wrapped with asbestos cloth. The only engine modification which was carried into the production design of the 3-kW sets was the addition of air scoops covering the lower half of the cooling air discharge. Figure 10 shows the final configuration of the production set which is still representative of fielded sets today (1983). Note the upward air scoops.

Figure 2. 3-kW MIL STD generator set in wooden acoustic housing and with double standard mufflers, circa 1968.

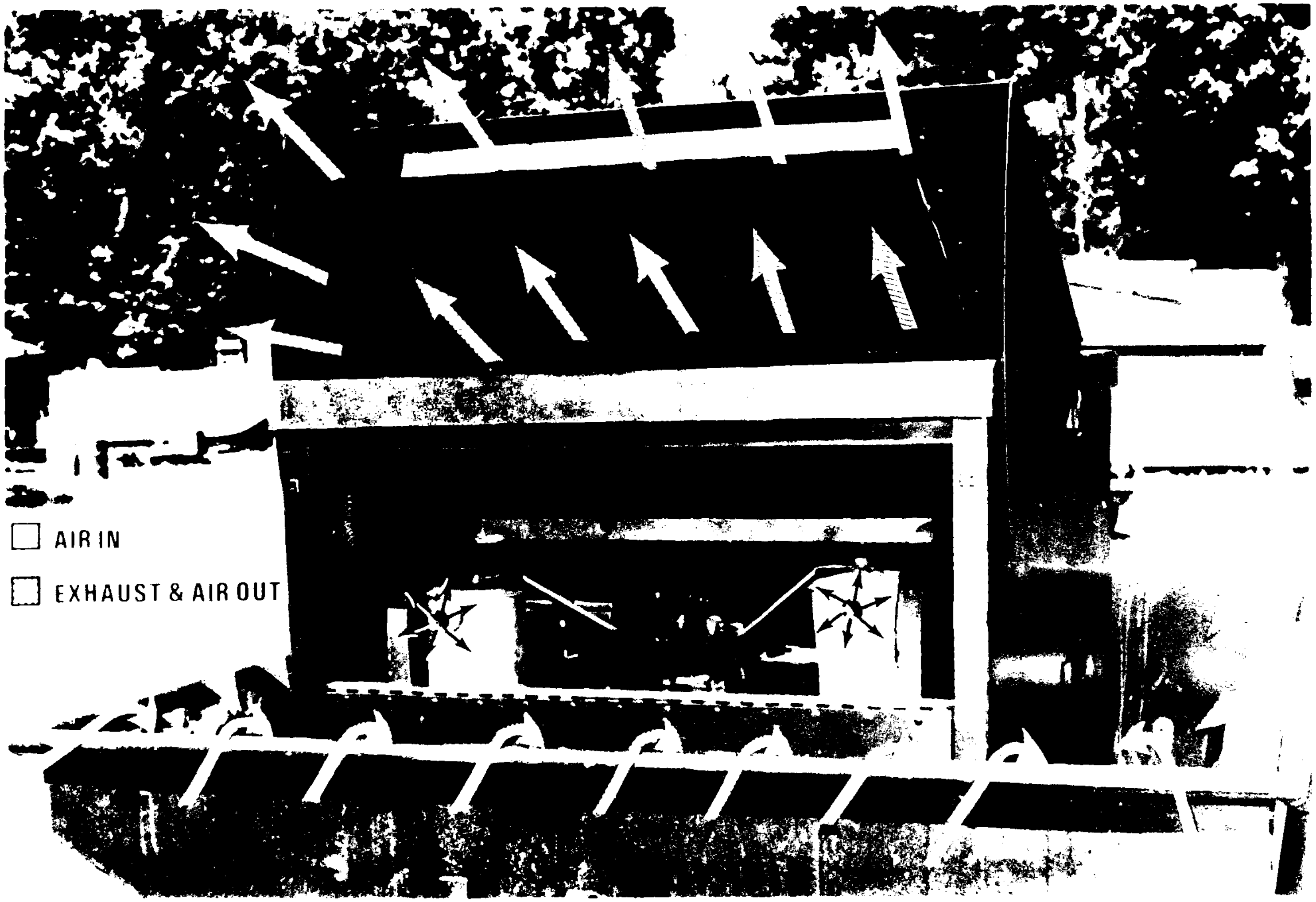


Figure 3. Lord Mfg. Co. acoustic housing for 3-kW MIL STD generator set.

Figure 4. Original prototype 6-hp MIL STD engine, circa 1959-1960.

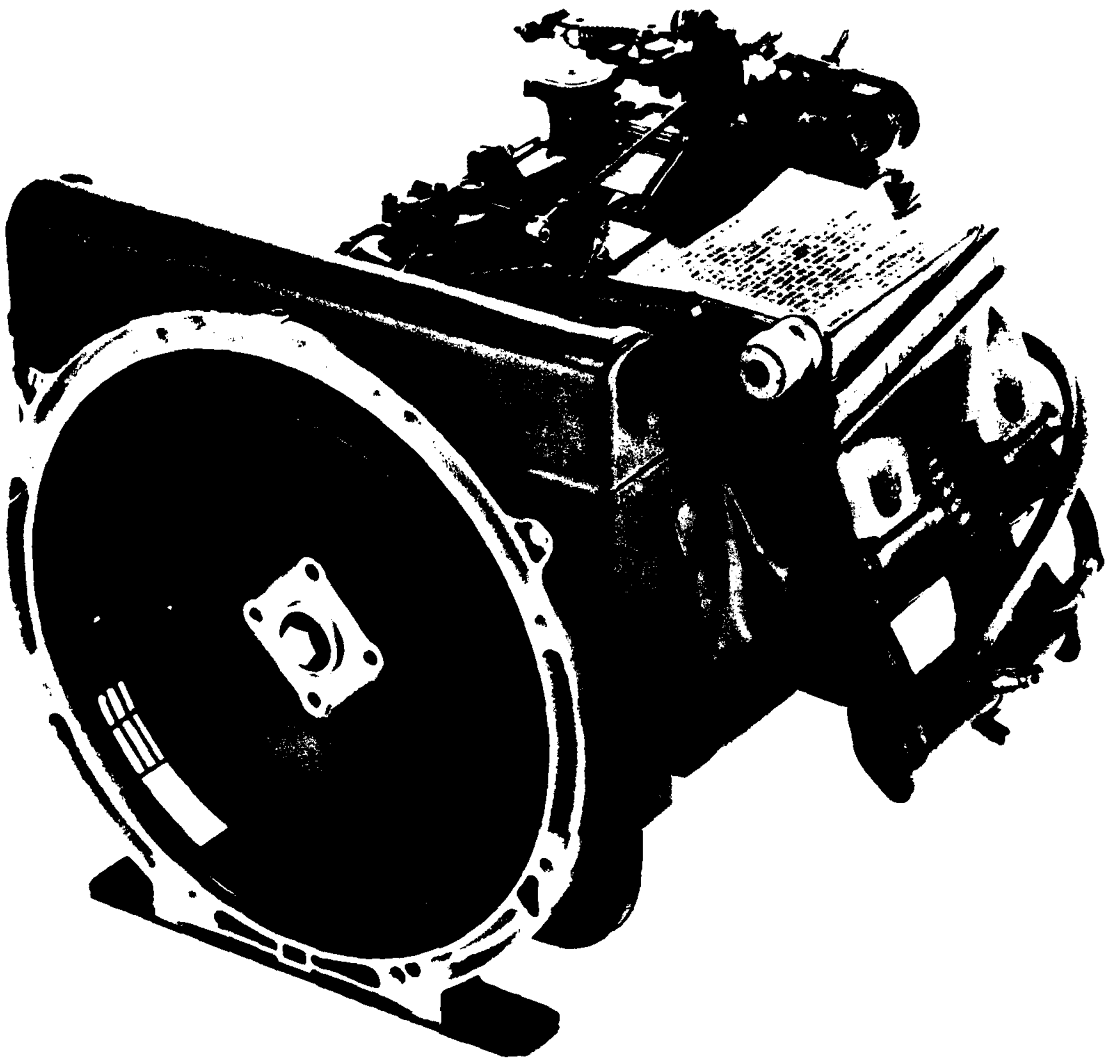


Figure 5. Production design 6-hp MIL STD engine showing winterization half shroud on top of cooling air discharge.

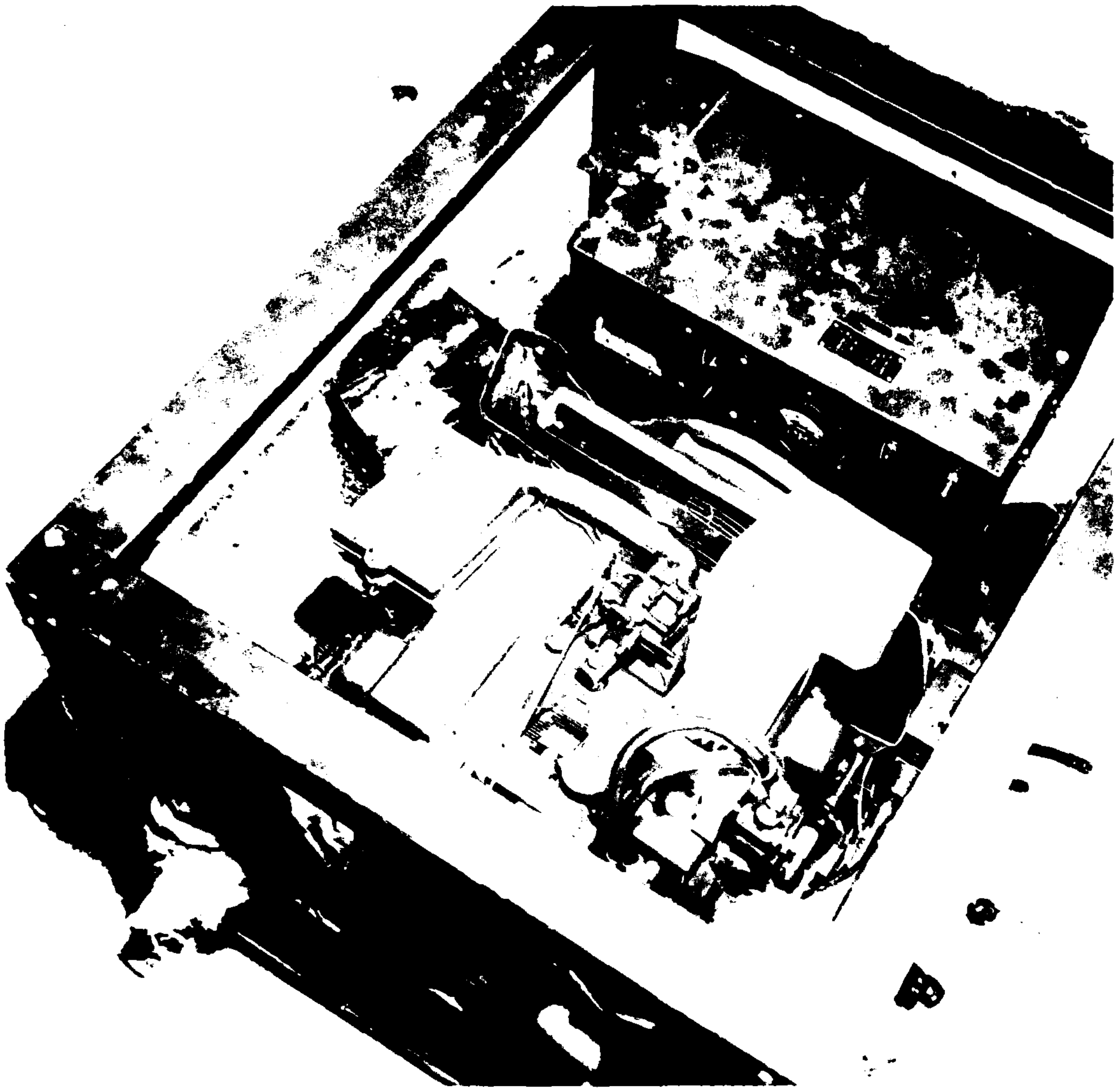


Figure 6. Prototype 3-kW MIL design generator set with pilot production 6-hp MIL STD engine, circa 1962.

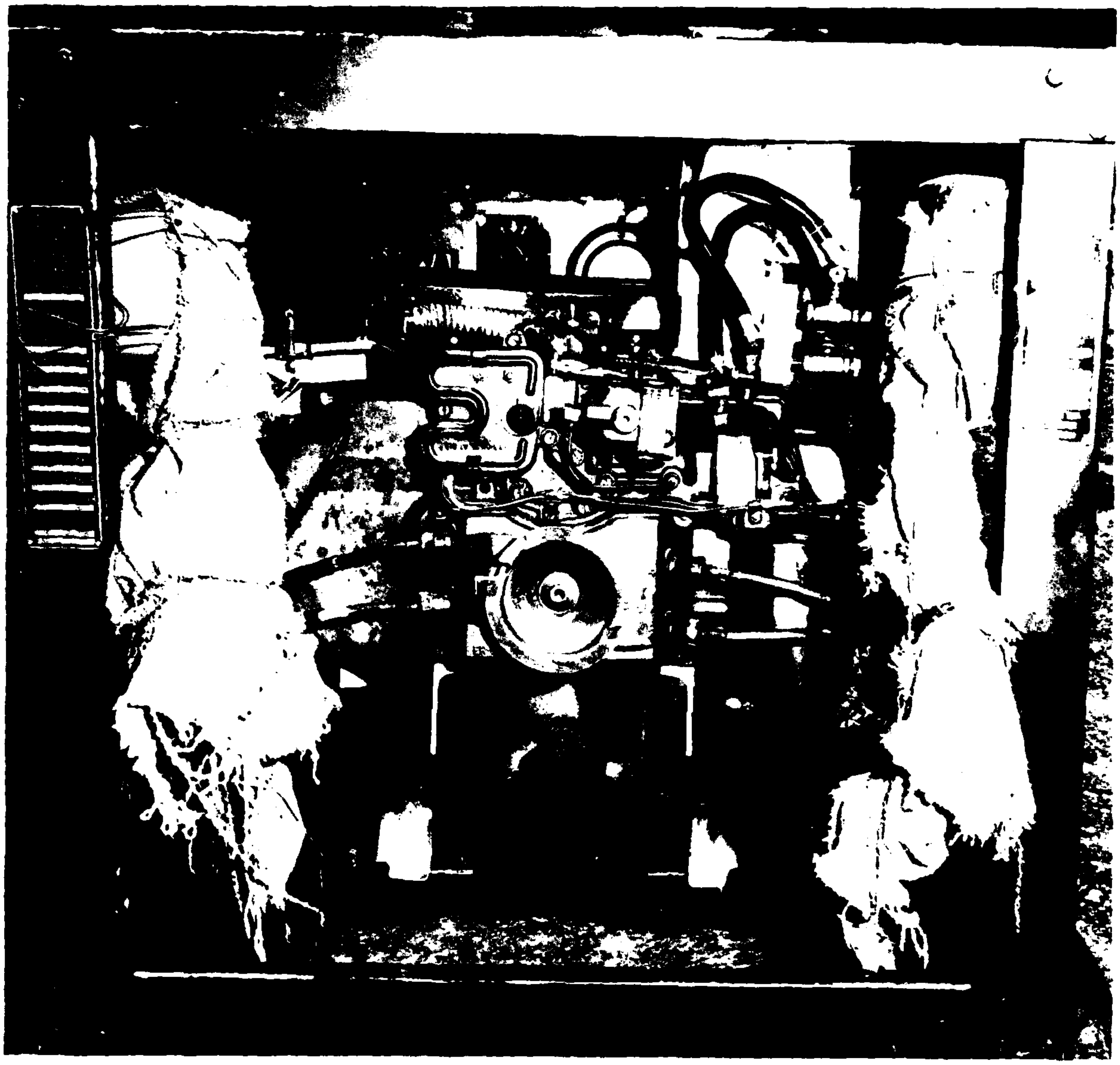


Figure 7. Prototype MIL design generator set with pilot production 6-hp MIL STD engine, circa 1962.

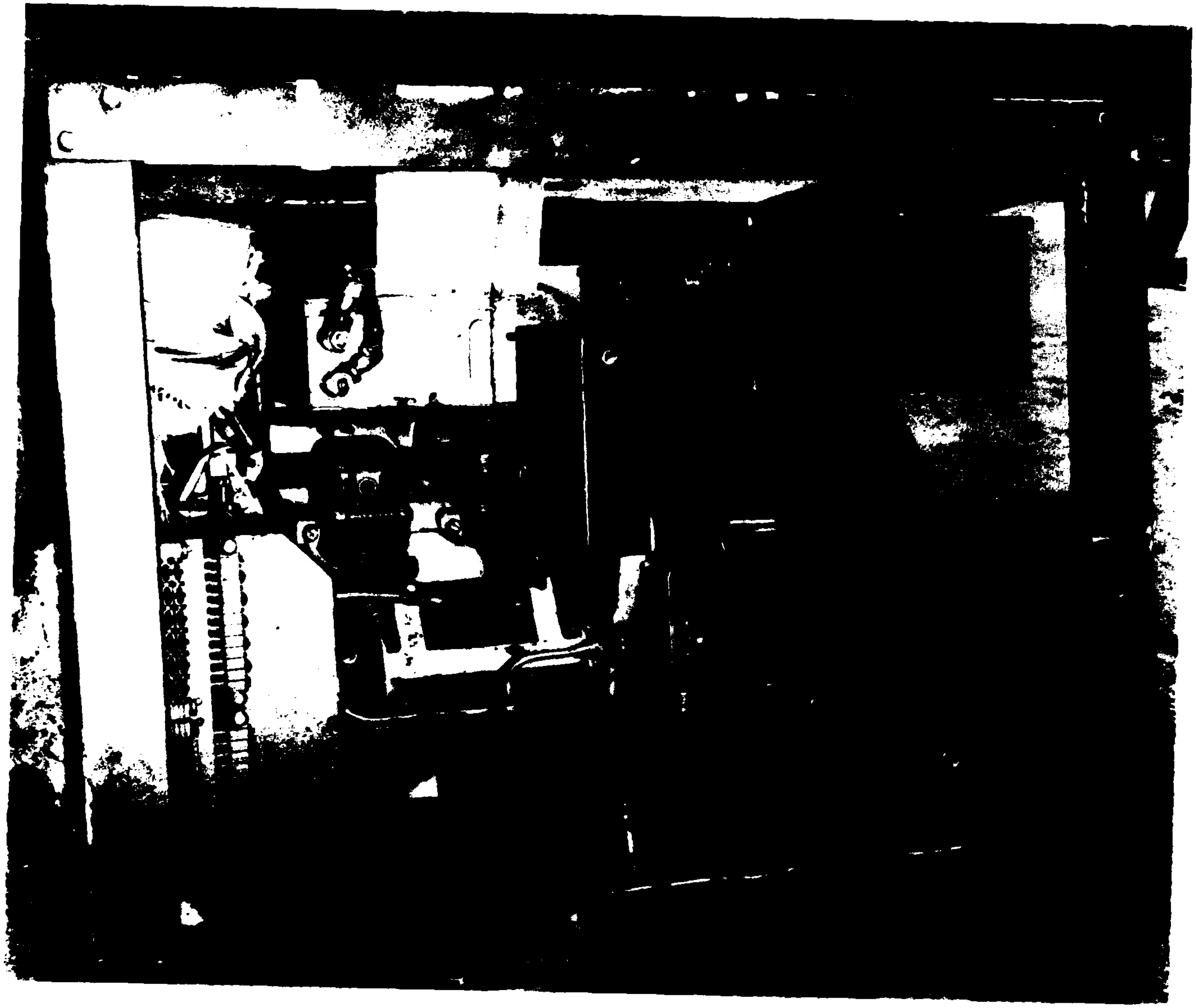


Figure 8. Prototype 3-kW MIL design generator set with pilot production 6-hp MIL STD engine, circa 1962.

Figure 9. Prototype 3-kW MIL design generator set with pilot production 6-hp MIL STD engine, circa 1962.

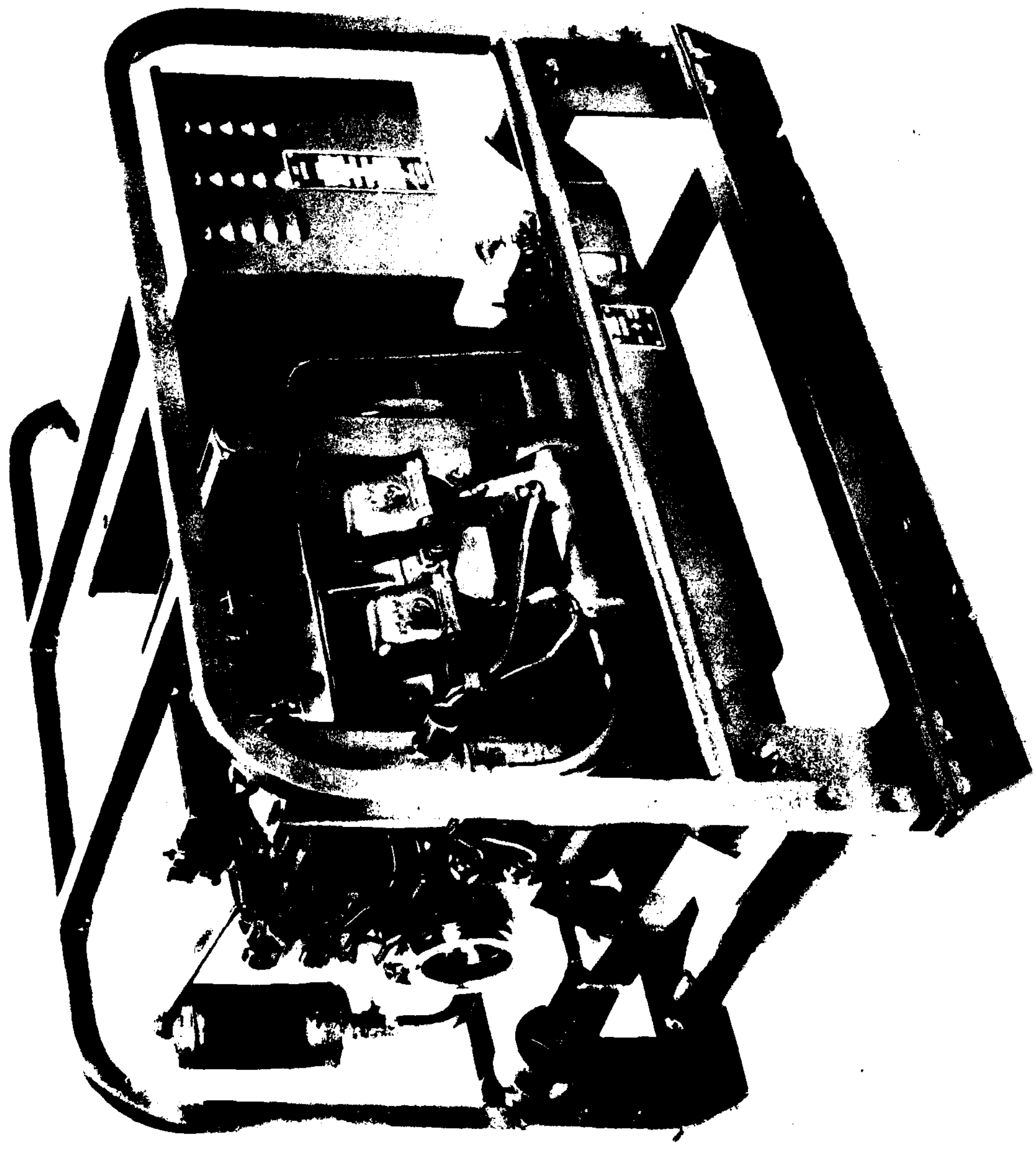


Figure 10. Current production 3-kW MIL design generator set.

When the 3-kW set reached its production configuration, the 6-hp engine flywheel housing cooling air exit area had been reduced from the original prototype of 52 $in.^2$ to approximately 17 $in.^2$. The 6-hp engine as installed in the 3-kW set operates with an effective cooling air exit area of one third that of the original prototype engine. Pressure build-up in the exhaust plenum area is sufficiently high that hot exhaust cooling air leaks out through the many cracks in the sheetmetal and past the generator cooling fan into the generator cooling air exit. The fit of the lower plenum air scoops provided in the generator set application is very poor. Typically, there can be cracks up to 1/2 in. wide between the scoops and upper plenum housing. These large cracks, in effect, negate the original intent of the scoops which were to prevent the leakage of hot air into the engine cooling air inlet.

The combination of restricted cooling air discharge and recirculation of the leakage cooling air back through the intake of the engine tends to increase the engine operating temperatures by a "boot strap" process. In high ambients, the standard 3-kW set runs "hot" in the open, unconfined configuration. When confined by any walled structure (i.e., revetment or trailer sides), the set runs "very hot." Lube oil will approach or exceed 300° F.

III. IN-HOUSE PROGRAM TO IMPROVE 3-kW COOLING SYSTEM TO ACCOMODATE ACOUSTIC SUPPRESSION

In an attempt to partially solve the 3-kW overheating problem and to provide the capability of operating the set in an acoustic housing without overheating, a set was modified by the author during 1970, as described below.

a. A new larger cooling air exhaust duct was designed and installed on the engine (Figures 11 and 12). This duct was fitted and sealed tightly around the flywheel housing. The effective opening area of the duct exit was approximately 50 $in.^2$ which approaches the original unrestricted area. The volume of the plenum was made as large as possible while still remaining within the confines of the set frame.

b. A circular plate was fabricated to attach to the face of the flywheel between the engine and generator. The purpose of the plate was to block the 1-1/4-in. gap between the edge of the flywheel fan and the housing casting. Figure 13 shows the standard flywheel configuration, and Figure 14 shows the air seal plate installed on the face of the flywheel. This plate effected a seal between the engine air exit plenum and the generator cooling air fan and thus, prevented leakage of hot cooling air from the engine fan, past the generator fan, and out the generator cooling air exit port against the set fuel tank.

Figure 11. Experimental enlarged engine air discharge duct installed on 3-kW MIL design generator set, circa 1970.

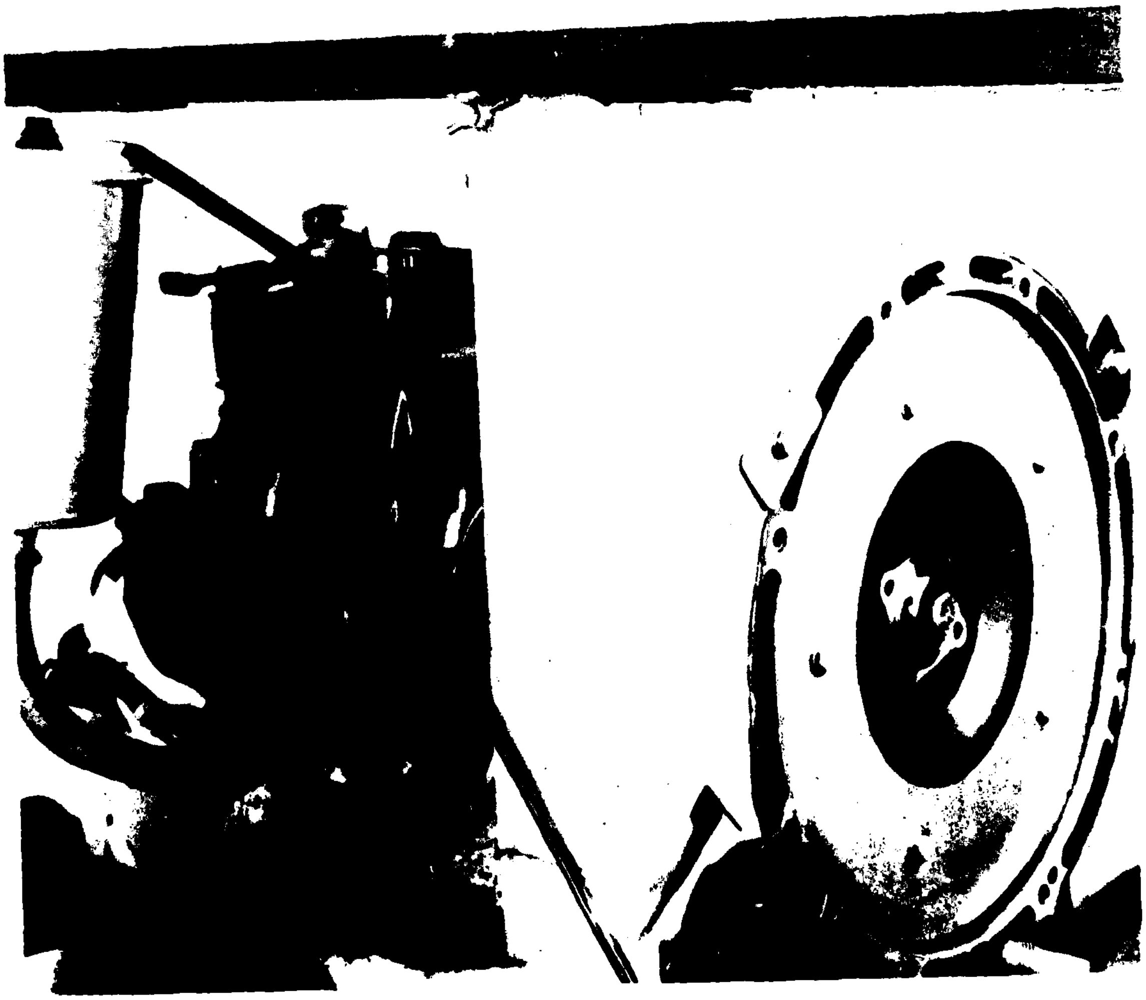


Figure 12. Experimental enlarged engine air discharge duct installed on 3-kW MIL design generator set, circa 1970.

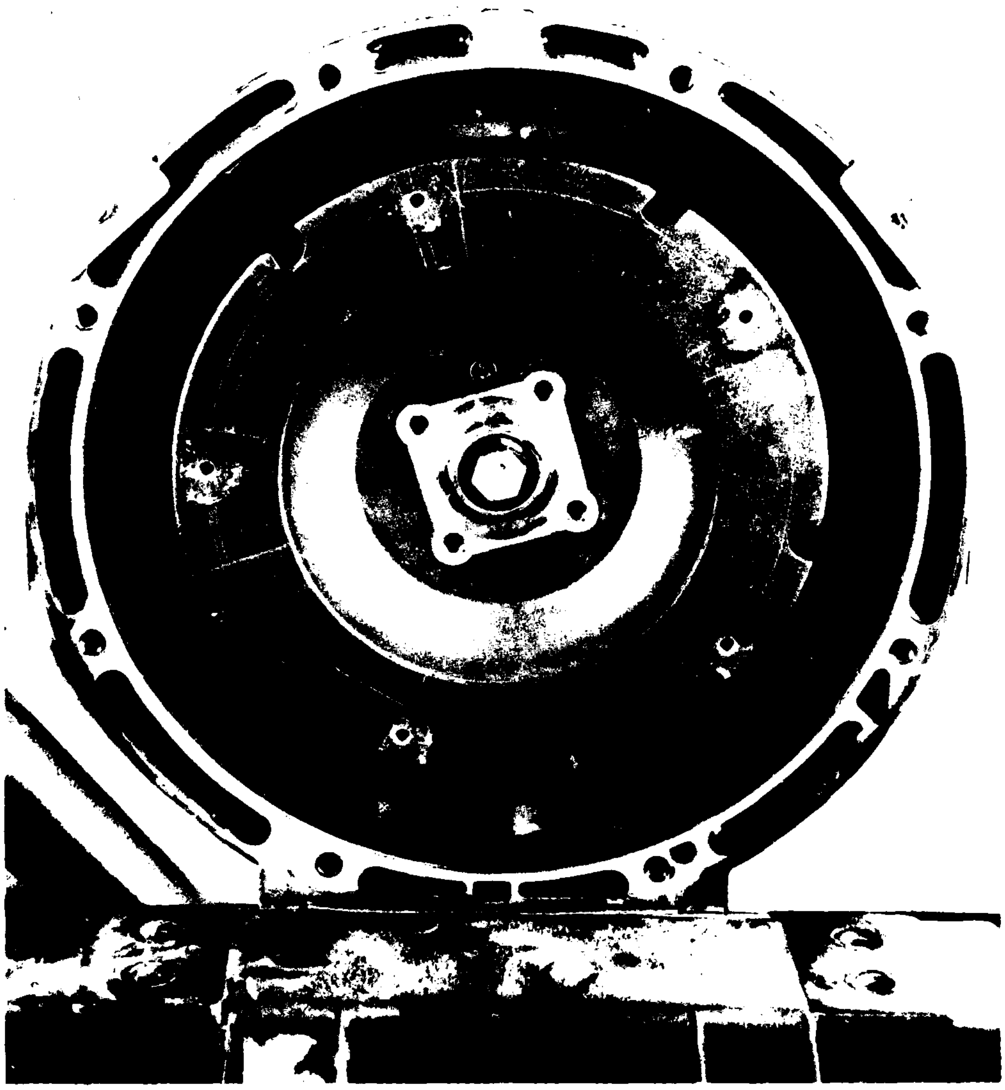


Figure 13. 6-hp MIL STD engine flywheel and flywheel housing- standard configuration.

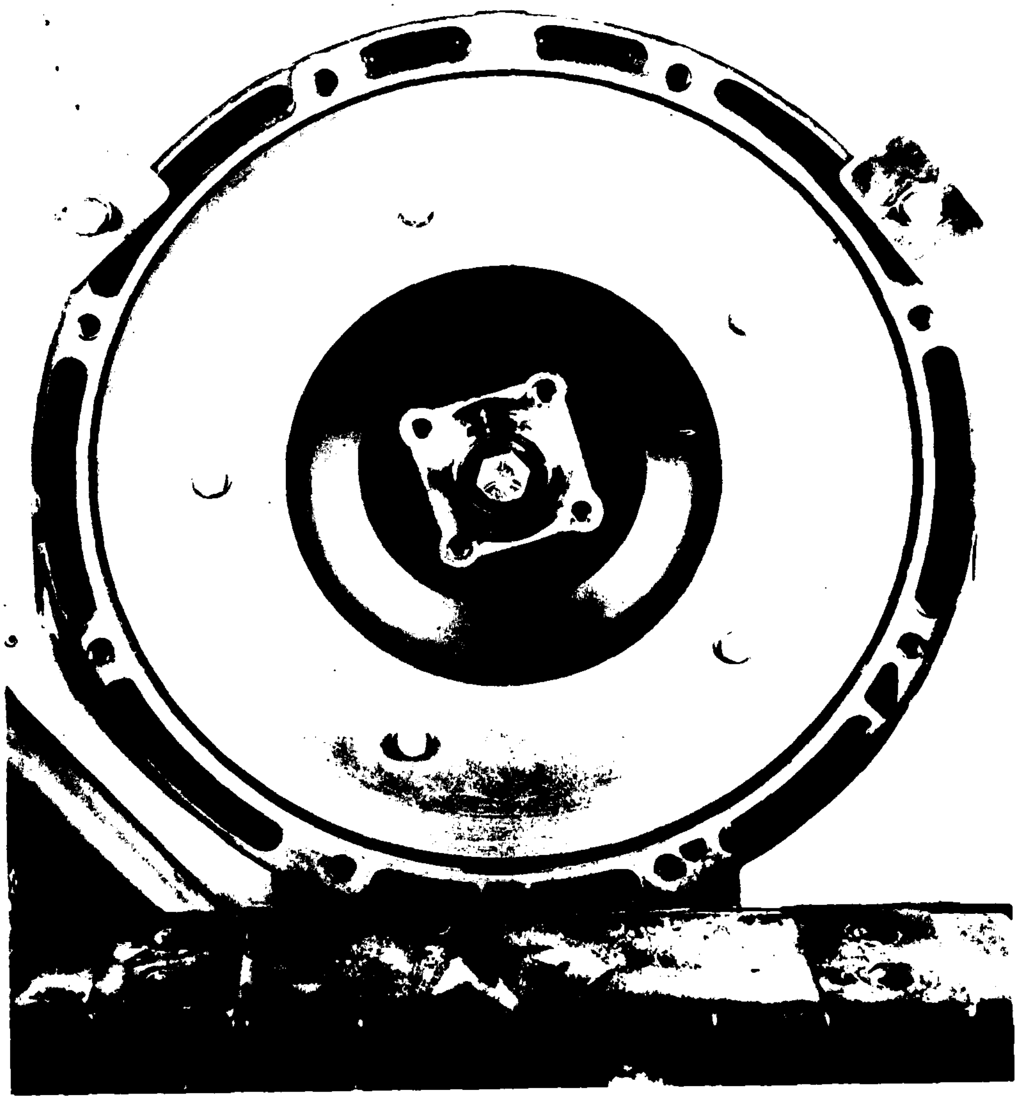


Figure 14. 6-hp MIL STD engine with MERDC design flywheel to housing air seal plate. This plate stops leakage of hot engine air into generator cooling air discharge. Experimental modification, circa 1970.

The total impact of the enlarged duct and flywheel fan seal was the virtual elimination of cooling air recirculation and greatly reduced restriction of the cooling air flow from the fan exit. All cooling air exited upward for normal and high-ambient operation. A manually operated discharge lid could be closed down to restrict the air flow, for cold weather operation. A recirculation air port (see Figure 15) was incorporated into the lower portion of the exit plenum. This port and a similar cover over the starter access hole could be opened for warm air recirculation during sub-zero operation. Operating temperatures of the modified set were only slightly lower than the standard unconfined set. However, the modified set could be operated inside of either a trailer or acoustic housing (developed by Lord Mfg. Co. during 1969-70) without overheating in ambients up to +125° F. The standard set suffers from overheating when operating in confined locations in any ambient above +90° F.

The completely modified 3-kW, 28-V d.c. set (Figures 16 and 17) included the following components:

(1) Enlarged cooling air outlet plenum.

(2) Flywheel fan air seal plate.

(3) Donaldson Company commercial dual-inlet, single-outlet muffler in series with the standard set mufflers.

(4) Electric starter (for convenience of starting engine in acoustic enclosure).

(5) Acoustic housing (fold-up design by Lord Mfg. Co.).

The noise level of this set with acoustic housing was significantly quieter than the standard set.
1970.

IV. SUMMARY AND CONCLUSIONS

The 6-hp MIL-STD gasoline engine as installed on the 3-kW military generator set exhibits problems due to engine overheating which relate to the following factors:

a. The suction cooling system on the 6-hp engine is not as efficient as the pressure cooling system on the other models (1-1/2-, 3-, 10-, and 20-hp) of the MIL-STD engines.

b. The cooling air discharge duct area on the 6-hp engine as installed in the 3-kW generator set is severely restricted as compared with the same engine installed in non-generator set applications.

Figure 15. 6-hp MIL STD engine with enlarged cooling air discharge duct. Note cooling air recirculation door which can be opened for sub-zero operation.

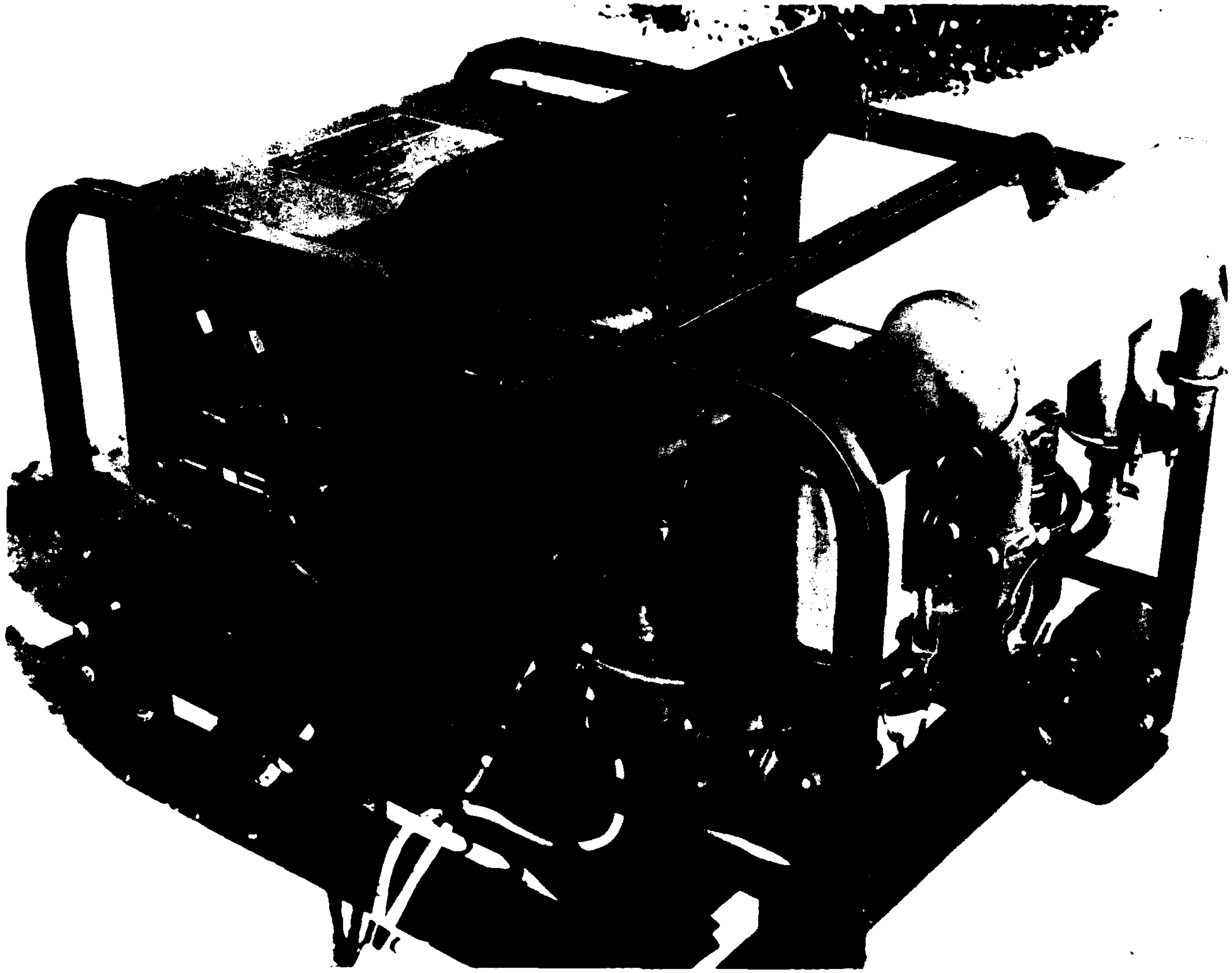


Figure 16. Final configuration of 3-kW MIL design generator set modified with enlarged sealed air discharge duct, quiet exhaust system, and electric starter. This unit was shipped to Korea in June 1970.

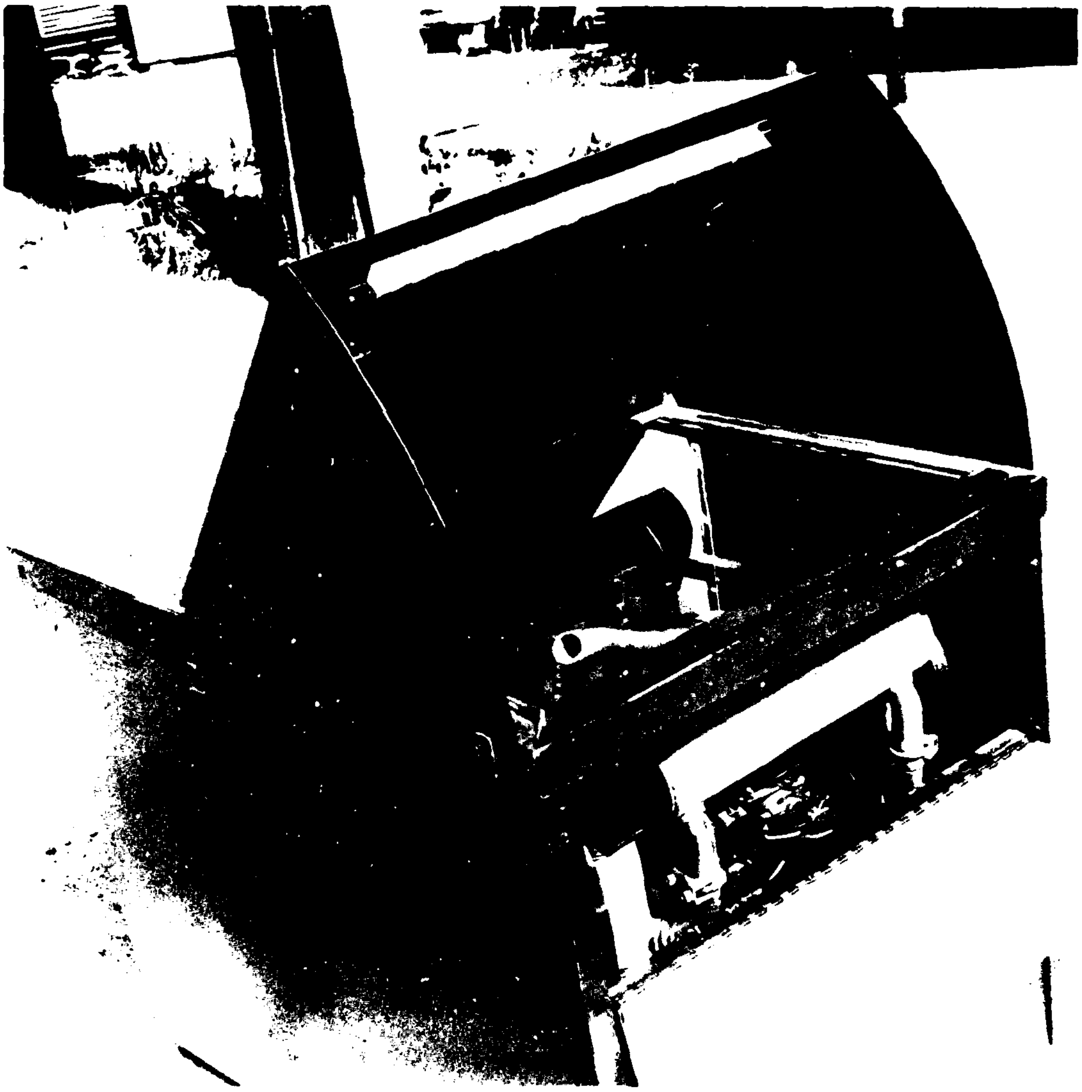


Figure 17. Lord Mfg. Co., acoustic housing for 3-kW MIL STD generator set. Set equipped with high attenuation mufflers and housing installed in M416 1/4-ton trailer.

c. The loose fitting discharge air scoops and the lack of an air seal between the flywheel fan and housing result in the leakage of a significant percentage of the hot engine cooling discharge air into the engine cooling air inlet areas (bottom side of cylinders). Also, the set fuel tank is constantly impinged with hot cooling air.

d. All of the above results in progressive overheating of the engine via a "boot strap" process. Under certain high ambient conditions, it has been observed that the engine lube oil temperature never stabilizes.

e. In view of the fact that a new production quantity of 6-hp MIL-STD engines will be available beginning in FY85 for installation in new 3-kW MIL Design generator sets, an opportunity exists to modify the design of the 3-kW generator set cooling system to eliminate the overheating problem, as described herein.

f. Cooling air improvements could be incorporated into the Technical Data Package for future procurements of the 3-kW (60-Hz, 400-Hz, or 28-V d.c.) generator sets.

DISTRIBUTION FOR BELVOIR RESEARCH AND DEVELOPMENT CENTER REPORT 2394

No. Copies	Addressee
	Department of Defense
12	Defense Technical Information Center Cameron Station Alexandria, VA 22314
	Department of the Army
1	Commander, HQ TRADOC ATTN: ATEN-ME Fort Monroe, VA 23651
1	HQDA (DAMA-CSS-D) Washington, DC 20310
1	Commander US Army Aberdeen Proving Ground ATTN: STEAP-MT-U (GE Branch) Aberdeen Proving Ground, MD, 21005
1	Commandant US Army Engineer School ATTN: ATZA-CDD Fort Belvoir, VA 22060
3	DOD Project Manager, Mobile Electric Power ATTN: AMC-MEP 7500 Backlick Road Springfield, VA 22150
2	TRADOC System Manager, Generators ATTN: ATZA-TSM-G Fort Belvoir, VA 22060

No. Copies	Addressee
	Belvoir R&D Center
1	Commander, STRBE-Z Technical Director, STRBE-ZZ Assoc Technical Director, STRBE-H Chief Engineer, STRBE-HE Chief Scientist, STRBE-HS Program Planning, STRBE-HP Program Support, STRBE-HR Systems Analysis, STRBE-HA CIRCULATE
1	Chief, Combined Arms Support Lab, STRBE-X Chief, Engineer Support Lab, STRBE-N Chief, Logistics Support Lab, STRBE-G Chief, Matl, Fuels & Lubricants Lab, STRBE-V Director, Product A&T Directorate, STRBE-T CIRCULATE
2	Engr Svc Spt Lab, STRBE-E
20	Electro Mech Div, STRBE-EM
3	Tech Reports Ofc, STRBE-WPG
3	Security Ofc (for liaison officers), STRBE-S
2	Tech Library, STRBE-WC
1	Program Support, STRBE-HR
1	Public Affairs Ofc, STRBE-I
1	Ofc of Chief Counsel, STRBE-L

END

FILMED

12-84

DTIC