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AIRESEARCH MANUFACTURING COMPANY

A DIVISION OF THE GARRETT CORPORATION

9851-9951 SEPULVEDA BOULEVARD • LOS ANGELES 9, CALIFORNIA

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SUMMARY REPORT
AIRESEARCH TURBOGENERATOR POWER SUPPLY
PICATINNY ARSENAL SUBCONTRACT
DA-04-495-ORD-3208

1. SECTION 1
- 1.1 Object - This report summarizes the work accomplished by the AiResearch Manufacturing Company, a Division of the Garrett Corporation, toward the design and development of a miniature solid-fuel turbo-generator as an adaptation Kit Power Source, Project TN2-8108, under Picatinny Arsenal Subcontract DA-04-495-ORD-3208, during the period from March 27, 1961 thru October 31, 1962.
- 1.2 Summary - A solid-fuel turbine-electrical power supply, delivering approximately 150 watts for 100 seconds, was designed and built by the AiResearch Manufacturing Company. Four turbogenerator assemblies and 25 gas generator assemblies, plus spares, were built during the program. Two of these units were underwent development tests at AiResearch and TKM Electric Corporation. Later these two units were refurbished and included in the delivery of four units to Picatinny Arsenal. Engineering tests during the development program demonstrated that the units were capable of performing to the specification. The complete assembly, including a loaded gas generator, weighed 3.81 pounds.



- 1.3 Conclusions - AiResearch Power Supply, P/N 551566-2, weighing 3.81 pounds, successfully met the specification "Requirements for a Solid Fuel Turbo Generator Power Supply" included as Appendix A to the Scope of Work, Control Number PA-SW-61-3.
- 1.4 Recommendations - It is recommended that the units be subjected to further tests by Picatinny Arsenal, and that they undergo flight test evaluation.
2. SECTION 2
- 2.1 Introduction - On March 27, 1961 the AiResearch Manufacturing Company, a Division of the Garrett Corporation, received a subcontract from Picatinny Arsenal to execute Phase 1 of a feasibility program toward development of a miniature turbo-generator power supply meeting the requirements of Picatinny Arsenal work statement DA-SW-61-3. These requirements were for a solid fuel turbo generator power supply capable of supplying 150 watts of electrical power for 100 seconds duration at 6.8 and 115 volts ac, 10,000 cycles per second, and 9 and 28 volts dc. This power supply will be used primarily in a one-shot missile application where small size and weight, ruggedness, reliability, and no field preparation or testing are first priority considerations. This report summarizes the work accomplished by AiResearch Manufacturing Company during the period from March 27, 1961 thru October 31, 1962 in initiating and implementing the scope work required by the subcontract.



2.2 Summary of Prominent Activity - A preliminary design was completed in June 1961 and was reviewed at AiResearch by representatives from Picatinny Arsenal on June 29 and 30th. As a result of this review, certain design changes were made and a second design review meeting was held at Picatinny Arsenal on July 20th. As a result of this meeting, Picatinny Arsenal approved continuance of this program into the parts fabrication phase. During the next three months alternators and regulator packages were fabricated by TKM Electric Corporation, turbines, gas generators, and miscellaneous parts by AiResearch Manufacturing Company, and propellants by Picatinny Arsenal. In November 1961, twenty-five gas generators were shipped to Picatinny Arsenal for loading with propellants. In December 1961, the first alternator was received by AiResearch from TKM Electric Corporation, and turbo alternator development tests commenced. The first loaded gas generators were received from Picatinny Arsenal in February 1962 and solid propellant testing of the complete turbo-generator unit was started.

During the next three months the entire turbo-generator unit was subjected to a large number of development tests, including environments of temperature extremes, vibration, and shock. During these tests it was found that the air gap on the alternator was insufficient to provide adequate clearance under all environmental and operating conditions. Therefore, the alternator was redesigned with a more powerful magnet which would permit a larger axial air gap. The first reworked alternator was received at AiResearch in May 1962. All of the alternator and regulator packages were received from TKM Electric Corporation by September 1962.



The first turbo-generator assembly, S/N 42-R4, was shipped to Picatinny Arsenal in June 1962. Two additional turbo-generator assemblies, S/N 42-R2 and S/N 42-R3, were shipped to Picatinny Arsenal in October 1962. Also shipped at this time were all of the remaining spare parts and test equipment which might be useful in the test at Picatinny Arsenal.

Status of the work was reported monthly in a series of progress reports prepared by AiResearch. A summary of these progress reports, showing the prominent activities, is shown in Table I.

1

TABLE I
SUMMARY OF
TURBOGENERATOR POWER SU
(PICATINNY AR)
AS DESCRIBED IN MONTHLY I

MONTH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER 1961	JANUARY 1962	FEBRUARY
REPORT NO.	M-1081-R DESIGN ANALYSIS TURBOGENERATOR LAYOUT	M-1099-R DESIGN ANALYSIS LAYOUTS GAS GENERATOR SPEC. SELECT ALTER- NATOR VENDOR	M-1115-R DESIGN COMPLETED COMPONENT SPECS COMPLETED DESIGN REVIEW DESIGN CHANGED TO REDUCE WEIGHT AND FABRICATION COSTS	M-1121-R GAS GENERATOR DETAILS COMPLETED LAYOUT OF LIGHT- WEIGHT UNIT COM- PLETED AND SUB- MITTED TO PICA- TINNY ARSENAL DETAIL DRAWINGS 90% COMPLETED	M-1134-R DRAWINGS COMPLETED AND RELEASED	M-1162-R MOUNTING BRACKETS DESIGNED	M-1183-R	M-1191-R	M-1208-R	M-1231-R	M-1250-R MOUNT REDESIG
FABRICATION AT AIRESEARCH					PROTOTYPE TUR- BINE DRIVE FOR TKM COMPLETED FABRICATION STARTED ON 4 TURBOGENERATORS FABRICATION STARTED ON 25 GAS GENERATORS	4 TURBO- GENERATORS PLUS SPARES BUILT 25 GAS GENERATORS NEARLY COMPLETED	ADDITIONAL FABRICATION ON 25 GAS GENERATORS	COMPLETED 25 GAS GENERATORS			FABRICA NEW HOU BRACKET
TEST			DEVELOPMENT TEST PLAN M-1102-R COMPLETED		TURBINE DRIVE FOR TKM TESTED		TURBO- ALTERNATOR TEST EQUIP- MENT DESIGNED TEST FUNDS RECEIVED 10-30-62	TEST EQUIPMENT BEING FABRICATED TURBINE- ALTERNATOR TESTED ON HOT GAS SAFETY PLUGS TESTED	TEST EQUIPMENT COMPLETED TURBO- ALTERNATOR TESTS STARTED UNIT TESTED UNDER TEMPER- ATURE EXTREMES	EVALUATION OF ALTERNATOR OUTPUTS RAPID ACCELER- ATION TESTS SHOCK TESTS TESTS USING AEROJET PROPELLANTS	VIBRATI ELECTRI OF 2ND TURBINE CY USIN PROPELL COMPLET WITH 50 PROPELL TESTS P- PLAN ST.
PICATINNY ARSENAL ACTIVITY	EXPT 5381 SELECTED AS THE					PILOT LOT OF PROPELLANT MADE TO DETERMINE PROPERTIES		EXTRADED AND INHIBITED FIRST PROPELLANT GRAINS	HEAVYWEIGHT FIRINGS STARTED	HEAVYWEIGHT FIRINGS 3 LIGHTWEIGHT FIRINGS -65, 70, 160F	
TKM ACTIVITY				SUBCONTRACT TO TKM ELECTRIC CORP. FOR ELEC- TRICAL COMPON- ENTS ORDERED	ALTERNATOR DESIGNED AND 1ST UNIT FABRICATED ELECTRICAL COM- PONENTS ORDERED	ALTERNATOR TESTED AND DE- SIGN VERIFIED 3 MORE ALTERNATORS FABRICATED REGULATOR BREADBOARD TESTED	REGULATOR BREADBOARD DEVELOPMENT TEST SINK DESIGN PROTOTYPE ALTER- NATOR DELIVERED TO AIRESEARCH	REGULATOR BREADBOARD DEVELOPMENT REGULATOR PACKAGING DESIGN	ALTERNATOR- REGULATOR S/N 701-1 DEL. TO AIRESEARCH	ALTERNATOR- REGULATOR S/N 701-2 DEL TO AIRESEARCH	
PHOTOGRAPHS								GAS GENERATOR TURBINE TEST SETUP	LOAD BANK TURBINE WHEEL TURBINE AND CARRIER (2) ALTERNATOR- REGULATOR TURBINE-ALTERNATOR ASSEMBLY		BROKEN / BRACKET 44151-2
CURVES, FIGURES, ETC.		ALTERNATOR TYPES SCHEMATICS PROGRAM PLAN		BLOCK DIAGRAM OF 551566-2 UNIT PROGRAM SCHEDULE	PROGRAM SCHEDULE	WEIGHT TABLE PROGRAM SCHEDULE	PROGRAM SCHEDULE		LOAD BANK SCHEMATIC	BOOST START (1)	TURBINE LOAD VS PRESSURE FOR NO. 1 AND 5 PROPELLA SUMMARY BURN RATE PRESSURE DRAWING FAILED 8 ORIENTAT AXES
DELIVERIES								25 GAS GENERATORS SHIPPED TO PICATINNY ARSENAL			
APPENDICES		M-1095-R PRELIMINARY TURBINE ANALYSIS M-1087-R OPERATION ON BOOST RELIEF VALVE	MINUTES OF DESIGN REVIEW MEETING								



TABLE I
SUMMARY OF
BOGENERATOR POWER SUPPLY PART 551566
(PICATINNY ARSENAL)
DESCRIBED IN MONTHLY PROGRESS REPORTS

DECEMBER 1961	JANUARY 1962	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER 1962
M-1208-R	M-1231-R	M-1250-R	M-1485-R	M-1491-R	M-1492-R	M-1493-R	M-1494-R	M-1495-R	M-1496-R	M-1554-R
		MOUNT REDESIGN		DELETED INNER SHIELDS FROM BEARINGS 20-HOLE FILTER SCREENS IN- CREASED TO 100 HOLES	DECISION TO REWORK ALTERNATORS FOR GREATER AIR GAP					
		FABRICATE NEW MOUNT BRACKETS								
ST EQUIPMENT MPLETED RBO- TERNATOR STS STARTED IT TESTED DER TEMPER- URE EXTREMES	EVALUATION OF ALTERNATOR OUTPUTS RAPID ACCELR- ATION TESTS SHOCK TESTS TESTS USING AEROJET PROPELLANTS	VIBRATION TESTS ELECTRICAL OUTPUT OF 2ND UNIT TURBINE EFFICIEN- CY USING SOLID PROPELLANT COMPLETE SYSTEM WITH SOLID PROPELLANT TESTS PER TEST PLAN STARTED	P/A PROPELLANTS WITH RAPID START 100 RUNS ON DOI-1 HOT RUNS ON UNIT F BOOST-START AIR- SUSTAIN TESTS SUCCESSIVE HOT RUNS	5 SOLID PROP- ELLANT RUNS 157 TEST RUNS ACCUMULATED ROTOR MAGNET FAILED			TURBO-ALTERNATOR S/N 42-R4 ASSEMBLED AND TESTED	TESTING COMPLETED ON TURBO-ALTERNATORS S/N 42-R2 AND S/N 42-R3		CHECK-OUT TESTS ON TURBO-ALTERNATOR S/N 42-R1
AVWEIGHT RINGS ARTED	HEAVYWEIGHT FIRINGS 3 LIGHTWEIGHT FIRINGS -65, 70, 100F		SHIPPED 12 MORE PROPELLANTS TO AIRESEARCH							
TERNATOR- ULATOR N 701-1 DEL. AIRESEARCH	ALTERNATOR- REGULATOR S/N 701-2 DEL TO AIRESEARCH			ALTERNATOR- REGULATOR S/N 701-3 DEL. TO AIRESEARCH ALTERNATOR- REGULATOR S/N 701-1 SHIPPED BACK TO TKM FOR OVERHAUL	ALTERNATOR- REGULATOR S/N 701-4 DEL. TO AIRESEARCH ALTERNATOR- REGULATORS S/N 701-2, 701-3 RECEIVED BACK FOR REWORK	REWORK OF ALTERNATORS 701-2 AND 701-3	REWORKED 701-2 AND 701-3 SHIPPED TO AIRESEARCH	AIRESEARCH LOAD BANK SHIPPED TO AIRESEARCH	ALTERNATOR- REGULATOR S/N 701-1 RECEIVED FROM TKM AIR TEST DRIVE AND LOAD BANK RETURNED TO AIRESEARCH TKM ACTIVITY COMPLETED	
AD BANK RBIINE WHEEL RBIINE AND VRIER (2) TERNATOR- ULATOR RBIINE-ALTERNATOR SEMBLY		BROKEN MOUNT BRACKET 44151-2	PROPELLANT WITH FAILED INHIBITOR	CRACKED ROTOR MAGNET GAS GENERATOR ASSEMBLY DISASSEMBLED FIRED GAS GENERATOR ASSEMBLY TURBOGENERATOR ASSEMBLY REAR MOUNT BRACKETS						TURBOGENERATOR ASSEMBLY
AD BANK HEMATIC	BOOST START	TURBINE U/C CURVES LOAD VS SPEED PRESSURE TRACES FOR NO. 1, 2, 3, AND 5 PROPELLANT TEST SUMMARY BURN RATE VS PRESSURE DRAWING OF FAILED BRACKET ORIENTATION OF AXES	6 PRESSURE-TIME TRACES INHIBITOR FAILURE TRACE BURN RATE VS PRESSURE DATA EXHAUST THROTTLE SKETCH GAS GENERATOR THERMOCOUPLES TEMPERATURE SURVEY	SUMMARY OF RUNS PRESSURE-TIME TRACES (2) WEIGHT BREAKDOWN						REVERSED BEARING RE- TAINER INSTALLATION SUMMARY CHART TABLE OF EXTRA PARTS AND EQUIPMENT SHIPPED APU OUTPUTS WITH CORRECTED LOAD BANK
						TURBOGENERATOR S/N 42-R4 SHIPPED TO PICATINNY ARSENAL		TURBOGENERATORS S/N 42-R2 AND 42-R3 SHIPPED TO PICATINNY ARSENAL		TURBOGENERATOR S/N 42-R1 SHIPPED TO PICATINNY EXTRA PARTS AND EQUIP- MENT SHIPPED TO PICATINNY ARSENAL



2.3 Specification Summary

2.3.1 Performance Requirements

Output:

35	watts	115	vac	0.8 pf	10,000 cycles
15	watts	6.8	vac	0.8 pf	10,000 cycles
28	watts	28	vdc		
72**	watts	9	vdc		
150	watts				

Duration:

Hot gas	100 seconds
Cold gas	5 minutes

Endurance:

Hot gas	10 duty cycles
Cold gas	75 duty cycles (approx. 6 hrs.)

Acceleration time:

0.75 seconds

Load Schedule:

TABLE I

Volts		Power Output		Time	
115	vac	35	watts	0-100	secs
6.8	vac	15	watts	0-100	secs
28	vdc	28	watts	0-100	secs
9	vdc	72	watts	80-100	secs

**9 volt circuit to also supply parasitic load circuit of 0 to 125 watts.



Environmental Requirements

Operational:

Temperature: -65 to +165°F
Humidity: To 100% plus frost and condensation
Pressure: 2 to 45 inches mercury absolute
Acceleration: Longitudinal: 100 g for 2 seconds
Laterally: 20 g

Non-operational:

Vibration: 10-23 cps 1.5 g
23-75 cps 0.072 inch
75-2000 cps 20 g

Shock: 150 g

Other: Salt spray, rain, sand and dust, and fungus

Storage: 5 years



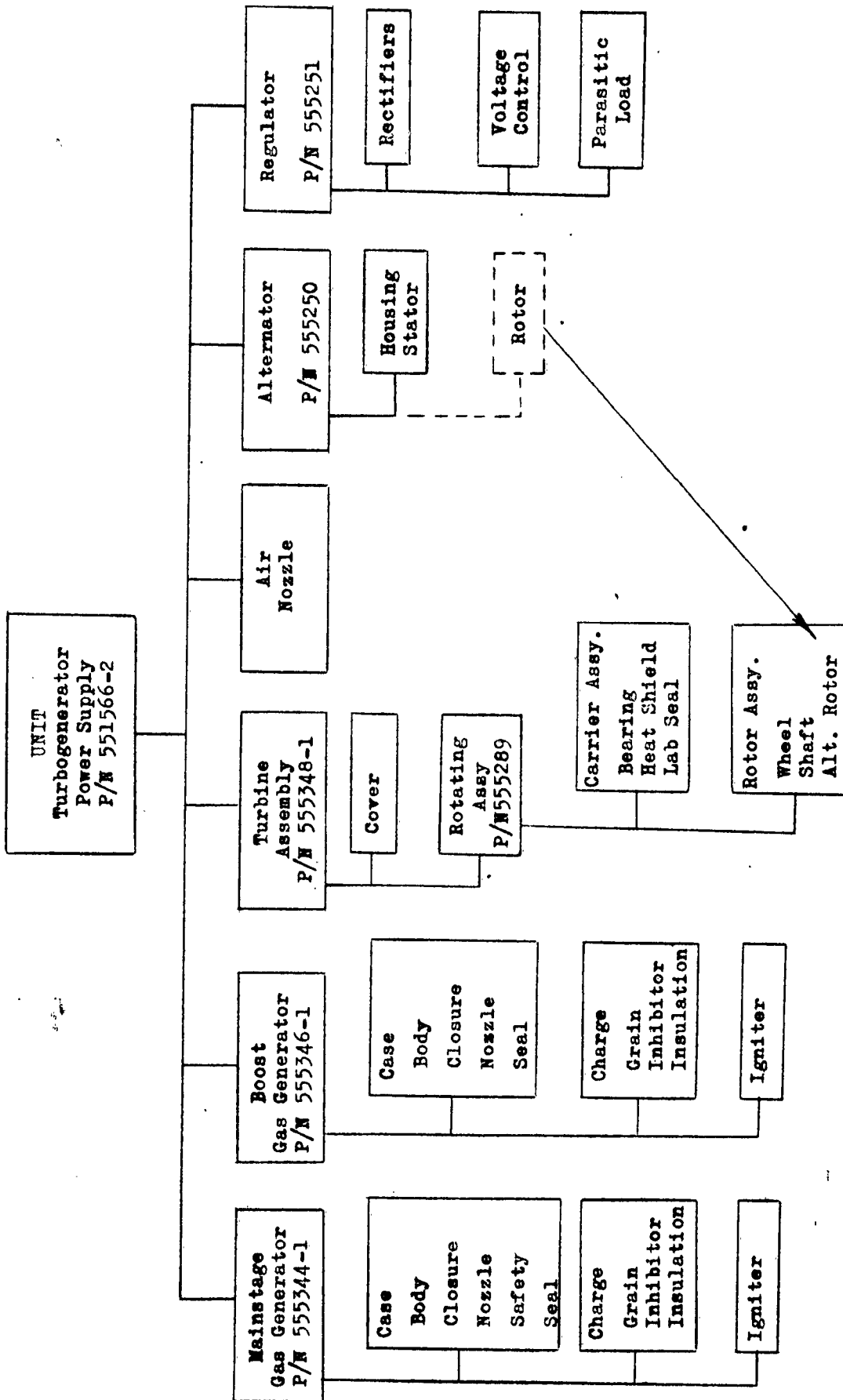
2.4 Description of the Unit - The unit consists of these major subassemblies:

Main Stage Gas Generator
Turbine Assembly
Alternator-Regulator Assembly
Boost Gas Generator
Air Nozzle

The relationship of these subassemblies is shown in Figure 1. These subassemblies are so designed that the physical interfaces coincide with the functional interfaces. This makes each component readily adaptable to component test and subassembly replacement can be accomplished without disturbing the calibration of the complete unit.

The main stage gas generator is approximately $1\frac{1}{4}$ inches in diameter and 12 inches long. At the outlet end is located the igniter, turbine nozzle, the safety plug and a screen. There is a removable closure at the opposite end to enable the gas generator to be reused for multiple firings. The turbine nozzle is an integral part of the gas generator; consequently all items which affect the performance of the gas generator are a part of that component and will be tested in the same manner as is the gas generator. This enables the maximum of control over this very critical part.

The boost gas generator, which will also contain its own nozzle, is screwed into another boss in the turbine housing. This same boss is also used for the air run-up fitting. It has been mutually agreed between AirResearch and Picatinny Arsenal to postpone development of the boost gas generator until somewhat later in the program, thus this relatively simple device can be designed after the units are built and the exact requirements are better known. Without the boost gas generator the unit will require approximately five seconds to obtain operating speed.



CALCULATED BY		BLOCK DIAGRAM SHOWING PHYSICAL RELATIONSHIP OF COMPONENTS		Figure 1	
TRACED BY		TURBOGENERATOR 551566-2		M-1607-R	
CHECKED BY		THE GARDNER CORPORATION Air Research Manufacturing Division LOS ANGELES, CALIFORNIA		Page 9	
APPROVED BY					
UNIT NO.					



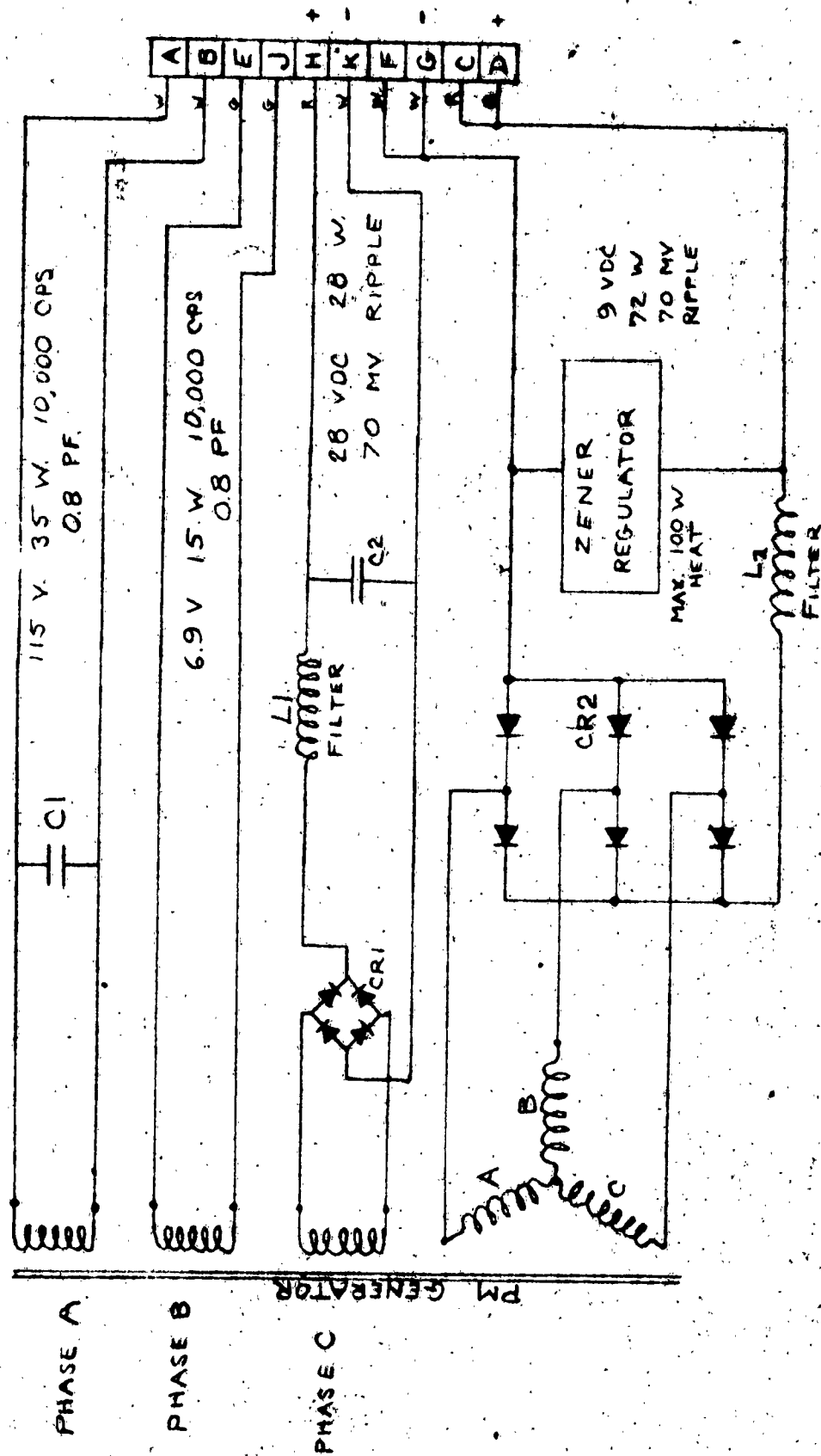
The turbine is of the lightest practical design having a titanium spot face wheel. The high temperature gas passages are held to minimum size and are well isolated from the remainder of the turbine assembly. These heat dams are sufficient that no heat sinks are provided to maintain the cooler parts of the turbine assembly within the desired operating range of less than 300°F.

An axial air gap permanent magnet alternator built by the TKM Electric Corporation was used. Speed control was obtained by a Zener diode parasitic load on the 9 volt D-C circuit. The alternator and regulator package was built as an integral assembly. Heat sink for the Zener diodes was obtained by submerging the diodes in a hermetically sealed wax reservoir. Wax, with a melting point of 195F, was used because of its relatively high heat of fusion. It will not require replacement or other servicing throughout the life of the unit as it is completely sealed within a tank in the alternator-regulator housing.

The complete turbo-generator assembly, P/N 5515662, is shown in Photo 45994-1. An electrical schematic diagram is shown in Figure 2.

2.5 Weight, Volume, and Center of Gravity

- 2.5.1 Weight - A weight breakdown of the Turbo-generator Assembly, P/N 551566-2, is shown in Table II, and a breakdown for the Alternator-Regulator Package is shown in Table III. It is estimated that further weight savings could be accomplished to reduce the weight to 3.31 pounds as shown in Table IV.



DESIGNED	WJW	7-1-61
DRAWN	WJW	7-1-61
APPROVED		

ELECTRICAL SCHEMATIC

P/N 551900

AIRESEARCH MANUFACTURING CO.
LOS ANGELES, CALIFORNIA

Figure 2

E-1607-R
Page 11



TABLE II

Weight Breakdown For APU-551566-2

	<u>Weight in Pounds</u>	
Gas Generator -		
Propellant, etc.	.685	
Metal Parts	.605	
		1.290
Turbine Assembly with Alternator Rotor		.450
Regulator and Alternator Stator		1.550
Nozzle Housing		.360
Mounts		.147
Bolts		.010
Total Pounds - - - -		<u>3.807</u>

TABLE III

Weight Breakdown For Alternator-Regulator Package S/N 701-2

	<u>Weight in Pounds</u>
Stator w/o Compensator	.142
Compensator	.119
Electrical Connector	.026
Regulator Package End Bell	.084
Regulator Barrel w/ Tru-arc Ring	.203
Alternator Housing	.159
9-Volt Heat Sinks (2)	.045
28-Volt Heat Sinks (2)	.046
Tank Assembly w/o Wax and Zener Diodes	.186
Zener Diodes (3)	.110
Rectifiers w/ Hardware (10)	.180
Wax	.100
Wire, Filters, Capacitors, Tape, etc.	.150
Total Pounds -	<u>1.550</u>

Part	Present Weight Lbs.	Improved Weight Lbs.	Method of Improvement
Gas Generator (Mainstage)	1.290	1.101	Spun Integral end Cap
Propellant, Inhibitor, Insulation and Igniter Case	{ .685 } { .605 }	(.416)	
Alternator (w/o rotor)	.420	.420	
Control Package	1.130	.930	Aluminum in place of brass wax tank. Thinnerwall housing.
Turbine Assembly w/ Alternator Rotor	.450	.414	"Shaved" bearing carrier, Titanium shaft.
Nozzle Housing	.360	.288	Investment Casting
Mounts	.147	.147	
Misc. (bolts, etc)	.010	.010	
	<u>3.807</u>	<u>3.310</u>	



TABLE IV
POSSIBLE WEIGHT REDUCTION
P/W 551566-2



2.5.2 Volume - The net volume of the Turbo-generator Assembly, complete with Gas Generator, is approximately fifty cubic inches. The installation drawing, 551566, is shown as Figure 3.

2.5.3 Center of Gravity - The center of gravity of the unit is as shown in Figure 4.

2.6 Test Program

2.6.1 Scope - The test program included these phases:

A. At TKM Electric Corporation:

1. Electrical Tests of the alternator and regulator package.

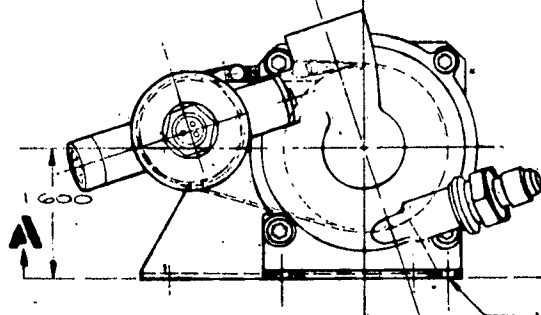
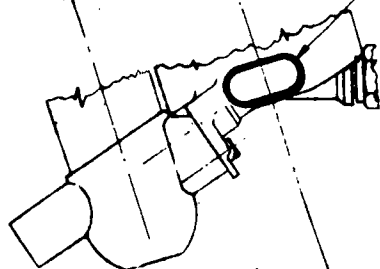
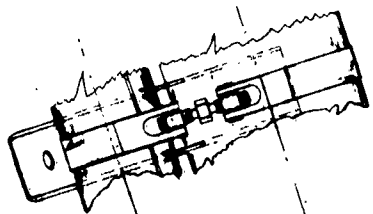
B. At Picatinny Arsenal:

1. Propellant evaluation tests in heavy-wall gas generators.
2. Gas generator tests using AiResearch supplied gas generator cases.

C. At AiResearch:

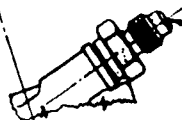
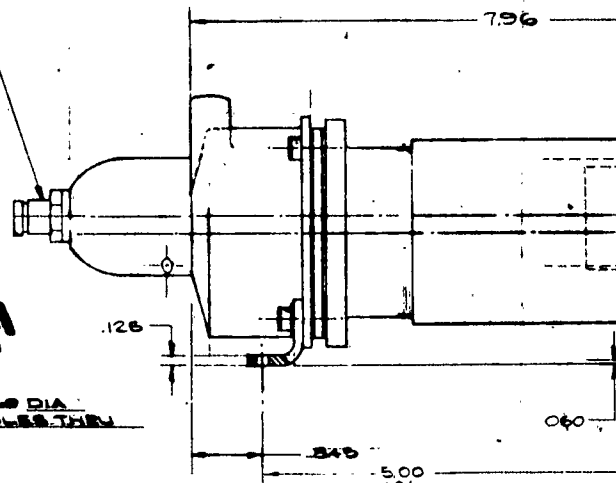
1. Turbine efficiency tests.
2. Turbine assembly temperature tests.
3. Turbo-generator performance tests using compressed air to drive the turbine.
4. Turbo-generator performance tests using solid propellant gases to drive the turbine.
5. Turbo-generator performance tests, using solid propellants, at temperature extremes.
6. Vibration test of complete assembly.
7. Shock test of complete assembly.
8. Functional test before delivery.

PART NO	REMARKS	POWER UNIT ASSY
PS1066-2-1	AS SHOWN	XS51067-2-1

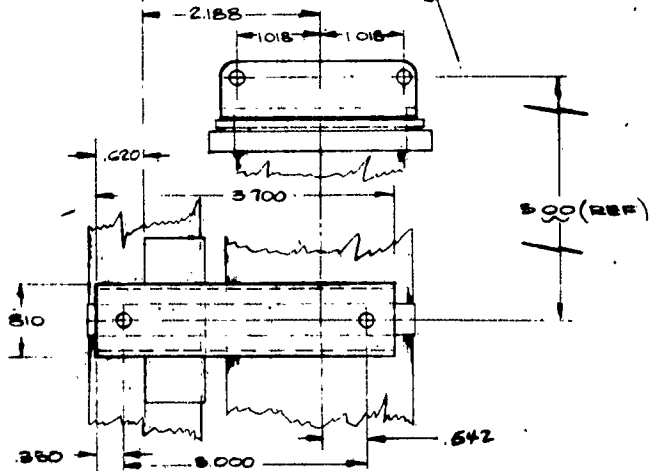


EXHAUST

MATES WITH "TITEFLEX 3102-7-608"



NOZZLE AIR-GRIND-RUN-UP
PER AND 10216-4
1-20-UP-2A THERMO REF

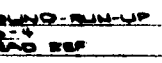


PARTIAL VIEW AA

1

ALL DIM'S ARE FOR IN
ONLY. TOLERANCE 3/
NOTES: UNLESS OTHERWISE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
A. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.																																																																																																			

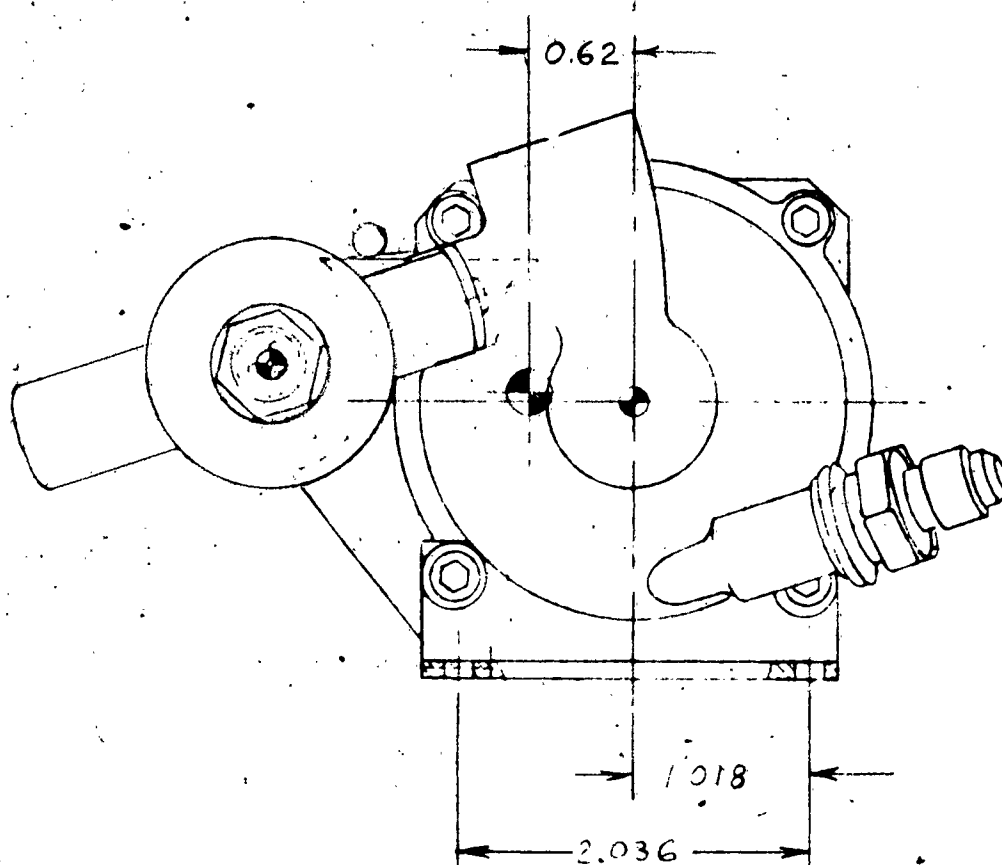


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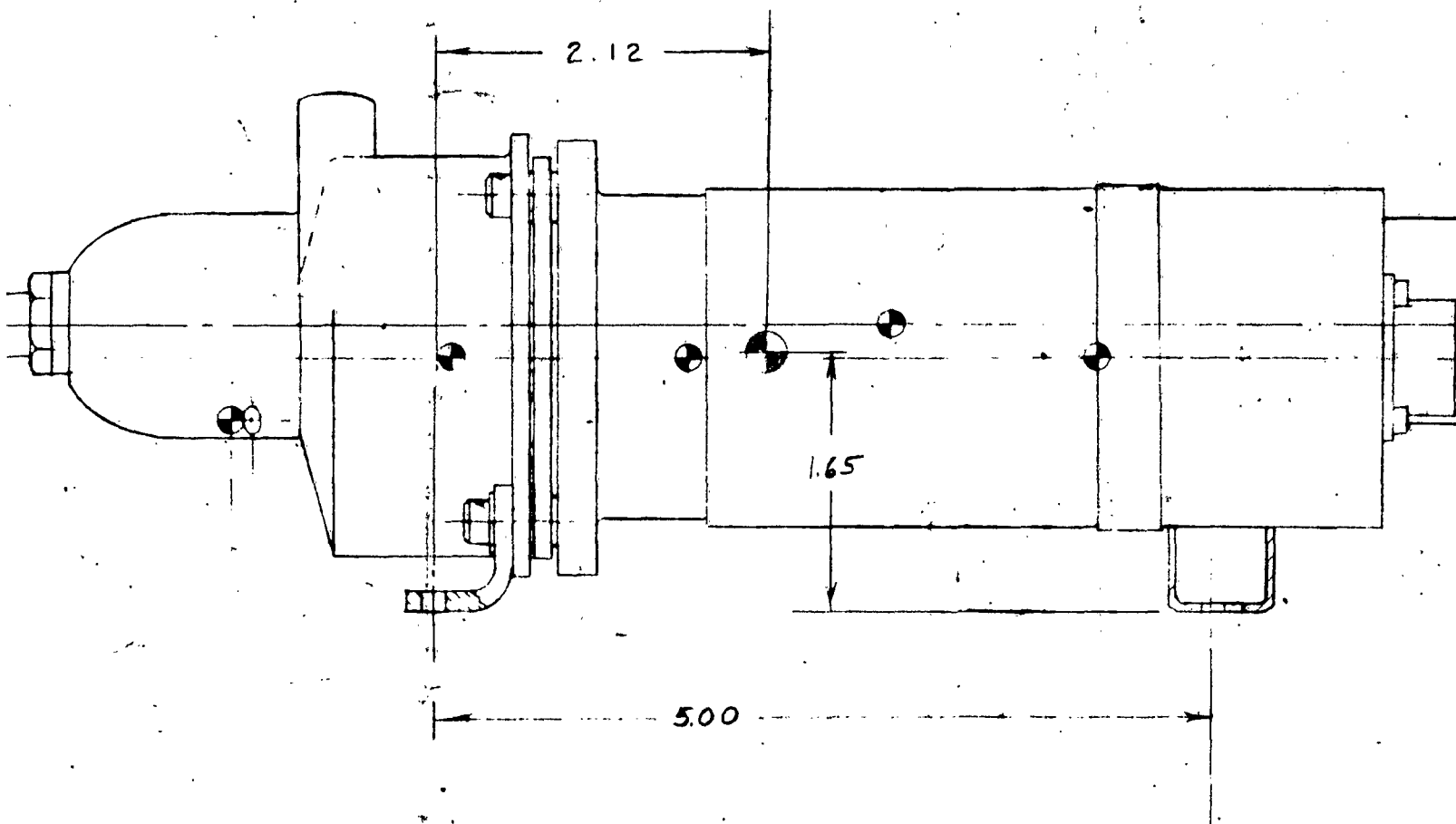
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DIMENSIONS UNLESS OTHERWISE SPECIFIED

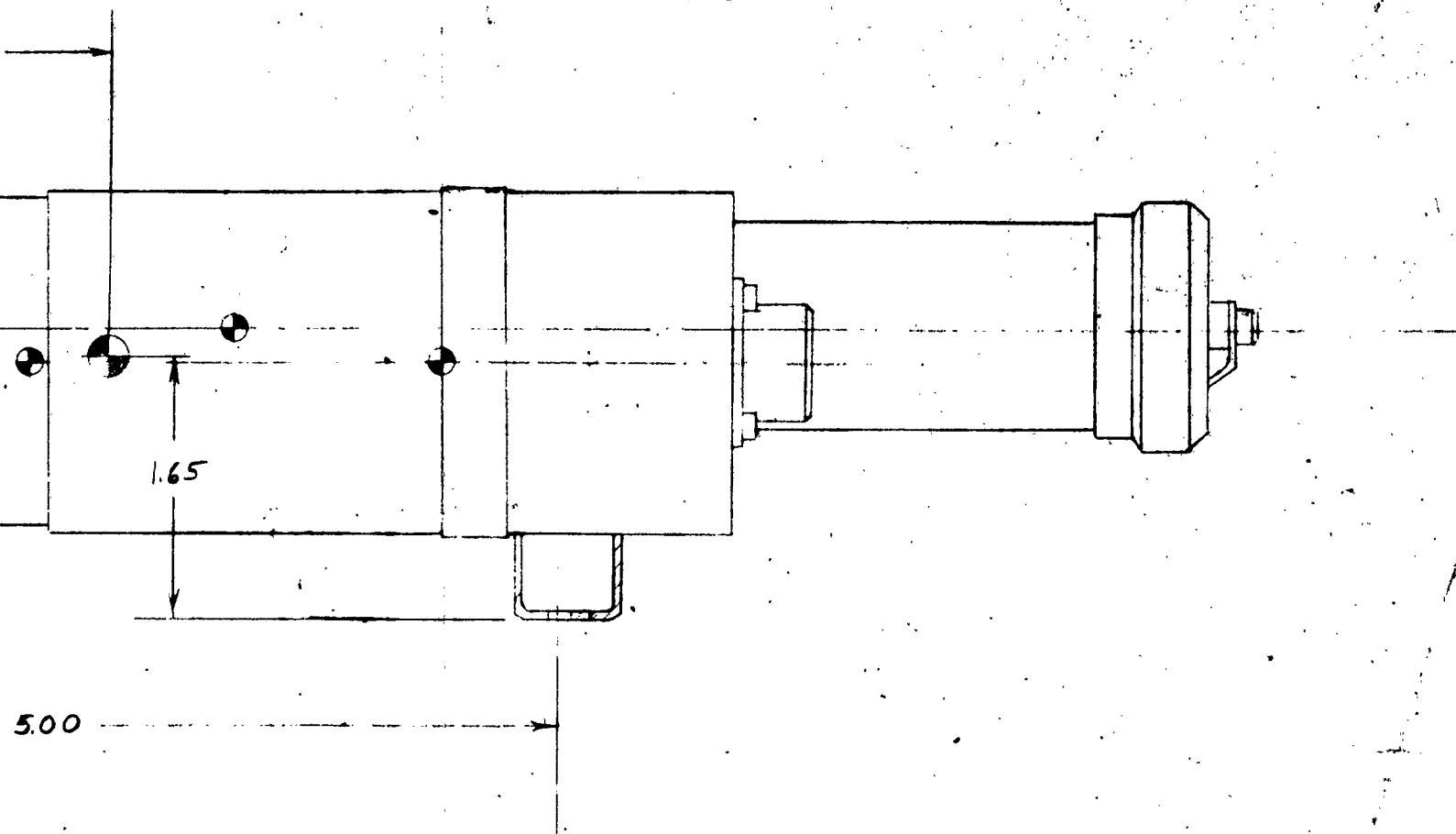


1



- COMPLETE ASSEMBLY CG.
● COMPONENT CG.

2



- COMPLETE ASSEMBLY CG.
- COMPONENT CG.

3

FIGURE 4.
CENTER OF GRAVITY
P/N 551566-2



- 2.6.2 Tests at TKM - AiResearch supplied TKM with an air-driven turbine assembly to drive the alternator during these tests. Thus the complete alternator-regulator package was quite thoroughly developed and tested before it was delivered to AiResearch. The AiResearch electrical load bank, shown in Photo 42920, was shipped to TKM for final testing to insure compatibility at the two test sites.
- 2.6.3 Test at Picatinny Arsenal - These tests are not reported here in as they are already better known by Contractor than by the Contractee.
- 2.6.4 Tests at AiResearch
- 2.6.4.1 Turbine Efficiency Tests - The turbine assembly was run, using a flywheel to absorb its output, through several tests using both cold gas and solid propellant gases, to determine the turbine efficiency. The result was slightly above that predicted for the design, and is shown in Figure 5.
- 2.6.4.2 Turbine Temperature Tests - The turbine assembly and a prototype alternator were completely insulated externally and subjected to several hot runs using the decomposition products of ethylene oxide (1800F) as a driving fluid. Thermocouples located at several places through the unit showed that the turbine bearings and the alternator rotor were not subjected to excessive temperatures.
- 2.6.4.3 Performance Tests - A large number of runs were made, both with hot and cold gas, to determine the overall performance of the unit. Exact measurements of the outputs was somewhat difficult because of the high frequency (10,000 cps). As far as could be determined, the unit provided the correct outputs into the specified simulated loads.

A summary of the number of runs made on each unit is shown in Figure 6.

CLEARPRINT CHARTS

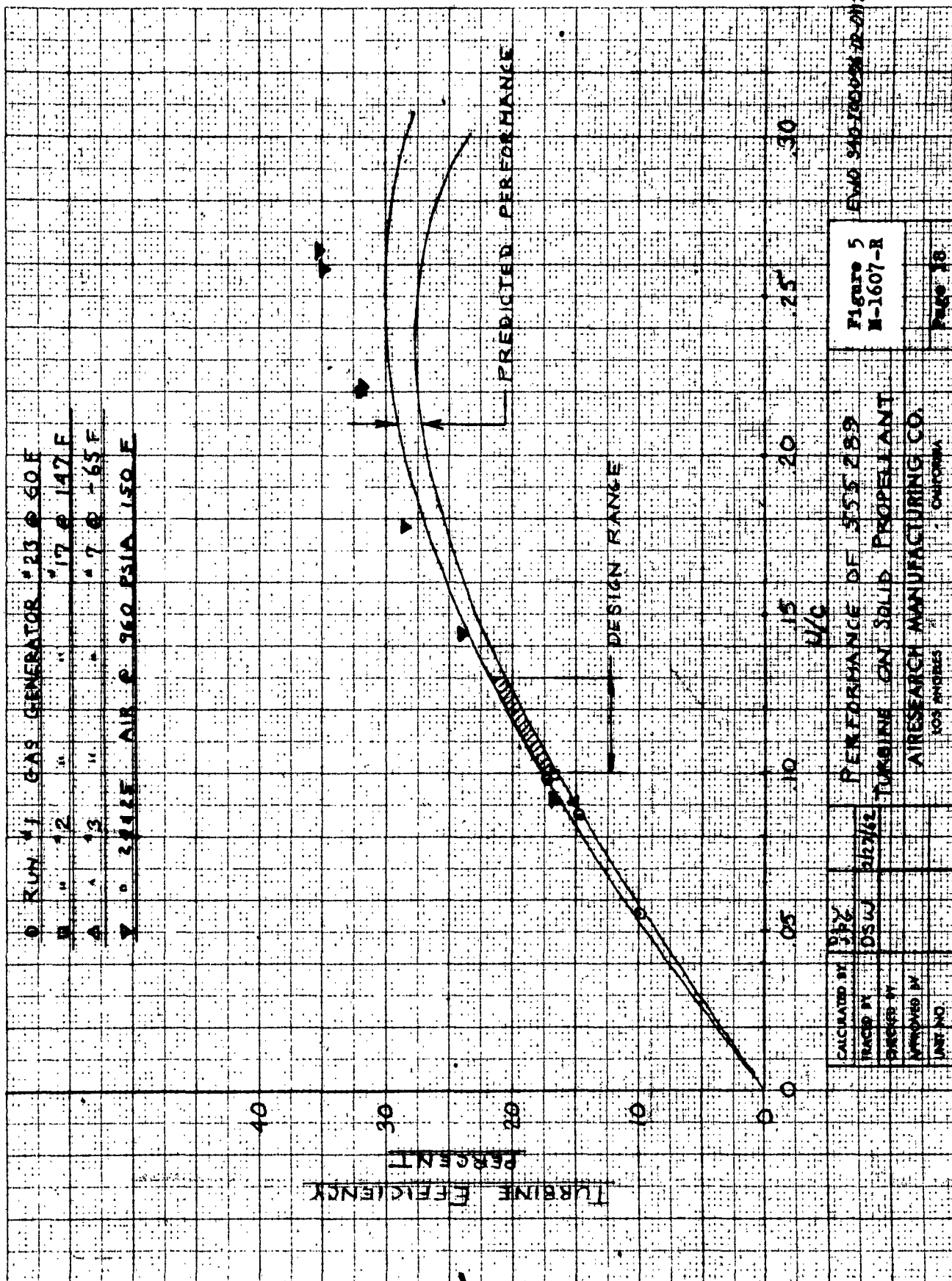
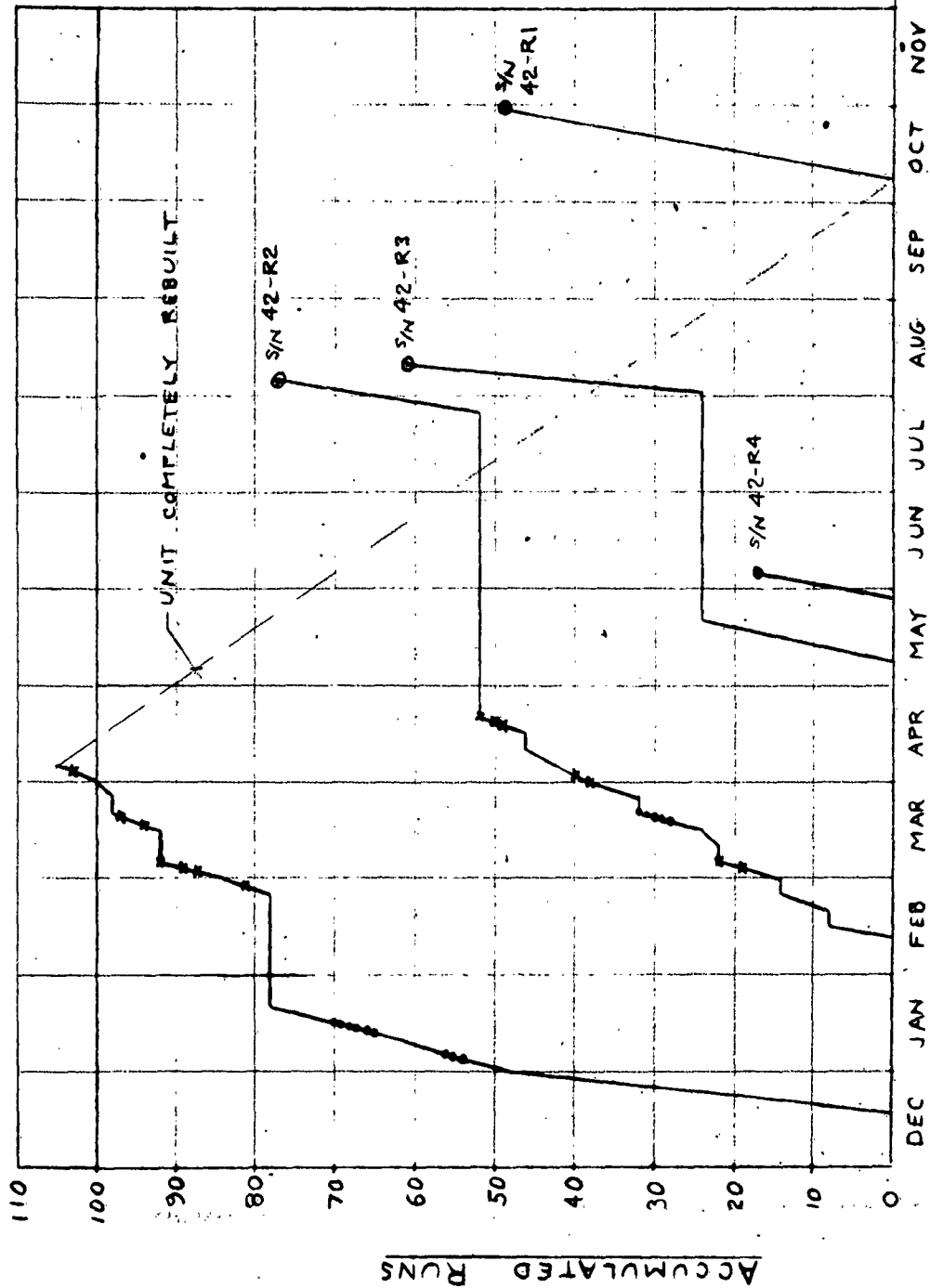


Figure 5
M-1607-R



• SOLID FUEL ACCELERATION
 x SOLID FUEL OPERATION
 ○ SHIPPED TO PICATINNY ARSENAL

SUMMARY OF TEST RUNS MADE
 TURBOGENERATOR P/N 551566-2



2.6.4.4 Vibration Tests - The unit, with a dummy propellant in the gas generator, was subjected to a vibration scan and then vibrated at the resonant frequencies. A failure of the rear mount bracket was experienced, and this was modified twice to obtain a structure adequate to withstand this environment.

2.6.4.5 Shock Test - The unit was subjected to the specified shock environment, and no failures were experienced.

2.6.5 Development Problems

2.6.5.1 Bearings - In the original design double-shielded grease-pack bearings were used. It was found that the shields would be forced from their positions at high rotational speeds. The design was modified so that only the outer shield, with respect to the mating bearing, was used and the volume between the bearings was packed with grease. This was satisfactory.

2.6.5.2 Balance - The first units were assembled unbalanced as the rotating assemblies were quite light and were inherently fairly well balanced. However, occasional unbalance problems were experienced, so later all of the assemblies were dynamically balanced after assembly.

2.6.5.3 Rotor-Stator Clearance - This unit has an axial air gap alternator; the nominal air gap in the original design being 0.010 to 0.015 inch. The stator assembly was mounted on a temperature-sensitive diaphragm that causes axial displacement as a function of temperature to compensate for the reduction in magnetic strength with temperature increase. It was found that when the unit was run hot (solid propellant at +165°F ambient), the compensator would displace the stator into the rotor and cause a rubbing failure. This was aggravated by the bearing mounting design which permitted the axial play to decrease the gap from nominal. This



problem was corrected by 1) increasing the magnet size and strength, thereby permitting a larger air gap (0.020 nominal), and 2) changing the retention method on the bearings so that the axial play tended to increase the gap from the nominal.

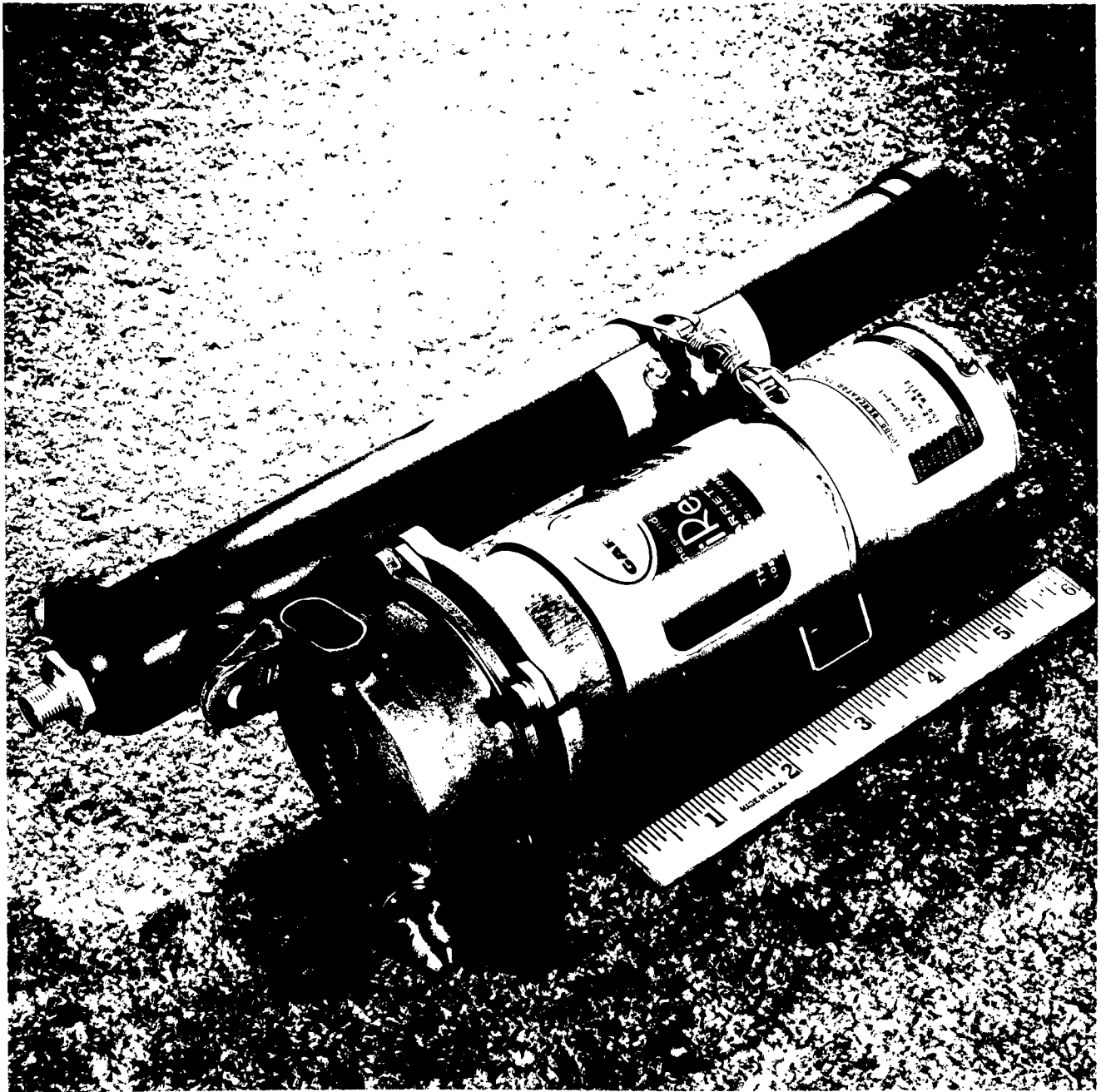
2.7 Deliveries

2.7.1 Gas Generators - Twenty-five gas generator cases, complete with miscellaneous mechanical parts, were delivered to Picatinny Arsenal in November of 1961. Several of these were shipped back to AiResearch after they were loaded at Picatinny Arsenal, and additional propellants and igniters were supplied for re-loading at AiResearch. All of the gas generators were returned to Picatinny Arsenal at the end of the program.

2.7.2 Turbo generator Assemblies - Complete Turbogenerator assemblies, with unloaded gas generators, were shipped to Picatinny Arsenal on these dates:

June 1962	S/N 42-R4
August 1962	S/N 42-R2
August 1962	S/N 42-R3
October 1962	S/N 42-R1

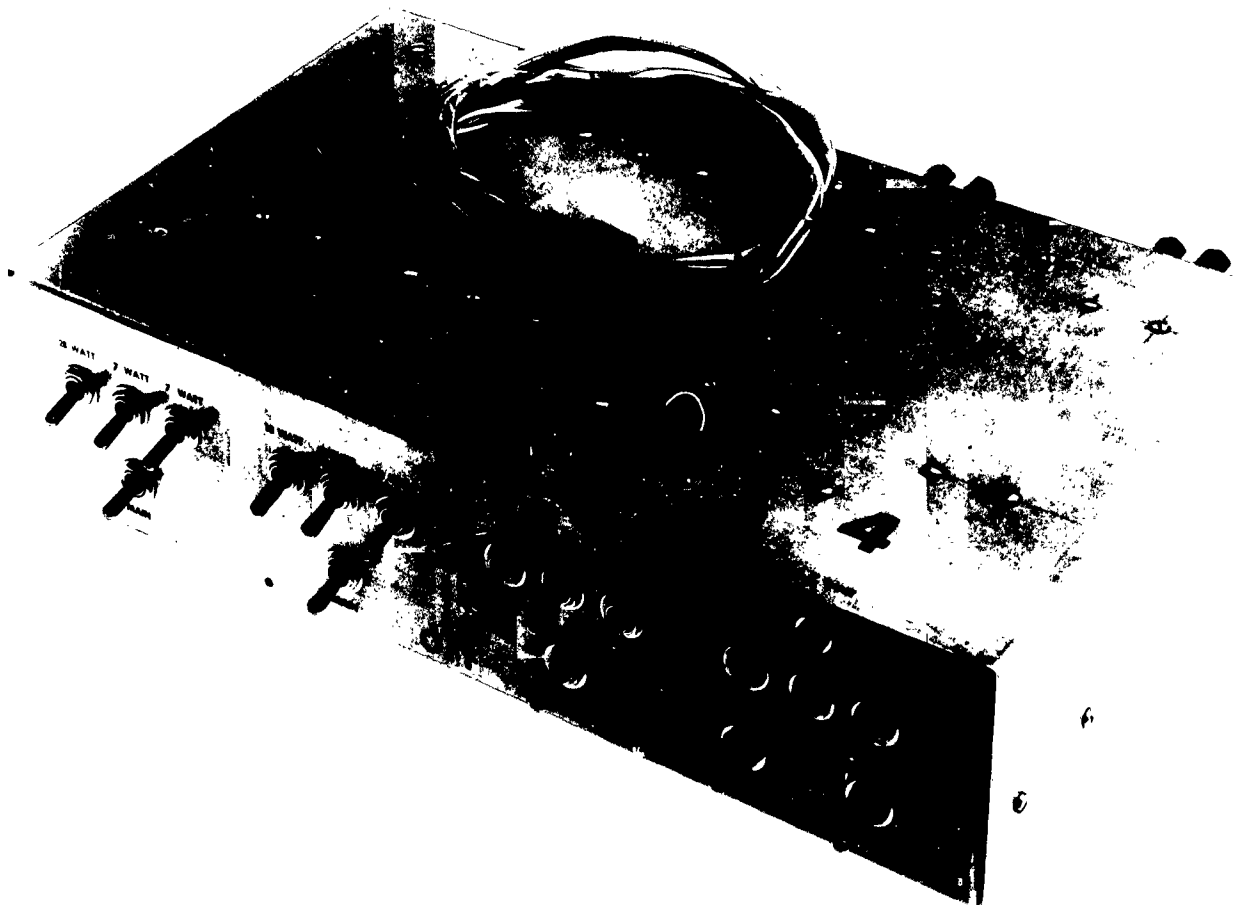
2.8 Reports - Monthly Progress Reports were submitted which describe the activities in considerable detail. Full use of these reports can be readily accomplished through the summary which is included as Table I of this report.



TURBOGENERATOR
P/N 551566-2-1
S/N 42-RI
DATE: 10-31-62
PHOTO 45984-1



Research Manufacturing Division
LOS ANGELES 48, CALIFORNIA



ELECTRICAL LOAD BANK
FOR APU P/N 551566-2
TOOL NO. 430-501047

PHOTO 42920



THE GARRETT CORPORATION

Air Research Manufacturing Division
LOS ANGELES 40, CALIFORNIA