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INVESTIGATION OF METHODS FOR IMPROVING THE TEMPERATURE COMPENSATION OF ECLIPSE, TYPE 1001 AND 1317 A.C. CARBON PILE VOLTAGE REGULATORS

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5. The Type 1001 and 1317 regulators are fitted with a bi-metal ring against which the main spring of the regulator abuts. As the operating temperature of the regulator varies, the angle of the concave abutment surface of the bi-metal ring changes, which causes the characteristics of the spring and magnetic circuit to change. The design of this bi-metal ring should be such that a constant output voltage is maintained under the varying temperatures encountered during operation. However, as previously stated, the compensation provided in the Type 1001 and 1317 regulators is unsatisfactory.

6. The work done thus far has not included a thorough investigation into the complete characteristics of these regulators. It has been undertaken with the object of obtaining an immediate improvement in the temperature characteristics of the Type 1317 unit, which will lend itself to the field conversion of regulators now in service.

CONDITIONS OF OPERATION

7. All of the information and observed data presented in this report were obtained when using an Eclipse Type 1317 regulator, Serial #Y-323, which is one of the units tested in reference (b). Since it was established in reference (b) that the use of the mechanical stabilizer had no appreciable effect upon the temperature characteristics of the regulator, it was not employed in this study. This regulator was used to control an Eclipse NEA-5 generator, Type (1097-3-C), Serial #1424, operating with a 9 microfarads series compensation. The D.C. voltage was maintained at approximately 27.5 volts and no D.C. load was applied.

8. The temperature characteristic of this regulator was improved by replacing the bi-metal abutment ring and its aluminum backing ring with an aluminum abutment ring having the same working angle, at an ambient temperature of 25 ± 5 degrees Centigrade as the original bi-metal, and a thickness equal to the combined thicknesses of the bi-metal and its backing ring. The aluminum ring used in this study was taken from an Eclipse Type 1042 D.C. carbon pile regulator and required no modification. The dimensions of the ring used are:

Outside Diameter - - - - 2.195 inches
Inside Diameter - - - - 1.370 inches
Thickness at Outer Edge 0.193 inches
Angle of Abutment Face - 4 degrees (approximately).

EFFECT OF AMBIENT AIR TEMPERATURE

9. In order to form a comparison between the operation of the regulator as it was received and after it had been modified, regulation runs were made at ambient temperatures of -50, +25 and +70 degrees Centigrade, both before and after the regulator warmed up. The runs made prior to the warm-up (all data for three speeds taken as quickly as possible after start of operation), are referred to as "cold" runs, while those made after the 30 minute warm-up period (pile dissipating approximately 30 watts) are

called "hot" runs. The results obtained when the regulator was operated before modification compare quite well with those reported in reference (b) for similar operating conditions. The results of these studies are presented in Table I, and the minimum and maximum values observed are encircled.

10. The improvement in temperature compensation which resulted from the substitution of a plain aluminum abutment ring in place of the standard bi-metal ring, can be seen by referring to Table I. By this expedient, the maximum spread in regulated voltage over the temperature and regulating range was reduced from 26 volts to 7.8 volts. The maximum value of regulated voltage also was reduced from 20.6 to 3.6 volts above the value obtained at an ambient temperature of +25 degrees Centigrade, with the generator running at 6000 r.p.m., full load, regulator and generator hot.

EFFECT OF REGULATOR WARM-UP

11. Another comparison of the temperature characteristics of the original and the modified regulator was made by placing the regulator in an ambient temperature of -55 degrees Centigrade for three and one-half hours. The unit was then placed in an ambient temperature of +25 ±5 degrees Centigrade, and immediately made to control the NEA-5 generator operating at such speed and load (6000 r.p.m. and 4.9 amperes load) to make the pile dissipate 30 ±5 watts. Readings of regulated voltage were taken until the voltage stabilized. The load was not shocked. These data are presented in Table II.

12. The results obtained when the regulator was operated under the extreme and normally unencountered temperature conditions described in paragraph 11, further demonstrate the improvement resulting from the use of the aluminum ring. In this study, the maximum value of regulated voltage was reduced from 29.1 to 8.3 volts above the value at which the voltage stabilized at the termination of the run. Under these conditions, the bi-metal ring allowed the voltage to drop slowly from the high initial value until it reached a stable value after the regulator became hot. When the aluminum ring was used, the regulated voltage dropped very rapidly from the initial value, and after approximately two minutes of operation, it had returned to the value at which the voltage finally stabilized. However, the voltage continued to drop during the first 10 minutes of operation, reaching a low value 6 volts below the final voltage, after which the voltage again rose. This slight drop in voltage is obviously more desirable than the present condition of operating the equipment at high voltages for an extended period of time.

13. A comparison of the maximum values of voltage listed in Tables I and II will reveal that the voltages in Table II are approximately 10 volts higher than those in Table I for operation at -50 and -55 degrees Centigrade. The following reasons account for this:

(a) Prior to the runs presented in Table II, the stabilized voltage (hot) was set about 5 volts higher than the value used in the runs of Table I.

(b) The generator speed, at which the initial voltage peak was observed, was higher in the runs of Table II than in those of Table I. By the time the 6000 r.p.m. regulation run of Table I was made, the regulator had been operating for about two minutes, hence the unit had warmed up resulting in a lower voltage.

CONCLUSIONS

14. The temperature compensation of the Eclipse Type 1317 A.C. carbon pile voltage regulator was improved by replacing the bi-metal abutment ring with an aluminum ring having the same dimensions. The following characteristics were observed during the initial warm-up period of the regulator as a result of this modification:

(a) The overall variation of voltage due to changes in regulator temperature, generator load and speed was substantially reduced.

(b) The regulated voltage remained at the initial high value for a considerably shorter period of time.

(c) During the first ten minutes of operation, the voltage dropped to a value slightly below that at which it finally stabilized when the regulator became hot, after which it again increased to the terminal value.

RECOMMENDATIONS

15. It is recommended that all Eclipse Type 1317 A.C. carbon pile voltage regulators now in service be modified as described in paragraph 8 of this report.

REFERENCES

16. (a) BuAer ltr Aer-E-3121 SHH, F36-1(1), dated 5 June 1945.

(b) NRL ltr to BuAer R-F42-1/21(759-2:JPB), R-759-5/45(lb), dated 20 July 1945.

(c) BuAer Spec. for airborne regulators NavAer M-615, dated 1 June 1945.

T A B L E I

REGULATION RUNS AT VARIOUS AMBIENT TEMPERATURES

		BI-METAL RING				ALUMINUM RING			
		COLD		HOT		COLD		HOT	
Temp. Degrees C.	Gen. Speed	No Load	Full Load	No Load	Full Load	No Load	Full Load	No Load	Full Load
-50	4500	137.3	133.8	129.7	127.1	118.8	116.2	115.1	113.7
	6000	134.3	132.0	129.1	127.4	117.8	115.8	115.2	114.2
	8000	132.0	128.8	129.1	126.0	116.9	114.1	116.0	113.8
+25	4500	120.0	119.2	117.8	115.9	112.8	111.8	115.3	114.0
	6000	120.8	119.8	118.3	116.7	113.2	112.8	115.8	115.2
	8000	121.3	118.3	119.2	115.8	114.0	112.8	116.8	115.2
+70	4500	114.1	113.0	114.1	112.2	111.8	111.0	115.7	113.7
	6000	115.1	113.2	115.3	112.8	112.7	112.1	116.1	114.8
	8000	115.8	112.0	116.1	111.3	113.6	112.1	116.7	114.6

T A B L E II

REGULATED VOLTAGE AS A FUNCTION OF OPERATING TIME

Conditions: Regulator was placed in an ambient temperature of -55 degrees Centigrade for three and one-half hours. The unit was then placed in an ambient temperature of +25 ±5 degrees Centigrade and immediately made to control the NEA-5 generator at such speed and load to make the pile dissipate 30 ±5 watts.

Time Minutes	Gen. Speed	Load Current	REGULATED VOLTS Bi-Metal	Aluminum
0	6000	0	149.0	128.8
0	↓	4.9 A.	145.4	128.2
2		↓	138.0	120.8
5			128.3	117.2
7			125.9	115.5
10			123.8	114.5
15			122.8	115.0
20			122.1	115.9
30			120.8	117.4
40			120.5	118.7
50			120.1	119.7
60			120.0	120.2
70			119.9	120.5
80			119.9	120.5

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AUTHORIZATION

1. The studies covered in this report were initiated by reference (a).

DEFINITIONS

2. In order to clarify the information presented below, it is felt that the following definitions are in order:

(a) Temperature compensation, as the term is applied to aircraft voltage regulators, is the means employed to counteract the effect of variations in regulator temperature upon the voltage setting and regulation characteristics of these units. The regulator temperature is dependent upon the ambient air temperature, the degree of forced cooling (air blast, etc.), and the power dissipated by the carbon pile, operating coils, resistors, and rectifiers as functions of operating time.

(b) Temperature characteristic, as the term is applied to aircraft voltage regulators, is that property which allows a variation in the voltage setting and the regulation characteristics of the regulators when their temperatures change. The optimum temperature characteristic exists when the performance of the regulators is not affected by changes in regulator temperature.

INTRODUCTION

3. The poor temperature compensation of the subject Eclipse Type 1001 and 1317 A.C. carbon pile voltage regulators has been a source of complaint from various field groups and the reason for the failure of these regulators to pass the test specifications of reference (c). One such failure is adequately illustrated by reference (b). The high values of voltage obtained during the initial warm-up period of these regulators, especially when operating at low ambient temperatures, are undesirable in that damage may result to various electronic equipments which are not designed for these high voltages.

4. An examination of the construction and operating principles of these regulators indicates that the following are the sources of this voltage variation:

(a) Expansion and contraction of the regulator housing and other component parts.

(b) The changes in the resistances of the fixed resistors and the regulating coil.

(c) The change in the characteristics of the dry disc rectifier, the carbon pile resistance element, and the spring.

(d) The change in the permeability of the iron in the magnetic circuit.