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NEL CONSTRUCTED PROTOTYPE OF THE SONAR TARGET CONVERTER.(U)

FEB 62 F D PARKER, D A BALDWIN, J W BEHRENDT

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REPORT 1099

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(6) NEL CONSTRUCTED PROTOTYPE OF THE SONAR TARGET CONVERTER. (U)

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U. S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIFORNIA

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THE PROBLEM

Construct a shipboard Sonar Target Converter for increasing the capability of positive control of aircraft for antisubmarine weapon delivery or target classification.

RESULTS

1. A prototype model of a Sonar Target Converter was constructed by the Navy Electronics Laboratory. The equipment produces a pip on the PPI display of the ship's surface search radar and uses the normal coordinate system of the display for indicating sonar target position. The ASW helicopter or fixed wing aircraft being tracked on the radar can then be vectored to the target by observing the position of the sonar target relative to that of the aircraft.

2. A Fleet operational evaluation showed that the Sonar Target Converter provides an effective means for controlling aircraft on ASW missions.

3. Using the Sonar Target Converter, helicopters can be positioned over submerged submarines to a range of 12,000 yards with an average error of less than 125 yards by even inexperienced air control officers.

4. No other known equipment effectively performs the above function.

5. This equipment should be adaptable to the DASH and LORELEI programs.

RECOMMENDATIONS

1. Accept the Sonar Target Converter for service use.

2. Instruct NEL to assist in the preparation of specifications, if procurement of the equipment is planned.

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ADMINISTRATIVE INFORMATION

The Sonar Target Converter prototype was constructed under S-F007 05 01, Task 6046 (NEL Problem S1-13) for COMDESFLOT THREE. The Acoustics Division had overall responsibility for the project, and the Technical Services Division fabricated the electronic and mechanical portions of the equipment.

This report covers work from March 1961 to October 1961, and was approved for publication 6 February 1962.

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CONTENTS

ILLUSTRATIONS

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INTRODUCTION

The U. S. Navy has not had, for antisubmarine weapon delivery or target classification, the capability of positive control of helicopter or fixed wing aircraft by a ship that is tracking a target on its sonar. The Sonar Target Converter (STC) was developed for this purpose. The concept of this equipment was originated by Lieutenant D. G. Campbell, U. S. Navy, presently assigned to the Staff of Commander Destroyer Flotilla THREE. LT Campbell also constructed an experimental model and conducted tests aboard USS DEHAVEN (DD 727) together with a helicopter and submarine. The results of these tests were encouraging and were reported by DESDEVPAC.[1] Commander Destroyer Flotilla THREE requested assistance from NEL in the production of a prototype.[2] LT Campbell's device seemed to have considerable merit and was certainly simpler and less expensive than any known design for accomplishment of its intended function. Accordingly NEL agreed to provide the requested assistance,[3] and constructed a prototype of the Sonar Target Converter. The NEL equipment is shown in figure 1, and a description of it is given later in this report. It was installed aboard USS SWENSON (DD 729) during the week of 18 September 1961, and tests at sea were conducted during the week of 25 September by DESFLOT THREE. The test results are contained in a report by COMDESDEVGRU PACIFIC which recommends that the equipment be accepted for service use.[4]

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[1] DesDevPac Letter Serial 3960, 3 February 1961, Report of Sonar Target Converter Test, CONFIDENTIAL, 3 February 1961

[2] Commander Destroyer Flotilla THREE Letter CDF-3:34 hs 3930 Serial 29 to Navy Electronics Laboratory, dated 12 January 1961

[3] Navy Electronics Laboratory Letter 3900 Serial 2003-11 to Commander Destroyer Flotilla THREE, dated 9 March 1961

[4] DesDevPac Project F/069 FY 61, Report on Project F069 FY 61 Fleet Operational Investigation of the Sonar Target Converter, CONFIDENTIAL, 21 October 1961

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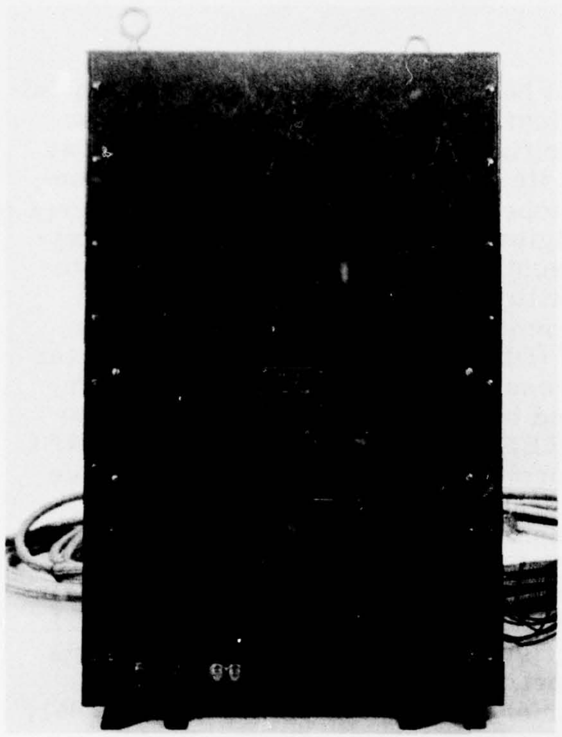

Figure 1. Front view of the Sonar Target Converter.

The Sonar Target Converter performs its function by inserting an identifiable pip on the ship's surface search radar console PPI and on its repeater scopes at the same range and bearing as the submerged target appears on the ship's sonar. A sketch of the radar display is shown as figure 2. The aircraft then flies at a suitable height to appear as a target on the radar scopes. This allows the air control officer to vector the aircraft to a point above the submerged target. Figure 3 is a photograph taken from the helicopter during the September tests at the instant the air control officer on the destroyer reported via radio that the aircraft should be directly over the target. With the helicopter flying at a height of 500 feet the camera photographed a square of the ocean 750 feet on a side. The submarine periscope and its associated wake can clearly be seen in the center of the photograph indicating that the aircraft was almost directly over the target. The range between the destroyer and submarine was greater than 10,000 yards.

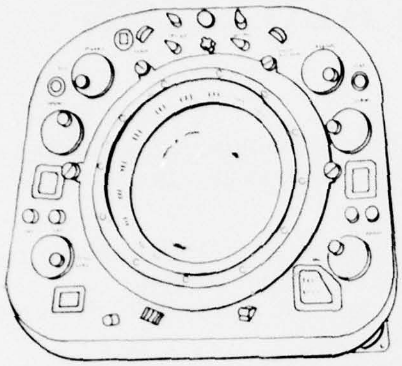

Figure 2. Sketch of radar display.

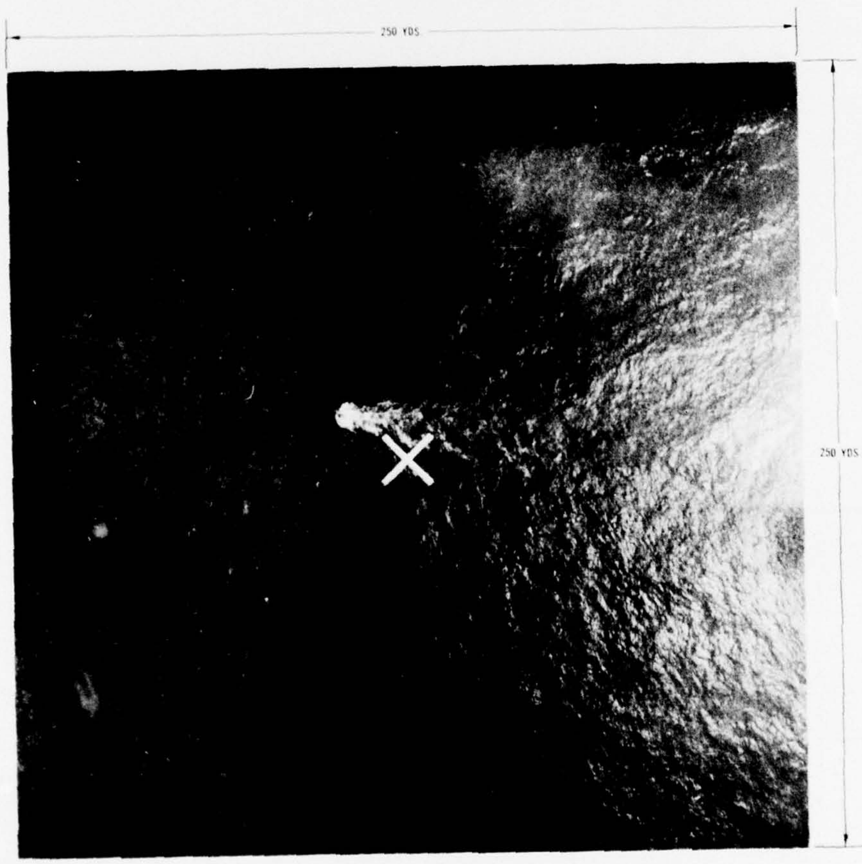

Figure 3. Vertical view of the sea surface taken from a helicopter at an altitude of 500 feet; the submarine's periscope is almost directly under the helicopter (indicated by cross).

OPERATIONAL EVALUATION RESULTS

The equipment performed effectively throughout the September tests without material failure.[4] However, three deficiencies were noted:

1. It appeared that the comparison switch should be redesigned to prevent failure on long term operation.
2. The generated target pip, on the radar PPI display, was too wide for ease of interpretation.
3. The radar range potentiometer was nonlinear over the range from 700 to 2000 yards.

Table 1 is a summary of the tests as reported in reference 4.

Table 2 is a summary of the test results as reported in reference 4. It should be noted that no photographs, from the helicopter, were obtained on the first 28 runs owing to camera difficulties in the helicopter.

TABLE 1. SUMMARY OF TESTS.

Tests	Date	No. of Runs	Range of Runs (kyd)	Air Controller
1	9/28	10	0.4 - 2.0	LTJG Dimond*
2	9/28	7	2.0 - 2.4	LTJG Sterkins*
3	9/28	11	1.5 - 2.2	LTJG Knowles
4	9/29	5	5.3 - 10.4	LTJG Dimond*
5	9/29	3	4.1 - 4.4	LT Campbell*
6	9/29	4	11.6 - 11.9	LTJG Knowles
7	9/29	4	11.1 - 11.4	LTJG Adams
8	9/29	18	11.1 - 11.5	LTJG Sterkins*

*Denotes experienced air controllers; other officers had no previous experience in controlling helicopters on ASW operations.

TABLE 2. SUMMARY OF RESULTS.

Run No.	Range (yd)	Miss Distance Estimated in Helicopter (yd)	Miss Distance Estimated in Submarine (yd)	Miss Distance Shown in Photographs (yd)	Approximate* Miss Distance (yd)
1	450	0	0	---	0
2	410	0	50	---	25
3	375	0	0	---	0
4	355	30	150	---	90
5	543	20	25	---	23
6	500	30	50	---	40
7	640	45	25	---	35
8	1260	20	15	---	18
9	1710	50	30	---	40
10	2030	50	120	---	85
11	2395	100	200	---	150
12	2140	60	150	---	105
13	2075	200	250	---	225
14	2055	50	125	---	88
15	2050	70	100	---	85
16	2055	40	90	---	65
17	2015	40	150	---	95
18	1725	150	500	---	325
19	1640	55	50	---	53
20	1600	200	300	---	250
21	1565	30	0	---	15

*Average of miss distances estimated in helicopter and submarine.

TABLE 2. (Continued)

Run No.	Range (yd)	Miss Distance Estimated in Helicopter (yd)	Miss Distance Estimated in Submarine (yd)	Miss Distance Shown in Photographs (yd)	Approximate* Miss Distance (yd)
22	1560	0	0	---	0
23	1550	0	0	---	0
24	1580	50	50	---	50
25	1620	20	25	---	23
26	1680	30	50	---	40
27	2215	0	0	---	0
28	2220	75	50	---	63
29	5300	70	150	125	---
30	4100	70	200	---	135
31	4420	20	100	90	---
32	4200	100	200	---	150
33	4100	30	60	68	---
34	4400	60	125	100	---
35	9640	30	0	60	---
36	10400	0	75	27	---
37	11800	50	200	90	---
38	11900	10	50	80	---
39	11600	30	0	100	---
40	11930	50	50	---	130
41	11400	500	400	---	450
42	11250	50	250	---	150

TABLE 2. (Continued).

Run No.	Range (yd)	Miss Distance Estimated in Helicopter (yd)	Miss Distance Estimated in Submarine (yd)	Miss Distance Shown in Photographs (yd)	Approximate* Miss Distance (yd)
43	11100	30	250	---	140
44	11100	130	350	---	240
45	11300	170	200	13	---
46	11450	30	400	40	---
47	11350	70	175	---	130
48	11300	100	300	---	200
49	11100	30	150	118	---
50	11300	0	150	37	---
51	11150	50	150	---	130
52	11300	80	250	---	165
53	11250	100	300	---	200
54	11150	0	100	50	---
55	11125	20	50	60	---
56	11120	80	400	---	240
57	11300	30	300	130	---
58	11250	70	100	---	130
59	11250	80	200	---	140
60	11100	0	50	40	---
61	11150	30	0	---	130
62	11200	0	0	65	---

Reference 4 also states that "It (STC) is simple for even the untrained controller to use . . . Comparing the accuracy of all runs at ranges less than 5, 000 yards with those at greater than 10, 000 yards. it was found that the former was 78 yards, whereas the latter was 124 yards or an increase roughly proportional to the increase in range."

As a part of the tests, the Sonar Target Converter was purposely misaligned to determine whether or not a typical electronics technician could carry out the entire alignment procedure. Reference 4 states that "one of SWENSON's electronic technicians (ETR 3) properly realigned the equipment using conventional tools within a period of 30 minutes. There were no equipment casualties during the tests, so the opportunity for repairs did not arise. But in the opinion of CO, SWENSON, should repair be necessary, shipboard electronic technicians and highly qualified radarmen will be able to repair the Sonar Target Converter."

EQUIPMENT MODIFICATION

After the tests the equipment was returned to NEL for a short period of time, and the following modifications were made to correct the deficiencies noted in the evaluation:

1. The comparison switch was redesigned to be more reliable, and a notched cam wheel and microswitch were incorporated.
2. The redesign of the comparison switch provided decreased width of the generated target on the radar PPI displays.
3. A potentiometer of adequate linearity was installed in the pulse delay generator servo. It had been recognized that the potentiometer was nonlinear over the range from 700 to 2000 yards prior to the tests, but vendors could not furnish the more suitable potentiometer until after the tests.

The equipment was then returned to DESFLOT THREE.

EQUIPMENT DESCRIPTION

The Sonar Target Converter is contained in a cabinet 30 inches high, 20 inches wide, and 16 inches deep. It weighs 80 pounds.

It combines and utilizes four types of existing ship's data:

1. Radar bearing: 1X and 36X information.
2. Sonar bearing: 1X and 36X information.
3. Sonar range: 1X and 36X information.
4. Radar trigger pulse.

The range and bearing synchro-mechanical components of the STC as well as the comparison switch and radar range potentiometer are combined on one chassis, shown in figure 4. Directly beneath this chassis are mounted the three necessary identical servo amplifiers and the range delay pulse generator, shown in figure 5. The power supply chassis is mounted at the bottom of the cabinet and is shown in figure 6 which is a photograph of the rear of the entire equipment. Six cables (fig. 6) are necessary in the installation of the STC. They are as follows:

1. Eight-conductor cable to sonar range servo amplifier.
2. Eight-conductor cable to sonar bearing servo amplifier.
3. Eight-conductor cable to radar bearing servo amplifier.
4. Coaxial cable for radar trigger pulse to input of range delay pulse generator.
5. Two-conductor cable for 117 volt ac power.
6. Coaxial cable for output signal to radar PPI displays.

Figure 7 is a block diagram of the equipment.

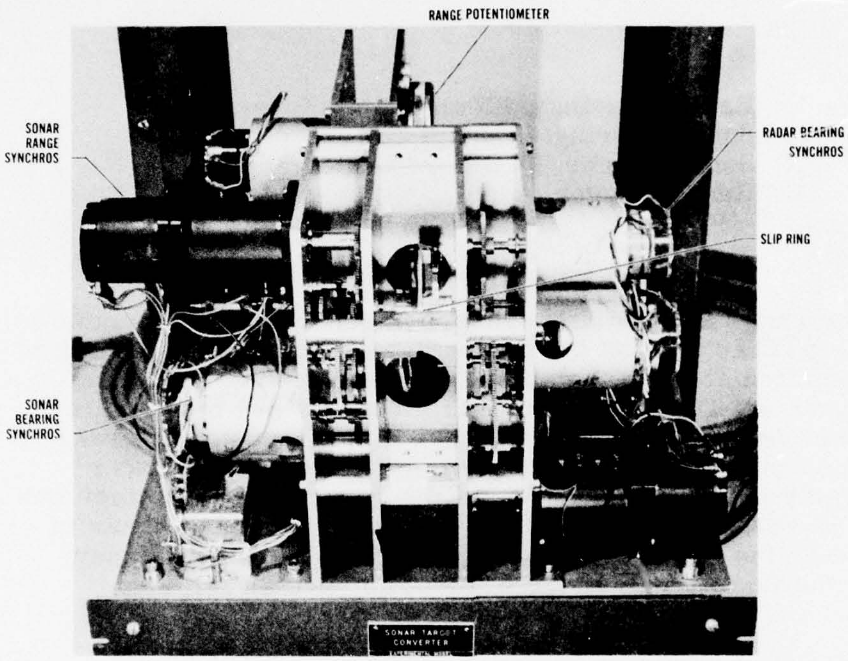

Figure 4. Mechanical arrangement of the Sonar Target Converter. A: Front view.

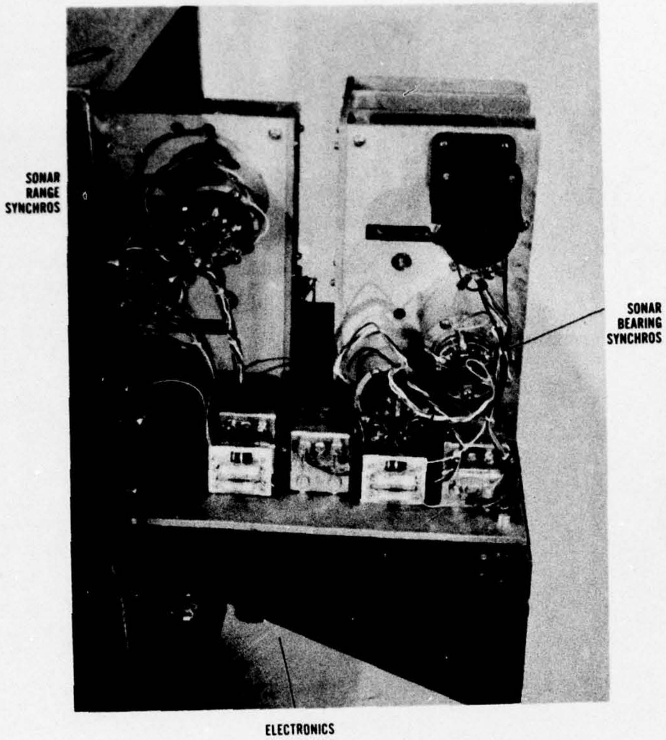

Figure 4B. Right side view.

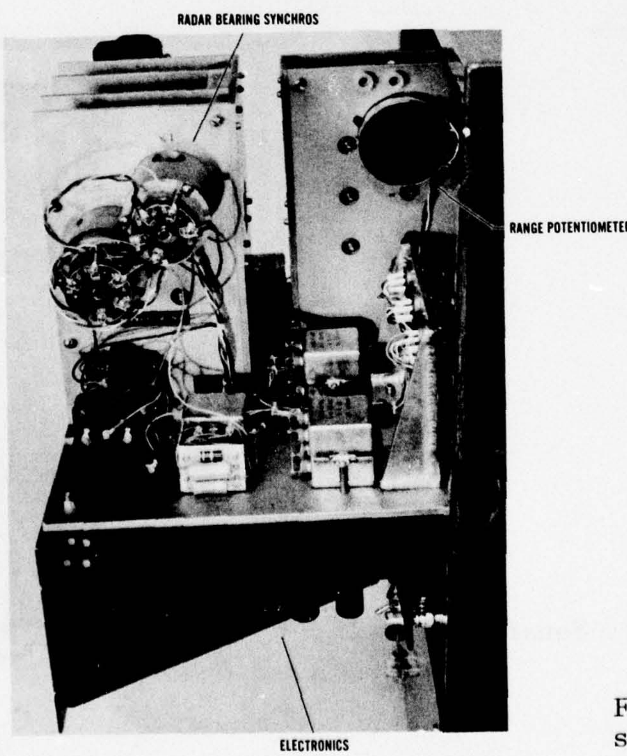

Figure 4C. Left side view.

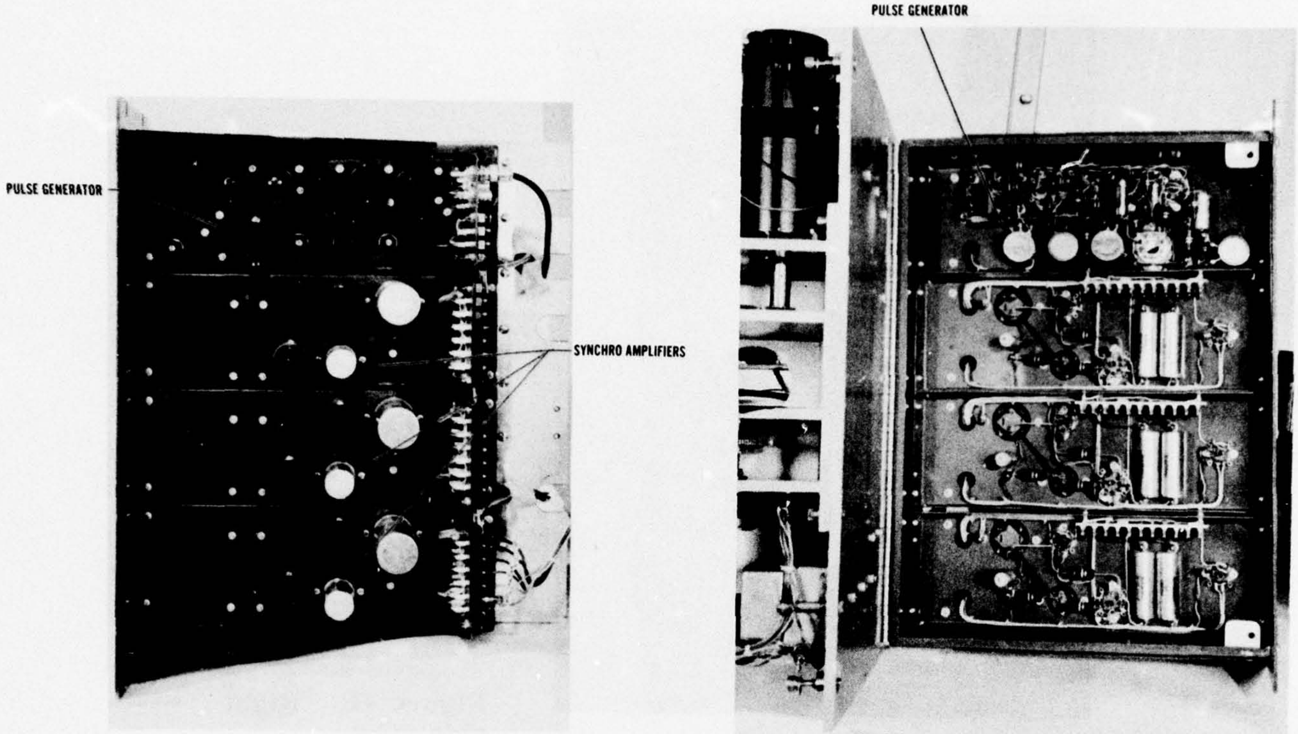

Figure 5. Center section showing the pulse generator and synchro amplifiers. A: Top view. B: Bottom view (right).

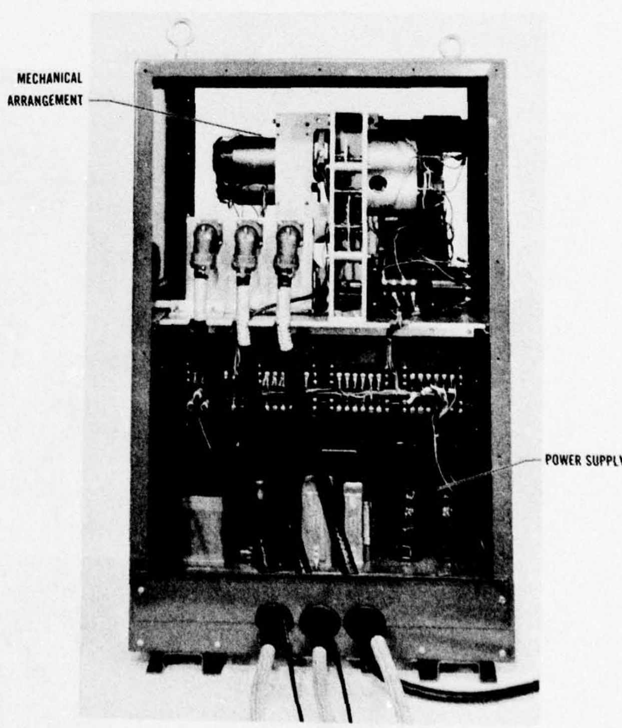

Figure 6. Rear view of the Sonar Target Converter.

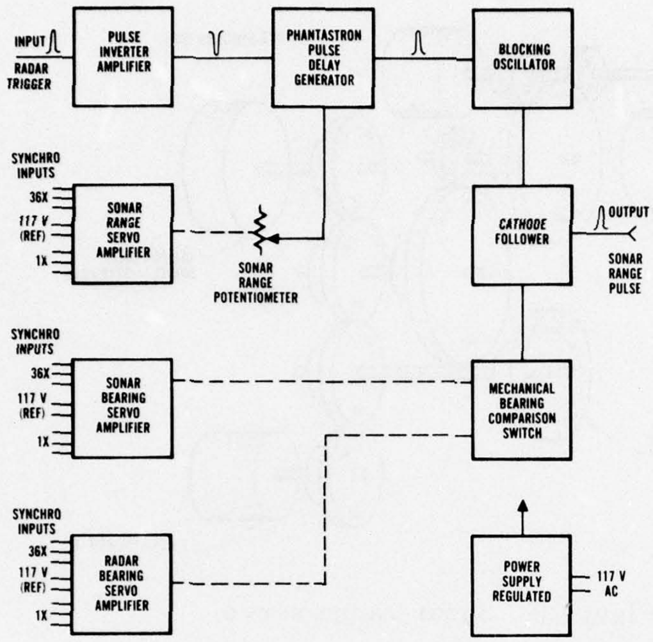

Figure 7. Block diagram of the Sonar Target Converter.

THEORY OF OPERATION

To present a generated signal representing a sonar target on the radar PPI displays, the existing sonar range and bearing information must be converted. Illustrations of the gearing and synchro systems are shown in figures 8 and 9.

The range servo system, coupled to the range control from the sonar console, positions a potentiometer shaft which in turn provides a linear variation of time delay in the range delay pulse generator. The pulse generator is synchronized by the trigger pulse from the radar.

The bearing servo system is coupled to the bearing controls from both the sonar and radar consoles. The combined servo repeated outputs position a bearing comparison switch assembly consisting of a cam wheel, slip rings, and microswitch. The cam wheel is so designed as to provide a readily distinguished group of marks on the radar display, as shown in figure 10. The sonar servo drives the cam wheel and the radar servo drives the microswitch-slip ring assembly.

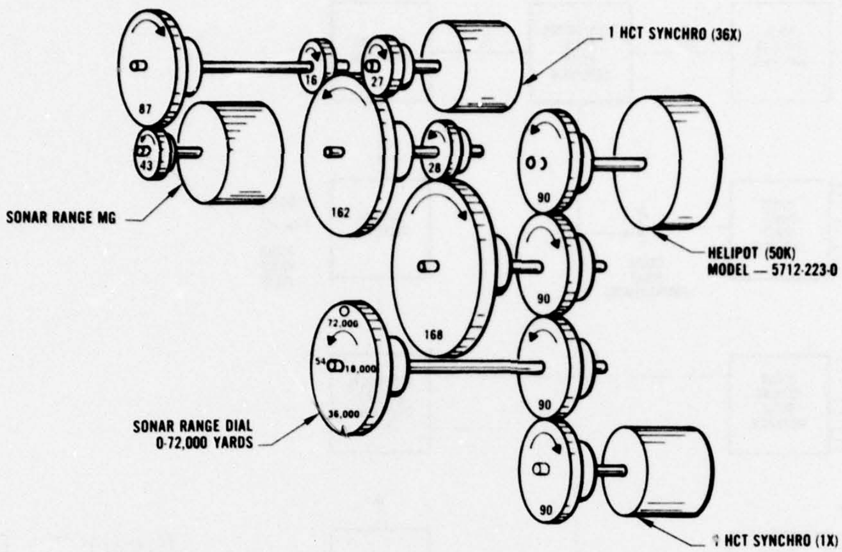

Figure 8. Sonar range servo.

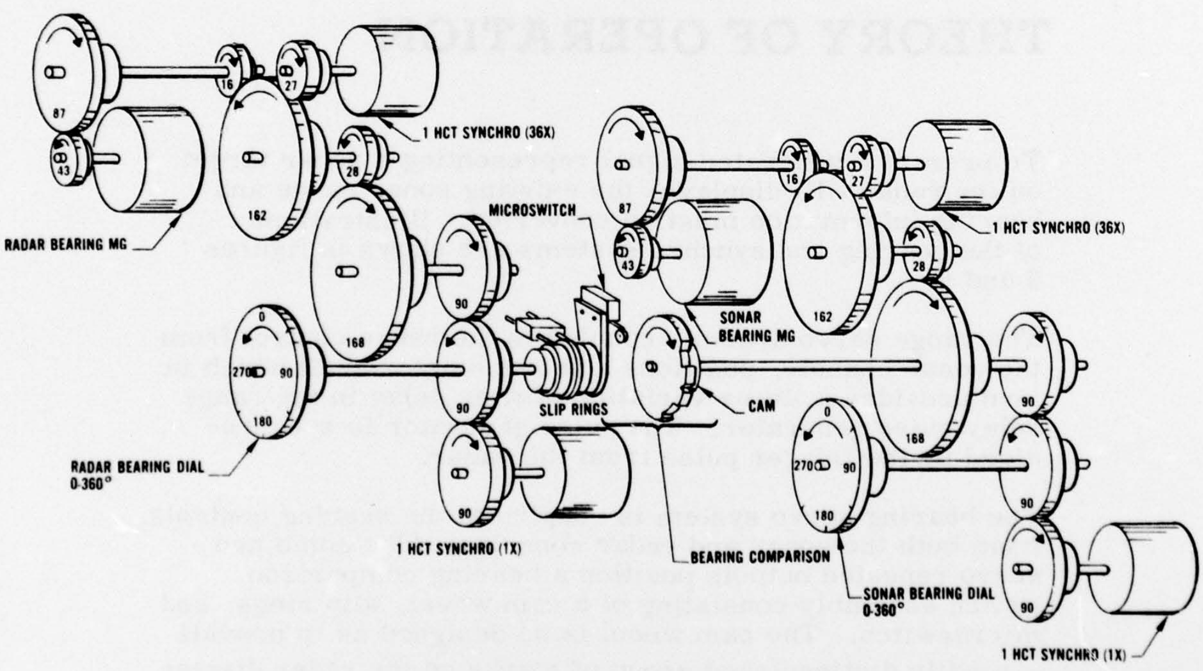

Figure 9. Sonar/radar bearing servo.

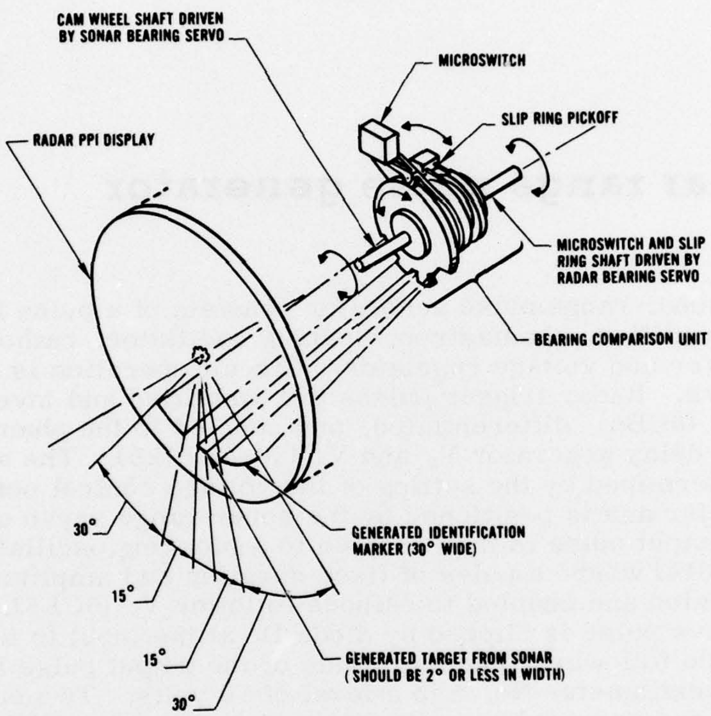

Figure 10. Method of generating sonar target on radar PPI display.

CIRCUIT DESCRIPTION

Figure 11 (a foldout at end of report) is a schematic diagram of the entire electronic circuit of the Sonar Target Converter.

sonar range pulse generator

The sonar range pulse generator consists of a pulse inverter amplifier, phantastron, blocking oscillator, cathode follower and voltage regulator. Circuit operation is as follows. Padar trigger pulses are amplified and inverted by V_1 (6CB6), differentiated, and coupled to the phantastron pulse delay generator V_2 and V_3 (5814, 5725). The amount is determined by the setting of the voltage control potentiometer and is positioned by the sonar range servo unit. The output pulse is then coupled to a blocking oscillator V_4 (5814) where a pulse of fixed duration and amplitude is generated and coupled to cathode follower V_5 (6CL6). The negative pulse is clipped by diode D_1 at the input to the cathode follower. The amplitude of the output pulse is set by potentiometer No. 4 to a level of 10 volts. Two output jacks are provided for connecting to ship radar PPI repeaters and to the radar-sonar bearing comparison circuit switch assembly. The two rotors of the comparison switch are positioned by the radar and sonar bearing servo units.

Calibration of the sonar range servo unit is set by adjusting potentiometer No. 1 to 110 microseconds with the sonar dial set at 18, 000 yards. Potentiometer No. 2 is set to 6. 1 microseconds for a 1000 yard sonar range dial setting. Should adjustment of the sonar range voltage potentiometer be required, it can be accomplished by unclamping the three screw clamps and rotating the potentiometer to a minimum voltage reading for zero sonar range, followed by clamping and calibrating as above.

Voltage regulator V_6 (6005) sets the phantastron supply voltage and should be set at 190 volts at the cathode of V_6.

servo amplifiers

The three servo amplifiers, radar bearing, sonar bearing, and sonar range, are identical electrically and are interchangeable. Figure 11 includes a schematic of one of them. The servo amplifier consists of three stages. A dual triode cascaded voltage amplifier (5814) is resistance-coupled to a cathode follower power amplifier (6005) and cathode loaded by the servo motor's armature. The cathode current is allowed to flow through the armature for damping of the motor circuitry. A dual diode (5726) at the input to the servo amplifier sets the maximum signal input level to this stage. The attenuator network (resistors 10K, 2.2K) in the grid circuit in combination with cathode feedback and the 1X synchro input effect amplification of signal errors larger than 2.5°. Servo error signals less than 2.5° are amplified through the input of the 36X synchro error voltage in the cathode of the second stage. An induction generator coupled to the motor shaft provides velocity modulation for minimum hunting in the over-all servo system.

If the direction of signal follow-up error aboard ship is in reverse to that of the target converter's bearing or range dial, this can be corrected by reversing the 1X and 36X synchro's S-1 and S-3 leads on the mechanical assembly.

Both the sonar and radar bearings (1X and 36X) are brought into the correct ship's bearing on the dial readings by loosening the three clamps holding the synchro's and zeroing them to ship's bearing.

power supply

The power supply is of the standard series-regulated type. An adjustment is provided for setting the output voltage (300 volts) in the event of change through replacement of tubes. Additional low voltages are obtained through a resistor divider network and a silicon rectifier to supply the negative low voltages required of the servo amplifiers.

CONCLUSIONS

As a result of the tests made on the Sonar Target Converter aboard SWENSON, the authors concur in the following conclusions which were noted in reference 4:

1. The Sonar Target Converter accurately reproduces sonar target coordinates on a radar scope, providing an effective means for controlling helicopters on ASW missions.

2. Using the STC, helicopters can be positioned over submerged submarines with an average error of less than 125 yards to a range of 12, 000 yards.

3. Air controllers do not require special training to be able to use the STC.

4. Additional channels for display with the STC are not required.

5. Electronics technicians aboard ship can align and maintain the STC.

It is further concluded that:

1. The NEL constructed prototype of the STC meets or exceeds the specifications as outlined in reference 1.

2. The equipment will increase the effectiveness of surface craft and aircraft in ASW operations.

3. The STC should be adaptable in the DASH and LORELEI programs.

4. No other equipment apparently satisfies all of the outlined requirements.

5. In production, the STC could be significantly decreased in physical size.

6. The productivity resulting from the cooperative effort related to the development and test of the Sonar Target Converter demonstrates how well the Laboratory can assist the Fleet in the expansion and adaptation of Fleet-conceived ideas.

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RECOMMENDATIONS

It is recommended that:

1. The Sonar Target Converter be accepted for service use.

2. If specifications are to be written for production of the STC NEL should assist in their preparation.

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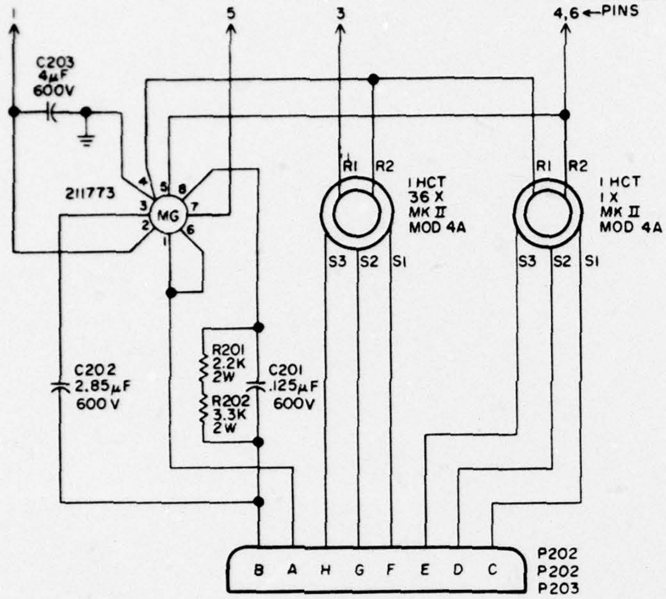
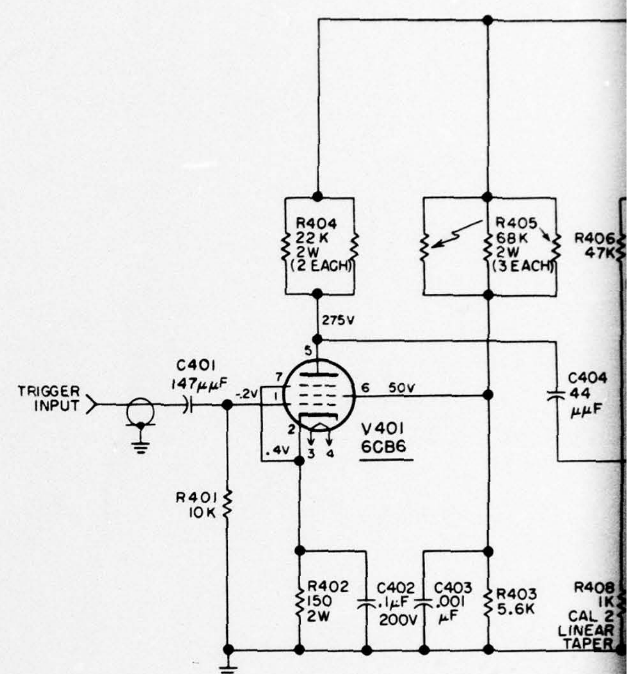
SERVO SYSTEM

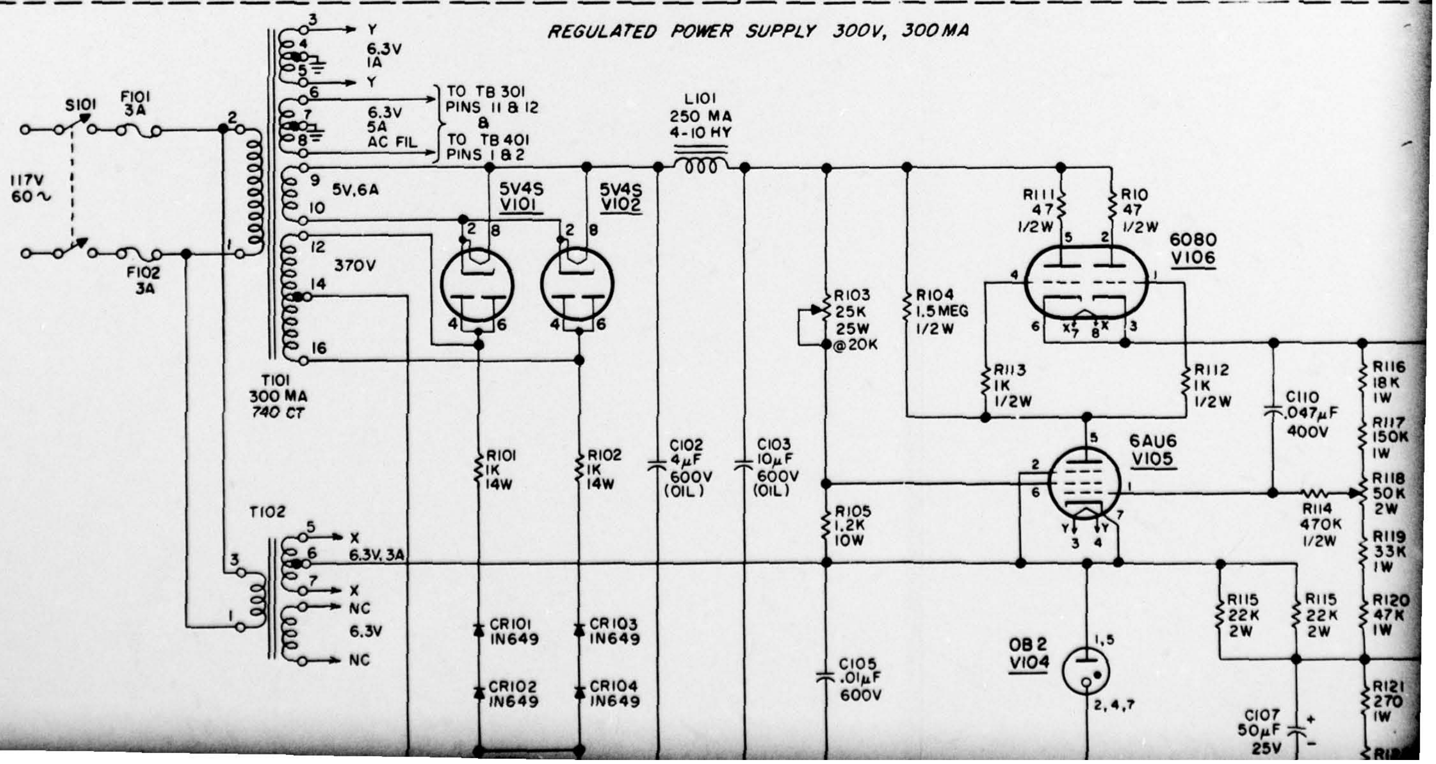


NOTE: 3 IDENTICAL SERVO SYSTEMS

1 EACH FOR: RADAR BEARING
SONAR BEARING
SONAR RANGE



REGULATED POWER SUPPLY 300V, 300MA



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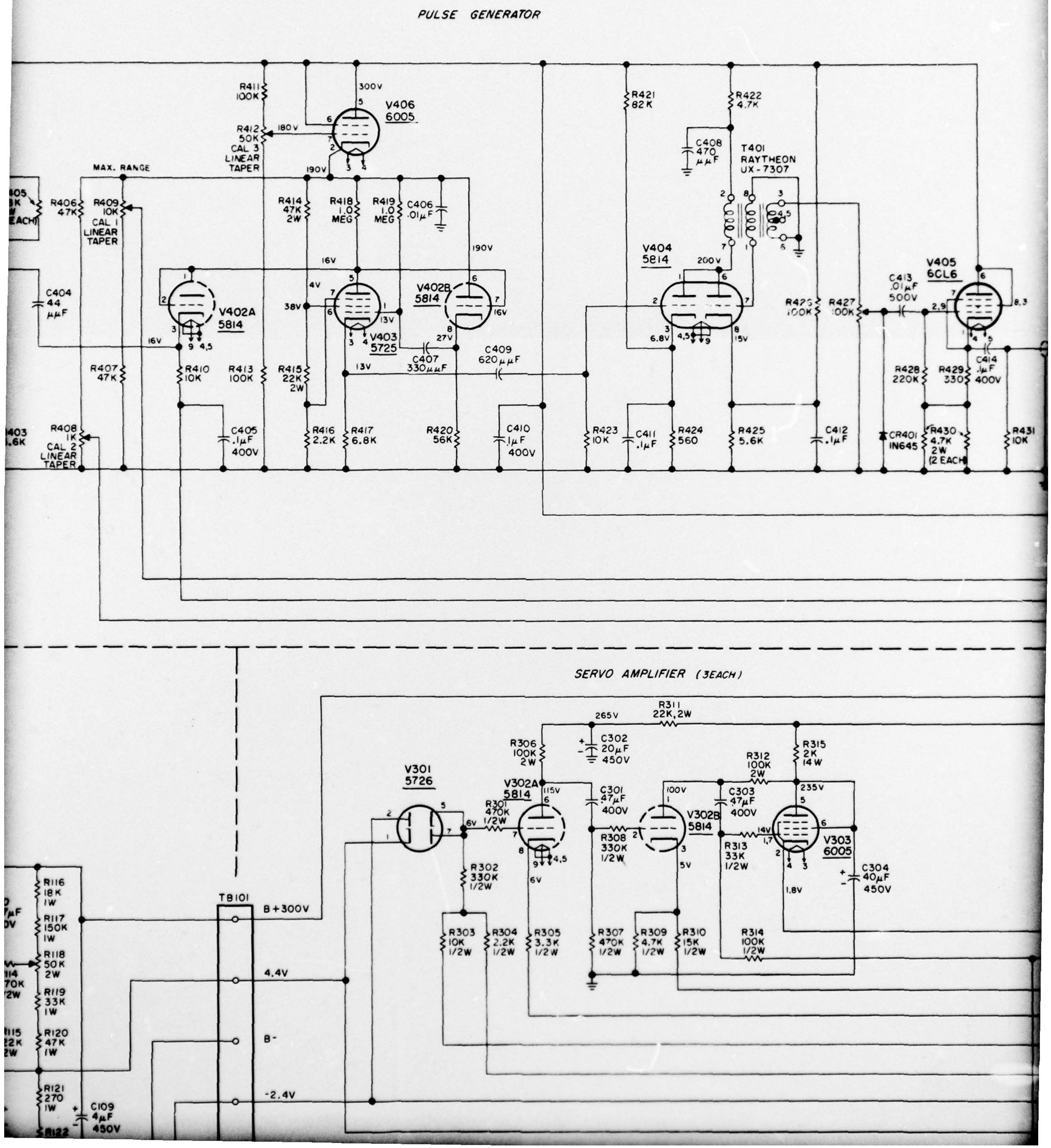

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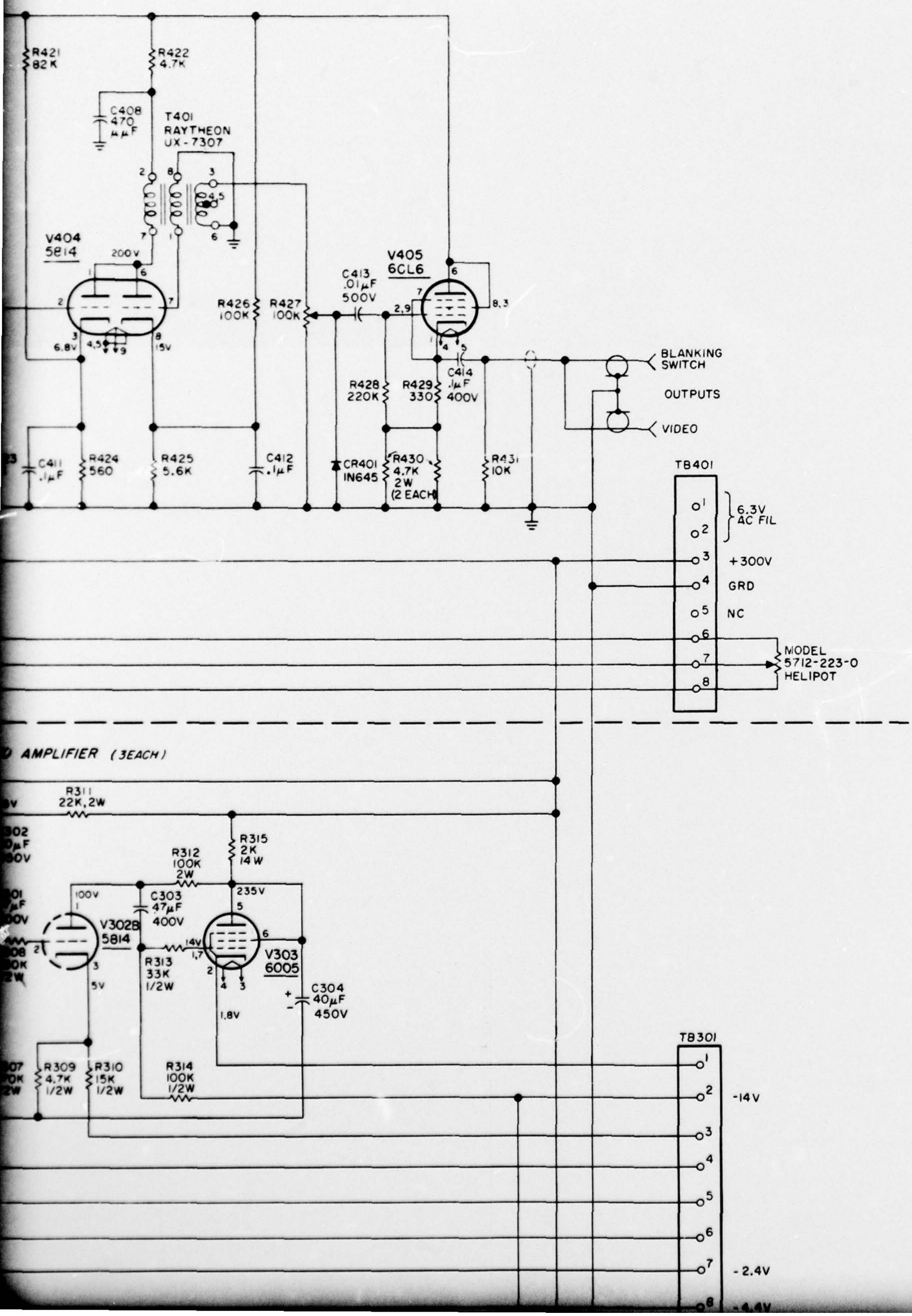

R421
82K
R422
4.7K
C408
470
μμF
T401
RAYTHEON
UX-7307
V404
5814
200V
6.8V
15V
R426
100K
R427
100K
C413
.01μF
500V
V405
6CL6
8,3
2,9
BLANKING
SWITCH
OUTPUTS
VIDEO
R428
220K
R429
330
C414
.1μF
400V
C411
.1μF
R424
560
R425
5.6K
C412
.1μF
CR401
IN645
R430
4.7K
2W
(2 EACH)
R431
10K
TB401
6.3V
AC FIL
+300V
GRD
NC
MODEL
5712-223-0
HELIPOT
AMPLIFIER (3EACH)
R311
22K, 2W
R315
2K
14W
R312
100K
2W
C303
47μF
400V
100V
235V
V302B
5814
14V
R313
33K
1/2W
V303
6005
5V
C304
40μF
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1.8V
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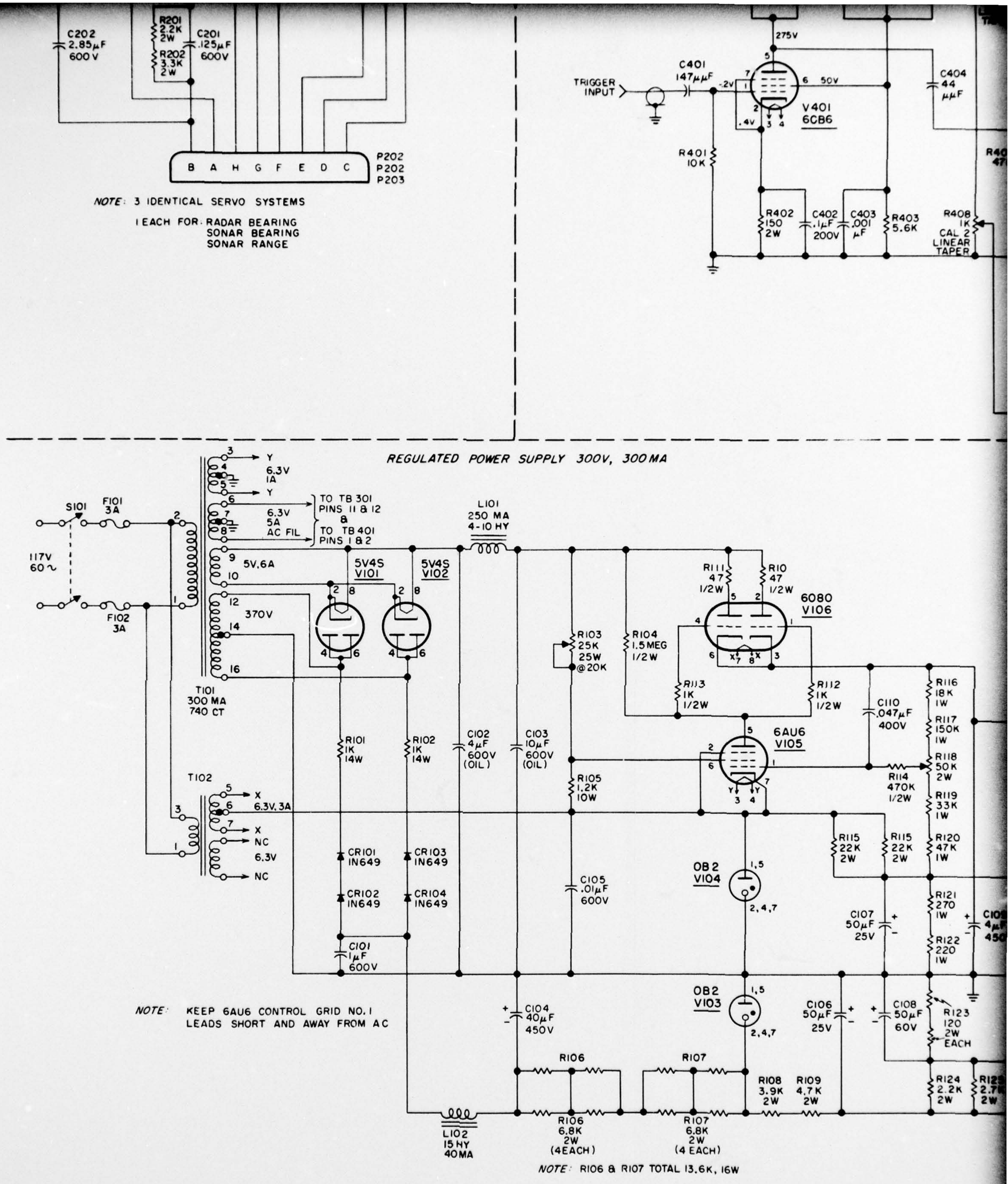
-14V
-2.4V



C202 2.85μF 600V
R201 2.2K 2W
R202 3.3K 2W
C201 .125μF 600V
B A H G F E D C
P202 P202 P203
NOTE: 3 IDENTICAL SERVO SYSTEMS
1 EACH FOR: RADAR BEARING
SONAR BEARING
SONAR RANGE
TRIGGER INPUT
C401 147μμF
-2V
275V
6 50V
C404 44 μμF
V401 6CB6
.4V
R401 10K
R402 150 2W
C402 .1μF 200V
C403 .001 μF
R403 5.6K
R408 1K CAL 2 LINEAR TAPER
REGULATED POWER SUPPLY 300V, 300MA
Y
6.3V 1A
Y
TO TB 301 PINS 11 & 12 &
6.3V 5A AC FIL
TO TB 401 PINS 1 & 2
S101
F101 3A
117V 60~
F102 3A
5V,6A
370V
T101 300 MA 740 CT
L101 250 MA 4-10 HY
5V4S V101
5V4S V102
R111 47 1/2W
R10 47 1/2W
6080 V106
R103 25K 25W @20K
R104 1.5 MEG 1/2W
R113 1K 1/2W
R112 1K 1/2W
R116 18K 1W
C110 .047μF 400V
R117 150K 1W
6AU6 V105
R118 50K 2W
R114 470K 1/2W
R119 33K 1W
R101 1K 14W
R102 1K 14W
C102 4μF 600V (OIL)
C103 10μF 600V (OIL)
R105 1.2K 10W
T102
X
6.3V, 3A
X
NC
6.3V
NC
R115 22K 2W
R115 22K 2W
R120 47K 1W
CR101 IN649
CR103 IN649
CR102 IN649
CR104 IN649
OB2 V104
C105 .01μF 600V
C107 50μF 25V
R121 270 1W
R122 220 1W
C101 1μF 600V
OB2 V103
NOTE: KEEP 6AU6 CONTROL GRID NO. 1 LEADS SHORT AND AWAY FROM AC
C104 40μF 450V
C106 50μF 25V
C108 50μF 60V
R123 120 2W EACH
R106
R107
R108 3.9K 2W
R109 4.7K 2W
R124 2.2K 2W
L102 15HY 40MA
R106 6.8K 2W (4EACH)
R107 6.8K 2W (4 EACH)
NOTE: R106 & R107 TOTAL 13.6K, 16W

H

24-Blank

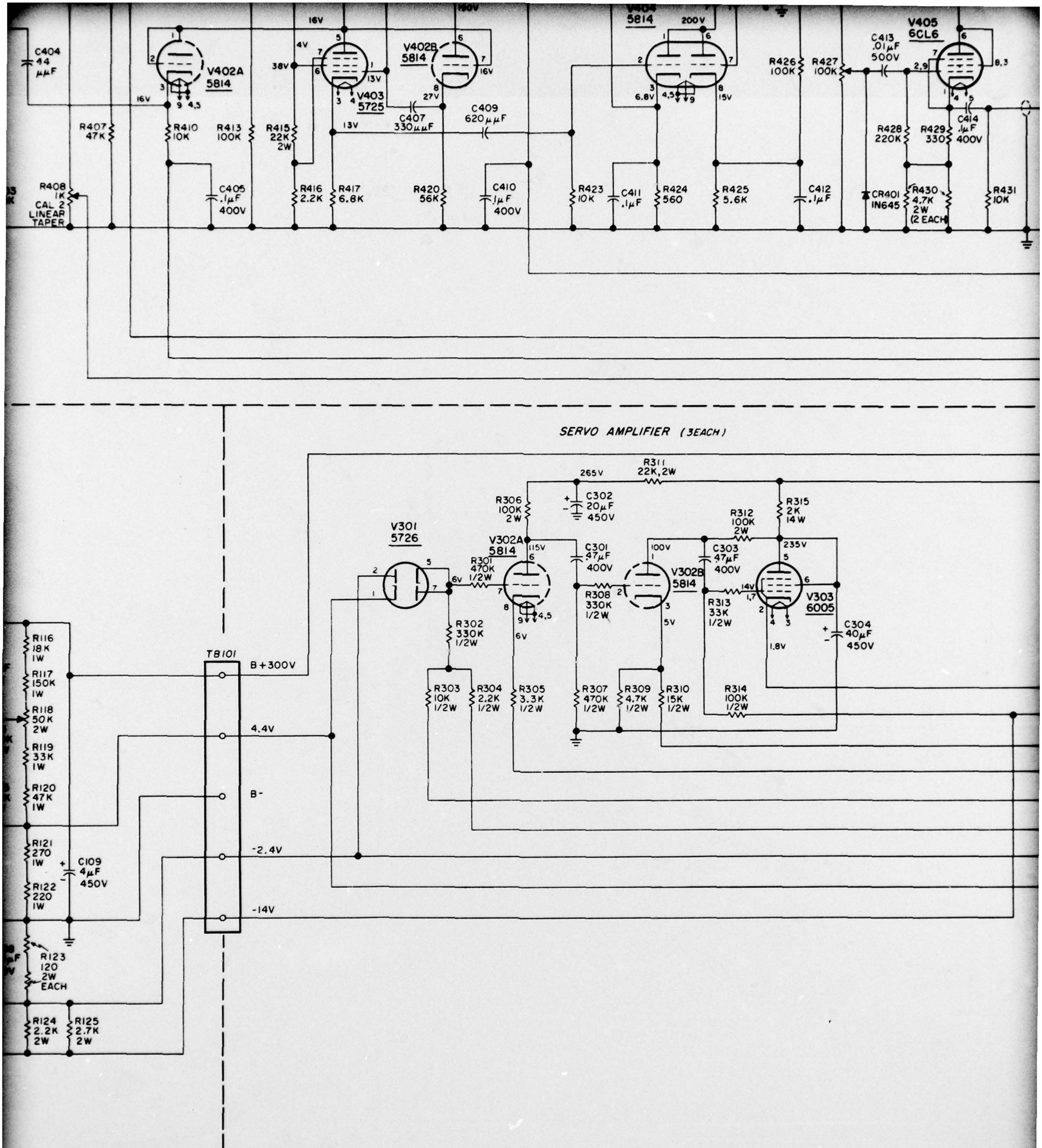


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Figure 11. Scher

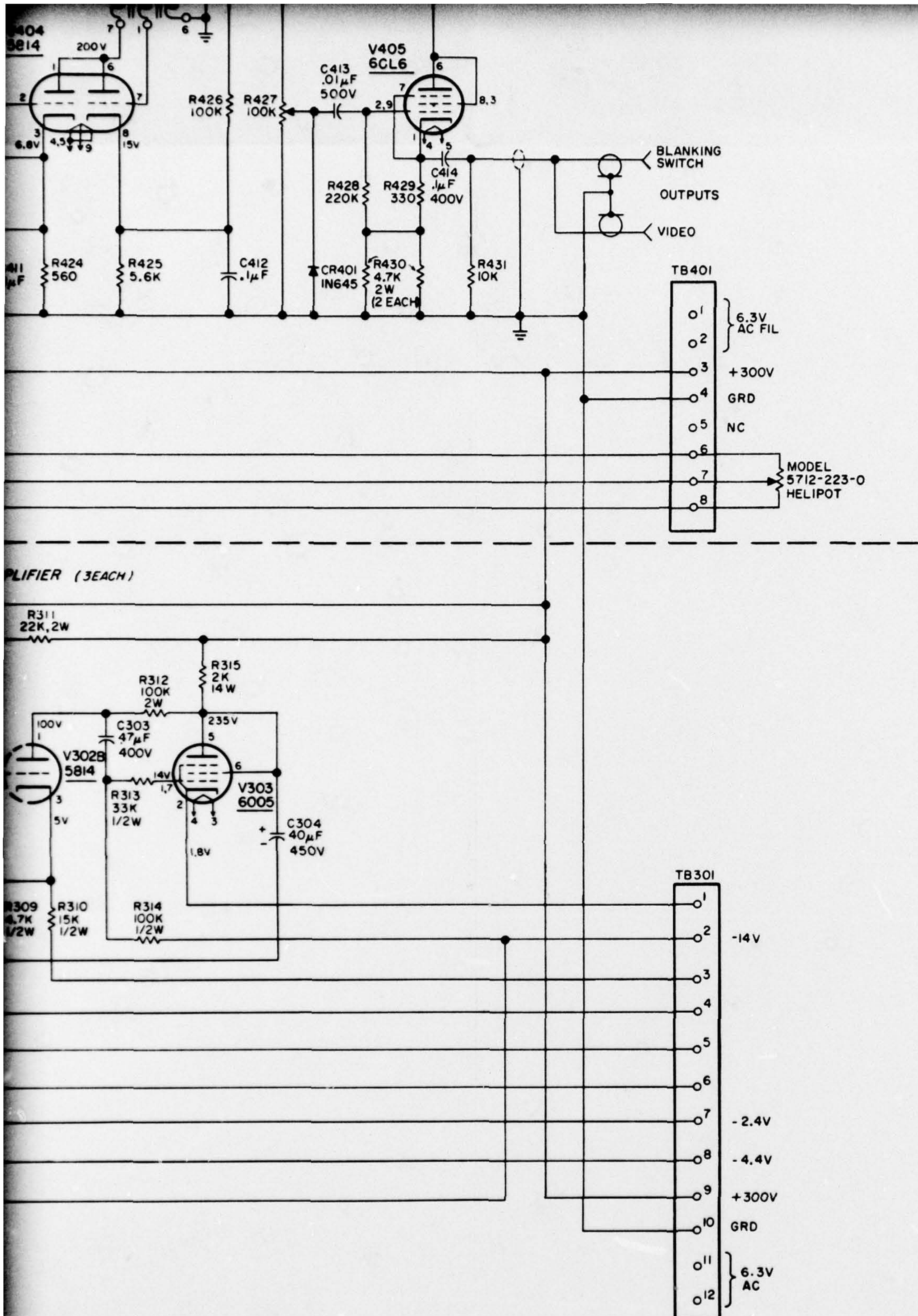

Figure 11. Schematic of Sonar Target Converter.

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1. Aircraft intercept control systems
2. Helicopters - Positioning
3. Sonar target converters

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II. Baldwin, D. A.
III. Behrendt, J. W.

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